USER'S MANUAL

MODEL 637

ELECTROMAGNET

POWER SUPPLY

Designed and Manufactured in the United States of America by

LakeShore
Measurement and Control Technologies

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Manual No. MAN-637B

3 January 1992

ISTPS?

Description Output current step limit status query.

Syntax

Input ISTPS?

Returned The value returned is 0 for off or 1 for on.

Remarks One character plus up to two terminators are returned.

STEP?

Description Output current step limit exceeded query.

Syntax

Input STEP?

Returned The value returned is 0 is the step limit has not been exceeded or 1 if it has been exceeded.

Remarks One character plus up to two terminators are returned.

STEPR1

Description Output current step limit status reset.

Syntax

Input STEPR1

Remarks When the output current step limit has been exceeded, this command must be issued before normal operation can be resumed.

LIMITED WARRANTY

Lake Shore Cryotronics, Inc. (henceforth Lake Shore), the manufacturer, warrants this product for a period of twelve (12) months (six months for sensors) from the date of shipment. During the warranty period, under authorized return of instruments or component parts to Lake Shore freight prepaid, the company will repair, or at its option replace, any part found to be defective in material or workmanship, without charge to the Owner for parts, service labor or associated customary shipping cost. Replacement or repaired parts will be warranted for only the unexpired portion of the original warranty.

All products are thoroughly tested and calibrated to published specifications prior to shipment. Calibration Certifications are offered for six month periods only. Where such documentation must be updated, a re-certification service is offered by Lake Shore at a reasonable cost.

LIMITATION OF WARRANTY

This warranty is limited to Lake Shore products purchased and installed in the United States. This same protection will extend to any subsequent owner during the warranty period. It does not apply to damage caused by accident, misuse, fire, flood, or acts of God, from failure to properly install, operate, or maintain the product in accordance with the printed instructions provided. This warranty does not apply to defects resulting from improper or inadequate maintenance, unauthorized modification or misuse, operation outside of the environmental specifications for any product or part or buyer-supplied software interfacing.

THIS WARRANTY IS IN LIEU OF ANY OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, WHICH ARE EXPRESSLY EXCLUDED. THE OWNER AGREES THAT LAKE SHORE'S LIABILITY WITH RESPECT TO THIS PRODUCT SHALL BE SET FORTH IN THIS WARRANTY, AND INCIDENTAL OR CONSEQUENTIAL DAMAGES ARE EXPRESSLY EXCLUDED.

CERTIFICATION

Lake Shore certifies that this product has been inspected and tested in accordance with its published specifications and that this product met its published specifications at the time of shipment. The accuracy and calibration of this product at the time of shipment are traceable to the United States National Institute of Standards and Technology (NIST); formerly known as the National Bureau of Standards (NBS).

TRADEMARK ACKNOWLEDGMENT

Many of the designations used by manufacturers and sellers to distinguish their products are claimed as trademarks. Where those designations appear in this manual and Lake Shore was aware of a trademark claim, the designations have been printed in initial capital letters and the ™ or ® symbol used.

Quad-Twist™ is a trademark of Lake Shore Cryotronics, Inc.

ISTP

Description Programs the Output Current Step Limit.

Syntax

Input ISTP [step limit]

[step limit] Full in the step limit parameter with a value between 0 and +999.9900

Remarks Normal resolution truncates the value to the 0.01 place. High resolution truncates the value to the 0.001 place.

The initial condition is +000.000A.

The step limit is always forced to a plus.

ISTP?

Description Output Current Step Limit Query.

Syntax

Input ISTP?

Returned The value returned is a number between 0 and +999.9900A

Remarks Nine characters plus up to two terminators are returned.

Value is shown as a "+", but applies to both positive and negative step changes.

ISTPS

Description Programs the status of the Output Current Step Limit.

Syntax

Input ISTPS [status]

[status] Fill in the status parameter with a:
0 to turn off the output current step limit
1 to turn on the output current step limit

Remarks The initial condition is 0.

Model 637 MPS Configuration

Control Unit Serial Number: _____

Control Unit Software Version: _____

Mainframe Serial Number(s): _____

_____

Mainframe Software Version: _____

Sales Order Number: _____

Control Unit Options:	Installed	Input 1	Input 2
6016 Liquid Helium Level and Gaussmeter Input Card	☐	☐	☐
6013 RS-232C Serial Interface	☐		
6015 Analog Output			
Output Current	☐		
Output Voltage	☐		

Mainframe Options:

6377 High Resolution Display and Programming . . . . . ☐

Special Configurations: _____

_____

_____

The cursor up and down arrow icon indicates parameters that can only be changed using the Use the Cursor keys to move the line indicator up and down. The up and down arrow icon indicates parameters that can only be changed using the Data Entry up and down arrows. All others can be changed using all the numeric entry modes, including the cursor. *(Review Section 3 for keypad operations.)*

The following are valid Output Current Step Limit entries:

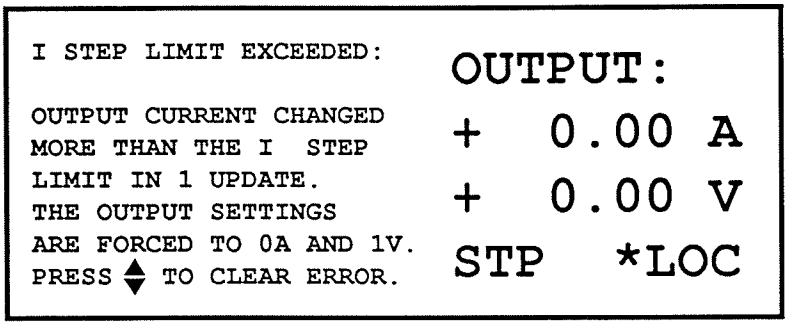
STATUS: <OFF> or <ON>

Output Current Step Limit Status. Use the Data Entry up or down arrows to toggle the status.

ISTEP: + 0.00 A to + 999.99 A

Output Current Step Limit. This value is the Output Current Step Limit setting. Use any numeric entry mode to change the value.

If the Mainframe detects a change in the output current that exceeds the step limit, the Mainframe enters the Step Limit Mode and forces the output settings to 0 amps and 1 volt. On the next update cycle, the Mainframe notifies the Control Unit that the step limit was exceeded. The Control Unit closes the FLT contacts to indicate the fault and the internal audio indicator beeps about once per second. The Control Unit displays the following:



The audio indicator continues to beep and operation is halted until the Data Entry up or down arrow is pressed to clear the current step limit fault. When current step limit fault is cleared, the Control Unit opens the FLT contacts and turns off the internal audio indicator and the display changes to the normal display.

Safety Summary

The following general safety precautions must be observed during all phases of operation, service, and repair 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. Lake Shore Cryotronics, Inc. assumes no liability for the customer's failure to comply with these requirements.

Ground The Instrument

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three-conductor AC power cable or a three-prong detachable connector. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet Underwriters Laboratories (UL) and International Electrotechnical Commission (IEC) safety standards.

Do Not Operate In An Explosive Atmosphere

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

Keep Away From Live Circuits

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. To avoid injuries, always disconnect power and discharge circuits before touching them.

Do Not Substitute Parts Or Modify Instrument

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an authorized Lake Shore Cryotronics, Inc. representative for service and repair to ensure that safety features are maintained.

Dangerous Procedure Warnings

A WARNING heading precedes potentially dangerous procedures throughout this manual. Instructions in the warnings must be followed.

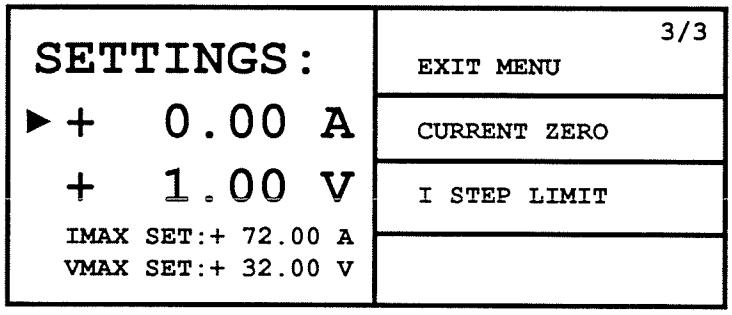
Description

When a superconducting magnet quench occurs, the magnet becomes resistive. The output current will force the MPS output to the voltage setting (constant voltage mode) and the output current will drop rapidly. To avoid excessive cryogen boil off, the output current setting should be changed to 0 as quickly as possible.

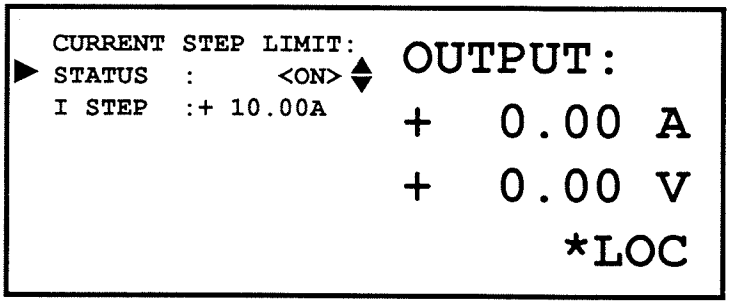
An output current step limit feature was added which allows the user to enter a current step limit which, if exceeded for any reason, automatically resets the output settings to 0A and 1V.

Operation

The output current step limit can be accessed from the control unit front panel. Press the Function Menu key. Function Menu 1 will be displayed. Press the Next Menu key. Function Menu 2 will be displayed. Press the Next Menu key again. Function Menu 3 will be displayed.



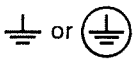
Press the I STEP LIMIT Function Key. The Current Step Limit screen will be displayed.



Safety Symbols

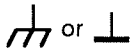
Instruction manual symbol: the product will be marked with this symbol in order to protect against damage to the instrument.

Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).



Protective conductor terminal. For protection against electrical shock in case of a fault. Used with field wiring terminals to indicate the terminal which must be connected to ground before operating equipment.

Low-noise or noiseless, clean ground (earth) terminal. Used for a signal common, as well as providing protection against electrical shock in case of a fault. A terminal marked with this symbol must be connected to ground in the manner described in the installation (operating) manual, and before operating equipment.



Frame or chassis terminal. A connection to the frame (chassis) of the equipment which normally includes all exposed metal structures.

Alternating current (power line).

Direct current (power line).

Alternating or direct current (power line).

WARNING

The **WARNING** sign denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in injury or death to personnel.

CAUTION

The **CAUTION** sign denotes a hazard. It calls attention to an operating procedure, practice, or the like which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product.

NOTE

The **NOTE** sign denotes important information. It calls attention to procedure, practice, condition or the like, which is essential to highlight.

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ZI?

Description Current Zero Value Query

Syntax

Input ZI?

Returned The value returned is a number between ±999.9999.

Remarks Nine characters plus up to two terminators are returned.

ZIS

Description Programs the Current Zero Status

Syntax

Input ZIS[status]

[status] Fill in the status parameter with **0** to turn off the current zero or **1** to turn it on.

Remarks When the current zero is turned off, the current zero value is reset to 0.

ZIS?

Description Current Zero Status Query

Syntax

Input ZIS[status]

Returned The value returned will be **0** if the current zero is off or **1** if it is on.

Remarks One character plus up to two terminators are returned.

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IMODE?

Description Mainframe Current Programming Mode Query.

Syntax

Input IMODE?

Returned The value returned will be 0 if the Mainframe I MODE switch is set to EXT or 1 if set to INT.

Remarks One character plus up to two terminators are returned.

When multiple Mainframes are present, the current programming mode of Mainframe 1 is reported.

VMODE?

Description Mainframe Voltage Programming Mode Query.

Syntax

Input VMODE?

Returned The value returned will be 0 if the Mainframe V MODE switch is set to EXT or 1 if set to INT.

Remarks One character plus up to two terminators are returned.

When multiple Mainframes are present, the voltage programming mode of Mainframe 1 is reported.

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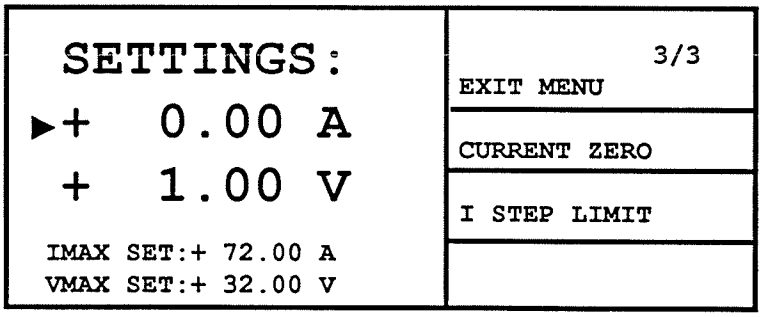
Description

The MPS Mainframe output current and voltage can be remotely programmed by external voltages or potentiometers in addition to the internal digital programming. External analog programming is enabled via the rear panel MODE switches. When the mode switch is in the INT I or V position, the external current or voltage programming mode is disabled. When the MODE switch is in the EXT I or V position, the external programming voltage is summed with the internal programming voltage.

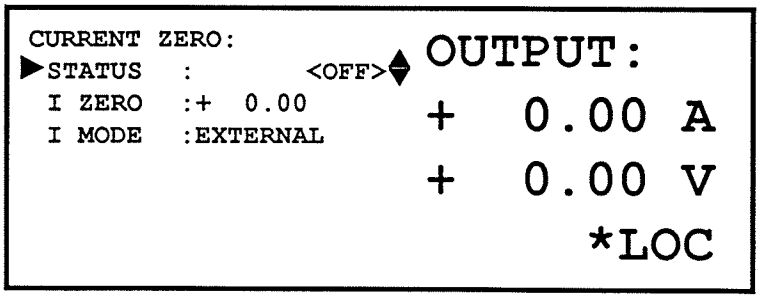
There may be configurations, like multiple auto-parallel Mainframes, that introduce an output current offset from zero. This small offset current could translate into a large energy stored in the magnet load. An output current zero feature was added which allows the user to zero this output current offset from the Control Unit front panel. The current zero feature is enabled when either internal or external programming is being used. The current zero value is stored in non-volatile memory in the Mainframe.

Operation

Output current zero can be accessed from the Control Unit front panel. Enter a current setting of zero and allow the output current to settle to the offset value. Press the Function Menu key. Function Menu 1 will be displayed. Press the Next Menu key. Function Menu 2 will be displayed. Press the Next Menu key again. Function Menu 3 will be displayed.



Press the CURRENT ZERO Function key. The Current Zero screen will be displayed. The Menu window will return to displaying the output values.



The Data Entry up or down arrows toggle the status. If the status is ON, it must be toggled to OFF to clear the old value before a new value will be accepted. When the status is toggled ON, the output current is stored as the current zero and is displayed as the I ZERO value.

INTRODUCING THE MODEL 637 ELECTROMAGNET POWER SUPPLY

1

General Description

The Model 637 Magnet Power Supply (MPS) consists of two instruments: a Model 637 Mainframe and a Model 601 Control Unit. The two communicate over a high speed digital control bus. The Control Unit acts as the human and computer interface giving commands to the Mainframe for implementation. The Control Unit continuously monitors Mainframe status.

The True, Four-Quadrant Output *(an industry first)*, can be programmed for either constant current *(CC)* or constant voltage *(CV)* operation with the capacity to source or sink up to 2000 VA. Maximum outputs are ±72 amperes and ±32 volts. Unlike conventional designs, power flow is bidirectional. Sink power is returned to the AC line as opposed to being wasted by an energy absorber in the form of excessive heat.

The Mainframe output control combines digital and analog circuitry to provide the most precise, stable output regulation possible. Output settings and limits are entered and monitored digitally under microprocessor control and converted to analog quantities using D/A converters in the analog control circuit. A precision shunt is used for output current stabilization. Remote and local sensing of the output voltage allows for compensation of IR drops in the output leads. High resolution A/D converters are used to monitor the output current and voltage. In addition to front panel and remote interface programming through the Control Unit, analog current and voltage programming inputs and monitoring outputs are provided on the Mainframe rear panel.

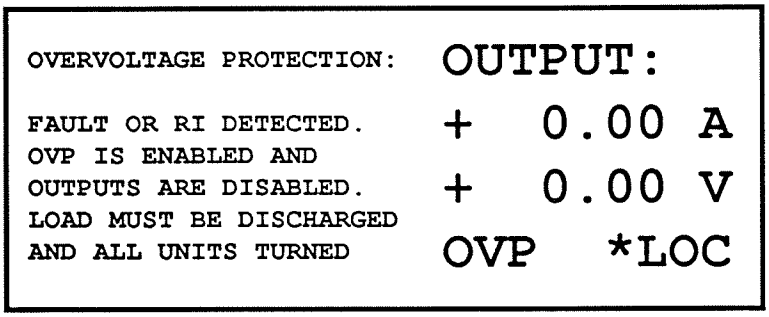
All operating parameters can be set and monitored from the Control Unit front panel as well as over the remote interfaces. Output voltage and current, CC and CV limits, output profiling *(ramp programming)*, field measurement, and instrument status can be accessed. An IEEE-488 interface is standard in the Control Unit.

The delicate nature of most loads necessitates several different types of protection. Load faults *(such as overvoltage)*, overtemperature, low or high AC input, or internal faults trigger the Mainframe to bring the output to zero in a fail safe mode. In the event of an AC utility loss, the MPS draws power from the load to keep the system functional. A discrete Fault Indicator *(FLT)* output and a Remote Inhibit *(RI)* input are provided on both the Mainframe and the Control Unit. These functions are interface independent and provide a hardware means of fault indication and remote shutdown in addition to the internal protection features.

The quiet switched-mode design incorporates power hybrid circuitry, active power factor correction, soft-start inrush current limiting and extensive internal shielding and output ripple filtering. The result is a highly efficient, compact unit capable of being air cooled.

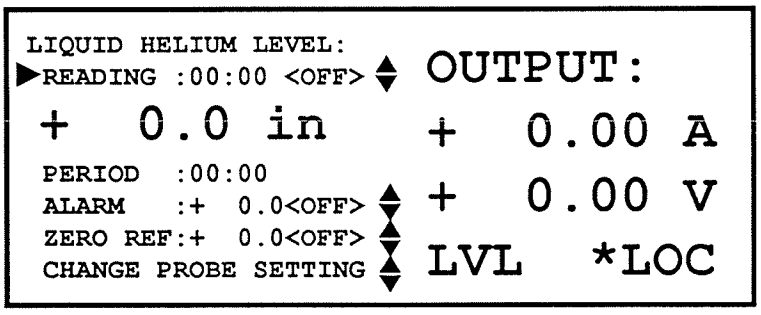
NOTE	If you are unpacking a new Model 637 MPS, you will want to refer to the inspection suggestions provided in Appendix A. A list of the available options can also be found there.

Overvoltage Protection Circuit Activated



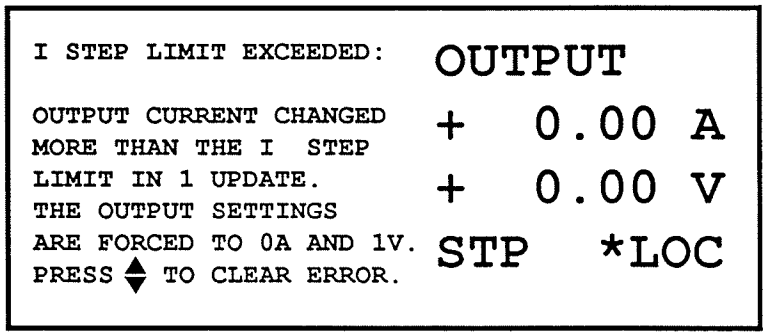
Refer to page 3-12 for a detailed description.

Level Alarm Reached



Refer to page 5-18 for a detailed description.

Output Current Step Limit Exceeded



Refer to page E2 for a detailed description.

Features

- **True, Four-Quadrant Bidirectional Power Flow**
  The current or voltage can operate as a source or a sink in either positive or negative polarities. Sink power is returned to the AC line instead of being dissipated by an energy absorber.

- **Low Noise, High Stability Current Regulation**
  The analog output control uses a precision shunt for current stabilization to better than 50 PPM.

- **±72A, ±32V Output that is CC/CV Autoranging at up to 2KVA continuous**
  Standard display and programming resolution is 10mA and 10mV. *(1mA and 1mV High Resolution Option is available.)*

- **No current reversal switch is required**
  Output current reversal is smooth and continuous with excellent near zero current performance.

- **Output is overvoltage (quench) protected**
  Internal overtemperature, AC input and unit fault protected as well. A discrete Fault Indicator *(FLT)* and a Remote Inhibit *(RI)* are provided on both the Mainframe and the Control Unit.

- **Remote and local sensing of the output voltage**
  allows for compensation of IR drops in the output leads.

- **Quiet switched-mode design**
  results in a highly efficient, lightweight unit capable of being air cooled.

- **Control Unit graphic display**
  allows continuous display of output while parameters are being set from the menu-driven keypad. Operating parameters that can be set and monitored are:
  Output current and voltage setting
  "Soft" current and voltage setting limits
  Status reporting
  Output current and voltage measurement
  Output ramp programming
  Field monitoring
  Output current zeroing
  Output current step limiting

- **Three methods of setting and monitoring all operating parameters:**
  from the Control Unit front panel, from the Control Unit remote interfaces, or through the Mainframe analog inputs and outputs.

- **IEEE-488 Interface is standard in the Control Unit**

- **RS-232C Interface and Analog Output Options available for the Control Unit**

- **Liquid Helium Level/Gaussmeter Input Option available for the Control Unit**

ERROR 01:

AN UNWRITEABLE NOVRAM DATA LOCATION EXISTS IN THE CONTROL UNIT. INITIALIZE THE NOVRAM BY PRESSING THE Esc KEY FOR 10 SECONDS. IF THE ERROR STILL EXISTS, CONTACT LSCI FOR A REPLACEMENT NOVRAM.

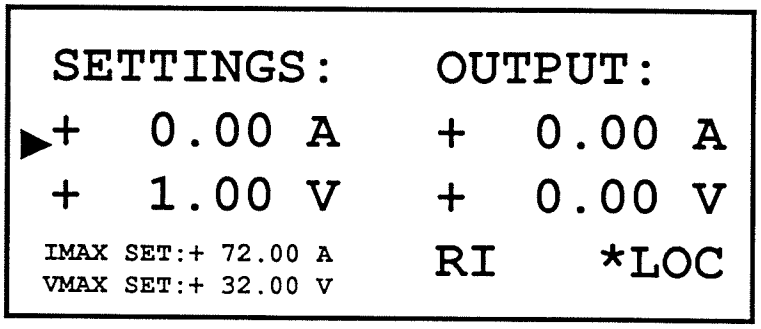
ERROR 02:

A NOVRAM DATA VERIFICATION ERROR EXISTS IN THE CONTROL UNIT. INITIALIZE THE NOVRAM BY PRESSING THE Esc KEY FOR 10 SECONDS. IF THE ERROR STILL EXISTS, CONTACT LSCI FOR A REPLACEMENT NOVRAM.

ERROR 06:

A CALIBRATION DATA NOVRAM ERROR EXISTS IN THE MAINFRAME. MAINFRAME CALIBRATION MUST BE PERFORMED. CONTACT LSCI.

Remote Inhibit Detected



Refer to page 3-11 for a detailed description.

Specifications

Model 637 Mainframe:

The Mainframe communicates with the Control Unit over a high speed digital control bus. Through this interface, the Mainframe carries out current and voltage output, ramp, and status commands and outputs measured parameters. The following performance specifications are given for current with a 1 Henry load and voltage with a resistive load.

DC Output: True, Four-Quadrant, Bidirectional Power Flow output. Current and voltage are autoranging and can operate as a source or a sink in either positive or negative polarity in current or voltage mode. Current and voltage can be programmed via front panel control, remote interfaces or analog input.

Current: 0 to ±72 A
Voltage: 0 to ±32 V
Maximum Power: 2000 VA continuous

DC Output Parameter	Current	Voltage
Stability (Drift) at 25 ±1 °C: Percent of full scale change in output over an 8 hour interval under constant line and load after a 30 minute warm-up.	±0.005% I_{MAX}	±0.01% V_{MAX}
Ripple and Noise (10 Hz to 10 MHz.):		
At 1000VA	20 µA rms	10 mV rms
At 2000VA	40 µA rms	20 mV rms
Temperature Coefficient: Change in output per °C after a 30 minute warm-up.	0.01% I_{MAX}	0.01% V_{MAX}
Source Effect: Line regulation for any line change within the rated line voltage.	0.005% I_{MAX}	0.05% V_{MAX}
Load Effect: Load regulation for a load change equal to maximum voltage in CC or maximum current in CV.	0.01% I_{MAX}	0.01% V_{MAX}
Standard Digital Programming Resolution: **High Resolution**	10 mA 1 mA	10 mV 1 mV
Standard Digital Programming Accuracy:	0.1% I_{MAX}	1% V_{MAX}
Digital Programming Repeatability:	0.01% I_{MAX}	0.1% V_{MAX}
Analog Resistance Programming Accuracy: 0 to 10 KΩ produces negative full scale to positive full scale current or voltage output. 5 KΩ is 0 current.	10% I_{MAX}	10% V_{MAX}
Analog Voltage Programming Accuracy: Voltage input is ±0.01 V/A and 0.01 V/V.	1% +100 mA	2% +100 mV
Ammeter/Voltmeter Standard Resolution: **High Resolution:**	4 mA 1 mA	1 mV 1 mV
Ammeter/Voltmeter Accuracy:	0.1% I_{MAX}	0.1% V_{MAX}
Ammeter/Voltmeter Standard Display Resolution: **High Resolution:**	10 mA 1 mA	10 mV 1 mV
Monitoring Output Accuracy: Voltage output is ±0.01 V/A, ±0.01 V/V.	1% +100 mA	2% +100 mV

Model 601 Control Unit Fuse Replacement

The line fuse is accessible from the rear of the unit without opening the case. Use the following procedure to check and/or replace the fuse:

WARNING **To prevent shock hazard, turn off the instrument and disconnect it from AC line power and all test equipment before replacing the fuse.**

1. Set the POWER switch to OFF and disconnect the power cord from the unit. The fuse compartment will not open with power cord in place. The fuse compartment is located just to the right of the power cord socket in the power connector assembly.

2. Open the fuse compartment by prying open the cover with a small screw driver from the right side of the assembly.

3. Remove the lower fuse holder by sliding it out of its position with the aid of the small screw driver.

WARNING **For continued protection against fire hazard, replace only with the same type and rating of fuse as specified for the line for the line voltage selected.**

4. Replace the fuse as the table indicates below.

Select	Range (VAC)	Fuse (A)
100	90-105	2 - SB
120	108-126	2 - SB
220	198-231	1 - SB
240	216-250	1 - SB

5. Replace fuse holder in the lower fuse position. Make sure the Line Voltage Selection wheel is in place with the proper line voltage facing out. Close fuse compartment and connect power cord.

Specifications cont.

Remote Sensing: Corrects for load lead drop of up to 0.5 V per lead. Operation with more drop per load lead is possible, however there will be a degradation of the load effect specification.

Output Terminals: Output bus bars are located on the rear panel. Both bus bars are isolated from the chassis *(earth)* ground.

Multiple Unit Operation: Up to two Mainframes may be connected in an auto-parallel configuration to provide increased output current capability.

Protection: Front panel annunciators, an audio indicator and a contact closure are used to indicate a fault is present.

Remote Inhibit (RI): The output settings are forced to 0 A and 1 V until the RI is no longer active. New output settings are required to continue normal operation.
Output Current Step: The output current settings are forced to 0 V and 1 V if a preset current step limit is exceeded. A key entry is required to continue operation.
Utility Low Line or Loss: Operation is maintained until the load is discharged or until the utility is restored.
Utility High Line: Turns off the input and maintains operation until the load is discharged.
Overvoltage: Crowbars output when voltage at the output terminals, induced by the load exceeds ±40 Vdc.
Overtemperature: Crowbars the output and turns off the input when the internal heat sink temperature exceeds 95 °C.

Input Current:

Nominal Line Voltage (Vac)	Line Voltage Range (Vac)	Nominal Input Current (A rms)	Peak Input Current (A rms)
200/208	180 to 210	14	16
220	198 to 231	13	14
240	216 to 250	12	13

AC Input: Factory set for operation from 200/208, 220, or 240 Vac (-10%, +5%) 50 to 60 Hz single phase.

Input Protection: The AC input is protected by a 20A two pole circuit breaker on the front panel. The Mainframe has the ability to turn off the breaker in the event of a fault.

Agency Approvals: The Mainframe is designed to comply with the following requirements.

UL 1244	Electrical and Electronic Measuring and Testing Equipment
VDE 0411	Electronic Measuring Instruments and Automatic Controls
FCC 15J	Level A RFI Suppression
VDE 0871	Level A RFI Suppression

Operating Temperature: 15 to 35 °C.

Dimensions, Weight: 483 mm wide x 178 mm high x 508 mm deep (19 in x 7 in x 20 in). Net weight 36.4 kg (80 lbs). Rack mounting is standard.

22. Send the command 'ICAL50' to the Mainframe. This will tell the Mainframe that the output current is being calibrated and to go to +50 amps. Verify that the DVM reads +0.05V ±10%.

23. Allow the Mainframe output to settle for approximately 2 minutes.

24. Convert to voltage read from the DVM to current. A reading of +0.512345V is equivalent to +51.2345A. Send the Mainframe the actual current using the command 'CALPL+xxx.xxxx'. If the actual current is +51.2345 amps, the command sent would be 'CALPL+51.2345'. The Mainframe will determine the positive current calibration constant.

25. As soon as the Mainframe has completed determining the positive current calibration constant, it automatically sets the output current to the same value with the opposite sign. Verify that the DVM reads -0.05V ±10%.

26. Allow the Mainframe output to settle for approximately 2 minutes.

27. Convert to voltage read from the DVM to current. A reading of -0.0487655V is equivalent to -48.7655A. Send the Mainframe the actual current using the command 'CALMN-xxx.xxxx'. If the actual current is -48.7655 amps, the command sent would be 'CALMN-48.7655'. The Mainframe will determine the negative current calibration constant.

28. As soon as the Mainframe has completed determining the negative current calibration constant, it stores the zero, positive, and negative current calibration constants. This takes approximately 1 second. After storing the current calibration constants, the Mainframe automatically sets the output current to 0. Verify that the DVM reads 0V ±0.00005V before continuing the calibration procedure.

29. Restore the IMAX, VMAX, and output current step status using the IMAX, VMAX, and ISTPS commands to the values noted in Step 6.

30. Turn off the Mainframe and disconnect the calibration loads.

31. Return the CMP communications configuration to the original settings.

32. Disable Mainframe calibration. Turn OFF (down position) **CAL AND ID** switch 8.

Specifications cont.

601 Control Unit:

The Control Unit acts as the human and computer interface sending commands to the Mainframe for implementation. It continuously monitors Mainframe status and can be mounted with the Mainframe or remotely. The Control Unit has a graphic display and menu driven keyboard for front panel entry and display of resulting quantities.

Operation: Operating parameters which can be set and monitored from the front panel and remote interfaces include:

Output current and voltage setting
"Soft" current and voltage setting limits
Status reporting
Output current and voltage measurement
Output ramp programming
Field monitoring
Output Current Zeroing
Output Current Step Limiting

The output ramp programming charging current is limited by magnet inductance and maximum charging voltage *(di/dt = V/L)*. The output can be programmed for a constant 0.01 to 99.99 amperes per second as long as di_{max}/dt is not exceeded. The magnet can be energized or de-energized at a pre-set voltage limit or ramp rate. The ramp can be put in a Hold *(Pause)* mode at any time during the ramp. While the ramp is holding, the output values are maintained until the ramp is continued.

Remote Interfaces: IEEE-488 is standard. All front panel functions can be controlled over the interfaces. In addition, displayed quantities are output through the interfaces. The unit also incorporates a high speed digital control bus for communications with the Mainframe. A control bus interconnecting cable *(Model 2001)* is provided.

Protection: Front panel annunciators, an audio alarm and a contact closure are used to indicate a fault is present.

Remote Inhibit (RI), Mainframe Overvoltage (OVP) or Fault: Forces the output settings to 0 A and 1 V until the fault is no longer active. New output settings are required to continue normal operation.

AC Input: Switch selectable operation from 100, 120, 220, or 240 Vac (-10%,+5%); 50 to 60 Hz single phase.

Input Protection/Current: The AC input is fuse protected. 100/120 Vac: 2.0A; 220/240 Vac: 1.0 A.

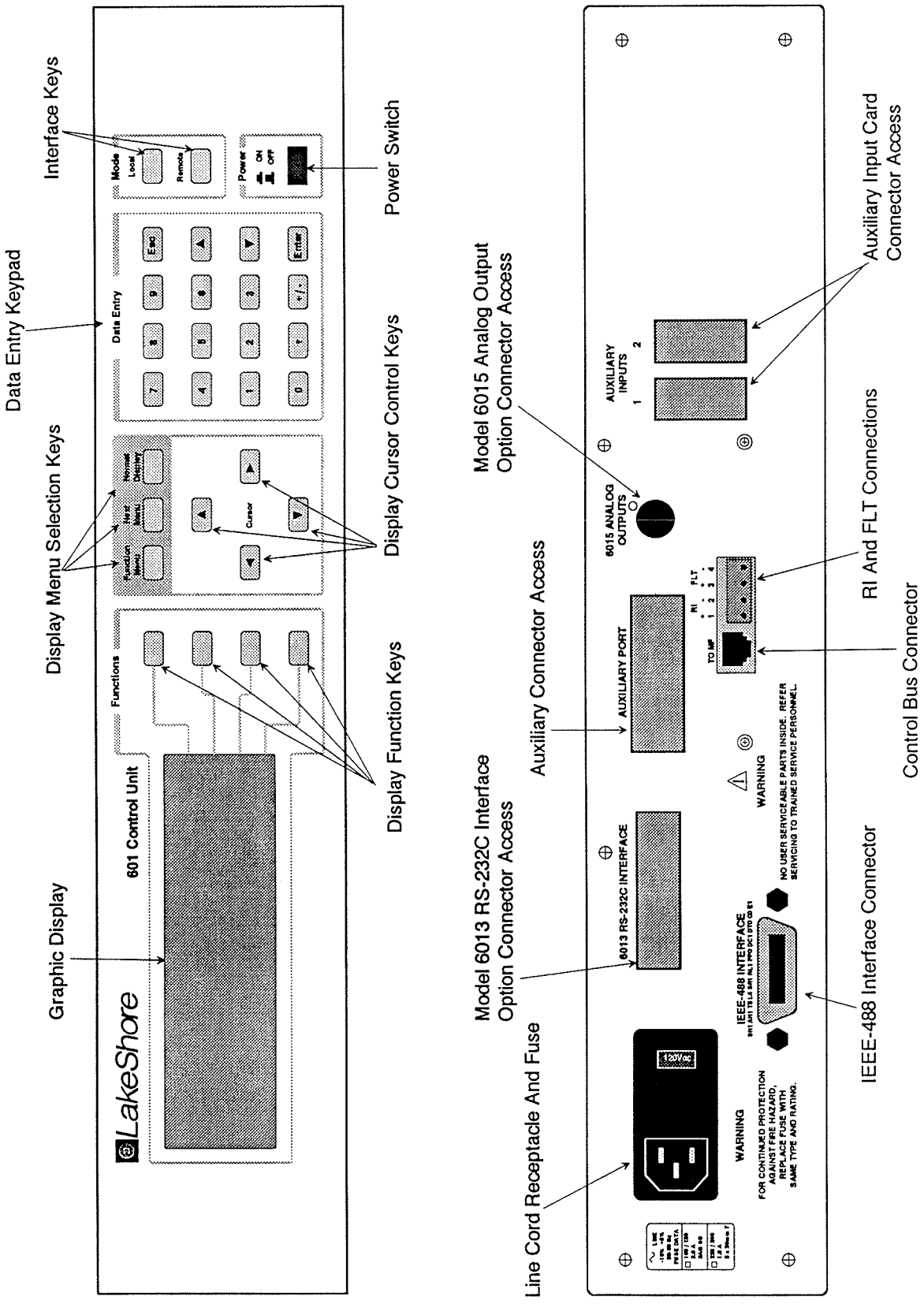
Operating Temperature: 15 to 35 °C.

Dimensions, Weight: 483 mm wide x 90 mm high x 419 mm deep (19 in x 3.5 in x 16.5 in). Net weight 7.7 kg (17 lbs). Rack mounting is standard.

The output current step feature must be off during calibration. Input and note the status of the output current step status using the ISTPS? command. Turn off output current step limiting by sending the ISTPS0 command.

7. Perform the output voltage calibration. Connect the DVM reading voltage across the +OUT and –OUT terminals.
8. Send the command 'VZER' to the Mainframe. This will tell the Mainframe that the output voltage is being calibrated and to go to 0V. Verify that the DVM reads 0V +0.1V.
9. Allow the Mainframe output to settle for approximately 2 minutes.
10. Read the actual output voltage from the DVM. Send the Mainframe the actual voltage using the command 'CALZ+xxx.xxxx'. If the actual voltage is +0.0123 volts, the command sent would be 'CALZ+0.0123'. The Mainframe will determine the zero voltage calibration constant.
11. Send the command 'VCAL5' to the Mainframe. This will tell the Mainframe to go to +5 volts. Verify that the DVM reads +5V ±10%.
12. Allow the Mainframe output to settle for approximately 2 minutes.
13. Read the actual output voltage from the DVM. Send the Mainframe the actual voltage using the command 'CALPL+xxx.xxxx'. If the actual voltage is +5.1234 volts, the command sent would be 'CALPL+5.1234'. The Mainframe will determine the positive voltage calibration constant.
14. As soon as the Mainframe has completed determining the positive voltage calibration constant, it automatically sets the output voltage to the same value with the opposite sign. Verify that the DVM reads -5V +10%.
15. Allow the Mainframe output to settle for approximately 2 minutes.
16. Read the actual output voltage from the DVM. Send the Mainframe the actual voltage using the command 'CALMN-xxx.xxxx'. If the actual voltage is -4.8766 volts, the command sent would be 'CALMN-4.8766'. The Mainframe will determine the negative voltage calibration constant.
17. As soon as the Mainframe has completed determining the negative voltage calibration constant, it stores the zero, positive, and negative voltage calibration constants. This takes approximately 1 second. After storing the voltage calibration constants, the Mainframe automatically sets the output voltage to 8. Verify that the DVM reads 0V ±0.1V before continuing the calibration procedure.
18. Perform the output current calibration. Connect the DVM across the current monitoring resistor.
19. Send the command 'IZER' to the Mainframe. This will tell the Mainframe that the output current is being calibrated and to go to 0 amps. Verify that the DVM reads 0V ±0.01V.
20. Allow the Mainframe output to settle for approximately 2 minutes.
21. Convert the voltage read from the DVM to current. A reading of +0.000345V is equivalent to +0.345A. Send the Mainframe the actual current using the command 'CALZ+xxx.xxxx'. If the actual current is +0.345 amps, the command sent would be 'CALZ+0.3450'. The Mainframe will determine the zero current calibration constant.

Model 601 Control Unit Front and Rear Panels



Model 637 Mainframe Calibration

Calibration Equipment Required:

The following equipment is required to perform a Mainframe calibration.

1. Current monitor shunt, 100mV output at 100A (1 milliohm), 0.02% accurate.
2. Load resistor, 10V at 100A (0.1 ohm), 1 kW.
3. DigitalVolt Meter (DVM) with a resolution of 100nV, 6 1/2 digits, 0.0035% accurate (HP 3457A or equivalent).
4. A computer with a RS-232C serial interface.
5. LSCI Model 2002 RJ-11 to DB-25 adaptor or Model 2003 RJ-11 to DB-9 adaptor, depending on which serial output connector the computer has.

Calibration Procedure:

1. Turn off the Mainframe before configuring it for calibration.
2. The control bus that the Mainframe uses to communicate with the Control Unit is the RS-485 interface. Communications over an RS-232C will require a re-configuration of the Mainframe Communications Processor (CMP). The CMP is plugged into the rear panel of the Mainframe. Loosen the two screws which secure the CMP to the Mainframe rear panel and slide the CMP out. Locate a set of DIP switches marked S1. Note the position of the 8 DIP switches so they can be returned to their proper position after calibration. Turn ON (opposite of OPEN) switches 1 through 4 and turn OFF (OPEN) switches 5 through 8. Replace the CMP. Connect the Mainframe control bus to the computer using the modular cable.
3. Connect current monitoring shunt and load resistor in series to +OUT and –OUT terminals.
4. Enable Mainframe calibration. Locate the **CAL AND ID** switches on the rear panel. Turn ON (up position) switch 8. Verify that the **MODE** switches are both in the **INT**ernal (up) position.
5. Plug the Mainframe in and turn it on. Allow a 1 hour warm up period.

NOTE

The Mainframe calibration involves determining a zero, positive span, and negative span digital calibration constant for both current and voltage.

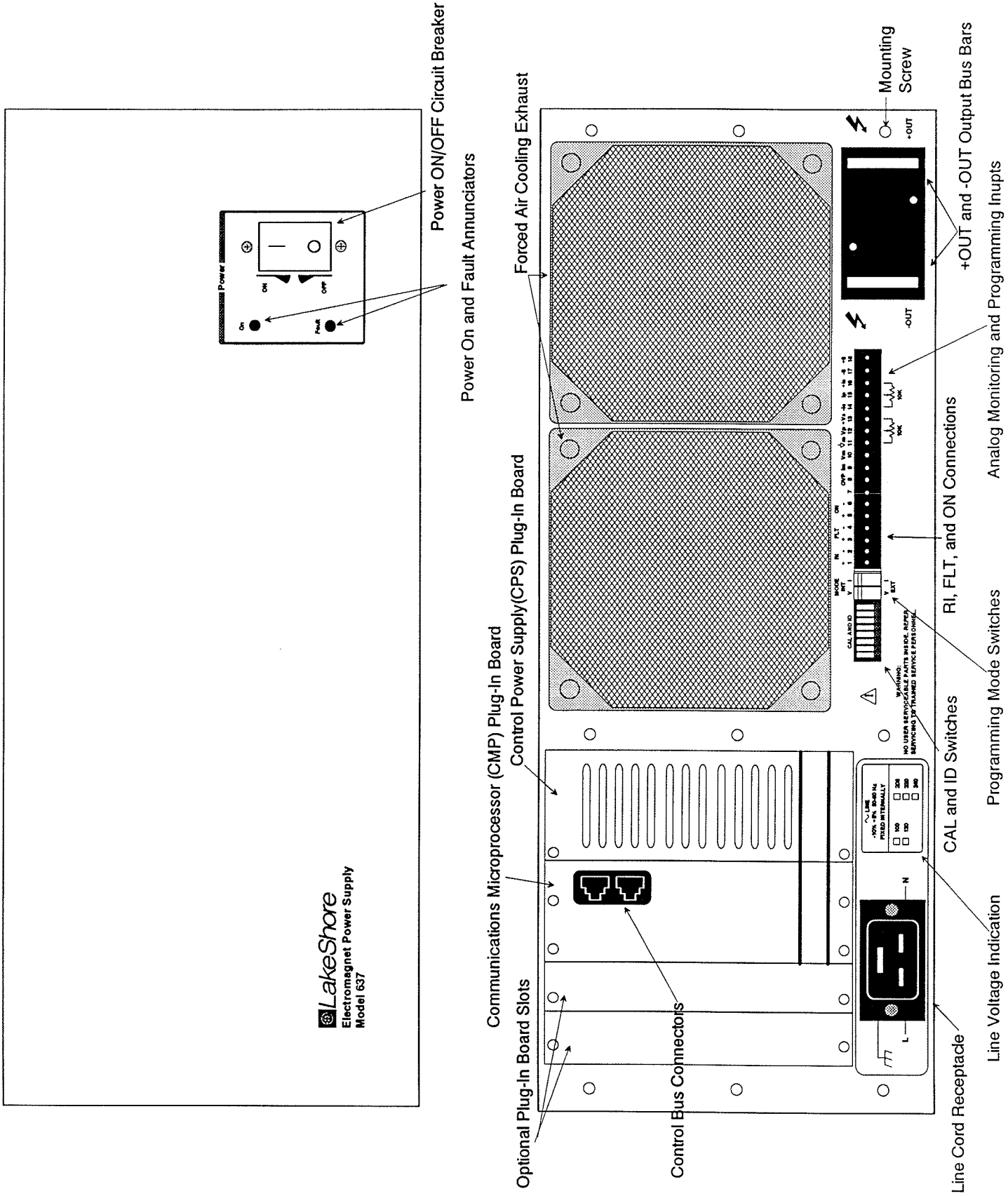
The calibration can be terminated at any time by issuing the CALDN command. The Mainframe power must be cycled to recover the calibration constants present prior to the calibration being initiated.

Extreme caution must be used in entering the calibration constants. If a constant is entered incorrectly, terminate the calibration procedure with the CALDN command and re-start the sequence.

6. When calibrating current, ISET will be forced to the calibration current, VSET will be forced to VMAX. When calibrating voltage, VSET will be forced to the calibration voltage, ISET will be forced to IMAX.

   The IMAX and VMAX settings should be equal to or greater than the calibration current and voltage settings to be used. Input and note the IMAX and VMAX values using the IMAX? andVMAX? commands. For this calibration procedure, set IMAX to 50 and VMAX to 5. The commands sent would be IMAX+50 and VMAX+5 respectively.

Model 637 Mainframe Front and Rear Panels



Computer Interface Verification

23. Use the computer to change the output current of the MPS. Send the command ISET50 over the IEEE-488 bus. Note that the interface mode on the display changes from **LOC** to **REM**. The output should change to +50A.

24. Read the output current using the IOUT? command. The Control Unit should return the value of the output current.

Fault/RI Operation Verification

25. Use a shorting jumper to short the RI input(s) of the Mainframe(s). The output current of the power supply should drop to 0A, and the audio indicator should sound about once per second. Verify the Control Unit displays the same messages as outlined in Step 13.

26. For each Mainframe, with the Mainframe ON, disconnect the AC power connector. The front panel circuit breaker should trip.

27. The performance verification is complete.

Output Voltage Verification

7. From the front panel of the Control Unit, change the maximum output voltage setting of the MPS. Use the procedure on Page 3-6 of the User's Manual to change VMAX SET to 20V. Press the **Normal Display** key on the front panel to return to the Normal Display screen.

8. Use the procedure on Page 3-5 of the User's Manual to set the output voltage to 10V and output current to +1A. Use the DVM to read the voltage across the output terminals of the Mainframe(s). The reading should be 10V±0.2V.

9. Set the output voltage to 20V. The DVM reading should change to 20V±0.2V.

10. Set the output current to –1A. The DVM reading should change to –20V±0.2V.

11. Set the output voltage to 10V. The DVM reading should change to –10V±0.2V.

Communications Verification

12. Unplug the control bus from the Control Unit. The Control Unit will display **NO MF RESPONSE** to the left of the interface status. Plug the control bus back into the Control Unit. Verify the **NO MF RESPONSE** message disappears after a short time.

13. Turn off the MPS Mainframe(s). Verify the Control Unit displays the RI screen shown on Page 3-11 of the User's Manual for SMF and the OVP screen shown on Page 3-12 of the User's Manual for MMF. Turn off the Control Unit.

Output Current Verification

14. Connect the current monitor shunt between the +OUT and –OUT terminals of the MPS Mainframe(s). Use AWG #4 wire for SMF or AWG #0 wire for MMF. Connect the DVM across the monitoring terminals of the shunt. Note the offset reading of the DVM.

15. Turn on the Mainframe(s) and the Control Unit. Within two seconds, the Control Unit display will return to the Normal Display screen.

16. Set the output voltage setting to 2V. Wait for 1 minute before continuing to the next step.

17. The DVM reading should be the same as recorded for Step 14 ±0.01mV.

18. Set the output current to +25A for SMF or +50A for MMF. The DVM reading should change to about +16mV. After about 1 minute, the DVM reading should be +16.666mV ±0.058mV (not including the offset from Step 14).

19. Set the output current to +50A for SMF or +100A for MMF. The DVM reading should change to about +33mV. After about 1 minute, the DVM reading should be +33.333mV ±0.117mV (not including the offset from Step 14).

20. Set the output current to –25A for SMF or –50A for MMF. The DVM reading should change to about –16mV. After about 1 minute, the DVM reading should be –16.666mV ±0.058mV (not including the offset from Step 14).

21. Set the output current to –50A for SMF or –100A for MMF. The DVM reading should change to about –33mV. After about 1 minute, the DVM reading should be –33.333mV ±0.117mV (not including the offset from Step 14).

22. Set the output current to 0A.

INSTALLING THE MODEL 637 ELECTROMAGNET POWER SUPPLY

2

WARNING	**The information contained in this section is intended for the use of service trained personnel who understand electronic circuitry and are aware of the hazards involved. Do not attempt to perform any of the procedures in this section unless you are qualified to do so.**

In this section you will learn how to install the Model 637 MPS. The main topics covered are as follows:

- *Environmental Requirements*
- *Mainframe Input Power Requirements*
- *Control Unit Input Power Requirements*
- *Connections*
- *Bench Use*
- *Rack Mounting*

637MPS Performance Test

The following performance tests are designed to verify that the MPS is operating properly into a resistive load, without testing all specified parameters. The tests should be performed on new equipment prior to being put into service, or on existing equipment to ensure proper operation. The abbreviation SMF is used to indicate a single MPS Mainframe configuration and MMF to indicate a multiple MPS Mainframe configuration. The tests do not include any troubleshooting information, but can provide information that may help to localize faults that are present.

WARNING	**The MPS must be returned to Lake Shore or a factory representative for service.**

Test Equipment Required

The following equipment is required to run the performance tests.

1. Current monitor shunt, 100mV output, rated at 150A for SMF or 300A for MMF, 0.25% accurate (or better). These values are typically stocked by shunt manufacturers. If a different value is used, the readings given in the procedure must be adjusted.

2. Digital Volt Meter (DVM) capable of reading DC voltage from 100mV with 0.1mV accuracy to 35V with 0.1V resolution.

3. A computer with IEEE-488 interface.

Performance Test

The test procedure includes both front panel and remote operation. The performance tests should be executed in the order given. Note any non-compliance if encountered.

Test Setup

1. Connect input power to the MPS Mainframe and Control Unit as outlined on Page 2-3 of the User's Manual.

2. For SMF configuration, connect the control bus from the MPS Mainframe to the Control Unit as outlined on Page 2-4 of the User's Manual. Connect the Remote Inhibit (RI) and Fault (FLT) indicators as outlined on Page 3-10 of the User's Manual. For MMF configuration, connect the Mainframes in the auto-parallel configuration as outlined on Page 2-8 of the User's Manual. Leave the output terminals open.

3. Set the Programming Mode Switches on the rear panel of the MPS Mainframe(s) to the INT (up) position. Set the CAL and ID switch 7 to the OFF (down) position.

4. Connect the IEEE-488 cable between the computer and the Control Unit.

5. Turn on the Mainframe(s). Initially, all the front panel annunciators will come on and the audio indicator will sound for a short period of time. Within one second, the Fault and Persistent Switch Heater On annunciators, and the audio indicator, will go off.

6. Turn on the Control Unit. Initially the display is cleared and the audio indicator will sound for a short period of time. Within two seconds, the display will show the Normal Display screen as outlined on Page 3-5 of the User's Manual.

Environmental Requirements

Operating Temperature

The Model 637 is for laboratory use. In order to meet and maintain specifications, this unit should be operated at an ambient temperature range of 20 to 30 5 °C. The unit may be operated within the range of 15 to 35 °C with reduced accuracy.

WARNING	**To prevent electrical fire or shock hazards, do not expose this instrument to rain or excess moisture.**

Location and Cooling

The Mainframe is fan cooled and must be installed with sufficient space in the rear and on the sides for air flow. Air is drawn in from the sides and exhausted from the rear. The ambient temperature of intake air should not exceed 35 °C.

Mainframe Input Power Requirements

The Mainframe may be operated from a nominal 200/208, 220, or 240 Vac (-10%, +5%) single-phase AC power source, 50 to 60 Hz. The input voltage range and input current required for each of the nominal inputs is given in Table 2-1. A label on the rear panel indicates the nominal line voltage the Mainframe was set for at the factory. The line voltage setting can not be changed in the field.

Table 2-1. Mainframe Line Voltage Limits

Nominal Voltage (Vac)	Line Voltage Range (Vac)	Maximum Input Current (A rms)
200/208	180 to 210	16
220	198 to 231	14
240	216 to 250	13

Control Unit Input Power Requirements

The Control Unit should be operated from the same AC power source as the Mainframe and is set at the factory to the same nominal line voltage as the Mainframe prior to shipment. The Control Unit is fused at 2.0 amperes for 100/120 Vac operation and 1.0 amperes for 220/240 Vac operation.

Setting System Voltage and Current Limits

The user must be very aware of the specifications established by the magnet manufacturer. A typical magnet specification sheet will list the rated field, rated current, inductance, and charging voltage.

The IMAX setting should be set to the rated current specification. (This will allow output current settings up to the rated current.) In general, the magnet is not warranted for operation above this current.

The VMAX setting should be set to the charging voltage used. (This will allow voltage settings up to the charging voltage.) This charging voltage typically results in the fastest charge without quenching.

The inductance and charging voltage define the fastest current ramp rate that can be achieved. For example, a 10 Henry magnet and a charging voltage of 1 volt results in a ramp rate of 0.1 amperes per second. Setting a ramp rate higher than this value will result in constant voltage ramping at 1 volt.

If these specifications are not known, or weren't supplied, contact the magnet manufacturer before performing system setup.

Setting Current Step Limit

The output current step limit feature automatically resets the output settings to 0A and 1V if an output current step exceeding the limit is detected. The current step limit can be used to either limit the rate at which the magnet is charged, or to force the output current setting to zero (0) as quickly as possible in the event of a quench.

The maximum charging rate of the magnet is based on magnet inductance and charging voltage. For example, a 10 Henry magnet and a charging voltage of 1 volt results in a maximum ramp rate of 0.1 amperes per second. Setting the current step limit above this value (1A/sec.) would result in allowing normal performance while still providing acceptable quench performance.

Connections

Mainframe and Control Unit Power Connections

WARNING	**For proper protection by the Mainframe circuit breaker and the Control Unit AC line fuse, the wire connected to the "L" terminal of the connector must be connected to the "L" *(hot)* side of the line and the wire connected to the "N" terminal must be connected to the "N" *(neutral)* side of the line.** **To protect operating personnel, the wire connected to the "GND" terminal must be connected to earth ground. These instruments should not be operated without an adequate ground connection.**

CAUTION	Before applying power to the Mainframe or Control Unit, verify that the AC source matches the line voltage listed on the rear panel.

NOTE	Connections to the AC power line must be made in accordance with applicable electrical codes. The international color code for identifying utility supply conductors is green/yellow, blue and brown for earth ("GND"), neutral (N) and line (L) respectively. The US and Canadian codes are green, white and black for earth, neutral and line respectively.

Input power is connected to the Mainframe via a three prong detachable connector *(supplied)* which mates with the UL/CSA/IEC approved AC input connector on the rear panel. The power cord is not supplied. It must be a three conductor cord rated for at least 85 °C operation. For 200/208, 220 or 240 Vac operation, each conductor must be AWG #14 or larger. Larger wires may be required to prevent excessive voltage drop in the AC power lines if the unit is located an extended distance from the main AC distribution terminals.

Use the following procedure to connect input power to the Mainframe:

1. Loosen the two connector cover screws and open the cover.
2. Slip the strain relief over the power cable with the flanged end at the end to be terminated.
3. Attach the wires to the connector in accordance with prevailing color codes: green or green/yellow to the "GND" terminal, white or blue to the "N" terminal, and black or brown to the "L" terminal.
4. Position the strain relief, close the cover, and then tighten the cover screws.
5. Connect the other end of the power cord to an appropriate AC power source.
6. Plug the power cord into the detachable power connector plug on the Mainframe rear panel.

Input power is connected to the Control Unit via a three prong UL/CSA/IEC approved input connector on the rear panel. A three conductor power cable is supplied and grounds the instrument when plugged into an appropriate receptacle.

Field Measurement Screens (If Present)

```
READING :       <OFF>     – Reading Status = Off
UNITS   :kG               – Field Units in Kilogauss
mV/kG   :+  0.800         – Field Probe Sensitivity
ZERO RDG:       <OFF>     – Field Probe Zero and Status = Off
SPAN KG :+  0.0<OFF>      – Field Probe Span and Status = Off
```

Output Current Zero Screen

```
STATUS  :       <OFF>     – Output Current Zero Status = Off
I ZERO  :+  0.00          – Output Current Zero Value
I MODE  :INTERNAL         – Output Current Programming Mode = Internal
```

Current Step Limit Screen

```
STATUS  :       <ON >     – Output Current Step Limit Status = Off
I STEP  :+ 10.00 A        – Output Current Step Limit = +10.00 Amps
```

Setup Considerations

There are a number of important topics to consider before attempting initial system setup. The first is a description of the ISET, VSET, IMAX, and VMAX settings. Once the operation of these settings are understood, you are ready to determine system current and voltage limits and settings. Finally, how to set output current step limits is described.

Understanding the ISET, IMAX, VSET, and VMAX Settings

ISET and VSET are the constant current and constant voltage output settings. IMAX and VMAX are the output current and voltage maximum setting limits. These limits do not set the output current and voltage. The output current and voltage settings entered are not allowed to exceed these limits. For example, if the VMAX setting is 1 volt (factory default), voltage settings in excess of 1 volt will be limited to 1 volt. If the VMAX setting is increased to 5 volts, and the VSET setting remains at 1 volt, the actual output voltage will only go up to 1 volt, not 5. Changing VSET to 2 volts allows the output voltage to go up to 2 volts, and so on.

When constant current ramping, the ramp di_{MAX}/dt is determined by VSET/L, where VSET is the output voltage setting (not VMAX) and L is the magnet inductance. The ramp rate, in amps per second, entered in the Ramp Status Screen must result in an output voltage that is less than the voltage setting in order fro the rate to be maintained. Setting a ramp rate higher than di_{MAX}/dt will result in a constant voltage ramp at the VSET voltage setting.

There is no separate entry screen for constant voltage ramping. A constant voltage ramp is performed by setting ISET to the desired destination current. The output will ramp at the VSET voltage setting until ISET is reached. At that point, the output will convert to constant current mode and will only deliver the voltage required to maintain the current. Constant voltage ramping is not as desirable as constant current ramping because some magnets exhibit a non-linear charging profile, resulting in a non-linear current ramp.

Connecting the Mainframe to the Control Unit

The Mainframe communicates with the Control Unit over a high speed digital control bus. The control bus is a half-duplex asynchronous RS-485 multi-drop interface which allows the Control Unit to be up to 4000 feet away from the Mainframe. RJ-11 modular sockets and data type cables *(Lake Shore Model 2001)*, which maintain pin 1 polarity, are used to simplify interconnection. Plug the interconnection cable *(provided)* into the socket labeled **TO MF** on the rear panel of the Control Unit and into either socket on the rear panel of the Mainframe. The Mainframe incorporates two sockets so that multiple Mainframes can be added to the control bus.

Mainframe and Control Unit Remote Inhibit and Fault Indicator Connections

The Mainframe and Control Unit each provide a discrete Remote Inhibit (RI) input and Fault Indicator (FLT) output. These functions are interface independent and provide a means for fault indication and remote output shutdown in the event of a catastrophic failure. These signals are chained together by connecting the RI input of one unit to the FLT output of the next unit. The Mainframe also provides a discrete ON indicator. Connections are made to a rear panel detachable terminal block and are defined in Table 2-2.

Table 2-2. RI, FLT, and ON Connections

Terminal	Label	Definition
1	+	Remote Inhibit.
	RI	Active low, TTL-compatible input to remotely
2	–	disable the output *(force the output settings to 0 A and 1 V)*.
3	+	Fault Indicator.
	FLT	Normally open contact closure to indicate a
4	–	fault condition has occurred. Contact rating: 0.25 A resistive at 100 Vdc, 3 W, 25 VA.
5	+	ON Indicator *(Mainframe Only)*.
	ON	Contact closure to indicate when the front
6	–	panel circuit breaker is in the ON position. Contact rating: 0.25 A resistive at 100 Vdc, 3 W, 25 VA.

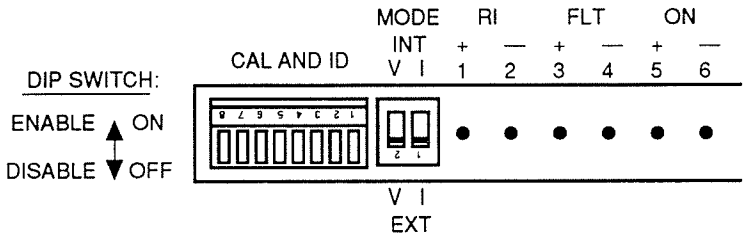


Figure 2-1. Mainframe RI, FLT, and ON Connections

WARNING **The information contained in this appendix is intended for the use of service trained personnel who understand electronic circuitry and are aware of the hazards involved. Do not attempt to perform any of the procedures in this appendix unless you are qualified to do so.**

Introduction

This appendix is provided to guide users through a number of setup, performance test, and calibration procedures. First is a list of factory presets. Next are important setup considerations. Then a Model 637MPS system performance test is provided to verify proper operation. Next is the Model 637 Mainframe calibration. Finally, a fuse replacement procedure for the Model 601 Control Unit is provided.

Initial Conditions from the Factory

The following is a list of initial conditions set at the factory. You may reinitialize the Model 601 Control Unit to the factory presets at any time by holding the Esc key in for approximately 15 seconds.

Normal Display Screen

```
I SET: +  0.00 A        – Current Setting
V SET: +  1.00 V        – Voltage Setting
```

Setup Screen

```
IEEE ADD:12             – IEEE Address
TERMS    :(CR)(LF)      – Terminator Status (Carriage Return & Line Feed)
EOI      :     <ON >    – EOI Status = On
VW ANGLE:5              – Viewing Angle (5 = Straight On)
IMAX SET:+ 72.00 A      – Maximum Current Setting (in Amps)
VMAX SET:+ 32.00 V      – Maximum Voltage Setting (in Volts)
```

Ramp Status Screen

```
SEGMENT :      <OFF>    – Ramp Segment = Off
STATUS  :HOLDING        – Ramp Status = Holding
FROM    :+  0.00 A      – Ramp From (in Amps)
TO      :+  0.00 A      – Ramp To (in Amps)
AT      :   0.00 A/SEC  – Ramp At (in Amps per Second)
```

Liquid Helium Level Screens (If Present)

```
READING :00.00 <OFF>    – Level Reading and Status = Off
PERIOD  :00.00          – Level Period (Continuous every 20 seconds)
ALARM   :+  0.0<OFF>    – Level Alarm and Status = Off
ZERO REF:+  0.0<OFF>    – Level Zero Reference and Status = Off

UNITS   :in (E)         – Level Probe Units – Inches (English)
LENGTH  :  19.5in       – Nominal Probe Length. Nominal Resistance is
                          11.43 ohms/inch (4.5 ohms/cm)
```

Mainframe Analog Monitoring and External Programming Connections

The Mainframe provides amplified and buffered current and voltage monitor output signals. These signals can be connected to external meters to indicate output current and voltage.

The output current and voltage can be remotely programmed by external voltages or potentiometers. External analog programming is enabled via the rear panel MODE switches. When the MODE switch is in the INT I or V position, the external current or voltage programming mode is disabled. When the MODE switch is in the EXT I or V position, the external programming voltage is summed with the internal programming voltage. If the internal programming is set to zero, the effect is to have only external programming. 10 KΩ potentiometers are used to control the output current or voltage over the entire range.

Connections are made to a rear panel detachable terminal block and are defined in Table 2-3.

NOTE The Mainframe includes a protection circuit which reduces the effect of open external programming leads. If the external programming lead becomes open circuited, the external programming voltage will be forced to approximately 0 volts.

The following line voltage settings are available for the 637 MPS and must be specified at the time of order. The 637 MPS is configured for this line voltage setting prior to shipment. The settings cannot be changed.

- 200/208 Vac (180-210), 50-60 Hz operation
- 220 Vac (216-250), 50-60 Hz operation
- 240Vac (216-250), 50-60 Hz operation

The following accessories are available for the Model 637 MPS.

- 2001 Modular Cable
- 2002 RJ-11 to DB-25 Adaptor
- 2003 RJ-11 to DB-9 Adaptor

Return Procedure

If the Model 637 appears to be operating incorrectly, contact Lake Shore or a factory representative for a Returned Goods Authorization (RGA) number. Instruments may not be accepted without and RGA number. Attach a tag with the following information when returning:

- RGA number
- Instrument model and serial number
- User's name, company, address and phone number
- Malfunction symptoms

Wrap instrument in a protective bag and use original spacers to protect controls. Repack the system in the LSCI shipping carton (if available) and seal it with strong paper or nylon tape. Affix shipping labels and "FRAGILE" warnings. Write the RGA number on the outside of the shipping container or on packing slip.

CAUTION	Ship the Model 637 Mainframe upside down to ensure even weight distribution in the shipping container and put less shipping stress on the internal components.

Table 2-3. Mainframe Analog Monitoring and Programming Connections

Terminal	Label	Definition
7	Reserved	
8	OVP	Overvoltage Protection Enable. Analog signal connected in parallel to other Mainframes to remotely activate the output overvoltage protection circuit.
9	Im	Output current monitor. Voltage output from Im to GND(M) is ±0.01 V/A.
10	Vm	Output voltage monitor. Voltage output from Vm to GND(M) is ±0.01 V/V.
11	⏚m	Monitor and program ground. *GND(M).*
12	Vp	External output voltage (CV) programming is enabled via the MODE switch.
13	+Vs	Voltage input from Vp to GND(M) is 0.01 V/V. A 10 KΩ potentiometer from +Vs to GND(M) with the center tap to Vp produces the minimum 0.32 V required for full scale output. The voltage applied to Vp is summed with the internal voltage programming voltage.
14	–Is	External output current (CC) programming is enabled via the MODE switch.
15	Ip	Voltage input from Ip to GND(M) is ±0.01 V/A.
16	+Is	A 10 KΩ potentiometer from +Is to -Is with the center tap to Ip produces the minimum ±0.72 V required for full scale current output. The voltage applied to Ip is summed with the internal current programming voltage.
17	–S	Remote voltage sense correction.
18	+S	Correction for load lead drops of up to 0.5 V per lead.

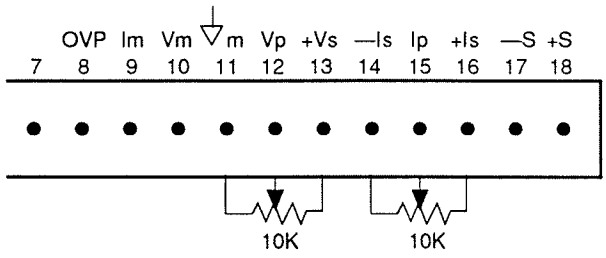


Figure 2-2. Mainframe Analog Monitoring and Programming Connections

Unpacking Your Model 637MPS

Inspect the shipping container for damage. If the shipping container is damaged or the cushioning material inside is stressed, keep them until you have checked the shipment for completeness and proper operation *(following procedures outlined in this manual)*. Keep all packing material in case of return.

If components are missing from your shipment, or if there is mechanical damage or defect (apparent or concealed), notify Lake Shore. If the shipping container or cushioning material shows signs of stress, notify the carrier as well as Lake Shore. Keep the shipping materials for inspection by the carrier.

Included

1 Model 637 Mainframe
1 Model 601 Control Unit
1 RM-3F Rack Mounting Kit for the Model 601 Control Unit
1 Model 2001 Modular Cable
1 Detachable Power Connector for the Model 637 Mainframe
1 Detachable Power Cord for the Model 601 Control Unit *(for 120 VAC operation)*
All Mating Connectors
1 Model 637 MPS User's Manual

Additional Options And Accessories

The following options are available to enhance the capabilities of the Model 637 Mainframe.

•Model 6377 High Resolution Display and Programming
The 6377 increases the current and voltage setting and monitoring resolution to 1 mA and 1 mV *(from 10 mA and 10mV)*. This option cannot be installed in the field and must be installed prior to shipment.

The following options and accessories are available for the Model 601 Control Unit.

•Model 6013 RS-232C Interface.
The 6013 provides remote operation of the Control Unit via the RS-232C interface. Inputs and outputs are the same as with the integral IEEE-488.

•Model 6015 Analog Output
The 6015 provides analog recorder outputs proportional to output current or voltage. Output is ±0.01 V/A or ±0.01 V/V with better than 0.001 V resolution.

•Model 6016 Liquid Helium Level and Gaussmeter Input Card
The 6016 combines liquid helium level and field monitoring on one input card. Liquid level can be monitored in percent, inches or centimeters. Field can be monitored in kilogauss or tesla. The field measurement is quantitative.

Mainframe Remote Voltage Sensing Connections

Remote voltage sensing is used to improve the output voltage regulation at the load. When used, the Mainframe will automatically increase the output voltage to compensate for the voltage drop in the leads. The wires used for the sense leads can be much lighter than the load leads. They should be a shielded, twisted pair to minimize the pickup of external noise. Any noise picked up on the sense leads will appear at the output of the unit. The sense shield should be grounded to the Mainframe chassis and should be an independent conductor.

Connections are made to a rear panel detachable terminal block defined in Table 2-3 and Figure 2-2.

NOTE The Mainframe includes a protection circuit which reduces the effect of open sense leads during remote voltage sensing operation. If the +S lead opens, the output voltage will change because it will be sensed between +OUT and the negative side of the load. If the –S lead opens, the output voltage will change because it will be sensed between the positive side of the load and –OUT. If both leads open, the output voltage is sensed internally.

Use the following procedure to configure the Mainframe for remote voltage sensing as shown in Figure 2-3.

1. Turn off the unit before changing the sense leads.
2. If present, disconnect any wires between the +OUT and –OUT terminals and the +S and –S connections on the Mainframe rear panel.
3. Connect the sense leads from the Mainframe +S and –S connections to the load. Maintain polarity when making these connections.
4. Connect the ground shield to the mounting screw.

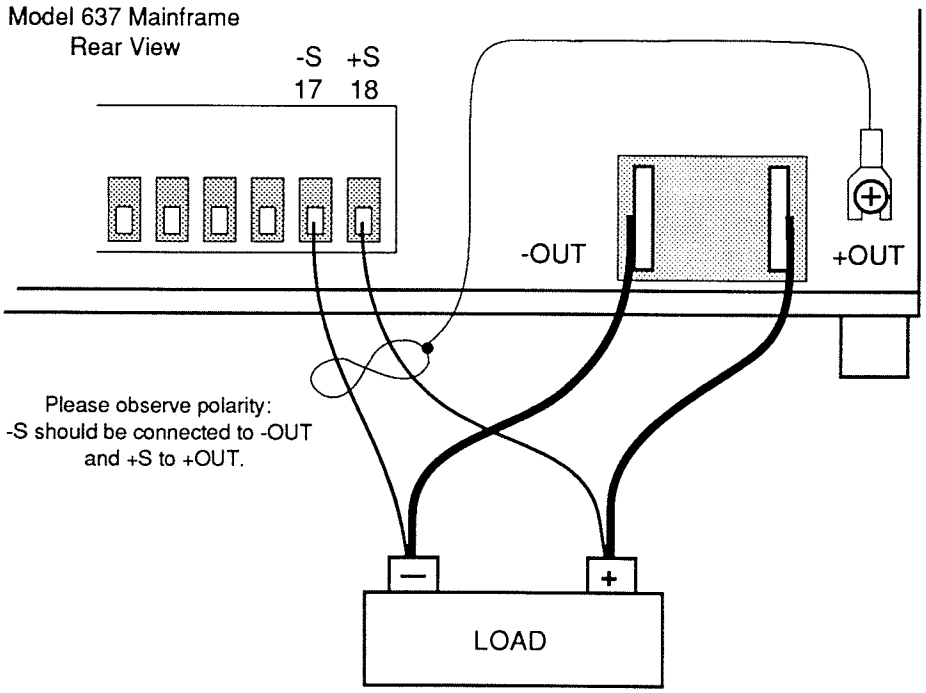


Figure 2-3. Mainframe Remote Sensing Connections

MODEL 6377
HIGH RESOLUTION DISPLAY AND PROGRAMMING OPTION

Description

The Model 6377 High Resolution Display and Programming Option increases the current and voltage setting, and monitoring resolution to 1 mA and 1 mV respectively. The standard display and programming resolution is 10 mA and 10 mV.

The standard current setting DAC *(digital to analog converter)* has a bipolar resolution of 15 bits. The smallest step change is 4 mA. The 6377 High Resolution current setting DAC has a bipolar resolution of 17 bits. The step change resolution is improved to 1 mA. The voltage setting, current and voltage monitoring go through the same type of resolution increase.

The 6377 High Resolution Option cannot be installed in the field and must be installed prior to shipment. If the 6377 option is installed, the Setting and Output display resolution is automatically expanded to the 0.001 place. Remote interface operation does not change since the remote resolution is already to the 0.0001 place. The increased resolution does not increase Mainframe stability or accuracy over the standard resolution

Specifications

Current Display and Programming Resolution	1 mA
Voltage Display and Programming Resolution	1 mV

Control Unit IEEE-488 Interface Connector

The IEEE-488 interface connector on the rear panel of the Control Unit is in full compliance with the IEEE Standard 488-1978. The connector has metric threaded mounting studs which are indicated by the color black. Metric threaded lockscrews must be used to secure an IEEE interface cable to the Control Unit. Model 8072 IEEE-488 Interconnect Cables *(one meter long)* are available from Lake Shore.

NOTE	For IEEE-488 interface commands, refer to Section 4.

Connecting the Mainframe to the Load

WARNING	**Turn off the AC power before changing any rear panel connections and verify that all connections are securely tightened before reapplying power.**

CAUTION	It is strongly recommended that the Control Unit be initially setup with the Mainframe connected but no load present. This will ensure familiarity with operation and lessen the chance for inadvertent damage to the load. Please refer to Appendix B for Initial Set up and Performance Verification Test Procedures.

Load connections to the Mainframe are made at the +OUT and –OUT terminals on the rear panel. The +OUT and –OUT terminals are plated copper bus bars and can accommodate 1/4 inch mounting hardware. The load wires must be heavy enough to limit the voltage drop to less than 0.5 volts per lead. This will ensure proper regulation and prevent overheating while carrying the output current. Remote sensing should be used to compensate for any voltage drop in the load leads. Solid AWG #4 wire is capable of carrying in excess of 125 amperes. Conductor temperature should be kept under 85 °C for a 35 °C ambient. Table 2-4 lists the ampacity and total +OUT and –OUT lead lengths for load connections.

If multiple loads are connected to the unit, each load should be connected to the output terminals using separate pairs of wires. Each pair of connecting wires should be as short as possible.

Table 2-4. Load Wire Lengths and Ampacity

AWG	Area (mm)	Ampacity	Resistivity Ω/1000 feet	Total Lead Length (feet) 75 A	100 A	125 A
0	53.5	245	0.09827	135	101	81
2	33.6	180	0.1563	85	64	51
4	21.2	135	0.2485	53	40	32
6	13.3	100	0.3951	33	25	—
8	8.4	75	0.6282	21	—	—

BFLD?

Description Field Query

Syntax

Input BFLD?

Returned The value returned is a number between ±999.9999.

Remarks Nine characters plus up to two terminators are returned.

BUNI

Description Programs the field units.

Syntax

Input BUNI [units]

[units] Fill in the units parameter with
kG for kilogauss
T for tesla (10 kilogauss)

Remarks The initial condition is kG.

Make sure there is a space between the command and the units parameter.

BUNI?

Description Field Units Query

Syntax

Input BUNI?

Returned The value returned will be **kG** for kilogauss or **T** for tesla (10 kilogauss).

Remarks Two characters plus up to two terminators are returned.

Multiple Auto-Parallel Mainframe Connection

Two Mainframes can be connected in an auto-parallel configuration to provide increased output current capability. Multiple Mainframe operation requires that each Mainframe be assigned a unique address: 1 for Mainframe 1 and 2 for Mainframe 2. The Control Unit polls the Mainframes on the control bus to determine if an auto-parallel configuration is present and how many Mainframes are involved. When the Control Unit determines that two mainframes are present, it polls Mainframe 1 for it's output current and voltage limits, ramp status, output current step limit and other operating parameters. These values are then sent to Mainframe 2 to assure that both units will operate the same.

Each Mainframe is programmed by the Control Unit for half of the total output current. This is true for the ramp destination current and ramp rate. Each mainframe will contribute half of the output current required. The Control Unit polls both Mainframes to determine the total output current. The Control Unit reports the output voltage, current settings during a ramp, and instrument status from Mainframe 1 only (since these will be the same for both units.)

An analog signal is also provided for remote activation of the output overvoltage protection circuit. These signals are connected in parallel so that the output overvoltage protection circuits can be activated in unison.

CAUTION	It is recommended that Lake Shore be contacted for consultation prior to operating multiple Mainframes in auto-parallel mode.

Use the following procedure and see Figure 2-4 to connect multiple Mainframes in an auto-parallel configuration.

1. Turn off all units and completely disconnect power at the source before changing the Mainframe configuration.
2. Determine which Mainframe will be assigned as Mainframe 1. Configure Mainframe 1 as follows:
   a. Locate the **CAL AND ID** DIP switches on the rear panel. Turn ON (up position) switches 1 and 4. Turn OFF (down position) switches 2, 3, and 5 through 8. *(Multiple Mainframe operation is designated by switch 4 being ON. Switches 3, 2, and 1 as OFF, OFF, ON respectively assign the Mainframe address as 1.)* Note that the **CAL AND ID** switch numbers are upside down *(as viewed from the rear panel).* Switch 8 is on the left and switch 1 is on the right. Use the switch numbers referred to even though they must be read upside down.
   b. Move both **MODE** switches to the **INT**ernal (up) position.
   c. The Communications Microprocessor (CMP) is plugged into the rear panel of the Mainframe. The CMP is the module with the two telephone jacks. Loosen the two screws which secure the CMP to the Mainframe rear panel and slide the CMP out. On the raised circuit board just inside the CMP, there is a set of DIP switches. Ensure that switches 5, 6, and 7 are On (closed) and switches 1–4 and 8 are Off (OPEN). *(Switches 1 through 4 define the control bus as RS-232C. Switches 5 through 8 define the control bus as RS-485 multidrop. Switch 8 activates bus termination for long communications loop runs. The control bus should be terminated only if the Mainframes are a significant distance from the Control Unit.)* Replace the CMP.

ZREFS

Description Programs the status of the probe zero reference.

Syntax

Input ZREFS[status]

[status] Fill in the status parameter with a:
1 to cause the zero reference value to be added to the level reading
0 to return the level reading to absolute

Remarks The initial condition is 0.

The level read above the zero reference will be + while the level read below the zero reference will be –.

ZREFS?

Description Zero Reference Query.

Syntax

Input ZREFS?

Returned The value returned will be **0** if the probe zero reference status is disabled or **1** if it is enabled.

Remarks One character plus up to two terminators are returned.

ZREF

Description Programs the probe zero reference.

Syntax

Input ZREF[zero reference]

[zero reference] Fill in the zero reference parameter with a value between 0 and ±999.9. The value is truncated (not rounded) to the tenths place.

Remarks The initial condition is 0.

The zero reference uses the existing units. Conversion is made if units are changed.

ZREF?

Description Probe Zero Reference Query.

Syntax

Input ZREF?

Returned The value returned will be a number between ±999.9000.

Remarks Nine characters plus up to two terminators are returned.

3. The remaining Mainframe will be configured as Mainframe 2 as follows.

   a. Locate the **CAL AND ID** switches on the rear panel. Turn On (up position) switches 2 and 4. Turn OFF (down position) switches 1, 3, and 5 through 8. *(Multiple Mainframe operation is designated by switch 4 being ON. Switches 3, 2 and 1 as OFF, ON, OFF, respectively, assign the Mainframe address as 2.)*

   b. Move both **I MODE** switches to the **INT**ernal (up) position.

   c. On the CMP, ensure that switches 5, 6 and 7 are On (closed) and switches 1–4 and 8 are Off (OPEN). Replace the CMP.

4. Connect the control bus. Use Lake Shore Model 2001 Modular Cables *(provided)* to interconnect the Control Unit with all Mainframes. Connect the Control Unit to the master Mainframe. Now, connect the master Mainframe to the slave Mainframe.

5. Connect the Mainframe overvoltage protection (OVP) pin 8 to Mainframe 2 pin 8.

6. Connect the RI and FLT signals. Connect the +RI (terminal 1) to the +FLT (terminal 3) on the slave Mainframe. Connect the -RI (terminal 2) to the -FLT (terminal 4) on the slave Mainframe. Do the same on the master Mainframe. Connect the +RI/+FLT connection of the slave Mainframe to the +RI/+FLT connection of the master Mainframe, then to +RI (terminal 1) of the Control Unit. Connect the -RI/-FLT connection of the slave Mainframe to the -RI/-FLT connection of the master Mainframe, then to -RI (terminal 2) of the Control Unit. If an external contact closure will be used to remotely inhibit operation, connect it across the +RI and -RI terminals of the Control Unit. The +FLT and -FLT contact closure of the Control Unit indicates a fault has occurred.

NOTE Refer to Section 3 Protection Circuits for a detailed description of the RI and FLT signals.

7. Review that all the connections outlined in the following table have been made:

Control Unit	Mainframe 1	Mainframe 2
Control Bus	Control Bus	
	Control Bus	Control Bus
	8 (OVP)	8 (OVP)
1 (+RI)	1 (+RI), 3 (+FLT)	1 (+RI), 3 (+FLT)
2 (-RI)	2 (-RI), 4 (-FLT)	2 (-RI), 4 (-FLT)

8. Connect the +OUT terminal of Mainframe 1 to the +OUT terminal of Mainframe 2. Connect the –OUT terminal of Mainframe 1 to the –OUT terminal of Mainframe 2. Make these leads as short as possible to minimize output potential differences between the two Mainframes. Connect the output terminals to the load.

NOTE For proper operation, turn On the Mainframe 1, then Mainframe 2, and finally the Control Unit.

LALMS

Description Programs the Level Alarm Status

Syntax

Input LALMS[status]

[status] Fill in the status with a **0** to turn off the level alarm or **1** to turn on the level alarm.

Remarks The initial condition is **0**.

LALMS?

Description Level Alarm Status Query

Syntax

Input LALMS?

Returned The value returned will be **0** or **1**. **0** indicates that the level alarm has not been reached. **1** indicates that the level is below the alarm value and the alarm has been activated.

Remarks One character plus up to two terminators are returned.

PER

Description Programs the sample period in hours and minutes.

Syntax

Input PER[hours]:[minutes]

[hours] Fill in the hours parameter with a value from 0 to 23.

[minutes] Fill in the minutes parameter with a value from 0 to 59.

Remarks The initial condition is 00:00.

00:00 defines a continuous sample period.

The time limitation is 23 hours, 59 seconds.

PER?

Description Sample Period Query

Syntax

Input PER?

Returned The value returned will have the hours and minutes programmed for the sample period, a comma and then the hours and minutes left in the sample period.

Remarks Eleven characters plus up to two terminators are returned.

Example **23:59,10:10[term]**
indicates that the sample period was programmed for 23 hours and 59 minutes, while the time remaining in the period is 10 hours and 10 minutes.

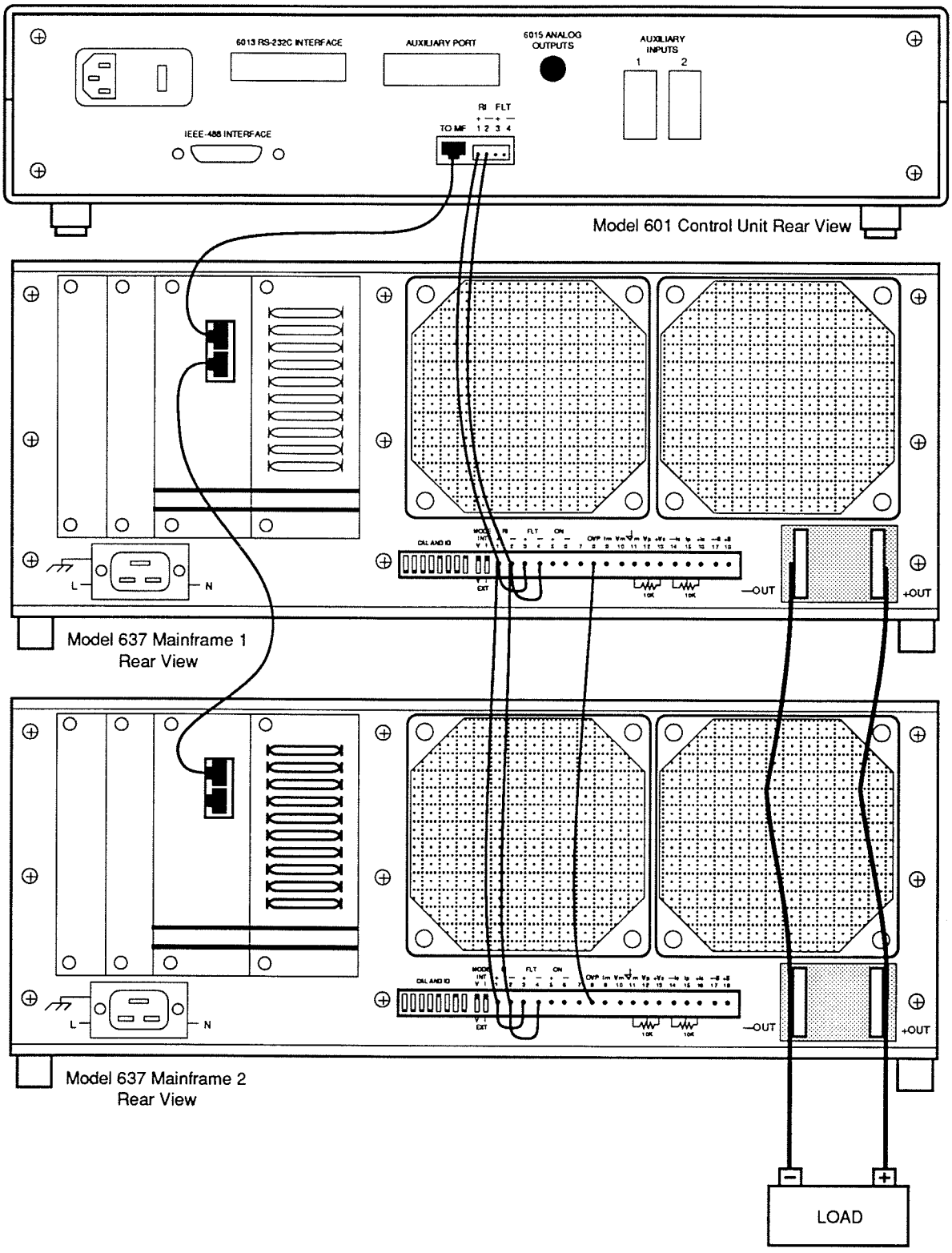


Figure 2-4. Multiple Mainframe Connections

LUNI?

Description Level Units Query

Syntax

Input LUNI?

Returned The value returned is
% for percentage
E for English units (inches)
M for metric units (centimeters)

Remarks One character plus up to two terminators are returned.

LALM

Description Programs the level alarm.

Syntax

Input LALM[alarm]

[alarm] Fill in the alarm parameter with a value between 0 to ±999.9. This will be the level at which the alarm is activated. The value is truncated *(not rounded)* to the tenths place.

Remarks The initial condition is 0.

The alarm value uses the existing units.

Conversion is made if units are changed.

LALM?

Description Level Alarm Query

Syntax

Input LALM?

Returned The value returned is a number between ±999.9000

Remarks Nine characters plus up to two terminators are returned.

Bench Use

The Mainframe and Control Unit are shipped with feet and are ready for use as bench top instruments. The Control Unit may be elevated by extending the tilt stands. This provides for convenient operation and viewing.

Rack Mounting

The Mainframe is shipped ready to be mounted in a standard 19-inch rack enclosure. An RM-3F-H Rack Mounting Kit is included for the Control Unit.

NOTE	It is strongly recommended that a slide rail or runner be installed in the rack to support the Mainframe.

Remote Operation Commands

LEVL?

Description Causes the level to be read.

Syntax

Input LEVL[status]

[status] Fill in the status parameter with a 1 to read the level or a 0 not to read it.

Remarks A minimum of 5 seconds is required to update the level reading.

LEVL?

Description Level Query

Syntax

Input LEVL?

Returned The value returned will be a number between ±999.9000

Remarks Nine digits plus up to two terminators are returned.

LUNI

Description Programs the level units.

Syntax

Input LUNI [units]

[units] Fill in the units parameter with
% for percentage
E for English units (inches)
M for metric units (centimeters)

Remarks The initial condition is E (inches).

Make sure there is a space between the command and the units parameter.

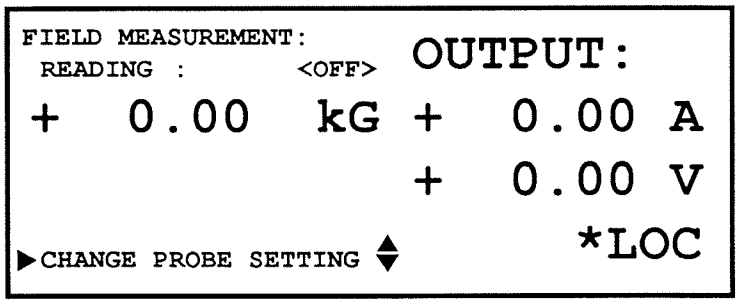
OPERATING THE MODEL 637 ELECTROMAGNET POWER SUPPLY

3

In this section you will learn how to operate the Model 637 MPS. The main topics discussed are as follows:

- *Operating Characteristics*
- *Power Up*
- *General Display Description*
- *Numeric Entry*
- *Additional Screens*
- *Protection Circuits*

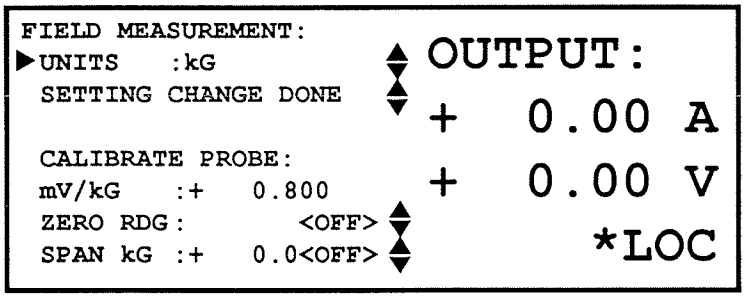
Press the Function Menu key. Press the Next Menu key. Function Menu 2 will be displayed. Press the FIELD Function key. The Field screen will be displayed. The Menu window will return to displaying the Output values.



The following are valid Field Measurement entries:

READING: <OFF>
Field Reading Status. The field reading is taken when the liquid helium level is not.

CHANGE PROBE SETTING
Change Field Probe Settings. Field probe units, and calibration can be changed when this screen is selected. Press the numeric up or down arrows to enter the Field Probe Setting screen.



The cursor up and down keys move the line indicator (▶). The up and down arrow icon indicates parameters that can only be changed using the Data Entry up and down arrows. When there are <ON > or <OFF> indicators, the Data Entry up and down arrows change the status. The following are valid Field Probe Setting entries:

UNITS :kG or T
Field Units. The Data Entry up or down arrows scroll through the available units: kG (kilogauss), or T (tesla).

SETTING CHANGE DONE
Field Probe Setting Change Done. The Data Entry up or down arrows exit the Field Probe Setting screen and return to the Field Measurement screen.

NOTE	The following procedures change the probe calibration. Do not perform them unless the probe is actually being calibrated.

mV/kG: + 0.800
Field Probe Sensitivity. Each Hall Probe comes with a mV/kG sensitivity. Use any numeric entry mode to change the value.

ZERO RDG: <OFF>
Field Probe Zero Reading. Connect the Hall Probe and place it in zero magnetic field. Press the Data Entry up or down arrows. The display will change to <ON > to indicate that the field probe zero is being read. When the field probe zero is complete, the display will return to <OFF>.

SPAN kG: + XXX.X <OFF>
Field Probe Span. For a known field, enter the value in kG at field. The unit will calculate a new probe sensitivity.

Operating Characteristics

The 637 MPS has a number of operating characteristics which ideally suit it for the charge and discharge cycling of magnet loads. These characteristics significantly differentiate the 637 MPS from conventional magnet power supplies and should be considered when making the decision about what magnet power supply is best suited for a particular application.

True, Four-Quadrant Bidirectional Power Flow

Model 637 Magnet Power Supply

The Model 637 MPS has the ability to set either positive or negative current and voltage values. This true, four-quadrant operation significantly simplifies test procedures as well as system design by eliminating the need for external switching or operator intervention to reverse the polarity of the current. The transition through zero current is smooth and continuous allowing the user to readily analyze samples at very small current increments *(as small as 1 mA)* about zero. Power flow is bidirectional. Sink power *(energy stored in the magnet)* is returned to the AC line instead of being dissipated in an energy absorber. The 637 MPS either transfers power from the AC line to the magnet, or from the magnet back to the AC line. In addition to bidirectional power flow, tolerance of AC line faults was also incorporated into the 637 MPS. In the event of the loss of utility power, power is drawn from the charged load to keep the unit functional until the utility is restored.

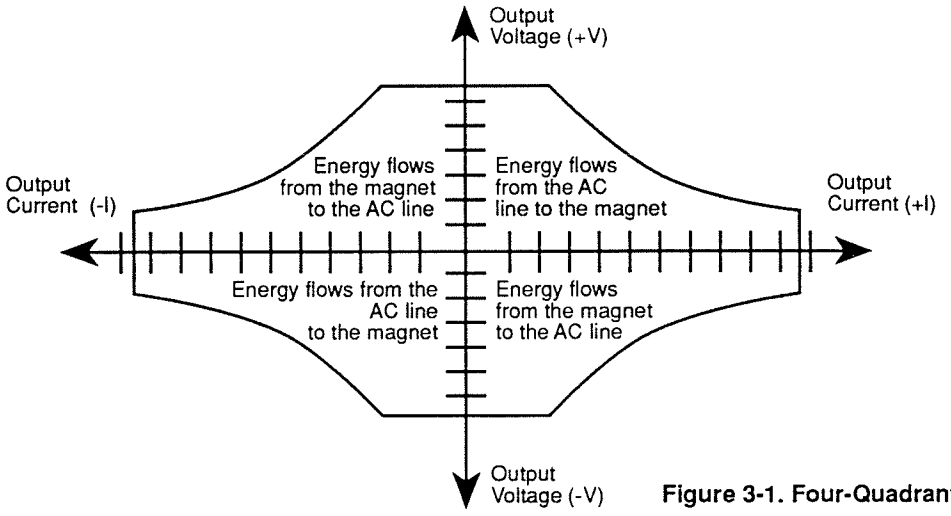
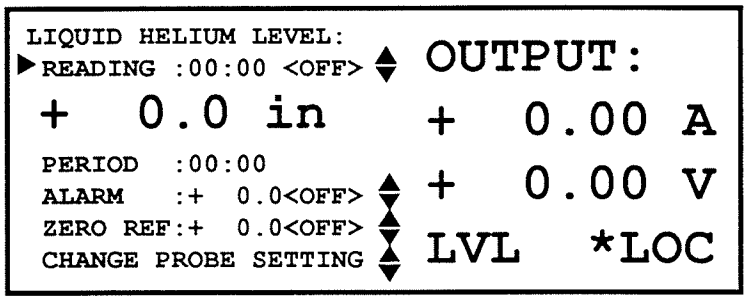


Figure 3-1. Four-Quadrant Power

Other Conventional Magnet Power Supplies

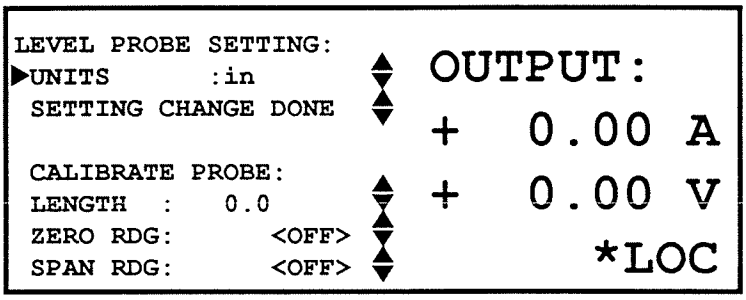
Some conventional magnet power supplies consist of a unipolar power supply with the addition of an energy absorber which dissipates the energy stored in the magnet when it is discharged. The energy absorber must keep the reverse voltage generated during the discharge from damaging the unipolar supply output. Other conventional supplies dissipate the magnet energy in the power supply output transistor pass-bank. This two-quadrant performance requires the output stage to be capable of absorbing considerable power during the discharge. In addition, uniform charging and discharging rates are not always ensured. In order to reverse the current, external current reversal switches or manual lead reversal is required. These units may operate in all four quadrants, but cannot provide the true, four-quadrant operation that the 637 MPS is capable of. This pseudo-four-quadrant operation introduces discontinuances at the current reversal point produced by switching the leads. Current reversal switches may incorporate direction detection diodes which reduce the available magnet charging voltage and dissipate additional power. Current reversal switches must also be interlocked in some way to keep the leads from being reversed if there is current present. Current reversal switches complicate the high power cabling requirements, increase the chances of introducing output current instabilities, and require time to reverse the leads. If the leads must be reversed manually, no continuity can be maintained at the current reversal point. Since the transition through zero current is not continuous, a small external supply may be required for near zero current analysis.

If the level alarm is on and the Control Unit detects that the level alarm has been reached, the Control Unit closes the FLT contacts to indicate the fault and the internal audio indicator beeps about once per second. The Control Unit displays the following:



The audio indicator continues to beep until the level alarm is turned off. When the alarm is turned off (or disabled), the Control Unit opens the FLT contacts and turns off the internal audio indicator.

Move the line indicator down to the CHANGE PROBE SETTING line and press the numeric up or down arrows to enter the Level Probe Setting screen.



The cursor up and down keys move the line indicator (▶). The up and down arrow icon indicates parameters that can only be changed using the Data Entry up and down arrows. When there are <ON > or <OFF> indicators, the Data Entry up and down arrows change the status. The following are valid Level Probe Setting entries:

UNITS: in (E) or cm or %
Level Units. The Data Entry up or down arrows scroll through the available units: in (inches), cm (centimeters), or % (percent).

SETTING CHANGE DONE
Level Probe Setting Change Done. The Data Entry up or down arrows exit the Level Probe Setting screen and return to the Liquid Helium Level screen.

NOTE	The following procedures change the probe calibration. Do not perform them unless the probe is actually being calibrated.

LENGTH: 24.0
Level Probe Length. Use any numeric entry mode to change the value.

ZERO RDG: <OFF>
Level Probe Zero Reading. Connect the level probe out of the liquid or connect a load resistor with resistance equivalent to the resistance of the total length of the probe and press the Data Entry up or down arrows. The display will change to <ON > to indicate that the level probe zero is being read. When the level probe zero is complete, the display will return to <OFF>.

SPAN RDG: <OFF>
Level Probe Span Reading. Connect the level probe in liquid at the probe length entered or connect a load resistor with resistance equivalent to the resistance of the active length of the probe and press the Data Entry up or down arrows. The display will change to <ON > to indicate that the level probe span is being read. When the level probe span is complete, the display will return to <OFF>.

Low Noise, High Stability Current Regulated Output

Model 637 Magnet Power Supply

The Model 637 MPS maintains a high stability, low noise current regulated output. Digital setting and monitoring electronics, and computer interfacing are integrated into the power management and precision analog control circuitry. This integration is required to maintain high output stability and repeatability. The output must also be very low in noise. Extensive output filtering and noise cancellation circuitry was designed into the 637 MPS. Standard display and programming resolution is 10 mA and 10 mV. A 1 mA and 1 mV high resolution option is available. The Control Unit graphic display allows the continuous display of output current and voltage while parameters are being set from the menu-driven keypad. An IEEE-488 interface is standard in the Control Unit. In addition to the front panel and remote interface programming, the Mainframe includes analog inputs and outputs for setting and monitoring operating parameters. The 637 MPS requires only 10.5 inches of rack space.

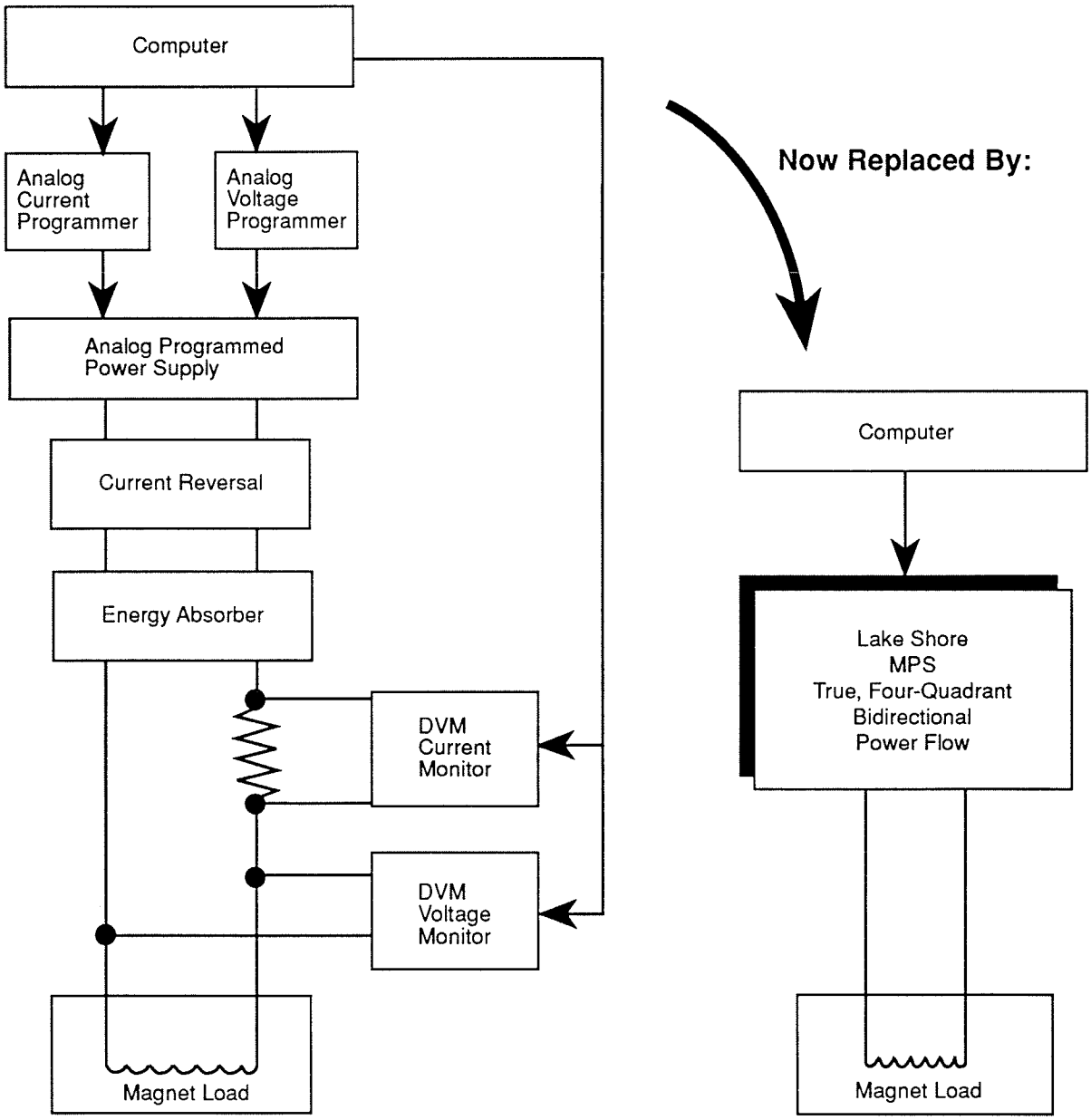
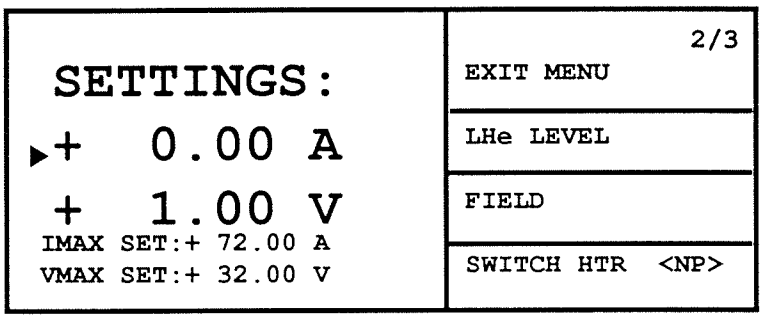


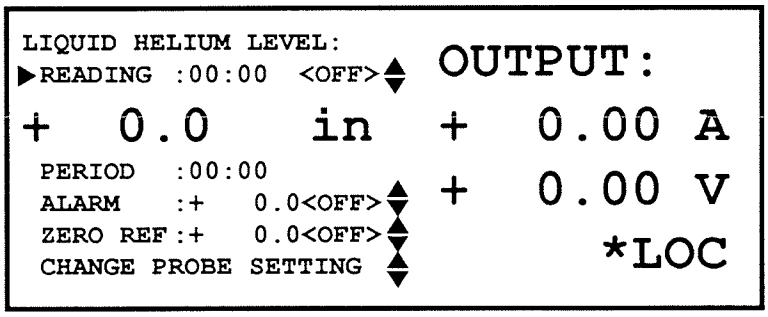
Figure 3-2. Comparison of Old and New MPS Designs

Operation

Liquid helium level and field monitoring can be accessed from the Control Unit front panel. Press the Function Menu key. Press the Next Menu key. Function Menu 2 will be displayed. If the 6016 option is not present, <NP> will appear next to LHe LEVEL and FIELD and the associated function keys will be ignored.



Press the LHe LEVEL Function key. The Liquid Helium Level screen will be displayed. The Menu window will return to displaying the Output values.



The cursor up and down keys move the line indicator (▶). The up and down arrow icon indicates parameters that can only be changed using the Data Entry up and down arrows. When there are <ON > or <OFF> indicators, the Data Entry up and down arrows change the status if they are the first data entry keys used. The following are valid Liquid Helium Level entries:

READING: 00:00 <OFF>
Level Reading Status. The Data Entry up or down arrows initiate a level reading.

PERIOD: 00:00
Level Sample Period. Time in hours:minutes. A time of 00:00 indicates a continuous reading *(20 second period, 5 seconds for the level reading)*. Use any numeric entry mode to change the value.

ALARM: + 0.0<OFF>
Level Alarm and Alarm Status. The Data Entry up and down arrows toggle the status. Use any numeric entry mode to change the value.

ZERO REF: + 0.0<OFF>
Level Zero Reference Value and Status. The Data Entry up and down arrows toggle the status. When Zero Reference is turned on, the value entered is taken as the zero reference reading and is subtracted from the actual level reading to give a "relative" level reading. Use any numeric entry mode to change the value.

CHANGE PROBE SETTING
Change Level Probe Settings. Level probe length, units, and calibration can be changed when this screen is selected.

Other Conventional Magnet Power Supplies

Some conventional power supplies use a constant voltage output, with current monitoring, to charge the magnet. Others require the output current to be driven against the output current limit or the output current will drift. Multi-turn potentiometers and digital *(or analog)* panel meters are generally used for front panel current and voltage setting. The elegance and repeatability of keypad entry is not available. No digital setting or monitoring is integrated into the output control circuitry. Computer interfacing is generally accomplished by adding computer controlled voltage sources to analog program the output current and voltage. Additional inputs must be added to digitize the output current and voltage. The resulting setting and monitoring resolution is one to two orders of magnitude poorer than the standard 637 MPS provides. Cabling requirements are complicated by the addition of this external setting and monitoring. Degradation of the output current stability due to the addition of external cabling is undefined. Output noise specifications are rarely given and sometimes vary with the type of magnet load being driven. These multiple unit configurations require up to 36 inches of rack space.

Highly Efficient, Air Cooled, Compact Unit

Model 637 Magnet Power Supply

The Model 637 MPS is a quiet switched-mode design. The output uses a proprietary pulse width modulated technique that incorporates power hybrid circuitry. Extremely low conduction loss components are used to minimize internal power dissipation. The 637 MPS is not a direct off-line switching supply. The output is fully floating and isolated from ground. Active power factor correction is used to minimize AC line harmonics and lower the AC current required. Power factor is the ratio of real power *(measured in watts)* to the apparent power *(measured in volt-amperes)*. Active power factor correction results in a sinusoidal AC current waveform being drawn from the utility. The combination of the quiet switched-mode design and active power factor correction results in a compact, air cooled unit with high overall efficiency.

Other Conventional Magnet Power Supplies

Most conventional magnet power supplies incorporate linear regulated outputs. The output transistor pass-bank must internally dissipate the power that is not being delivered to the magnet. Some units use an off-line switching supply to provide the bulk power and add output regulation. Input power factor correction is not even a consideration. Low overall efficiency means higher input power, requiring higher input current. Without power factor correction, this current is non-sinusoidal with high peaks. Tremendous stress is placed on fuses, circuit breakers, outlets and wiring. Dedicated lines may be required because of the potential interaction with other equipment. These factors result in low overall efficiency, large size and considerable weight.

Connections

The 6016 has one rear panel 9-pin connector for interfacing with the level and field probes. The lead connection definition is given below.

Terminal	Description
1	Field -Current
2	Field -Voltage
3	Field +Voltage
4	Field +Current
5	Shield
6	Level -Current
7	Level -Voltage
8	Level +Voltage
9	Level +Current

Installation

WARNING **The information contained in this section is intended for the use of service trained personnel who understand electronic circuitry and are aware of the hazards involved. Do not attempt to perform any of the procedures in this section unless you are qualified to do so.**

The 6016 Liquid Helium Level and Gaussmeter Input Option is factory installed if ordered with a Control Unit or can be field installed at a later date. If field installation is required, use the following procedure.

WARNING **To prevent shock hazard, turn off the instrument and disconnect it from AC line power and all test equipment before removing cover.**

1. Set the POWER switch to off and disconnect the power cord from the unit.
2. Remove the six screws on the sides of the top enclosure half and lift the cover off.
3. The calibration cover will now be seen.
4. Remove the calibration cover by taking out the six screws on the top of the cover. Also, remove the two screws in the center of the rear panel of the instrument located near the top. Lift the cover off.
5. Remove the cover plate from AUXILIARY INPUT 1 on the rear panel.
6. Carefully plug the 6016 printed circuit board into Input Slot 1 with the component side to the left of the units as viewed from the front. The 6016 rear panel connector must be guided into the AUXILIARY INPUT 1 opening before the card can be plugged in.
7. Locate the internal ID DIP switches. They are to the left of the IEEE connector near the rear panel. Turn ON *(opposite of OPEN)* switch 1 to indicate a 6016 option is present.
8. Replace the calibration cover and the top enclosure half.

CAUTION	The 637 MPS can be programmed to provide up to ±72 amperes and ±32 volts. These settings may exceed the capabilities of some components in the electromagnet system. Before programming the output current or voltage, refer to the Setup Considerations in Appendix B.

Power Up

NOTE	It is strongly recommended that the Control Unit be operated separately prior to connecting it to the Mainframe. This will ensure familiarity with operation.

Mainframe

Turn on the Mainframe. The Mainframe requires approximately 2 seconds for initialization. Initially, all the front panel annunciators will come on and the audio indicator will sound for a short period of time. Within 1 second, the Fault annunciator and the audio indicator will go off. If the Mainframe detects a high or low AC line fault, it will blink the front panel Fault annunciator and turn off the input circuit breaker. If this occurs, verify that the AC source matches the line voltage listed on the Mainframe rear panel.

Control Unit

Turn on the Control Unit. Initially, the entire display is cleared and the audio indicator will sound for a short period of time. While the display is clear, the Control Unit initializes itself and polls the control bus to determine the configuration. Once the Control Unit has communicated with the Mainframe, the display goes to the Normal Display screen. A blinking asterisk indicates each Mainframe update.

General Display Description

In general, the various screens of the display are split up into two sections. The left section is the Entry Window. This is where new parameters are entered. The right section is the Menu Window. This is where the Menus are displayed when the Output values are not. The right triangle (▶) is the line indicator. The cursor up and down keys move the line indicator.

```
 SETTINGS:     OUTPUT:
▶+   0.00 A    +   0.00 A
 +   1.00 V    +   0.00 V
IMAX SET:+ 72.00 A
VMAX SET:+ 32.00 V          *LOC
```

Shown above is the Normal Display screen. The Normal Display screen is unique because it allows Settings entry at any time. The IMAX SET and VMAX SET values are the soft current and voltage setting limits. Settings entered will not be allowed to exceed these limits. These limits can be changed from the SETUP screen.

NOTE	If no Mainframe responds after polling the control bus, **NO MF RESPONSE** will appear to the left of the interface status. For multiple mainframes, **NO MF1 RESPONSE** or **NO MF2 RESPONSE** indicates no response from Mainframe 1 or 2 respectively.

The OUTPUT screen indicates the output values and the interface status. The Normal Display key returns the display to this screen at any time.

Hall Sensor Probe Mounting Considerations

The Lake Shore 9010-001 (transverse) and 9010-002 (axial) Hall sensors are four terminal, solid state devices that produce an output voltage proportional to the product of the input current, magnetic flux density, and the sine of the angle between the field vector and the plane of the Hall generator.

The active area of the 9010-001 transverse Hall sensor is approximately 0.04" in diameter with the center indicated by a cross on one face of the package. When the control current is applied with the red lead positive with respect to the black lead, and the magnetic field is perpendicular into the face of the probe with the cross on it, the Hall voltage will be positive at the blue lead with respect to the yellow lead. A reversal in the mechanical orientation or in the direction of either the magnetic field or the control current will result in a polarity change of the output voltage.

The active area of the 9010-002 axial Hall sensor is approximately 0.02" in diameter in the center of the face opposite the leads. When the control current is applied with the red lead positive with respect to the black lead, and the magnetic field is perpendicular into the face of the probe opposite the leads, the Hall voltage will be positive at the blue lead with respect to the yellow lead. Again, a reversal in the mechanical orientation or in the direction of either the magnetic field or the control current will result in a polarity change of the output voltage.

The Hall sensor cannot be handled the same way most other electronic components are handled. The ceramic substrate is brittle and very sensitive to bending stress. Mounting must be accomplished in such a way to minimize mechanical strains when the sensor is cooled. Failure rates approaching 10% have occurred on initial cooldown with sensors that have not been properly installed (sensors surviving initial cooldown generally experience no problems on subsequent cycles). Avoid applying tension to the leads and avoid bending them close to the substrate. The leads may be bent at any angle as long as the bend is at least 1/8" away from the substrate connection. The device should be mounted to a non-flexible, smooth surface that has a coefficient of thermal expansion that is no greater than a factor of three different from that of the ceramic substrate (which is about 7×10^{-6} in/in per K).

The preferred mounting procedure is to locate the probe in a cavity that is 0.003" wider and 0.01" longer than the substrate. The depth of the cavity should be the same or slightly greater than the thickness of the package. Tack the leads outside the slot with GE-7031 varnish or other similar substance. Sparingly apply the mounting substance to the corners or a dot on each side of the sensor to hold it in place. Avoid getting the mounting substance on top of the sensor. Alternately, kapton tape or a mechanical cover could be used over the top of the sensor to keep it in place. The tape or cover should apply only light pressure to the sensor. If epoxy must be used as a mounting substance, it should be used sparingly and be the same as is used in the sensor, stycast 2850-FT epoxy. The probe should never be potted.

A room temperature calibration over the range of ±30 kG is provided with each probe. The calibration specifies the terminating resistor (not included) required to maintain an accuracy of ±1% of reading up to ±30 kG and ±2% of reading up to ±150 kG over the entire temperature range. This terminating resistor should be metal film resistor with 1% or better accuracy mounted across the output voltage leads as close to the probe as is practical. If the leads must be extended, AWG 34 stranded copper with teflon insulation should be used (this is the same wire type that is used on the probe). Any impedance in the output leads will act as a voltage divider with the terminating resistor. Reproducibility of the probe reading will be within ±1% over repeated thermal cycling between 4.2 K and room temperature.

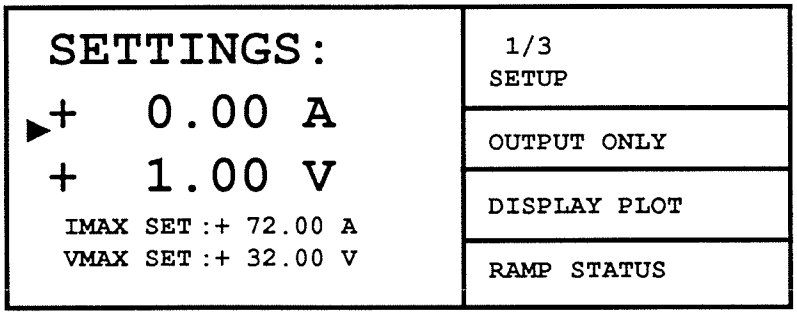
Numeric Entry

Move the line indicator to the line where you wish to change a value. Numeric entry includes using the up or down arrows *(not cursor keys)* to increment or decrement the value. The Enter key accepts the update, while the Esc key returns to the value prior to any change being initiated. The cursor right and left keys can be used to move the cursor to a particular digit, or numeric entry can be done using the Data Entry keys.

Additional Screens

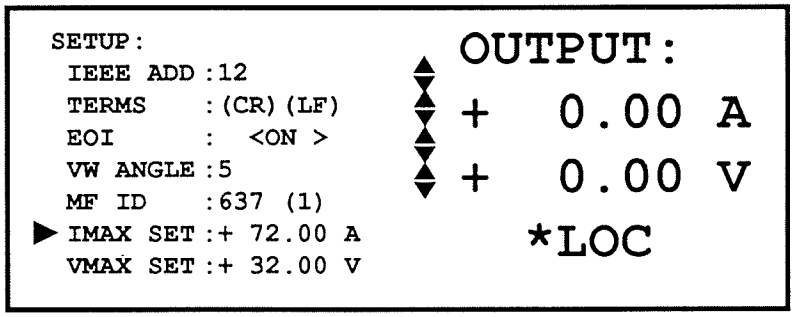
Function Menu 1 Screen

Press the Function Menu key. Function Menu 1 will be displayed. The 1/3 in the upper right corner indicates Menu 1 of 3. Function Menu 1 is exited by pressing the Function Menu key again.



Setup Screen

To verify the setup status, press the SETUP Function key. The Setup screen will be displayed. The Menu window will return to displaying the Output values.



Use the Cursor keys to move the line indicator up or down. The up and down arrow icon indicates parameters that can only be changed using the Data Entry up and down arrows. All others can be changed using all the numeric entry modes, including the cursor. The following are valid Setup entries.

IEEE ADD: 1 to 30
IEEE-488 interface address. Initial condition is 12. Use the Data Entry up or down arrows to increment or decrement the address.

TERMS: (CR)(LF) or (LF)(CR) or (LF) or (DAB)
IEEE-488 communication terminators. Initial condition is (CR)(LF). Use the Data Entry up or down arrows to scroll through the available terminators.

MODEL 6016
LIQUID HELIUM LEVEL AND GAUSSMETER INPUT OPTION

Description

The Model 6016 Liquid Helium Level and Gaussmeter Input Option is designed to be installed in a Control Unit and combines liquid helium level and field monitoring on one input card. Since continuous liquid level monitoring is not generally required, field is monitored when the liquid helium is not. The field measurement is quantitative. Each input has independent, isolated excitation.

Liquid level can be displayed in percent inches or centimeters. Field can be displayed in kilogauss or tesla.

The level probe interfacing is designed to support NbTi filaments and includes entry of probe length and determination of probe resistance over the length. A unique level probe zero reference feature allows the user to define the current liquid level reading as the "zero reference" and reads levels above or below that reference. A software level alarm notifies the user and host computer that the continuously variable liquid level set point has been reached.

When the liquid level measurement is not active, the field measurement is. The field interfacing is designed to support Hall sensors and includes probe zero and entry of probe sensitivity in millivolts per kilogauss.

Specifications

Liquid Helium Level:	
Probe Type	Filament
Number of Inputs	1 four lead measurement
Nominal Excitation Current	70 mA at up to 25 volts compliance
Input Voltage Resolution	Better than 1 mV out of 25 volts full scale
Sample Interval	1 minute to 24 hours, continuous, or read on demand
Sample Period	Fixed at 5 seconds
Display Resolution	1%, 0.1 inch, 0.1 cm
Electronic Accuracy	1% of full scale
Gaussmeter:	
Probe Type	Lake Shore 9010-001 (transverse) or 9010-002 (axial) Hall Sensor
Number of Inputs	1 four lead measurement
Nominal Excitation Current	100 mA
Probe Magnetic Sensitivity	0.8 mV/kilogauss ±30% @ 100 mA
Nominal Field Range	Greater than ±200 kilogauss
Input Voltage Resolution	Better than 0.01 mV out of 0.25 volts full scale
Sample Interval	Probe is excited continuously and read when level is not
Display Resolution	0.01 kilogauss, 0.001 tesla
Electronic Accuracy	1% of full scale

EOI: **<ON > or <OFF>**
IEEE-488 EOI status. Initial condition is <ON >. Use the Data Entry up or down arrows to toggle the status.

VW ANGLE: **2 to 9**
Display viewing angle. 9 indicates viewing from above, 5 in the middle, and 2 from below. Initial condition is 5. Use the Data Entry up or down arrows to increment or decrement the value.

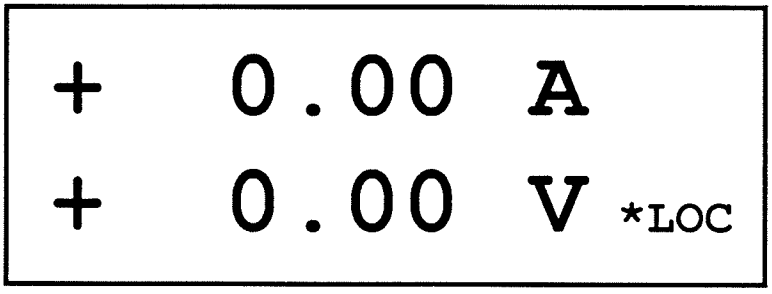
MF ID: **637 (1)**
Mainframe ID. A 1 indicates only one Mainframe is present. A 2 indicates a multiple Mainframe configuration is present. The Mainframe and quantity are determined from polling done at power up. This line is skipped in the cursor up and down line selection.

IMAX SET: **+0.00 A to + 72.00 A**
Soft current limit. A current setting entered will be not be allowed to exceed this limit. Initial condition is + 72.00 A. Use any numeric entry mode to change the value.

VMAX SET: **+0.00 V to + 32.00 V**
Soft voltage limit. A voltage setting entered will be not be allowed to exceed this limit. Initial condition is +32.00 V. Use any numeric entry mode to change the value.

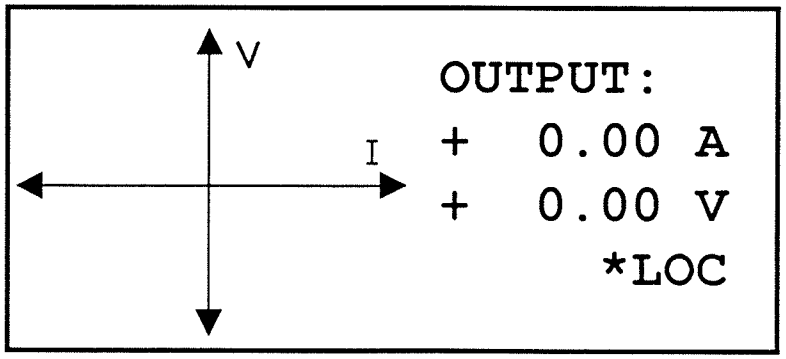
Output Only Screen

Press the Function Menu key. Function Menu 1 will be displayed. Press the OUTPUT ONLY Function key. This screen fills the display with the output values.



Graphic Screen

Press the Function Menu key. Function Menu 1 will be displayed. Press the DISPLAY PLOT Function key. The Graphic screen displays the output and a graphic plot of output values.



Calibration

WARNING	**The information contained in this section is intended for the use of service trained personnel who understand electronic circuitry and are aware of the hazards involved. Do not attempt to perform any of the procedures in this section unless you are qualified to do so.**

The Model 6015 has been calibrated to specification prior to shipment. If recalibration is needed, use the following procedure. The following equipment is used to calibrate the 6015 Analog Output:

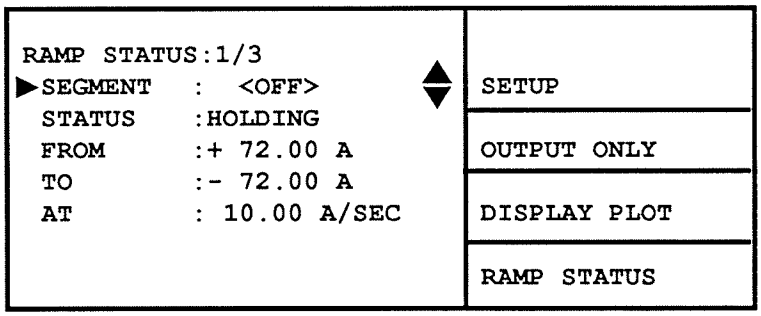
•**Digital Voltmeter/Multimeter (DVM)** – 4 1/2 digit resolution or better.

The unit should be allowed one hour to warm up to achieve rated specifications. Use the following procedure to calibrate the 6015 Analog Output:

1. Disconnect the control bus which runs between the Control Unit and Mainframe.
2. Remove the top enclosure half *(see previous page).*
3. Connect the DVM plus lead to the 6015 ANALOG OUTPUTS connector pin C and the minus lead to pin D.
4. Locate the internal ID DIP switches. They are to the left of the IEEE connector near the rear panel. Turn on (opposite of open) switch 8 to indicate the 6015 will be calibrated. The analog output will now be the output current or voltage setting instead of the actual output current or voltage.
5. Enter a negative current or voltage setting. A setting of -60 amps or -30 volts are very close to an even number of resolution bits. Adjust the trimpot labeled Z(R2)(for Zero) on the calibration cover until the voltmeter reading corresponds to -0.01v/A or -0.01v/v. Enter a setting of +60 amps or +30 volts and adjust the trimpot labeled S(R1)(for Span).
6. Repeat procedure in step 5 until there is no further Zero or Span adjustment required.
7. Return the internal ID DIP switch 8 to the OFF (OPEN) position. The analog output will now track the output current or voltage.
8. Replace the calibration cover top enclosure half.

Ramp Status Screen

Press the Function Menu key. Function Menu 1 will be displayed. Press the RAMP STATUS Function key. The Ramp Status screen will be displayed.



Use the Cursor keys to move the line indicator up or down. The up and down arrow icon indicates parameters that can only be changed using the Data Entry up and down arrows. All others can be changed using all the numeric entry modes, including the cursor. The following are valid Ramp Status entries.

SEGMENT: <OFF> or <ON >
Ramp status. The ramp segment can be put in the Hold (Pause) mode at any time during the ramp. Use the Data Entry up or down arrows to toggle the status.

STATUS: HOLDING or RAMPING
Indicates the ramp status. If the ramp is OFF, the status will be HOLDING. If the ramp is on, it will be RAMPING. This line is skipped in the cursor up and down line selection.

FROM: + 72.00 A to - 72.00 A
Initial ramp current. This value is the present current setting, or the current setting when the ramp was put in hold mode. If the ramp is put in the hold mode, the value will be whatever the current output setting is. When the ramp is complete, this value is changed to the present current setting.

TO: + 72.00 A to - 72.00 A
Destination ramp current. Use any numeric entry mode to change the value.

AT: 0.00 A/SEC to 99.99 A/SEC
Ramp rate. Use any numeric entry mode to change the value.

While ramping, the message: ▲ RAMPING
▼ TO HOLD
will appear to the left of the interface status. This allows the ramp segment to be put in the hold mode using the Data Entry up or down arrows from any screen.

Installation

WARNING	**The information contained in this section is intended for the use of service trained personnel who understand electronic circuitry and are aware of the hazards involved. Do not attempt to perform any of the procedures in this section unless you are qualified to do so.**

The 6015 Analog Output is factory installed if ordered with a Control Unit or can be field installed at a later date. If field installation is required, use the following procedure.

WARNING	**To prevent shock hazard, turn off the instrument and disconnect it from AC line power and all test equipment before removing cover.**

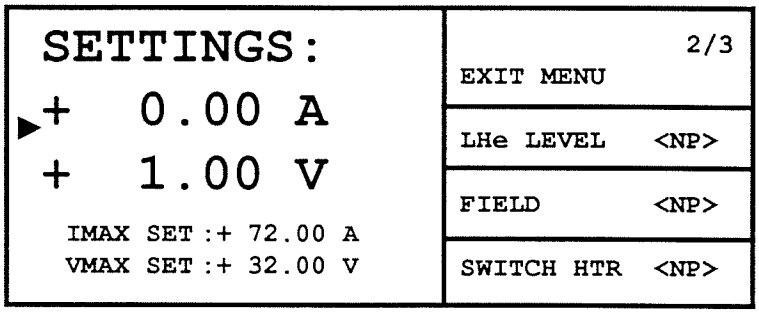
1. Set the POWER switch to off and disconnect the power cord from the unit.
2. Remove the six screws on the sides of the top enclosure half and lift the cover off.
3. The calibration cover will now be seen.
4. Remove the calibration cover by taking out the six screws on the top of the cover. Also, remove the two screws in the center of the rear panel of the instrument located near the top. Lift the cover off.
5. Configure the red jumper on the 6015 printed circuit board for **I OUT** (Output Current) or **V OUT** (Output Voltage).
6. Plug the 8225 printed circuit board into Option Slot 1 or 2 with the component side to the left of the unit as viewed from the front.
7. Remove the cover plate from the 6015 ANALOG OUTPUTS on the rear panel. Position the 7-pin connector in the opening on the rear panel and secure it in place with the nut provided.
8. Thread the two black and white wires from the 6015 along the inside edge of the rear panel and solder the white wire to the 6015 ANALOG OUPUTS connector – Pin C and black wire to Pin D.
9. Replace the calibration cover and the top enclosure half.

Operation

The output resolution and equivalence is given in the Specifications. For an Output Current display of +50.00A, the 6015 will output +0.500V. The output is rounded to the equivalent unit for the 1mV output. A display of +53.42A will result in an output of +0.534V and a display of +53.47A will result in an output of +0.535V.

Function Menu 2 Screen

To determine if there are any secondary functions available, press the Function Menu key. Function Menu 1 will be displayed. Press the Next Menu key. Function Menu 2 will be displayed. <NP> indicates the function is not present and the associated function key will be ignored.



EXIT MENU
Will return to the display screen the Function Menu 2 was entered from.

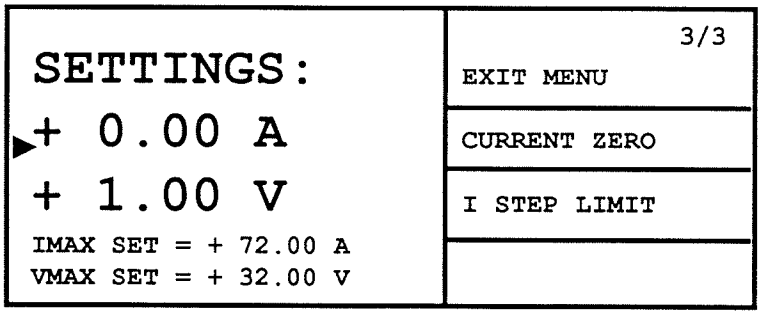
LHe LEVEL <NP>
The LHe Level screen is not used in electromagnet systems.

FIELD
Will enter the Field screen. Refer to Section 5 for a detailed description.

SWITCH HTR <NP>
The Persistent Switch Heater option is not used in electromagnet systems.

Function Menu 3 Screen

Press the Function Menu key. Function Menu 1 will be displayed. Press the Next Menu key. Function Menu 2 will be displayed. Press the Next Menu key again. Function Menu 3 will be displayed.



EXIT MENU
Will return to the display screen the Function Menu 3 was entered from.

CURRENT ZERO
Will enter the Current Zero screen. Refer to Appendix D for a detailed description.

I STEP LIMIT
Will enter the Current Step Limit screen. Refer to Appendix E for a detailed description.

MODEL 6015 ANALOG OUTPUT OPTION

Description

The Model 6015 Analog Output option is designed to be installed in a Control Unit and provide an analog output proportional to the output current or voltage for the purpose of recording, either with a strip chart recorder or other similar device.

Specifications

Output Range	0.000 to ±10.000 V
Output Resolution	1mV out of 10V
Output Resistance	Less than 10W
Output Equivalence	
Output Current:	0.000 to ±9.999 V for display of 0 to ±999.9 A
Sensitivity:	10 mV/A
Output Voltage:	0.000 to ±9.999 V for display of 0 to ±999.9 A
Sensitivity:	10 mV/V.

Connections

The analog output is present on the 6015 ANALOG OUTPUTS connector on the unit's back panel with pin C being the V+ output and pin D being the V- output. A jumper on the 6015 selects output current or voltage data.

Error Screens

If an error is detected, the error and a brief description will be displayed. An example of what an error will look like is shown below. Refer to Appendix C for a detailed list of errors.

```
ERROR 02:

A NOVRAM DATA VERIFICATION ERROR
EXISTS IN THE CONTROL UNIT. INITIALIZE
THE NOVRAM BY PRESSING THE Esc KEY FOR
10 SECONDS. IF THE ERROR STILL EXISTS,
CONTACT LSCI FOR A REPLACEMENT NOVRAM.
```

Protection Circuits

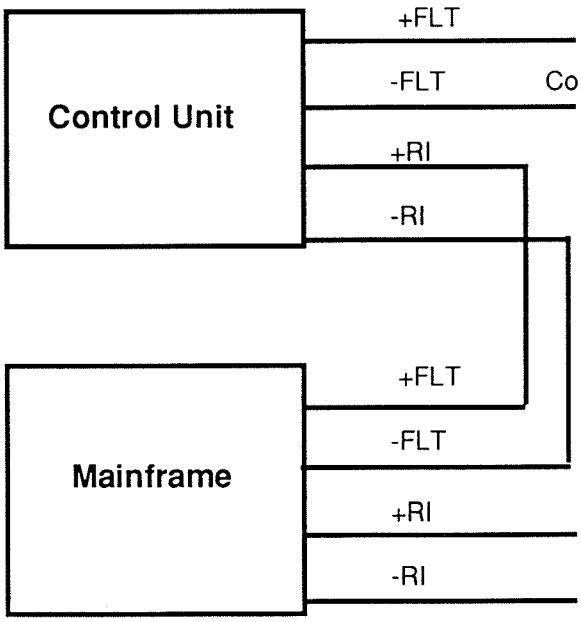
Protection circuits in the Mainframe may limit or turn off the output, or turn off the input in the event of an abnormal condition. Front panel annunciators, an audio indicator, and a contact closure are used to indicate that a fault is present.

RI and FLT Indicator Configuration and Operation

The Remote Inhibit (RI) and Fault (FLT) indicators provide a hardware means of fault indication and remote shutdown in addition to the internal protection features. The FLT indicator is a set of normally closed contacts when the unit is off. When the unit is on and no fault is present, the contacts are open.

NOTE	Do not connect the FLT output of the Control Unit to the RI input of the Mainframe(s). This will disable all units from operating.

In the standard 637 MPS configuration, the RI and FLT indicators should be connected as follows:

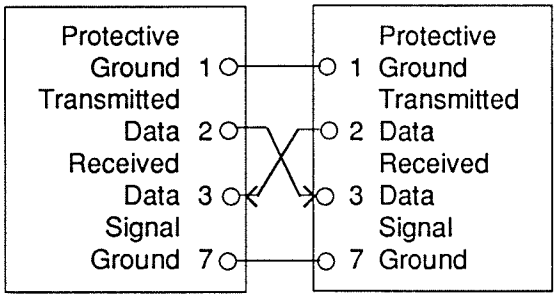


Contact closure to indicate a fault has occurred.

Contact closure to remotely inhibit operation.

Example 4 For an IBM use the following program in Quick Basic

General Serial Interface Interconnection for Half Duplex without Handshake



NOTE	It may be necessary to jumper pins 5, 6, 8 and 20 to disable the handshake functions of the Host. This is not required for the 6013 Interface.

Test Program for RS232 Communications in Quick Basic 4.0

```
OPEN "com1,o,7,1,RS" FOR RANDOM AS #1 LEN = 256'SERIAL PORT INITIALIZATION
L1:INPUT "ENTER COMMAND"; A$                    'GET COMMAND FROM USER
PRINT #1, A$ + CHR$(13) + CHR$(10);             'SEND COMMAND AND CR
                                                'LF TO INSTRUMENT
LINE INPUT #1, B$                               'GET RESPONSE FROM THE
                                                'INSTRUMENT
PRINT B$                                        'PRINT INSTRUMENT RESPONSE
GOTO L1                                         'JUMP BACK FOR NEXT
                                                'COMMAND
```

Test Program for RS232 Communications in BASICA

```
10 OPEN "com1,o,7,1,RS" AS #1                   'SERIAL PORT INITIALIZATION
20 INPUT "ENTER COMMAND";A$                     'GET COMMAND FROM USER
30 PRINT #1, A$                                 'SEND COMMAND TO
                                                'INSTRUMENT
40 LINE INPUT #1, B$                            'GET INSTRUMENT RESPONSE
50 PRINT B$                                     'PRINT INSTRUMENT RESPONSE
60 GOTO 20                                      'JUMP BACK FOR NEXT
                                                'COMMAND
```

NOTE	For these simple programs, a query must be included as the last part of a command string or the program will stop when it tries to read the instrument response.

If the Mainframe detects an internal fault or an RI input assertion from an external contact closure, the Mainframe enters the Remote Inhibit Mode and forces the output settings to 0 amps and 1 volt. The Fault annunciator on the front panel is turned on. The Mainframe FLT contacts are closed to indicate a fault and the internal audio indicator beeps once per second. When the Control Unit detects the fault, the Control Unit FLT contacts are closed to indicate a fault and the internal audio indicator beeps once per second. The Control Unit displays the following:

```
REMOTE INHIBIT:                OUTPUT:

THE OUTPUT SETTINGS ARE      +   0.00 A
FORCED TO 0 A AND 1 V.
                             +   0.00 V
THE OUTPUT SETTINGS
CANNOT BE CHANGED UNTIL      RI     *LOC
RI IS RELEASED.
```

When the Mainframe detects the RI input is no longer active, it turns off the front panel Fault annunciator and internal audio indicator. It also opens the FLT contacts. When the Control Unit detects the FLT contacts are no longer closed *(RI is inactive)*, the display changes to the Normal Display:

```
SETTINGS:      OUTPUT:
▶+   0.00 A    +   0.00 A
 +  32.00 V    +   0.00 V
IMAX SET:+ 72.00 A
VMAX SET:+ 32.00 V    RI     *LOC
```

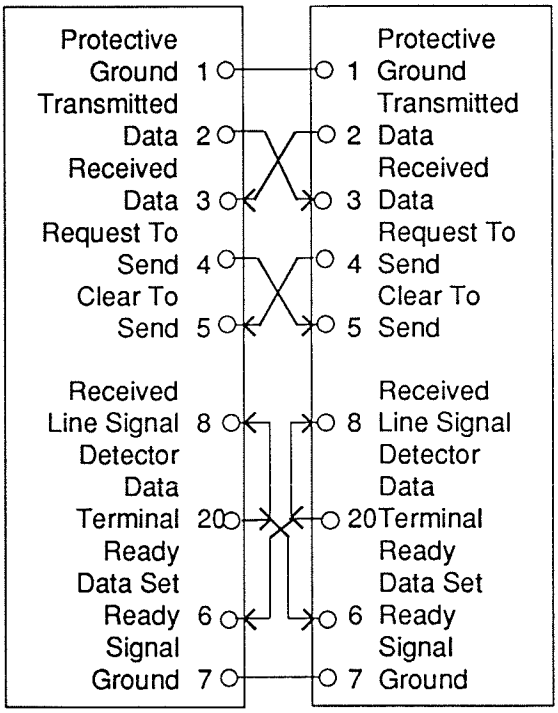
The Control Unit continues to display RI and the audio indicator continues to beep until new output settings are entered. This latching action is intended to inform the user that the RI was active. The Control Unit opens the FLT contacts as soon as it detects the RI inactive. When new output settings are entered, the Control Unit turns off the RI and internal audio indicator.

A delay can be added to the Mainframe FLT contact closure when it detects an RI. CAL AND ID switch 7 ON *(up position)* inserts a 2 to 3 second delay between the time the RI is activated and the fault operation is initiated. If the delay is active, the Mainframe will poll the RI indicator after the delay to see if it is still active. If RI is still active, the fault operation is continued. If it is not, it is ignored.

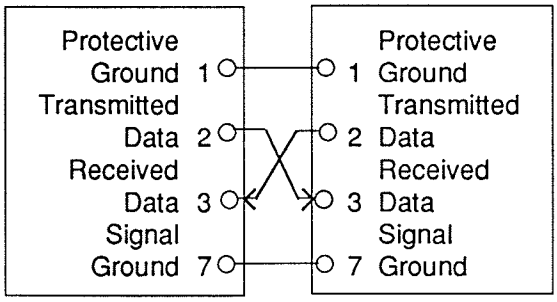
Example 3 General Serial Interface Interconnection.

The HP-86B Serial Interface Standard cable configuration already takes care of some of the interface interconnection problems to route signals to their proper pins. Given below are more general interconnection configurations for Half Duplex with and without Handshake.

General Serial Interface Interconnection for Half Duplex with Handshake

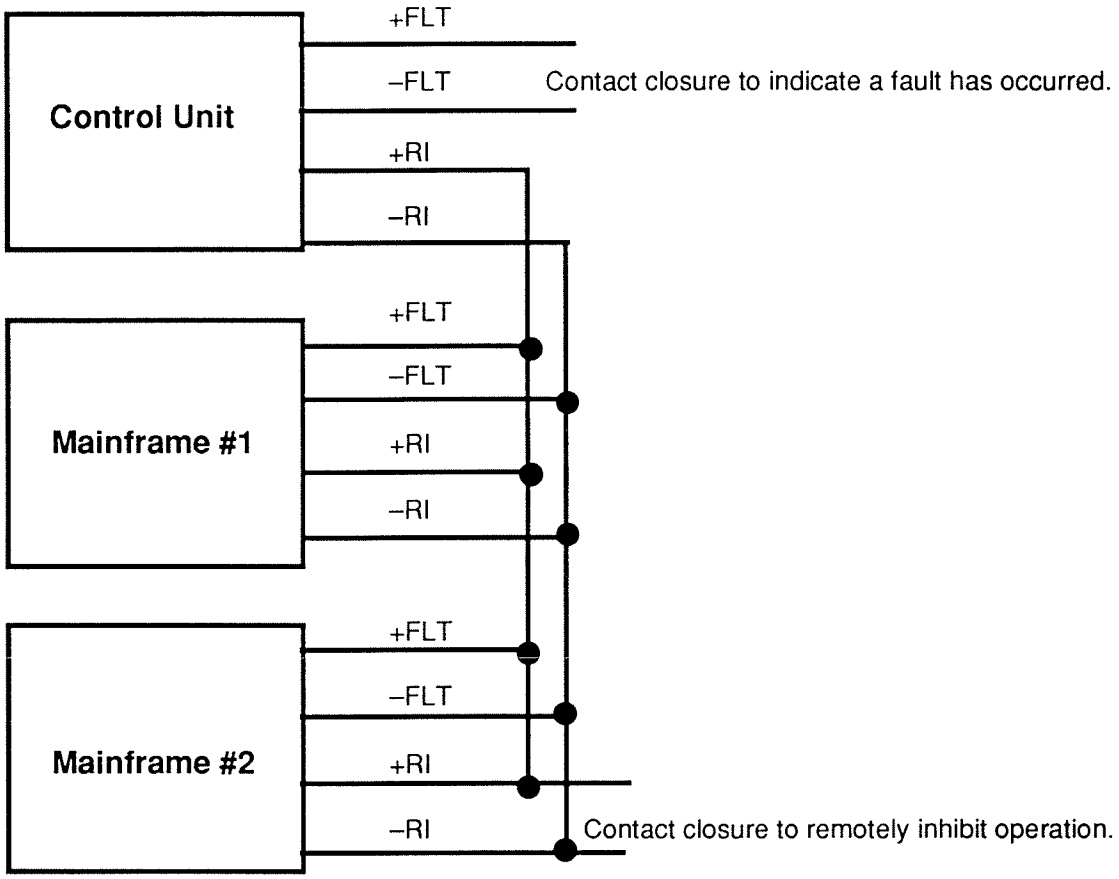


General Serial Interface Interconnection for Half Duplex without Handshake



NOTE	It may be necessary to jumper pins 5, 6, 8 and 20 to disable the handshake functions of the Host. This is not required for the 6013 Interface.

In the multiple Mainframe configuration, the RI and FLT indicators should be connected as follows:



In multiple Mainframe configuration, if the Mainframe RI indicators are activated from an external contact closure, the Mainframes enter the Multiple Mainframe Remote Inhibit Mode. They activate their output overvoltage protection circuits and turn off their output circuits. If a charged load is present, it will be discharged by the OVP circuits. The front panel Fault annunciators are turned on, and the internal audio indicators beep about once per second. If a Mainframe detects a fault, it will initiate the Multiple Mainframe Remote Inhibit Mode by closing the FLT contacts. No delay is allowed (CAL AND ID switch 7 OFF, down position) and multiple Mainframe operation (CAL AND ID switch 4 ON, up position) must be selected. After the load is discharged, all units must be turned off to reset. The Control Unit displays the following:

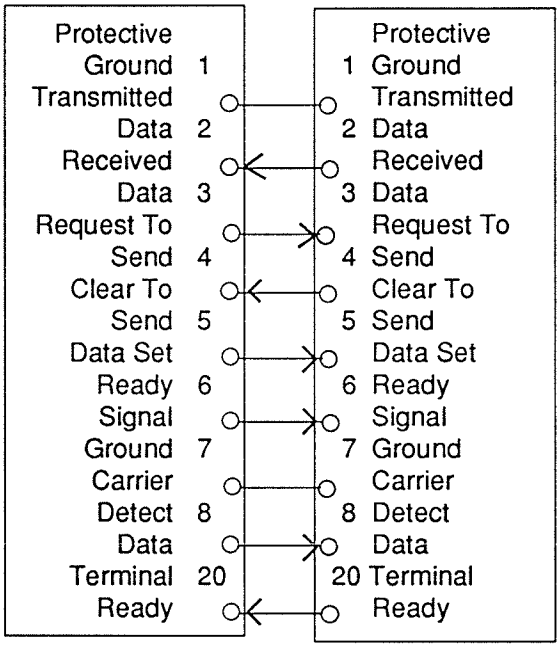
```
OVERVOLTAGE PROTECTION:        OUTPUT:

FAULT OR RI DETECTED.          +   0.00 A
OVP IS ENABLED AND
OUTPUTS ARE DISABLED.          +   0.00 V
LOAD MUST BE DISCHARGED
AND ALL UNITS TURNED           OVP   *LOC
OFF TO RESET.
```

Example 2. HP-86B Computer, Half Duplex, with Handshake.

The adapter cable for Half Duplex with handshake communications is with an HP-86B Serial Interface is shown here. The arrows indicate the source and direction of signal flow.

Half Duplex With Handshake



The Auto Handshake capability of the HP-86B Serial Interface must be enabled. The addition of the program line:

```
16 CONTROL  10,2;7                    ! ENABLE DSR,DCD,CTS
```

to the program above enables the HP to receive and transmit in a handshake mode.

Utility Low Line or Loss Protection

If the AC line falls below 80% of the nominal line selected, the Mainframe enters the AC Loss Mode. If this occurs on power up, the Mainframe turns off the front panel circuit breaker. This is generally an indication that the AC source does not match the line voltage listed on the rear panel.

If the utility loss occurs during normal operation of the standard 637 MPS configuration and a charged load is present, the utility input circuitry is disabled and the load is used to source energy to the Mainframe. The front panel Power annunciator is turned off. The Fault annunciator on the front panel is turned on. The Mainframe FLT contacts are closed to indicate a fault and the internal audio indicator beeps about once per second. The output voltage compliance will be set to the level required to maintain Mainframe operation. The output current will be continuously monitored. If the utility recovers, the Mainframe enters the Remote Inhibit Mode with the output settings forced to 0 amps and 1 volt. If the utility does not recover when the output current drops below 10 amps, the Mainframe will activate the output overvoltage protection circuit and turn off the front panel circuit breaker. When the Mainframe is powered down, it also enters the AC Loss Mode.

NOTE If there is a utility loss when the Mainframe is returning energy from a charged load to the utility, there is not a hazard to personnel that may be working on the utility circuit. The Mainframe is not a UPS. It uses the utility voltage waveform to draw energy from the utility with a sinusoidal current and return energy to the utility with a sinusoidal current. If the utility reference signal is not present, the Mainframe will disable the utility input circuitry and use the load to source energy required for operation.

If the utility loss occurs during normal operation in a multiple Mainframe configuration, the Mainframe detecting the utility loss initiates the Multiple Mainframe Remote Inhibit Mode by closing the FLT contacts and turning off the front panel circuit breaker. The remaining Mainframe and the Control Unit enter the Multiple Mainframe Remote Inhibit Mode outlined earlier.

Utility High Line Protection

If the AC line rises above 120% of the nominal line selected at any time, the Mainframe will turn off the front panel circuit breaker and enter the AC Loss Mode outlined earlier. This is done to keep excessive utility voltages from being applied to the internal circuitry.

Interfacing Examples

Example 1 HP-86B Computer, Half Duplex Without Handshake.

The HP82939A Serial Interface for the HP-86B is preset at the factory for the following default values:

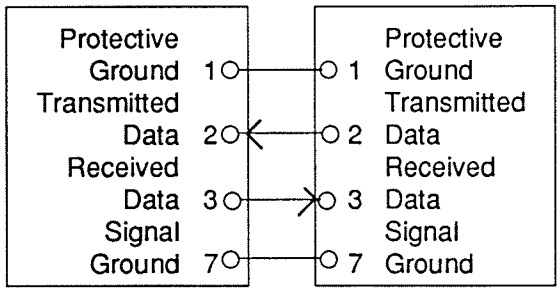
1. Interface select code = 10
2. Baud rate = 300 Baud
3. Autohandshake = Off
4. Character Length = 7 bits
5. Parity = Odd
6. Stop bits = 1
7. Cable Option = Standard (25 pin socket)

Since the HP default Baud rate, character length, parity and stop bit configuration are the same as those of the Model 6013 Interface when shipped, none of the switches on the 6013 board need to be changed.

When connecting the HP-86B Serial Interface to the 6013 Interface, a transition cable needs to be made to connect the socket connector of the HP to the socket connector of the 6013 Interface.

The adapter cable that must be made is shown here. The arrows indicate the source and direction of signal flow.

Half Duplex W/O Handshake



The following program will input a command from the keyboard and output it to the 6013. The program will then input the specified 6013's response, display it and return for another command.

```
10 REM HALF DUPLEX W/O HANDSHAKE
15 REM I/O TEST (RS232 TEST1)
20 DIM A$[256],B$[3000]
25 REM A$ IS OUTPUT, B$ IS INPUT
30 INPUT A$                          ! MAKE SURE TO GIVE AN
35                                   ! OUTPUT STATEMENT COMMAND
40 OUTPUT 10 ; A$                    ! OUTPUT COMMAND
50 ENTER 10 ; B$                     ! INPUT THE DATA
55                                   ! FROM THE CONTROL UNIT
60 DISP B$                           ! DISPLAY DATA
70 GOTO 30                           ! RETURN FOR MORE
80 END
```

Output Overvoltage Protection

If the voltage across the Mainframe output terminals rises above ±40 volts for any reason, the output overvoltage protection (OVP) circuit is activated. The Mainframe also has the ability to activate the overvoltage protection circuit in response to faults detected. If the OVP circuit activates, the output voltage will be limited to between 1 and 1.3 volts. If this occurs, change the output current setting to zero.

The Mainframe determines if the OVP is active when it is turned on *(output current greater than ±1 A)*. The Fault annunciator on the front panel is turned on. The Mainframe FLT contacts are closed and the internal audio indicator beeps twice per second. When the Control Unit detects the fault, the Control Unit FLT contacts are closed to indicate a fault and the internal audio indicator beeps once per second. The Control Unit displays the following:

```
OVERVOLTAGE PROTECTION:     OUTPUT:

THE OUTPUT SETTINGS ARE     +   0.00 A
FORCED TO 0 A AND 1 V.
                            +   0.00 V
OVP IS ACTIVE UNTIL THE
OUTPUT CURRENT FALLS        OVP   *LOC
BELOW 1 A.
```

When the output current falls below 1 A, the Mainframe turns off the front panel Fault annunciator and internal audio indicator. It also opens the FLT contacts. When the Control Unit detects the OVP is no longer active, the display changes to the Normal Display:

```
SETTINGS:       OUTPUT:
▶+   0.00 A     +   0.00 A
+   1.00 V      +   0.00 V
IMAX SET:+ 72.00 A
VMAX SET:+ 32.00 V   OVP   *LOC
```

The Control Unit continues to display OVP and the audio indicator continues to beep until new output settings are entered. This latching action is intended to inform the user that the OVP was active. The Control Unit opens the FLT contacts as soon as it detects the OVP inactive. When new output settings are entered, the Control Unit turns off the OVP and internal audio indicator.

Output Current Step Limiting

If the output current changes rapidly (indicative of a magnet quench) and the magnitude of the current exceeds the output current step limit of the Mainframe, the output settings will automatically be reset to 0 A and 1 V. Refer to Appendix E for a detailed description of the Output Current Step Limit feature.

Internal Faults

If an internal overtemperature condition or other internal fault is detected, the Mainframe will activate the OVP circuit, turn off the front panel circuit breaker and then turn itself off. The OVP circuit will stay active until the load is completely discharged.

There are four errors that could be detected by the 6013 interface.

1. **Err10 - Parity Error -** may be caused by signal line transients or incorrectly specified parity.

2. **Err11 - Overrun Error -** caused by the main processor not reading the input character before the next one becomes available. The overrun character(s) are lost.

3. **Err12 - Framing Error -** may be caused by signal line transients or incorrectly specified stop bits or character length.

4. **Err13 - Input Buffer Overrun -** caused by more than 256 characters being input to the FIFO buffer. Any characters received after the 256th character are lost.

Detection of an error does not affect the operation of the interface. The software that interprets the data tries to match the character input to the possible command inputs and processes the command. The error is also transmitted by the interface the next time it is asked for a response. The error is transmitted in addition to the Output Statement data output. For example, if a framing error was detected in a command string transmitted to a Control Unit as;

ISET+10; ISET?

the interface might respond with:

Err12
+010.0000(CR)(LF)

If the error was detected in the transmission of the "ISET", the current setting would be ignored; if it was in the "+10", one or two numerics may have been generated. Although errors rarely occur, it is suggested that any commands sent to the Control Unit be echoed back by sending the appropriate querycommand and inputting the stored parameters. Any error that is detected is cleared following the first transmission after the error.

REMOTE OPERATION OF THE MODEL 637 ELECTROMAGNET POWER SUPPLY

4

This section shows you the fundamentals of remotely operating the Model 637 MPS. It includes a description of:

- *IEEE-488 Interface*
- *General IEEE Specifications*
- *Interface Functions*
- *IEEE-488 Commands*
- *Serial Interface*
- *Operational Commands*
- *Interface Commands*
- *Ramping Commands*
- *Status Registers*
- *Common Commands*

Operation

The Model 6013 RS-232C Interface has a 256 character FIFO buffer for input commands. The interface accepts commands, the same as for the IEEE-488 Interface, until it sees the End-of-Line (EOL) sequence. The 6013 requires a carriage return/line feed (CR)(LF) or just line feed (LF) as its input EOL and transmits carriage return/line feed (CR)(LF) as its output EOL. Following the EOL Sequence, the command string is processed.

Operation of the Interface link is initiated by the computer. The computer will transmit either a command or a query to the 6013 Interface. The Control Unit will respond to the query with the appropriate response or with the response and an error message *(if an error was detected)*. The interface responds to commands by storing the parameters input.

The commands and queries the 6013 will respond to given in Section 4. The commands T and Z will be accepted and updated even though they have no relevance to the interface (the EOL terminator sequence is always (CF)(LF) and there is no EOI status). The M command can be considered the "OFF LINE" (Local) and "ON LINE" (Remote or Remote with Local Lockout) states.

The queries will result in the requested data being output immediately following the reception of the EOL sequence. If more than one query command is given, the last one received will be acknowledged. Commands and queries can be sent in the same command string. For example, the command string:

ISET+10; VSET+10

would result in the Current Setting being updated to +10 amps, and the Voltage Setting to +10 volts. No query was given therefore, no response will be output by the interface. The command string:

ISET+10; VSET+10; ISET?

will result in the Current Setting being output by the interface.

IEEE-488 Interface

The IEEE-488 Interface is an instrumentation bus with hardware and programming standards designed to simplify instrument interfacing. The Control Unit IEEE-488 Interface complies with the IEEE-488.2 standard and incorporates the functional, electrical, and mechanical specifications of the standard unless otherwise specified in this manual.

General IEEE Specifications

All instruments on the interface bus must be able to perform one or more of the interface functions of TALKER, LISTENER, or BUS CONTROLLER. A TALKER transmits data onto the bus to other devices. A LISTENER receives data from other devices through the bus. The BUS CONTROLLER designates to the devices on the bus which function to perform.

The Control Unit performs the functions of TALKER and LISTENER but cannot be a BUS CONTROLLER. The BUS CONTROLLER is your digital computer.

Interface Functions

Table 3-1 lists the codes and interface capabilities of the Control Unit. These codes are also listed on the Control Unit rear panel.

Table 3-1. Interface Functions

Code	Interface Function
SH1	Source handshake capability
AH1	Acceptor handshake capability
T5	Basic TALKER, serial poll capability, talk only, unaddressed to talk if addressed to listen
L4	Basic LISTENER, unaddressed to listen if addressed to talk
SR1	Service request capability
RL1	Complete remote/local capability
PP0	No parallel poll capability
DC1	Full device clear capability
DT0	No device trigger capability
C0	No system controller capability
E1	Open collector bus drivers

Installation

WARNING	**The information contained in this section is intended for the use of service trained personnel who understand electronic circuitry and are aware of the hazards involved. Do not attempt to perform any of the procedures in this section unless you are qualified to do so.**

The Model 6013 RS-232C Interface is factory installed if ordered with a Temperature Controller or can be field installed at a later date. If field installation is required, use the following procedure.

WARNING	**To prevent shock hazard, turn off the instrument and disconnect it from AC line power and all test equipment before removing cover.**

1. Set the POWER switch to off and disconnect the power cord from the unit.
2. Remove the six screws on the sides of the top enclosure half and lift the cover off.
3. The calibration cover will now be seen.
4. Remove the calibration cover by taking out the six screws on the top of the cover. Also, remove the two screws in the center of the rear panel of the instrument located near the top. Lift the cover off.
5. Remove the red jumper (**JMP6**) on the microprocessor board. This is the jumper closest to the bottom of the board near the rear edge.
6. Configure the 6013 baud rate and word structure switches.
7. Plug the internal interface cable into the 6013 printed circuit board (PCB) with the locking tab configured properly.
8. Plug the 6013 PCB into Option Slot 2 with the component side to the left of the unit as viewed from the front.
9. Carefully thread the RS-232C internal cable along the inside edge of the rear panel so that it will not interfere with the installation of the calibration cover or top cover.
10. Remove the plastic cover plate from the 6013 RS-232C Interface on the rear panel. Position the 25-pin RS-232C Interface connector in the opening on the rear panel and secure it in place using the screws provided.
11. Replace the calibration cover and the top enclosure half.

IEEE-488 Commands

The Control Unit supports several command types. These commands are broken into three groups:

1. Bus Control
   - •Universal
     - •Uniline
     - •Multiline
   - •Addressed Bus Control
2. Common
3. Device Specific

Bus Control Commands

The Universal Commands

A Universal Command is a command that addresses all devices on the bus. Universal Commands include Uniline and Multiline Commands.

A ***Uniline Command*** (Message) is a command which results in a single signal line being asserted. The following are uniline commands:

ATN (Attention) - The ATN commands are sent when the information on the bus is a universal or addressed command. When the ATN line is not asserted, the byte on the bus is considered data.

REN (Remote Enable) - The BUS CONTROLLER sends this command to all devices on the bus when remote operation is desired.

EOI (End Or Identify) - EOI is asserted during the last byte of a multibyte transfer.

IFC (Interface Clear) - The IFC command sets the bus to a known state when asserted.

SRQ (Service Request) - This line is asserted by a device on the bus that requires service.

A ***Multiline Command*** involves a group of signal lines. All devices equipped to implement such commands will do so simultaneously when the command is transmitted. These commands are transmitted with the Attention (ATN) line asserted low. There are two Multiline commands recognized by the Control Unit.

NOTE	*The programming examples are in HP basic for an HP-85 or HP-86B computer.*

DCL (Device Clear) - The DCL command is used to clear the Control Unit and put it in a bus idle state.

DCL Programming Example. Select a screen other than the Normal Display Screen from the Control Unit front panel. Enter the following statements:

```
REMOTE 7 (END LINE)
REMOTE 712 (END LINE)
CLEAR 7 (END LINE)
```

The 7 refers to the computer interface 7, the IEEE interface. The 712 refers to the IEEE interface device address 12. The REMOTE 7 command asserts the REN line. Note that the interface mode on the display changes from LOC to REM after the END LINE key of the REMOTE 712 command is pressed. When the END LINE key is pressed after CLEAR 7, the Control Unit reverts to the Normal Display Screen. The Ramp Status is forced to the Hold mode and any latched error is cleared. In addition, the Status Byte and the Standard Event Status Registers are cleared.

Configuration of Dip Switches

Selection of Baud Rate

The Model 6013 has a field selectable baud rate using DIP switch package S1 *(8 switches)* on the Interface card. The baud rate is selected by closing the switch position for the desired baud rate and making sure all other positions are open. The baud rate selection is given in the table below. Only the 300 and 1200 baud rates have been tested and are fully supported.

Baud Rate Switch S1 Selection Table

Switch S1 1 2 3 4 5 6 7 8	Baud Rate
1 0 0 0 0 0 0 0	75
0 1 0 0 0 0 0 0	110
0 0 1 0 0 0 0 0	135
0 0 0 1 0 0 0 0	150
0 0 0 0 1 0 0 0	200
0 0 0 0 0 1 0 0	**300**
0 0 0 0 0 0 1 0	600
0 0 0 0 0 0 0 1	**1200**

Word Structure Selection

The word structure is determined by switch settings for character length, parity and stop bits using DIP switch package S2 on the Interface Card *(6 switches)*. Refer to the table below for settings where "0" is OPEN and "1" is CLOSED.

Word Structure Switch S2 Selection Table

Switch S2 1 2 3 4 5 6	Word Structure Choices
	Stop Bits
0 0 X X X X	Invalid
0 1 X X X X	1 Bit
1 0 X X X X	1 *(not supported)*
1 1 X X X X	2 Bits
	Parity Genertn/Chck
X X 1 X X X	Even
X X 0 X X X	Odd
	Parity Enable
X X X 1 X X	Enable
X X X 0 X X	Disable
	Character Length Bits
X X X X 0 0	5 *(not supported)*
X X X X 0 1	6 *(not supported)*
X X X X 1 0	7 *(supported)*
X X X X 1 1	8 *(not supported)*

NOTE	For the not supported settings, the interface will respond, but the card has not been tested with these settings at the factory. X is a don't care setting for that switch.

The Universal Commands continued:

LLO (Local Lockout) - The BUS CONTROLLER sends the LLO command to disable the local operation of the Control Unit. Once the Control Unit receives the LLO command, all the front panel controls (except Power ON/OFF) are locked out.

LLO Programming Example. Enter the following statements:

REMOTE 712 (END LINE)
LOCAL LOCKOUT 7 (END LINE)

Note that the interface mode on the display is REM after the REMOTE 712 command and LLO after the LOCAL LOCKOUT 7 command. Press the front panel keys and notice that they have been locked out. Refer to the GTL Addressed Bus Command to get the Control Unit out of the LLO mode without cycling the power.

UNT (Untalk) - The BUS CONTROLLER sends the UNT command to clear the bus of any talkers.

UNL (Unlisten) - The BUS CONTROLLER sends the UNL command to clear the bus of any listeners.

The Addressed Bus Control Commands

The Addressed Bus Control Commands are Multiline commands which must include the Control Unit listen address before it will respond to the command in question. Note that only the addressed device will respond to these commands.

SPE (Serial Poll Enable) - The serial poll command is used to read the Control Unit status byte. In general, serial polling is used to determine which device on the bus has requested service using the SRQ line. The serial polling sequence is as follows:

1. The BUS CONTROLLER asserts the ATN line.
2. The BUS CONTROLLER puts the SPE command on the bus.
3. The Control Unit is addressed to talk.
4. The BUS CONTROLLER releases the ATN line.
5. The Control Unit places its status byte on the bus.
6. The BUS CONTROLLER asserts ATN and puts the SPD (Serial Poll Disable) command on the bus to end the serial polling sequence.

SPE Programming Example. The HP Basic SPOLL command automatically performs the serial polling sequence. Enter the following statements:

REMOTE 712 (END LINE)
S=SPOLL (712) (END LINE)
DISP S (END LINE)

When the END LINE key of the S=SPOLL (712) command is pressed, the computer performs the serial polling sequence. When the END LINE key of the DISP S command is pressed, the status byte value is displayed on the computer screen.

The Model 6013 RS-232C Interface has a 25-pin D style connector located on the rear panel. Pin Assignments are shown below.

Pin	Description	Signal
1	Protective Ground	AA
2	Transmitted Data	BA
3	Received Data	BB
4	Request To Send	CA
5	Clear To Send	CB
6	Data Set Ready	CC
7	Signal Ground	AB
8	Received Line Signal Detector	CF
20	Data Terminal Ready	CD

The RS-232C signals are used in the following manner:

Protective Ground (AA) - conductor is taken to case ground potential and is common with the signal ground (AB).

Transmitted Data (BA) - transmits data using the EIA voltage levels (+12V and -5V).

Received Data (BB) - accepts data using EIA voltage levels.

Request to Send (CA) - indicates to the host computer or terminal that the controller Interface is ready to transmit data. The Interface transmits data on line BA when the "ON" state is maintained on CC, CB and CF, while a low level on these lines inhibits transmission by the Interface.

Clear to Send (CB) - indicates to the Interface that data transmission is allowed. Internally pulled up to maintain "ON" state when left disconnected.

Data Set Ready (CC) - indicates to the Interface that the host computer or terminal is not in a test mode and that power is ON.

Signal Ground (AB) - this line is the common signal connection for the Interface.

Received Line Signal Detector (CF) - this line is held positive ("ON") when the Interface is receiving signals from the host computer. When held low ("OFF") the BB line is clamped to inhibit data reception. Internally pulled up to maintain "ON" state when left disconnected.

Data Terminal Ready (CD) - asserted by the Interface whenever the Control Unit/6013 power is "ON" to indicate that the Interface is ready to receive and transmit data.

The Addressed Bus Control Commands continued:

SPD (Serial Poll Disable) - The BUS CONTROLLER automatically sends the SPD command on the bus to end the serial polling sequence.

SDC (Selected Device Clear) - The SDC command performs essentially the same function as the DCL command except that only the addressed device responds.

SDC Programming Example. Select a screen other than the Normal Display Screen from the Control Unit front panel. Enter the following statements:

REMOTE 712 (END LINE)
CLEAR 712 (END LINE)

When the END LINE key is pressed after CLEAR 7, the Control Unit reverts to the Normal Display Screen. The Ramp Status is forced to the Hold mode and any latched error is cleared. In addition, the Status Byte and the Standard Event Status Registers are cleared.

GTL (Go To Local) - The GTL command return the addressed device to the local mode. GTL also unlocks front panel controls that were previously locked out by the LLO command.

GTL Programming Example. Place the Control Unit in the remote lockout mode. Enter the following statements:

REMOTE 712 (END LINE)
LOCAL LOCKOUT 7 (END LINE)

Note that the interface mode on the display is REM after the REMOTE 712 command and LLO after the LOCAL LOCKOUT 7 command. Press the front panel keys and notice that they have been locked out. Enter the following statement to initiate the GTL sequence:

LOCAL 712 (END LINE)

The GTL Addressed Bus Command will put the Control Unit in the local with local lockout mode. The Control Unit will return to the LLO mode the next time it is put in remote mode. Use the following command sequence to clear the LLO status entirely:

LOCAL 7 (END LINE)
REMOTE 7 (END LINE)

or:

OUTPUT 712; "MODE 0" (END LINE)

MODEL 6013 RS-232C INTERFACE OPTION

Description

The Model 6013 RS-232C Interface is designed to provide an interface with an external RS-232C instrument such as a computer, modem or CRT. The interface operates in a half duplex mode *(it can only transmit and receive information in one direction at a time)* and data transmission is asynchronous *(each character is bracketed by start and stop bits that separate and synchronize the transmission and receipt of data)*. The baud rate is switch selectable at 300 or 1200 baud and the interface maintains EIA voltage levels for data transmission.

Specifications

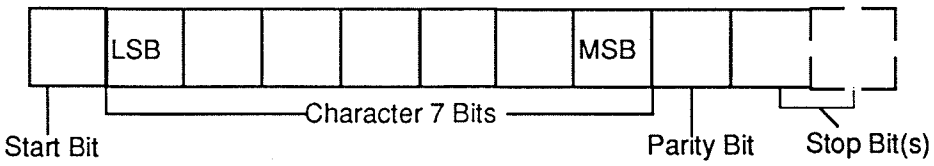
Timing Format	Asynchronous
Transmission Mode	Half Duplex
Baud Rate	300 or 1200 Bits/sec (Factory set to 300)
Bits per Character	7(excluding start, stop or parity bits)
Parity Enable	Enabled/Disabled (Factory set Enabled)
Parity Select	Odd or Even (Factory set Odd)
Number of Stop Bits	1 or 2 (Factory set to 1)
Data Interface Levels	Transmit or receive using EIA voltage levels (+12V and -5)

Introduction

The figure below gives a transmission format which shows the data bits framed by the start and stop synchronization bits. The data are transmitted using two voltage levels which represent the two binary states of the digit. A logic 0 *(or SPACE)* is +3 to +12 VDC. A logic 1 *(or MARK)* is -3 to -5 VDC. When data is not being transmitted, the line is held low *(MARK state)*. When the transmission device is ready to send data, it takes the line to the high *(SPACE)* state for the time of one bit. This transition is called the start bit. The remaining data is then transmitted. If a parity bit is used, it follows the character. The parity bit is determined by the number of 1 bits in the character.

Number of "1"s In character	Parity Specified	Parity Bit
Odd	Odd	0
Even	Odd	1
Odd	Even	1
Even	Even	0

Word Structure



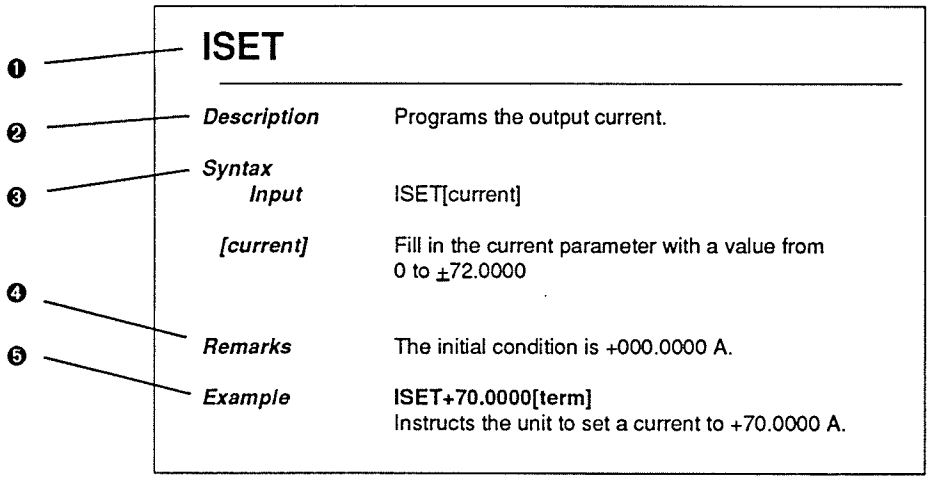
Common Commands

Common Commands are addressed commands intended to make some commonality between instruments on the bus. All instruments that comply with the IEEE-488.2 standard share these commands and their format. The common commands all begin with a "*". They are generally related to "bus" and "instrument" status and identification.

Device Specific Commands

Device Specific Commands are addressed commands. The Control Unit supports a variety of Device Specific commands to allow the user to program the instrument remotely from a digital computer and to transfer measurements to the computer. Most of the Device Specific commands have a function that can also be performed from the front panel.

There are individual discussions of each command. The individual discussions are handled in the format described below.



❶ Command Name

❷ Brief Description of Function

❸ Syntax of what user must input. For commands, any additional information needed on input will be described in parameters. All parameters are enclosed in brackets. For queries, an explanation will be given of what the user can expect to have returned.

❹ The remarks section will only be used if any additional features about the command need to be discussed. If an initial condition is listed, it is the value that will be used if the command is sent without parameters.

❺ The example section will only be used if an example is required.

MODEL 637 ELECTROMAGNET POWER SUPPLY OPTIONS

5

This section describes the options which are available for the Model 637 Magnet Power Supply. The options available for the Model 601 Control Unit are as follows:

- ***Model 6013 RS-232C Interface***
- ***Model 6015 Analog Output***
- ***Model 6016 Liquid Helium Level and Gaussmeter Input Card***

The options available for the Model 637 Mainframe are as follows:

- ***Model 6377 High Resolution Display and Programming***

Additional Notes On Commands

- When the term **free field** is used, it indicates that the decimal point is a floating entity and can be placed any appropriate place in the string of digits.
- Plus and minus signs are considered numeric characters. If a numeric is sent to the control unit without a sign, it is considered plus.
- Leading zeros and zeros following a decimal point are not needed in a command string, but they will be sent in response to a query. Leading spaces are allowed, but embedded spaces are not.
- **[term]** is used when examples are given and indicates where terminating characters should be placed by the user or where they appear on a returning character string from the 637.
- Commands may be chained together when they are separated by a ";". Multiple queries cannot be chained. The Control Unit will respond to the last query entered when addressed as a talker.
- Queries generally have the same syntax as an associated setting command followed by a "**?**". They most often return the same information that is sent. There are some queries that have no command form.
- Numbers sent from the instrument are preceded by a header of alpha characters which identify the type of data being sent. The header cannot contain embedded spaces. No suffixes are attached to the numeric data.
- When a parameter is an alpha character, there must be a space between the alpha header and the character in order for the command to be interpreted properly.

Serial Interface

The optional Serial Interface allows the Control Unit to communicate with instruments having an RS-232C interface. Communication parameters are discussed in Section 5 in the 6013 Option card description. The Serial Interface shares Device Specific commands with the IEEE-488 interface. However, without the advantage of the IEEE-488 Architecture, there are several limitations:

•None of the Bus Control Commands apply.

•The serial poll feature is not supplied.

•Terminators are fixed to **CRLF**.

•A query must be added to the end of a command string if the Control Unit is required to return information. *(Over IEEE-488, the last query response is sent when addressed to talk.)*

Example: **ISET10;ISET?[CR][LF]**
would set the output current and allow a query of the output current setting.

Operational Commands

These commands are for the basic operation of this instrument and are used to configure the various functions.

ISET

Description

Programs the output current.

Syntax

Input ISET[current]

[current] Fill in the current parameter with a value between 0 and ±72.0000.

Remarks

Normal resolution truncates the value to 0.01 place. High resolution truncates the value to the 0.001 place.

The initial condition is +000.0000 A.

ISET?

Description

Output Current Setting Query.

Syntax

Input ISET?

[returned] The value returned is a number between ±72.0000 A.

Remarks

Nine characters plus up to two terminators are returned.

IOUT?

Description

Output Current Query.

Syntax

Input IOUT?

[returned] The value returned is a number between ±72.0000 A.

Remarks

Nine characters plus up to two terminators are returned.

VSET

Description Programs the output voltage in the voltage mode.

Syntax

Input VSET[voltage]

[voltage] Fill in the voltage parameter with a value from 0 to +32.0000

Remarks Normal resolution truncates the value to 0.01 place. High resolution truncates the value to the 0.001 place.

The initial condition is +00.0000 V.

The voltage setting is always forced to a "+".

VSET?

Description Output Voltage Setting Query.

Syntax

Input VSET?

[returned] The value returned is a number between 0 and +32.0000 V.

Remarks Nine characters plus up to two terminators are returned.

VOUT?

Description Output Voltage Query.

Syntax

Input VOUT?

[returned] The value returned is a number between ±32.0000 V.

Remarks Nine characters plus up to two terminators are returned.

*ESR?

Description Standard Event Status Register Query - Reads the Standard Event Status Register.

Syntax

Input *ESR?

[returned] An integer from 000-255.

Remarks The integer returned represents the bits that have been set in the Service Request Enable Register. It is a sum of the bit weighting of each bit set. This Query supplies various error conditions and whether the Control Unit has been powered off and on since the last query.

Three digits plus up to two terminators are returned.

CUID?

Description Control Unit Identification Query.

Syntax

input CUID?

[returned] Manufacturer, Model Number,0,Firmware Date.

Remarks A 0 in the returned syntax is in place of the serial number.

Seventeen characters plus up to two terminators are returned.

Example LSCI,601,0,080191[term]

CUOPT?

Description Control Unit Input Card and Option Query.

Syntax

Input CUOPT?

[returned] [IN1-Input Card (4 characters),[IN2-Input Card (4 characters),[1-Option 1 Present (4 characters)],[2-Option 2 Present (4 characters)],[3-Option 3 Present (4 Characters)].

Remarks Thirty-eight characters plus up to two terminators are returned.

Example IN1-6016,IN2-EMPT,1-6015,2-6013,3-EMPT[term]

Which indicates a 6016 LHe Level/Gaussmeter input card in Auxiliary Input 1; Auxiliary Input 2 is empty; a Analog Output option in Option Slot 1; an RS-232C Interface Option in Slot 2; and Option Slot 3 is empty.

IMAX

Description Programs an upper (soft) current limit that the unit will accept.

Syntax

Input IMAX[current]

[current] Fill in the current parameter with a value between 0 and +72.0000.

Remarks Normal resolution truncates the value to 0.01 place. High resolution truncates the value to the 0.001 place.

The initial condition is +000.0000 A.

The current limit is always forced to a plus (+).

IMAX?

Description Current Limit Query.

Syntax

Input IMAX?

[returned] The value returned is a number between 0 and +72.0000 A.

Remarks Nine characters plus up to two terminators are returned.

Value is shown as a "+", but applies to both positive and negative entries.

VMAX

Description Programs an upper (soft) voltage limit that the unit will accept.

Syntax

Input IMAX[voltage]

[voltage] Fill in the voltage parameter with a value between 0 and +32.0000.

Remarks Normal resolution truncates the value to 0.01 place. High resolution truncates the value to the 0.001 place.

The initial condition is +000.0000 V.

The voltage limit is always forced to a plus.

VMAX?

Description Voltage Limit Query.

Syntax

Input VMAX?

[returned] The value returned is a number between 0 and +32.0000 A.

Remarks Nine characters plus up to two terminators are returned.

*ESE

Description

Enables status reports in the Standard Event Status Enable Register.

Syntax

Input *SRE[bit weighting]

[bit weighting] The bit weighting parameter should be filled in with the bit weighting of each bit to be set added together. The value can be 000 to 255. Refer to the discussion on registers and below for further explanation.

Remarks

Each bit is assigned a bit weighting. Refer to the format of the Standard Event Status Register (given below) to see where the bits are placed in the register and what the bit weighting is for each bit. Further explanation of each bit is discussed in the register section following the Common Command Table.

7	6	5	4	3	2	1	0	— Bit
128	*64*	*32*	*16*	*8*	*4*	*2*	*1*	— Weighting
PON	*not used*	**CME**	**EXE**	**DDE**	**QYE**	*not used*	**OPC**	— Bit Name

Example

To set a bit, send the command *ESE with the sum of the bit weighting for each bit you want. For example, to set bits 0, 3, 4, 5 and 7, send the command *ESE175. 175 is the bit weighing for each bit added together.

Bit	Bit Weighting
0	1
3	8
4	16
5	32
7	128
	175

*ESE?

Description

Standard Event Status Enable Query - Reads the Standard Event Status Enable Register.

Syntax

Input *ESE?

Returned An integer from 000-255.

Remarks

The integer returned represents the bits that have been set in the Standard Event Status Enable Register. It is a sum of the bit weighting of each bit set.

Three digits plus up to two terminators are returned.

?

Description Output Summary Query.

Syntax

Input ?

[returned] [IOUT], [VOUT], [STB], [I MODE], [V MODE].

Remarks Twenty-seven characters plus up to two terminators are returned.

The command must be the first character to be sent in order to be interpreted properly.

OVP?

Description Overvoltage Protection Circuit Status Query.

Syntax

Input OVP?

[returned] The value returned is **0** if the circuit is inactive or **1** if it is active.

Remarks One character plus up to two terminators are returned.

RI?

Description Remote Inhibit Status Query.

Syntax

Input RI?

[returned] The value returned is **0** if the remote inhibit is inactive or **1** if it is active.

Remarks One character plus up to two terminators are returned.

ERR?

Description Error Status Query.

Syntax

Input ERR?

[returned] [OVP] [RI] [STEP]

The value returned is **0** if the error is inactive or **1** if it is active.

Remarks Three characters plus up to two terminators are returned.

*SRE?

Description Service Request Enable Query - Reads the Service Request Enable Register

Syntax

Input *SRE?

[returned] An integer from 000-255.

Remarks The integer returned represents the bits that have been set in the Service Request Enable Register. It is a sum of the bit weighting of each bit set.

Three digits plus up to two terminators are returned.

*STB?

Description Status Byte Query - Reads the Status Byte Register.

Syntax

Input *STB?

[returned] An integer from 000-255.

Remarks The integer returned represents the bits that have been set in the Status Byte Register. It is a sum of the bit weighting of each bit set. It acts like a serial poll, but using this query does not reset the register to all zeros. It acts like a serial poll.

Three digits plus up to two terminators are returned.

Interface Commands

These commands help configure the IEEE-488 interface so that it is compatible with the variety of computer equipment being used.

END

Description Programs the Control Unit Interface EOI (End Or Identify) Status.

Syntax

Input END[status]

[status] Fill in the status parameter with **0** to enable the EOI or a **1** to disable it.

Remarks When EOI is enabled, the hardware EOI line becomes active with the last byte of a transfer.

END?

Description End Of Identify (EOI) Query

Syntax

Input EOI?

[returned] **0** is returned if EOI is enabled or **1** if it is disabled.

Remarks One character plus up to two terminators are returned.

MODE

Description Programs the Control Unit Interface mode status.

Syntax

Input MODE[status]

[status] Fill in the status parameter with **0** for local mode, **1** for remote mode or **2** for remote mode with local lockout.

*CLS

Description

This is the clear status command. It clears the bits in the Status Byte Register and the Standard Event Status Register and terminates all pending operations.

Syntax

Input *CLS

Remarks

This command is designed to clear the Status Register, NOT the instrument. The instrument related command is *RST.

*SRE

Description

Enables status reports in the Service Request Enable Register.

Syntax

Input *SRE[bit weighting]

[bit weighting] The bit weighting parameter should be filled in with the bit weighting of each bit to be set added together. The value can be 000 to 255. Refer to the discussion on registers and below for further explanation.

Remarks

Each bit is assigned a bit weighting. Refer to the format of the Status Byte Register (given below) to see where the bits are placed in the register and what the bit weighting is for each bit. Further explanation of each bit is discussed in the register section following the Common Command Table.

7	6	5	4	3	2	1	0	— Bit
128	*64*	*32*	*16*	*8*	*4*	*2*	*1*	— Weighting
SDR	SRQ	ESB	OVP	ERR	RSC	LIM	ODR	— Bit Name

Example

If a bit in the Service Request Enable Register is set (1), then that function is enabled and will be reported in the Status Byte Register. For example, to enable bits 1, 2, 4 and 6, simply send the command *SRE86. 86 is the bit weighting for each bit added together.

Bit	Weighting
1	2
2	4
4	16
6	64
	86

MODE?

Description Interface Mode Status Query

Syntax

Input MODE?

[returned] The value returned will be **0** for local mode, **1** for remote mode or **2** for remote mode with local lockout.

Remarks One character plus up to two terminators are returned.

TERM

Description Programs the Control Unit Interface terminating characters.

Syntax

Input TERM[type]

[type] The following are choices for the type parameter.

0 for a carriage return and line feed (CR)(LF^{EOI})
1 for a line feed and carriage return (LF)(CR^{EOI})
2 for a line feed (LF^{EOI})
3 for no terminating characters (DAB^{EOI}) *DAB = Last Data Byte*

Remarks Terminating characters are sent when the Control Unit has completed its message on output. They also identify the end of an input message.

TERM?

Description Terminator Query

Syntax

Input TERM?

[returned] **0** for a carriage return and line feed (CR)(LF^{EOI})
1 for a line feed and carriage return (LF)(CR^{EOI})
2 for a line feed (LF^{EOI})
3 for no terminating characters (DAB^{EOI}) *DAB = Last Data Byte*

*OPC

Description Causes the Control Unit to set an update cycle counter to 2. Each time through an update cycle, parameters entered by device dependent commands are updated and the cycle count is decremented. After 2 update cycles, all pending device dependent commands have been completed. When this occurs, the Control Unit will set the operation complete bit in the Standard Event Status Register (not the IEEE-488.2 defined operation).

Syntax

Input *OPC

Remarks The Operation Complete Status is forced to 0 when the command is input.

*OPC?

Description Operation Complete Status Query

Syntax

Input *OPC?

Returned **0** or **1**

0 indicates incomplete, 1 indicates complete.

Remarks Places a 1 in the instrument's output queue and sets the Operation Complete Bit in the Standard Event Status Register when all pending selected device operations have been finished. This must be sent as the last command in a command string.

One character plus up to two terminators are returned.

*WAI

Description The wait-to-continue command prevents the instrument from executing any further commands or queries until all previous ones have been serviced.

Syntax

Input *WAI

Remarks This command is accepted but not supported *(not the IEEE-488.2 defined operation).*

Ramping Commands

these commands are used to configure the various functions of the ramping features.

RAMP

Description

Programs the ramp segment parameters

Syntax

Input RAMP[segment],[initial ramp current],[final ramp current],[ramp rate],[00],[--:--:--:--]

[segment] Fill in the segment parameter with a 1. *(Future updates will allow up to nine segments.)*

[initial ramp current] Fill in the initial ramp current parameter with a value in the range of 0 to ±72.0000 A.

[final ramp current] Fill in the final ramp current parameter with a value in the range of 0 to ±72.0000 A.

[ramp rate] Fill in the ramp rate parameter with a value in the range of 0 to 99.9999 A/S.

[00] Reserved for future use (Operation to perform).

[--:--:--:--] Reserved for future use (DWELL time in days, hours, minutes and seconds).

Remarks

Normal resolution truncates the value to 0.01 place. High resolution truncates the value to the 0.001 place.

The values must be entered with no embedded spaces.

Any parameter not defined will be set to 0.

Example

RAMP1,+72.0000,-72.0000,01.0000,00,--:--:--:--[term]
Indicates:
The ramp segment is 1
The initial ramp current is +72.0000 A
The final ramp current is -72.0000 A
Ramp rate is 01.0000 A/S

RAMP?

Description

Ramp Parameter Query.

Syntax

Input RAMP?

[returned] The value returned will be the same format as described above for programming in the ramp segments.

Remarks

48 characters and up to two terminators are returned.

*TST?

Description

Self Test Query - Causes the instrument to report any failures.

Syntax

Input *TST?

Returned 0 through 9

0 All tests passed.

1 Control Unit Error 1
the Control Unit encountered an unwriteable NOVRAM data location. This error is not correctable by the user. Contact Lake Shore for a replacement NOVRAM.

2 Control Unit Error 2
the Control Unit detected a NOVRAM data verification error. Initialize the NOVRAM by pressing the front panel Esc key for 10 seconds. If the error still exists, contact Lake Shore for a replacement NOVRAM.

3 Control Unit Error 3 - Reserved.

4 Control Unit Error 4 - Reserved.

5 Mainframe Error 1.
A control bus error exists. The Mainframe is not responding. Check the control bus connections between the Control Unit and the Mainframe.

6 Mainframe Error 2.
The Mainframe detected a calibration data NOVRAM error. Mainframe calibration must be performed. Contact Lake Shore.

7 Mainframe Error 3 - Reserved.

8 Mainframe Error 4 - Reserved.

9 Reserved

Remarks

One character plus up to two terminators are returned.

SEG

Description Programs the active ramp segment.

Syntax

Input SEG[segment]

[segment] Fill in the segment parameter with a **1**. *(Future updates will allow up to 9 ramp segments).*

SEG?

Description Active Ramp Segment Query

Syntax

Input SEG?

[returned] The value returned is 1. *(Future updates will allow up to 9 ramp segments).*

Remarks One character plus up to two terminators are returned.

RMP

Description Turns ramping on or off.

Syntax

Input RMP[ramp status]

[ramp status] Fill in the ramp status parameter with **0** to turn off (HOLD) the ramp definitely or **1** to turn on the ramp segment or continue a ramp that was put on hold.

RMP?

Description Ramp Status Query

Syntax

Input RMP?

[returned] The value returned is **0** for holding or **1** for ramping.

Remarks One character plus up to two terminators are returned.

Common Commands

Common Commands are input/output commands defined by the IEEE-488 standard and are shared with other instruments complying with the standard. Common commands always begin with an "*".

*IDN?

Description

Identification Query

Syntax

Input *IDN?

Returned Manufacturer, Model Number, 0, Firmware Date

Remarks

"0" in the returned syntax is in place of the serial number.

Seventeen characters plus up to two terminators are returned.

Example

LSCI,637,0,080191[term]

*RST

Description

The reset command restores the Control Unit and Mainframe to the power up settings.

Syntax

Input *RST

Remarks

This command has the same effect as the DCL and SDC bus commands. The Control Unit reverts to the Normal Display Screen. The ramp status is forced to the Hold mode and any latched error is cleared. The Status Byte and The Standard Event Status Registers are cleared.

Status Registers

Status Byte Register and Service Request Enable Register

The Status Byte Register consists of a single byte of data containing six bits of information about the Control Unit's condition.

STATUS BYTE REGISTER FORMAT

7	6	5	4	3	2	1	0	— Bit
128	*64*	*32*	*16*	*8*	*4*	*2*	*1*	— Weighting
SDR	**SRQ**	**ESB**	**OVP**	**ERR**	**RSC**	**LIM**	**ODR**	— Bit Name

If the Service Request is enabled, any of these bits being set will cause the Control Unit to pull the SRQ management low to signal the BUS CONTROLLER. These bits are reset to zero upon a serial poll of the Status Byte Register. These reports can be inhibited by turning their corresponding bits in the Service Request Enable Register to off.

The Service Request Enable Register allows the user to inhibit or enable any of the status reports in the Status Byte Register. The *SRE command is used to set the bits. If a bit in the Service Request Enable Register is set (1), then that function is enabled. Refer to the *SRE discussion.

Setting Data Ready (SDR) Bit (7)
When this bit is set, the current and voltage settings have been reset to 0 A and 1 V because either the OVP or RI are active.

Service Request (SRQ) Bit (6) determines whether the Control Unit is to report via the SRQ line and five bits determine which status reports to make. If bits 0, 1, 2, 3, 4 and/or 5 are set, then the corresponding bit in the Status Byte Register will be set. The Control Unit will produce a service request only if bit 6 of the Service Request Enable Register is set. If disabled, the Status Byte Register can still be read by the BUS CONTROLLER by means of a serial poll (SPE) to examine the status reports, but the BUS CONTROLLER will not be interrupted by the Service Request. The *STB common command will read the Status Byte Register but will not clear the bits. It must be understood that certain bits in the Status Byte Register are continually changing.

The bit assignments are discussed below as they pertain to the Status Byte Register. These reports can only be made if they have been enabled in the Service Request Enable Register.

Event Status (ESB) Bit (5) When bit 5 is set, it indicates if one of the bits from the Standard Event Status Register has been set. *(See the section concerning the Standard Event Status Register.)*

Overvoltage Protection (OVP) Bit (4) Indicates the overvoltage protection circuit has been activated.

Error (ERR) Bit (3) Indicates if an operation error has occurred. The error is displayed on the front panel and can be read using the *TST? Command.

Ramp Segment Complete (RSC) Bit (2) Indicates the active ramp segment has been completed.

Limit Exceeded (LIM) Bit (1) Indicates a new current or voltage setting has exceeded the current or voltage limit. The new setting can be read using the ISET? or VSET? commands.

Output Data Ready (ODR) Bit (0) When this bit is set, current and voltage readings are available.

Standard Event Status Register and Standard Event Status Enable Register

the Standard Event Status Register supplies various conditions of the instrument.

STANDARD EVENT STATUS REGISTER FORMAT

7	6	5	4	3	2	1	0	— Bit
128	*64*	*32*	*16*	*8*	*4*	*2*	*1*	— Weighting
PON	*not used*	**CME**	**EXE**	**DDE**	**QYE**	*not used*	**OPC**	— Bit Name

Bits 2 and 6 are not used. The user will only be interrupted with the reports of this register if the bits have been enabled in the Standard Event Status Enable Register and if bit 5 of the Service Request Enable Register has been set.

The Standard Event Status Enable Register allows the user to enable any of the Standard Event Status Register reports. The Standard Event Status Enable command (*ESE) sets the Standard Event Status Enable Register bits. If a bit of this register is set, then that function is enabled. To set a bit, send the command *ESE with the bit weighting for each bit you want to be set added together. See the *ESE command discussion for further details.

The Standard Event Status Enable Query, *ESE?, reads the Standard Event Status Enable Register. *ESR? reads the Standard Event Status Register. Once this register has been read, all of the bits are reset to zero.

Power On (PON) Bit (7) This bit is set when the power is cycled from off to on.

Command Error (CME) Bit (5) If bit 5 is set, a command error has been detected since the last reading. This means that the instrument could not interpret the command. This is due to a syntax error, an unrecognized header, unrecognized terminators, or an unsupported command.

Execution Error (EXE) Bit (4) If bit 4, the EXE bit is set, an execution error has been detected. This occurs when the instrument is instructed to do something not within its capabilities.

Device Dependent Error (DDE) Bit (3) Reserved for future use.

Query Error (QYE) Bit (2) The QYE bit indicates a query error. It occurs rarely and involves loss of data because the output queue is full.

Operation Complete (OPC) Bit (0) This bit is generated in response to the *OPC (operation complete) common command. It indicates when the Control Unit has completed all selected pending operations.