Sorensen

Instruction Manual for

Internal GPIB Interface for XT and HPD Series Power Supplies

TM-9BGP-6HSN

ABOUT THIS MANUAL

This is the technical manual for the GPIB Interface, a microprocessor-controlled option card installed inside your XT (60 watts) or HPD (300 watts) Series DC output power supply. This manual provides you with descriptions and specifications, user options, and configuration instructions, in addition to a command set which will enable you to manage your power supply from an external source. Error messages, calibration procedures, schematics, and parts lists are also included.

This manual is designed for the user who is familiar with basic electrical laws especially as they apply to the operation of power supplies. This implies a recognition of Constant Voltage and Constant Current operation modes and the control of input and output power, as well as the observance of safe techniques while affecting supply or pin connections and any changes in switch settings. The user should also have experience with a computer-based communications software package.

Refer to your power supply manual for installation, configuration, and operating procedures for your XT or HPD supply.

The seven major sections in this manual are:

Section 1. Description	Describes the interface and lists its features.
Section 2. Installation and Configuration	Reviews initial inspection, then goes through the basic installation procedure, communications, and user options and settings.
Section 3. Operation	Lists the complete command set, status registers, and error codes.
Section 4. Calibration	Provides detailed procedures for voltage and current mode calibration as well as Over Voltage Protection (OVP) calibration.
Section 5. Maintenance	Covers troubleshooting and lists replacement parts.
Appendix A: Specifications	Contains the specifications for the power supply with the GPIB interface installed.
Appendix B: Assembly Schematic	Contains the schematic for the GPIB interface printed circuit board.

Manual Revisions

The current release of this manual is listed below. Insert pages will update already-printed manuals. Reprinted manuals may note any minor corrections and additions on the Manual Changes list (page ii). A new release of the manual is identified by a new release number and printing date and will include all of the additional or corrected information since the last release.

Release 2.1 (2001/06) - contact information change only. Technical information is current to (97/10/23)

Warnings, Cautions, and Notes

Warnings, cautions, and notes are defined and formatted as presented below.

WARNING
Describes a potential hazard which could result in injury or death, or a procedure which, if not performed correctly, could result in injury or death.

CAUTION
Describes a procedure which, if not performed correctly, could result in damage to data, equipment, or systems.

Note: Describes additional operating information which may affect the performance of the equipment.

MANUAL CHANGES

There are no changes or additions at this time.

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1. FEATURES AND SPECIFICATIONS

1.1 Introduction to the GPIB Interface

The Internal GPIB Interface card allows you to operate your power supply from a computer controller via the IEEE-488 communications bus. This interface is used with the 60 watt and 300 watt series DC power supplies. Figure 1.1-1 shows a sample configuration using the GPIB interface.

The GPIB Interface enables complete remote programming of your power supply, including status reporting, settings query, and interrupt generation with user-designated fault conditions. Both the voltage and current output are precisely programmed directly in volts and amps with 16-bit resolution. Additionally, the built-in DVM and current shunt measure the actual power supply output and provide you with accurate 16-bit readback. The programming command set is easy-to-use and includes software calibration commands. The interface card comes standard with several protection features such as programmable overvoltage protection, foldback, load isolation signal, and soft limits.

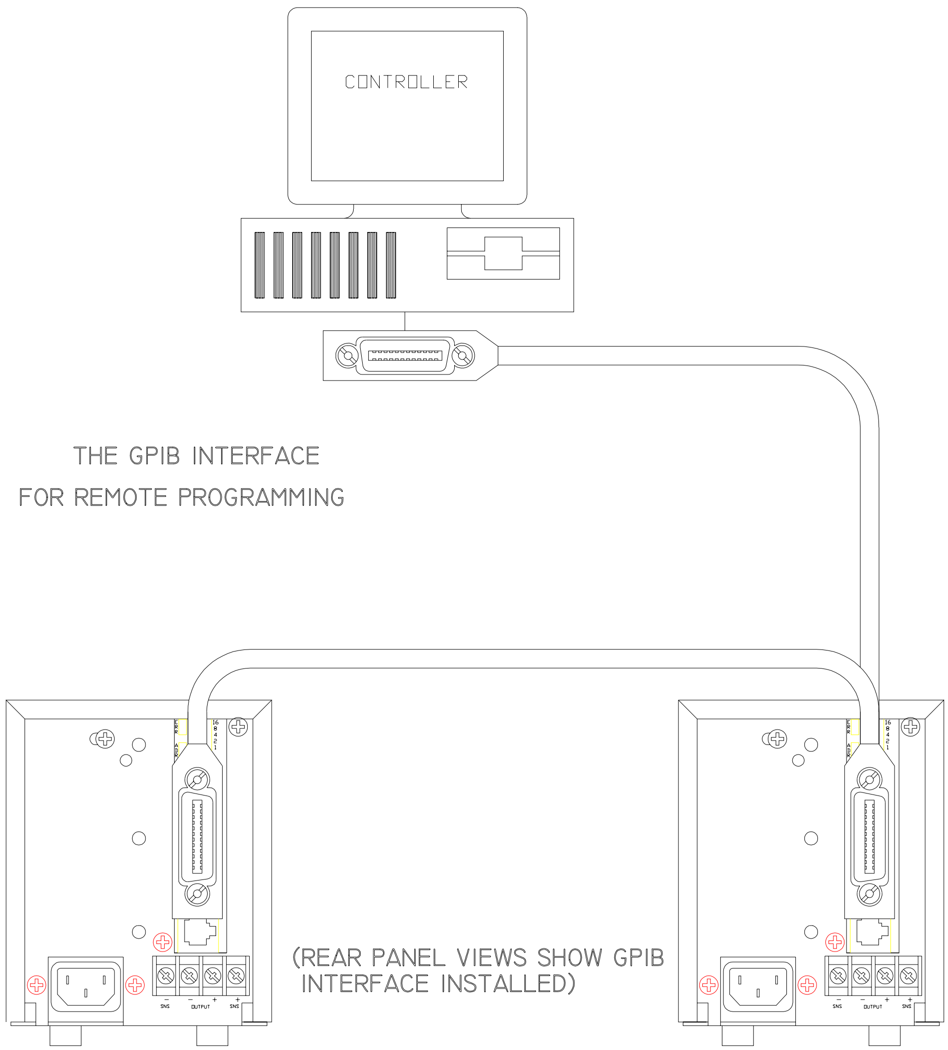


Figure 1.1-1 Sample Configuration using GPIB Interface

1.2 Features and Functions

Features

- 16-bit programming and readback of voltage and current
- Programmable soft limits for voltage and current
- Programmable overvoltage protection with reset
- Easy-to-use, self-documenting command set
- Isolated user-programmable signals such as fault, polarity, isolation, and auxiliary signals.
- LED status signals: error, addressed, service request, overvoltage protection, and remote operation
- Foldback in CV or CC mode with reset
- Local Lockout capability
- Software calibration

Programmable Functions

- Output voltage and current
- Soft limits for voltage and current
- Overvoltage protection
- Output enable/disable
- Maskable fault interrupt
- Hold and trigger
- User-programmable output relay signals

Readback Functions

- Actual measured voltage and current
- Voltage and current settings
- Soft voltage and current limits
- Overvoltage protection setting
- Present and accumulated power supply status
- Programming error codes
- Fault codes
- Power supply model and version identification
- Firmware revision levels

2. INSTALLATION AND CONFIGURATION

2.1 Introduction

To use this product, you must have the following equipment:

- 60 Watt or 300 Watt variable DC output power supply
- IEEE-488 connector and cable
- Digital controller with an IEEE-488 interface
- Computer-based communications software package

We usually install the GPIB Interface in a power supply at the factory. Your local distributor or service centre can also install the interface, especially if it is to be used in a previously-purchased supply already on site. We set the interface's PCB switches or program its EPROM to identify the power supply model to the interface during installation, so you will not have to do this. However, you will need to configure the GPIB Interface-enhanced supply for your system using Section 2.3 Basic Setup Procedure**.**

2.2 Initial Inspection

CAUTION
If you remove the unit's cover, use proper static control techniques to avoid damage to static-sensitive digital components on the printed circuit board.

On first receiving your unit, perform a quick physical check.

- Each package should contain a power supply with its GPIB Interface board installed, the AC input cable, and manuals for the power supply and the GPIB Interface. Any additional parts shipped with the power supply will be identified in the supply's documentation.
- Inspect the unit for any signs of physical damage such as scratches, cracks, or broken switches, connectors, or displays.
- Check the printed circuit board and components if you suspect internal damage.

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

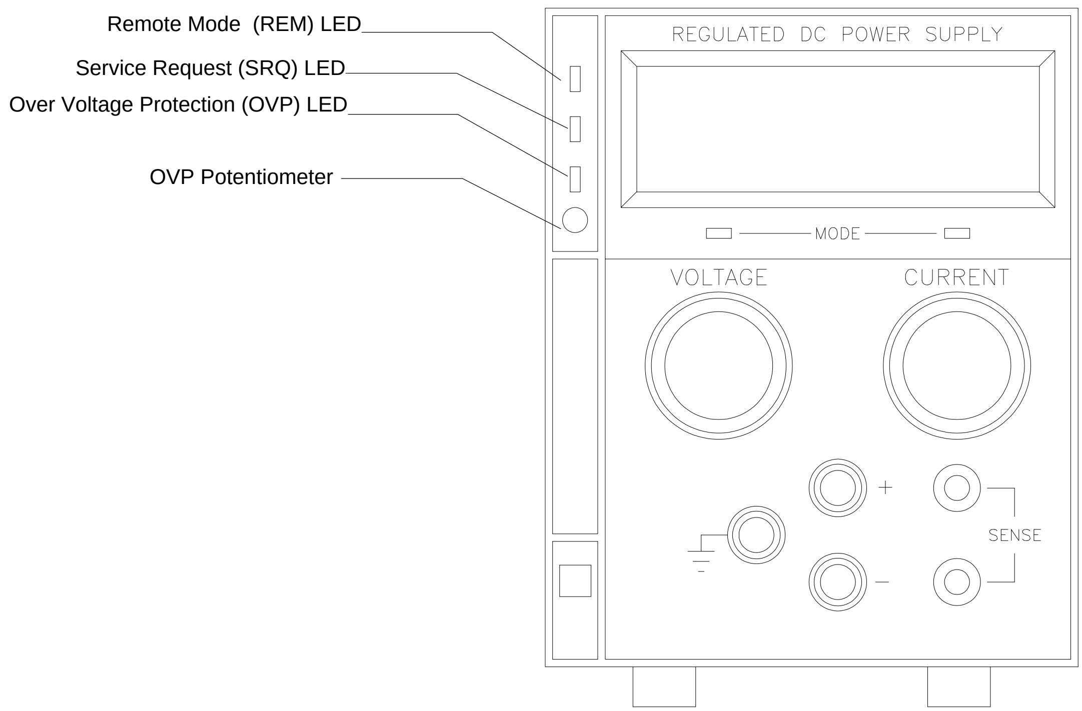
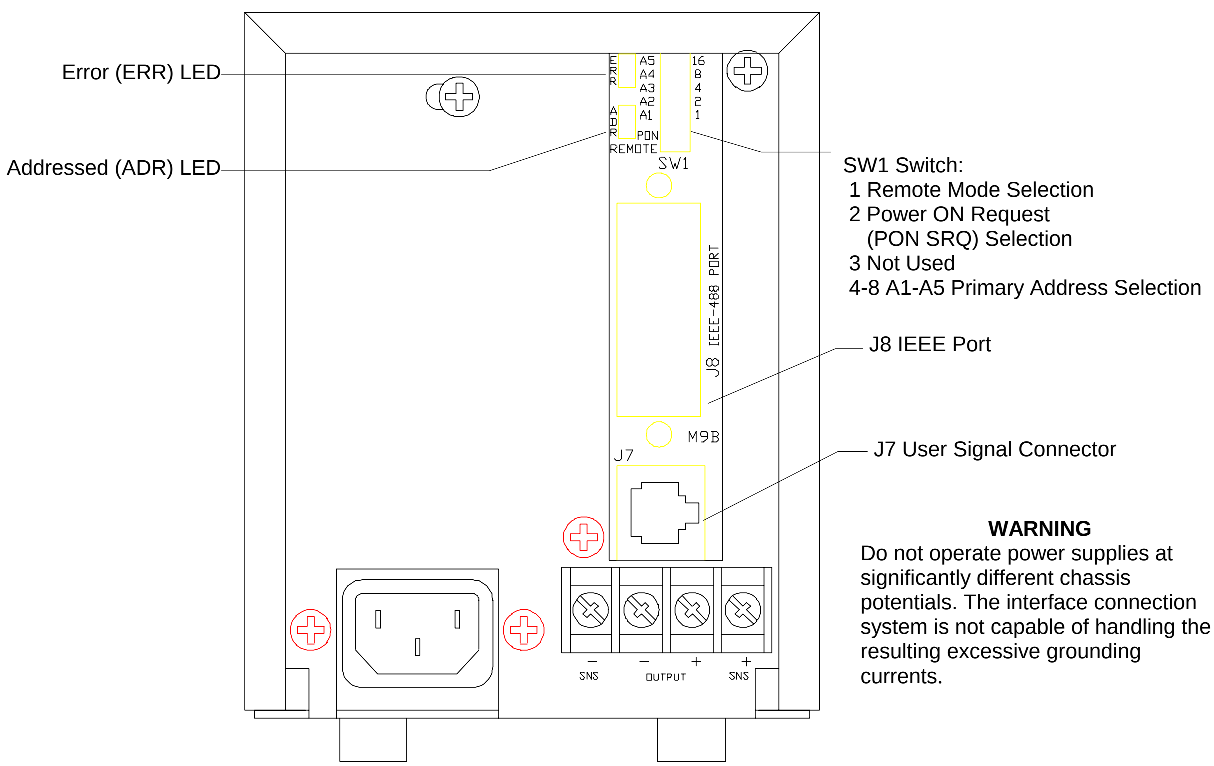


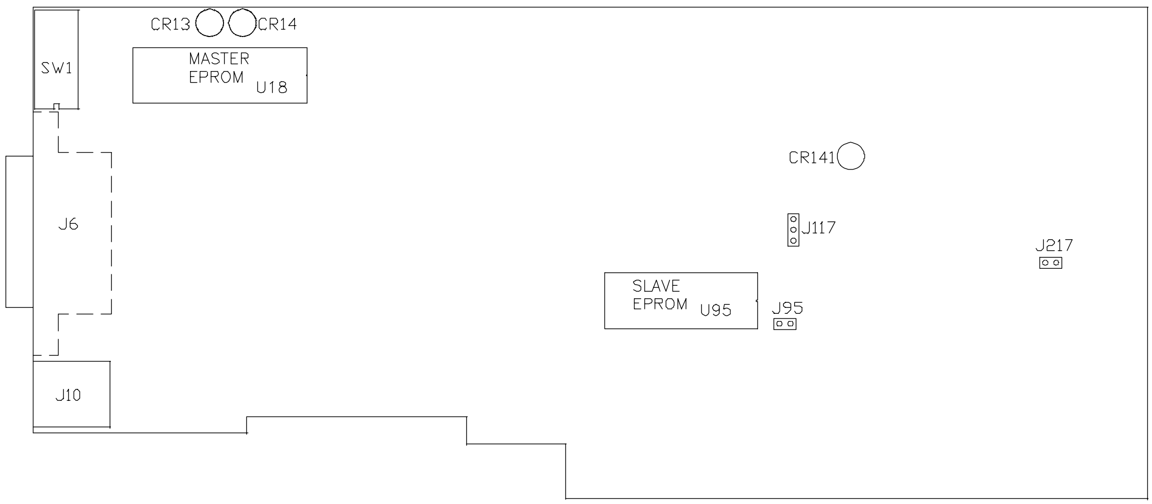
Figure 2.2-1 Power Supply Front Panel (GPIB Interface Installed)
(60 watt supply shown)



WARNING
Do not operate power supplies at significantly different chassis potentials. The interface connection system is not capable of handling the resulting excessive grounding currents.

Figure 2.2-2 Power Supply Rear Panel (GPIB Interface Installed)
(60 watt supply shown)

CAUTION
Use proper static control techniques to avoid damage to static-sensitive components on the printed circuit board.



JUMPER SELECTION

J95	Local Mode Disable Selection	[closed [default] See Section 2.3.3 [open] Software control of power supply only. See Section 2.3.3
J117	User TTL Shutdown (S/D) Selection	[1-2] User TTL S/D line active low [2-3] User TTL S/D line active high [default]
J217	OVP Control Selection	[closed] [default] See Table 2.3-2 [open] Front Panel OVP Control. See Table 2.3-2

Note: All other jumpers are not user-selectable.

LED INDICATORS

CR13	Green Diagnostic LED	Bus error on Master circuitry
CR14	Red Diagnostic LED	Soft restart on Master circuitry
CR141	Red Diagnostic LED	Bus error or soft restart on Slave circuitry

EPROMS

U18	Master EPROM	See revision number stamped on EPROM.
U95	Slave EPROM	See revision number stamped on EPROM.

CONNECTORS

J6	IEEE 488 Bus Connector (J8 on rear panel subplate)
J10	User Signals Connector (J7 on rear panel subplate)

Figure 2.2-3 GPIB Interface PCB for 60W and 300W Series Supplies

2.3 Basic Setup Procedure

This procedure can be used as a quick reference for those familiar with the configuration requirements for the GPIB Interface. For those who want more information, each step refers to more detailed procedures located in subsequent sections. Unless indicated otherwise, all procedures apply to the 60 watt and 300 watt Series DC power supplies. Refer also to Figure 2.2-1,
Figure 2.2-2, and Figure 2.2-3 for drawings of the front panel, the rear panel, and the GPIB Interface printed circuit board (PCB) for 60 watt and 300 watt Series supplies. The assembly schematic is found in Appendix B.

Table 2.3-1 Setup Procedure

Step #	Description	Action	Reference
1	OVP Selection	By default, you control the over voltage protection (OVP) function via remote operation.	Section 2.3.1 OVP Selection
2	Primary Address Selection	Use GPIB interface rear panel switches SW1-4 to SW1-8 to select a unique primary address. This identifies the power supply to the computer controller in a GPIB system.	Section 2.3.2 IEEE-488 Primary Address Selection
3	Remote/Local Operation Selection	Set the unit to remote mode using rear panel switch SW1-1 (Open).	Section 2.3.3 Remote/Local Operation
4	IEEE-488 Cable Connection	Connect the IEEE-488 bus to the supply at connector J8.	Section 2.3.4 IEEE-488 Controller Connection
5	Power ON	Power on the unit. Before proceeding, check to ensure that the green REMOTE LED on the front panel is on.	See Section 2.3.5 Power On Service Request (PON SRQ) and Section 2.4 User Signals for information on Power ON Service Request and auxiliary connector J7 user signals.
6	Configure Computer Controller	Configure the controller to match the power supply identification and characteristics using one of the available programs.	One such program is IBCONF (Interface Bus Configuration) from National Instruments. This program is used in this manual as an example only.
7	Test	Test the link by communicating with the power supply:	Example: VSET2;ISET1 This command string sets power supply voltage to 2V and its current limit to 1A. Example: ibwrt "vset2;iset1" As above, using IBIC. *

* This text uses National Instruments' IBIC (Interface Bus Interactive Control) program commands developed for their GPIB interface for computer controllers <u>as examples only</u>.

2.3.1 OVP Selection

CAUTION
If you remove the unit's cover, use proper static control techniques to avoid damage to static-sensitive components on the printed circuit board.

Over voltage protection (OVP) on the GPIB Interface is set at the factory for remote software operation. When operating the power supply in remote mode, you control the OVP trip level using the OVSET software command. If you return the power supply to local operation, the control of the OVP trip level switches to the front panel potentiometer.

Jumper J217 is the OVP control jumper. Opening jumper J217 disables remote OVP control of the power supply, limiting control of the OVP trip level to the front panel potentiometer. The local mode disable jumper, J95, also affects the location of OVP control. Table 2.3-2 shows a table of jumper settings and OVP programming selection. See Section 2.3.3 for a detailed description of the local mode disable jumper, J95.

Table 2.3-2 OVP Control Mode Selection

PCB Jumper 217 Position	PCB Jumper J95 Position	OVP Programming Selection
Closed (default)	Closed (default)	Software or Front Panel OVP control (dependent on the power supply operating state)
Closed	Open	Software OVP control only
Open	Closed	Front Panel OVP control only
Open	Open	Front Panel OVP control only

2.3.2 IEEE-488 Primary Address Selection

1. Assign a primary address to each power supply. Select a number between 0 and 30 which is unique to your IEEE-488 bus, that is, different from other device addresses on the same bus.
2. Locate switch SW1 on the GPIB Interface rear panel. See Figure 2.2-1 for the rear panel drawing.
3. Use five switch positions, A1 to A5, to set the primary address. Refer to Table 2.3-3 for switch positions.

Switch left = 0 (OFF, OPEN) Switch right = 1 (ON, CLOSED)

Table 2.3-3 IEEE-488 Primary Address Selection

Address	A1	A2	A3	A4	A5	Address	A1	A2	A3	A4	A5
0	0	0	0	0	0	16	0	0	0	0	1
1	1	0	0	0	0	17	1	0	0	0	1
2	0	1	0	0	0	18	0	1	0	0	1
3	1	1	0	0	0	19	1	1	0	0	1
4	0	0	1	0	0	20	0	0	1	0	1
5	1	0	1	0	0	21	1	0	1	0	1
6	0	1	1	0	0	22	0	1	1	0	1
7	1	1	1	0	0	23	1	1	1	0	1
8	0	0	0	1	0	24	0	0	0	1	1
9	1	0	0	1	0	25	1	0	0	1	1
10	0	1	0	1	0	26	0	1	0	1	1
11	1	1	0	1	0	27	1	1	0	1	1
12	0	0	1	1	0	28	0	0	1	1	1
13	1	0	1	1	0	29	1	0	1	1	1
14	0	1	1	1	0	30	0	1	1	1	1
15	1	1	1	1	0						

2.3.3 Remote/Local Operation

You can enable or disable remote or local operation of your power supply in one of four ways:

- Rear panel Remote/Local switch SW1-1, or
- IEEE-488 Local Lockout command, or
- Device-dependent LOC command, or
- Local Mode Disable Jumper J95 selection.

Remote/Local Switch

Use the rear panel Remote/Local switch SW1-1 to toggle between remote and local operation without losing programmed values. To locate the switch, refer to the rear panel drawing in Figure 2.2-2. Refer to Table 2.3-4 for switch positions.

Table 2.3-4 Remote/Local Mode Operation Selection

Rear Panel SW1-1 Position	Operation Selected
Open	Remote Operation Selected
Closed	Local Operation Selected

Powering up in remote mode will result in the default operating conditions in Table 2.3-5. See also Section 3.5 Command Reference.

Table 2.3-5 Remote Mode Power ON Conditions

Condition	Default	60W Model 7-6 Defaults
Voltage	0 Volts	**VSET 0**
Current	0 Amps	**ISET 0**
Soft Voltage Limit	VMAX (see models)	**VMAX 7**
Soft Current Limit	IMAX (see models)	**IMAX 6**
OVP Trip Voltage	Model VMAX + 10%	**OVSET 7.7**
Delay	0.5 seconds	**DLY 0.5S**
Foldback Protection	OFF	**FOLD OFF**
Output	ON	**OUT ON**
Hold	OFF	**HOLD OFF**
Unmask	NONE	**UNMASK NONE**
Service Request Capability	OFF	**SRQ OFF**
AUXA	OFF	**AUXA OFF**
AUXB	OFF	**AUXB OFF**
Local Mode	OFF (Remote Mode)	**LOC 0 or OFF**

IEEE-488 Local Lockout Command

Once the IEEE-488 cable is connected (see Section 2.3.4), you may send Local Lockout to the power supply via the IEEE-488 bus to override the REMOTE switch SW1-1 on the power supply's rear panel. With Local Lockout activated, the computer controller determines whether the unit operates in local or remote mode. Using this command also prevents anyone from returning the power supply to local control with the switch on the rear panel of the unit. See Section 3.2.5 for an example using local lockout.

2.3.3 Remote/Local Operation (continued)

LOC Command

The **LOC** command overrides the Local Lockout command which in turn overrides the Remote/Local switch. Use **LOC** to enable or disable one or all slave supplies to operate in local mode. See Section 3.5 Command Reference.

Example:	ibfind GPIB0	Address the computer controller.
	ibsic	Put the controller in charge by sending an Interface Clear.
	ibcmd "?_@\x11"	Send commands (UNL, UNT, MTA0, LLO) in ASCII.
	ibfind "devname"	Address the unit (devname or device name as configured originally with ibconf).
	ibloc	Set unit to local mode.
	ibwrt"id?"	Any access to the unit now puts it back to remote mode.
	ibloc	Toggle back to local mode.

This example employs National Instrument's IBIC commands.

Local Mode Disable Jumper J95

You can disable local control of the power supply by removing jumper J95 on the PCB. We recommend that you remove jumper J95 only if you never plan to control the power supply from the front panel. Otherwise, the remote/local switch on the rear panel combined with the software commands will offer you greater flexibility in controlling your supply.

When the Local Mode Disable Jumper J95 is closed, you can select between operating the power supply in either local mode or remote mode by using the rear panel remote/local switch or by using the software commands. With jumper J95 open, you can only operate the power supply in remote mode. Opening the J95 jumper disables the rear panel remote/local switch and the front panel voltage and current limit potentiometers. You cannot return to local mode using software commands without closing jumper J95.

Table 2.3-6 Local Mode Disable Jumper J95 Selection

Jumper J95 Position	Operating State
Closed	Remote or Local control of Power Supply
Open	Software Control Only

Note: The location of over voltage protection control is dependent on the position of jumper J95 and of OVP control jumper J217. Table 2.3-2 shows how jumper position affects the location of OVP control.

2.3.4 IEEE-488 Controller Connection

CAUTION
Do not operate power supplies at different chassis potentials. The interface connection system is not capable of handling the resulting excessive ground currents.

Use an approved IEEE-488 connector and cable when connecting the GPIB Interface to your IEEE-488 GPIB network. The IEEE-488 connector uses mating connector J8 on the rear panel. Refer to the GPIB Interface rear panel drawing in
Figure 2.2-2.

2.3.5 Power On Service Request (PON SRQ)

Setting the rear panel PON SRQ switch SW1-2 to open causes the power supply to send a service request to the computer controller when the power supply is turned on or when it reinitializes after a momentary power interrupt. When a service request is sent, the front panel SRQ LED will also turn on. You can clear the service request and turn off the SRQ LED by performing a serial poll. See also Section 3.5 for information about the SRQ command.

Table 2.3-7 SRQ Enable Switch Selection

Rear Panel Switch SW1-2	PON SRQ State
Open	PON SRQ Enabled
Closed	PON SRQ Disabled

2.4 User Signals

2.4.1 Connector J7 User Signals

Auxiliary connector J7, located on the GPIB Interface rear panel, provides several signals plus external power and ground to increase your operating control of the supply. The operation of the J7 signals requires that you provide external Vcc and ground. To locate the connector, refer to GPIB Interface rear panel drawings in
Figure 2.2-2. See also Section 3.5 Command Reference.

Table 2.4-1 J7 User Signal Connector

PIN	Description
J7-1	External TTL shutdown input signal
J7-2	Polarity signal, open collector (asserted by **VSET -x**)
J7-3	Isolation signal, open collector (asserted by **OUT OFF**)
J7-4	Fault signal, open collector (asserted when bit set in **FAULT** register)
J7-5	External Vcc, 18V maximum (supplied by connecting and operating an external source)
J7-6	External ground and shutdown return (supplied by connecting and operating an external source)
J7-7	Open collector user signal (asserted by **AUXA ON**)
J7-8	Open collector signal (asserted by **AUXB ON**)

2.4.2 J7 Cable Connection

Use a standard 8-position telephone jack and data cable to connect to J7. Add a ferrite block to reduce radiated emission. The one inch square ferrite block with built-in housing clip is packaged and shipped with the power supply interface card.

To install the ferrite block:

1. Position the block no more than 5 cm (2") from the power supply end of the J7 user cable.
2. Open the ferrite block housing.
3. Loop the cable through the ferrite block. See Figure 2.4-1.
4. Close the housing clip.

The ferrite block ensures that the power supply system meets radiated emission requirement 89/336/EEC for CE mark approval. See the power supply's operating manual for noise specifications.

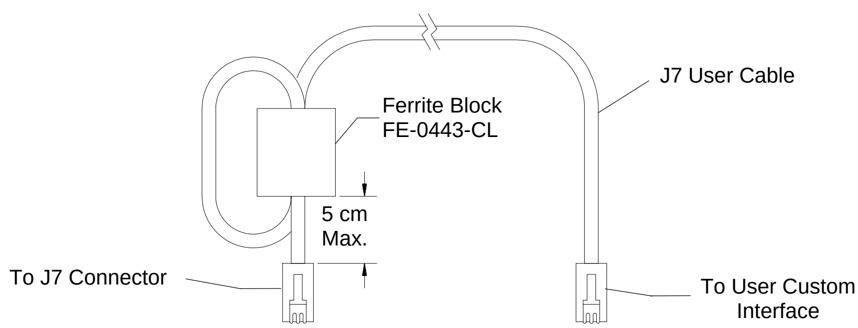


Figure 2.4-1 J7 User Cable with Ferrite Block

3. OPERATION

3.1 Introduction

This section covers GPIB Interface programming, starting with IEEE-488 functions, continuing with an extensive set of device-dependent commands, and, finally, providing error codes, and status and fault register information.

3.2 GPIB Operation

A GPIB interface controller card enables you to control an IEEE-488 bus system via computer, identifying which of its interconnected devices are to send and receive data. Interconnected devices could include programmable AC or DC power supplies, oscilloscopes, signal generators, digital voltmeters, universal counters, readouts, relay switches, and printers.

Use the GPIB Interface to relay GPIB instructions from a computer controller to a power supply located at a selected IEEE-488 address and then to return responses from the power supply to the computer. You will also use the computer controller to issue device-dependent commands such as output voltage level and status queries.

Note: This text employs National Instruments' IBIC (Interface Bus Interactive Control) program commands developed for their GPIB interface for computer controllers as examples only.

Table 3.2-1 IEEE-488 Interface Upgrades Implemented

	Mnemonic	Capability	Description
Multiline Control Functions	SH1	Source Handshake	Device must properly transfer a multiline message
	AH1	Acceptor Handshake	Device must properly receive remote multiline messages
	T6	Talker	Device must be able to transmit
	L4	Listener	Device must receive commands and data
Interface Functions	DC1	Device Clear	Device can be initialized to a previously determined state
	DT1	Device Trigger	A device function can be initiated by a talker on the bus
	E1	Open Collector Drivers	Describes the type of electrical drivers in a device
	PP1	Parallel Poll	Upon controller request, device must uniquely identify itself if it requires service
	RL1	Remote/Local	Device must be able to operate from front panel and via remote information from bus
	SR1	Service Request	Device can asynchronously request service from controller
	SP1	Serial Poll	All talkers on the bus assume a serial poll mode. Each device when addressed will provide an 8-bit word of status information.

3.2.1 Multiline Control Functions

The GPIB Interface and the computer controller implement the Acceptor Handshake, Source Handshake, Listener, and Talker functions. No user action is required. The unit's ADR (Addressed) LED turns on when the power supply is addressed to listen or talk.

3.2.2 Device Clear

The power supply will implement Device Clear regardless of whether it is in local or remote control. Device Clear is typically used to send all or selected devices to a known state with a single command. The power supply will be set to Initial (Power On) Conditions after Device Clear. See Sections 2.3.3 and 2.3.5.

Example:	ibclr	Low level command directed to entire bus, or
	ibwrt"clr"	Device-dependent command directed to a specific device.

3.2.3 Device Trigger

Device Trigger will enable the most recently programmed values whether the unit is in local or remote control. If the power supply is in local mode, the new values will be implemented when it is switched from local to remote control. Device Trigger is typically used to synchronize the operation of a number of addressed devices.

Example: Use HOLD Command to set values to be executed when triggered. See Section 3.5 Command Reference. Then, use:

ibtrg	Command directed to entire bus, or
ibwrt"trg"	Command directed to a specific device.

3.2.4 Parallel Poll

Parallel Poll allows the computer controller to determine quickly which of a number of instruments on the bus requested service. The parallel poll response corresponds to bit 7 of the serial poll status byte. Parallel Poll does not reset the service request. The power supply must be configured remotely to respond to a parallel poll with either a "1" or "0" on one of the DIO lines if the unit is requesting service.

Example:	ibrpp	Conduct a parallel poll.

3.2.5 Local Lockout

Send Local Lockout from the computer controller to ensure that a power supply operates in remote mode. The IEEE-488 Local Lockout command overrides the Remote/Local switch SW1-1 on the rear panel. If the switch is set to OFF (or Local), the Local Lockout command can force the supply into remote mode. See Section 2.3.3 Remote/Local Operation.

Example:	ibfind GPIB0	Address the computer controller.
	ibsic	Put the controller in charge by sending an Interface Clear.
	ibcmd "?_@\x11"	Send commands (UNL, UNT, MTA0, LLO) in ASCII.
	ibfind "devname"	Address the unit (devname or device name as configured originally with ibconf).
	ibloc	Set unit to local mode.
	ibwrt"id?"	Any access to the unit now puts it back to remote mode.
	ibloc	Toggle back to local mode.

3.2.6 Service Request

Service request is a uniline message asserted by the power supply at power on and for fault conditions. Six (6) power supply conditions are defined as faults. See Section 3.6 Accumulated Status, Status, and Fault Registers for more information about CV, CC, OV, SD, ERR, and FOLD. Power ON (PON) can also be flagged in the fault register if the supply's rear panel power on service request (PON SRQ) switch is set to ON. See Section 2.3.5 Power On Service Request (PON SRQ).

Enabling or disabling a condition from asserting service request does not affect the condition within the power supply, nor the external status indicators.

3.2.7 Serial Poll

In a serial poll, the controller polls each device.

Example: ibrsp Return serial poll byte.

The power supply responds with a status byte defined as follows:

Table 3.2-2 Serial Poll Status Register

Bit Position	Decimal Weight	Description	Reset By
0 (LSB)	1	**Fault** - Set when any bit in the fault register is set by a fault condition in the supply. See also Section 3.6.	**FAULT?** query to reset
1	2	Not Used	
2	4	Not Used	
3	8	Not Used	
4	16	**Ready** - Set when power supply is ready to accept commands.	Power supply, during command processing period
5	32	**Error (ERR)** - Set when **ERR** bit asserted in status register. See also Section 3.6.	**ERR?** query or a new, error-free command
6	64	**Request Service (SRQ)** - Set when power supply requests service.	Serial Poll
7 (MSB)	128	**Power On (PON)** - Set when unit initializes at power on.	**CLR** or Device Clear

3.3 Command Syntax

3.3.1 Command Format and Parameters

Format: COMMAND <parameter> or COMMAND <parameter>,<parameter>

Table 3.3-1 Command Parameters		
Key	**Explanation**	**Examples/References**
<current>	<float> plus A (amps; default) or mA (milliamps)	
<fault mask>	a combination of CV, CC, OV, SD, and/or FOLD.	See MASK and UNMASK commands in Section 3.5 Command Reference.
<float>	optional sign, integer.integer, .integer, integer, integer., optional E (scientific notation): optional sign, optional integer. After the E plus a sign, you must use an integer, At least one digit must precede E. Lower case e and upper case E are treated as the same.	Example: +1.23 or -1.23 or 1.23 Example: 1.2 Example: .1 Example: 1 Example: 1. Example: 1.23 E-1 Example: E-1 or E+1
<seconds>	<float> followed by s (seconds; default) or ms (milliseconds)	
<status mask>	a combination of CV, CC, OV, SD, FOLD, ERR, and/or REM	See Section 3.6 Accumulated Status, Status, and Fault Registers.
<voltage>	<float> followed by V (volts; default) or mV (millivolts)	
<other>	Command-specific parameters such as 1, 0, ON, OFF, ALL, or NONE	See Section 3.5 Command Reference

Notes:

1. The angle brackets < > in this manual signal values you will need to specify when you use a command. Do not include the angle brackets in the command line you send to the system.
2. You may enter commands and parameters in upper or lower case letters.
3. Do not further abbreviate command names or parameters.
3. Use a space between the command and the first parameter. Any number of consecutive spaces is treated as one space.
   Example: OUT ON
4. Numeric data may contain leading spaces. Embedded spaces between digits or between digits and decimal point are not accepted.
5. Use commas between parameters in those commands with more than one parameter, and between mnemonic parameters as in the MASK and UNMASK commands. Only one comma is allowed and it may be preceded or followed by any number of spaces.
   Example: MASK CV,OV , FOLD

3.3.2 Command Strings

If you send more than one command per line, separate the commands with a semicolon. The semicolon may be preceded or followed by spaces.

Example: ISET 2.0A;VSET 5 or ISET 2.0A ; VSET 5V

3.3.3 Command Terminators

Terminators indicate the end of a command string and tell the power supply to execute the command. The termination character is line feed (LF).

Format: COMMAND1 <parameter1>;COMMAND2 <parameter1>,<parameter2>LF

Line feed is sent by most computer controllers automatically with output statements.

You may also terminate commands by asserting EOI on the GPIB concurrently with the last byte of the command.

```
Example:    VMAX 5.25
                    E
                    O
                    I
```

All data sent by the power supply to the computer controller is terminated by a carriage return and a line feed character. **EOI** is asserted concurrently with linefeed.

```
Example:    VMAX 5.250CRLF
                         E
                         O
                         I
```

3.3.4 Order

You may send commands in any order, keeping in mind that only those commands received after a HOLD and before a TRG (trigger) will be released by the TRG command. In addition, only those commands received after a supply disable and before a RST (reset) or OUT ON command will be released by the RST command or the OUT command.

3.4 Command Summary

Use these commands to control the operation of the supply. They are listed here in order of function such as PROGRAMMING, QUERY, CALIBRATION, and STATUS commands. See Section 3.5 Command Reference for more detailed information about each command and its use.

Table 3.4-1 Programming Commands

Command	Description
AUXA	Selects the state of the signal on the J7-7 connector.
AUXB	Selects the state of the signal on the J7-8 connector.
CLR	Initializes the power supply to its Power ON (PON) state.
DLY	Sets a programmable time delay executed by the supply before reporting fault conditions after a new output voltage or current is specified.
FOLD	Sets foldback mode for a supply.
HOLD	Enables or disables voltage/current setting hold mode for the supply.
IMAX	Sets an upper soft limit on the programmed output current for the supply.
ISET	Sets the output current of the supply in amps (default) or in milliamps.
LOC	Enables or disables the supply to operate in local mode.
OUT	Enables or disables voltage/current output for the supply.
OVSET	Sets the over voltage protection trip point for the supply in volts (default) or in millivolts.
RST	Resets the supply to present voltage and current settings if output is disabled by OVP or foldback protection.
SRQ	Specifies the power supply's ability to generate a service request.
TRG	Implements programmed voltage and current settings which had been in hold mode for the supply.
VMAX	Sets an upper soft limit on the programmed output voltage for the supply.
VSET	Sets the output voltage of the power supply in volts (default) or in millivolts.

Table 3.4-2 Query Commands

Command	Description
AUXA?	Queries the state of the set value for AUXA command
AUXB?	Queries the state of the set value for AUXB command
CMODE?	Queries the power supply calibration mode status.
DLY?	Queries the programmable delay time setting for the supply before reporting fault conditions.
ERR?	Queries the most recent remote programming error which occurred in the supply since the last time the error query command (ERR?) was used.
FOLD?	Queries the present foldback setting for the supply.
HOLD?	Queries the present hold mode setting.
ID?	Queries the power supply model name and master EPROM version.
IMAX?	Queries the soft current limit setting for the supply.
IOUT?	Measures the actual current output for the supply.
ISET?	Queries the present output current setting for the supply.
LOC?	Queries the present enabled/disabled status of local mode operation for the supply.
OUT?	Queries the present enabled/disabled status of the output voltage/current for the supply.
OVSET?	Queries the present over voltage protection limit for the supply.
ROM?	Queries the version number of the master and slave EPROMs on the interface PCB.

Continued on next page.

Table 3.4-3 Query Commands (continued)	
Command	**Description**
SRQ?	Queries the present enabled/disabled status of the IEEE-488 Service Requests generated by the supply.
VMAX?	Queries the soft voltage limit setting for the supply.
VOUT?	Measures the actual voltage output for the supply.
VSET?	Queries the present output voltage setting for the power supply.

Table 3.4-3 Calibration Commands	
Command	**Description**
CMODE	Places the supply into calibration mode.
IDATA	Causes the slope and intercept to be calculated for current programming.
IHI	Sets the current output to the high calibration point.
ILO	Sets the current output to the low calibration point.
IRDAT	Causes the slope and intercept to be calculated for current readback.
IRHI	Sets the current output to the high readback point.
IRLO	Sets the current output to the low readback point.
OVCAL	Causes the over voltage protection (OVP) to be calibrated.
VDATA	Causes the slope and intercept to be calculated for voltage programming.
VHI	Sets the voltage output to the high calibration point.
VLO	Sets the voltage output to the low calibration point.
VRDAT	Causes the slope and intercept to be calculated for voltage readback.
VRHI	Sets the voltage output to the high readback point.
VRLO	Sets the voltage output to the low readback point.

Table 3.4-4 Status Commands	
Command	**Description**
ASTS?	Queries the accumulated status register for the supply.
FAULT?	Queries the fault register for the status preset operating conditions for the supply.
MASK	Disables the supply's previously unmasked operating conditions from setting bits in the fault register.
STS?	Queries the present status register of the supply.
UNMASK	Enables you to select those supply's operating conditions that you are most interested in monitoring for fault occurrence.
UNMASK?	Queries the supply's fault conditions which are currently enabled (unmasked).

3.5 Command Reference

Table 3.5-1 Command Reference

Command	Description
ASTS?	Queries the accumulated status for the supply. The accumulated status register stores any bit that was entered in the status register since the accumulated status query command (ASTS?) was last used (if at all), regardless of whether the condition still exists. The accumulated status register has the same bits, weights, and conditions as the status register. A bit in the accumulated status register will be set at 1 if the corresponding bit in the status register has been 1 (true) at any time since the register was last read. See Section 3.6 Accumulated Status, Status, and Fault Registers. Response: ASTS <status bits> where status bits is the decimal equivalent of the total bit weights for the operating conditions as listed in the status register.
AUXA <0/1> or **AUXA <OFF,on>**	Controls the AUXA signal level at J7-7. Active low. Initial value: AUXA 0
AUXA?	Queries the present set value of the AUXA signal. Response: AUXA 0 (OFF) AUXA 1 (ON)
AUXB <0/1> or **AUXB <OFF/on>**	Controls the AUXB signal level at J7-8. Active low. Initial value: AUXB 0
AUXB?	Queries the present set value of the AUXB signal. Response: AUXB 0 (OFF) AUXB 1 (ON)
CLR	Initializes the power supply to its Power ON (PON) condition. Resets the PON bit (position 7) in the serial poll register.
CMODE <on/OFF> **or** **CMODE <1/0>**	CMODE ON places the power supply into calibration mode so that calibration commands can be processed legally. Initial value: CMODE OFF or CMODE 0
CMODE?	Queries the power supply calibration mode status. Response: CMODE 0 (disabled) 1 (enabled)
DLY <seconds>	Sets a programmable time delay employed by the supply before reporting fault conditions after a new output voltage or current is specified (VSET, ISET), or RST, TRG, or OUT ON commands are received. During delay time, the power supply disables CV, CC, and FOLD conditions from generating faults, preventing possible nuisance foldback or service requests if the supply momentarily switches modes while changing an output setting. Range: 0 to 32 seconds, with 32ms resolution. Initial value: 0.5 second
DLY?	Queries the programmable delay time setting for the supply. Response: DLY <seconds>
ERR?	Queries the most recent remote programming error. When the supply detects a programming error, it sets the ERR bit in the status and fault registers, which can be unmasked (UNMASK) on the fault register to request service. The remaining portion of the command line is discarded. An error query or a new, error-free command clears the ERR bit in both the status register and the serial poll register. See Section 3.7 Error Codes. Response: ERR <error number>Example: ERR 0 (if no error)
	Continued on next page.

Table 3.5-1 Command Reference (continued)

Command	Description
FAULT?	Queries the fault register for the supply's fault condition status. When a bit is set in the fault register, the rear panel J7 connector Fault Line 4 is also asserted. The fault line from any supply in a system may be tied to the External Shutdown Line J7-1 of all supplies to provide shutdown of the system, independent of the GPIB, for user-defined faults. The FAULT? query clears bits in the supply's fault register and fault lines. See Section 3.6 Accumulated Status, Status, and Fault Registers. Response: FAULT <fault mask> where fault mask is the decimal equivalent of the total bit weights for the operating conditions as listed in the fault register.
FOLD <OFF/CV/CC> **or** **FOLD <0/1/2>**	Sets foldback mode for a supply. Foldback protection disables the power supply output when the output enters the fold condition. Reset with the RST command. Example: Specify FOLD CV or FOLD 1 (Constant Voltage) when you mean the supply to operate in Constant Current mode and have foldback protection disable the output if the supply switches to Constant Voltage mode. Initial value: FOLD OFF or FOLD 0 (CC or 2 is for Constant Current)
FOLD?	Queries the present foldback setting for the specified slave supply. Response:FOLD <mode> where mode is: 0 (OFF) or 1 (CV or Constant Voltage mode) or 2 (CC or Constant Current mode)
HOLD<OFF/on) **or** **HOLD <0/1)**	Enables or disables voltage/current setting hold mode for the supply. When HOLD ON is specified, hold mode is enabled so that all voltage and current settings which would normally be implemented by the supply are held until a TRG (trigger) command is received. This allows you to synchronize the operation of several supplies. Initial value: HOLD OFF or HOLD 0
HOLD?	Queries the present hold mode setting. Response: HOLD 0 (OFF or disabled) or 1 (ON or enabled)
ID?	Queries the power supply model and the master EPROM version. Response: ID <model name><version>
IDATA <Ilo>,<Ihi>	Calculates the slope and offset for current programming. Uses IHI and ILO data. Specifies the actual high and low current settings (as measured by an external source) which correspond to the programmed high and low calibration current settings for the power supply. Set CMODE ON before using this command. <Ilo> and <Ihi> are in <current> format.
IHI	Sets the output current for the power supply to the internally-programmed high calibration current setting. This data is uploaded from the supply. Set CMODE ON before using this command.
ILO	Sets the output current for the power supply to the internally-programmed low calibration current setting. This data is uploaded from the supply. Set CMODE ON before using this command.

Continued on next page.

Table 3.5-1 Command Reference (continued)

Command	Description
IMAX <current>	Sets an upper soft limit on the programmed output current for the supply. If the soft limit is exceeded, or if the soft limit value is lower than the present output current setting, the supply will ignore the command, turn on the ERR LED, and set the ERR bit in the status and serial poll registers. Range: 0 to model maximum output current (IMAX) Initial value: model IMAX
IMAX?	Queries the soft current limit setting for the supply. Response: IMAX <current>
IOUT?	Measures the actual current output for the supply using the built-in current readback A/D converter. Response: IOUT <current>
IRDAT <Ilo>,<Ihi>	Calculates the slope and offset for current readback. Uses IRHI and IRLO data. Specifies the actual high and low current settings (as measured by an external source) which correspond to the programmed high and low calibration current readback settings for the power supply. Set CMODE ON before using this command. <Ilo> and <Ihi> are in <current> format.
IRHI	Sets the output current for the power supply to the internally-programmed high calibration current readback setting. This data is uploaded from the supply. Set CMODE ON before using this command.
IRLO	Sets the output current for the power supply to the internally-programmed low calibration current readback setting. This data is uploaded from the supply. Set CMODE ON before using this command.
ISET <current>	Sets the output current of the power supply in amps (default) or in milliamps. This programmed current is the actual output in CC mode or the current limit in CV mode. Range: 0 to model maximum output current (IMAX) Initial value: 0 amps
ISET?	Queries the present output current setting for the supply. Does not apply to current settings which are being held. (See HOLD command.) Response: ISET <current>
LOC <on/OFF> **or** **LOC <1/0**	Enables or disables the supply to operate in local mode. This command overrides the rear panel Remote switch and the IEEE-488 Local Lockout command. See Sections 2.3.3 and 3.2.5**. The command does not work if PCB jumper J95 is open.** Initial value: LOC OFF or LOC 0
LOC?	Queries the present enabled/disabled status of local mode operation for the specified supply. Response: LOC 0 (disabled) 1 (enabled)
MASK <mnemonics>	Disables the supply's previously unmasked operating conditions from setting bits in the fault and status registers. See Section 3.6 Accumulated Status, Status, and Fault Registers. Mnemonics are separated from each other by commas, and may be sent in any order. MASK mnemonics: CV, CC, OV, SD, ERR, FOLD (Constant Voltage, Constant Current, Overvoltage Protection, Shutdown, Error, and Foldback) Note: UNMASK NONE = MASK ALL (Initial value) MASK NONE = UNMASK ALL
	Continued on next page.

Table 3.5-1 Command Reference (continued)	
Command	**Description**
OUT <ON/off> **or** **OUT<1/0>**	Enables or disables voltage/current output for the supply. The supply will continue to accept new commands while the output is disabled but these will not be implemented until OUT ON or OUT 1 is received. OUT OFF (or OUT 0) also sets the isolation signal on the rear panel J7 connector, line 3, which may be used to trip external relays to isolate the power supply from the load. Initial value: OUT ON (or OUT 1) for output enabled
OUT?	Queries the present enabled/disabled status of the output voltage/current for the supply. Response: OUT 1 (output enabled) or OUT 0 (output disabled)
OVCAL	Enables automatic calibration of the overvoltage protection circuitry for the power supply. Set CMODE ON before using this command. Ensure jumper J217 on the interface PCB is connected. See Section 4.4.
OVSET <voltage>	Sets the overvoltage protection trip point for the supply in volts (default) or in millivolts. Range: 0 to 110% of model maximum output voltage (VMAX) Initial value: 110% of model VMAX
OVSET?	Queries the present overvoltage protection limit for the supply. Response: OVSET <voltage>
ROM?	Queries the version number of the master and slave EPROMs on the interface PCB. Response: ROM MASTER:<version> SLAVE:<version>
RST	Resets the supply to present voltage and current settings if output is disabled by overvoltage or foldback protection. Output values may be changed via VSET, ISET, and OVSET while the unit is disabled but will not take effect until RST is used.
SRQ <on/OFF> **or** **SRQ <1/0>**	SRQ ON enables the supply to respond to a variety of supply fault conditions with a request for service to the IEEE-488 bus controller. With SRQ ON, the SRQ line will be asserted true whenever the FAU bit in the serial poll register changes from 0 to 1. Therefore, the mask register, in addition to specifying which conditions set the FAU bit, also determines which conditions can generate service requests. Six (6) power supply conditions are defined as faults: CV, CC, OV, SD, ERR, and FOLD. Use the FAULT? query to discover which condition caused the service request. A request for service at Power ON (PON) is set via a rear panel switch on the supply. See Section 2.3.5. SRQ remains disabled until the FAULT bit in the serial poll register is cleared by a FAULT? query. Initial value: SRQ OFF or SRQ 0
SRQ?	Queries the present ability to generate service requests. Response: SRQ 0 (disabled) 1 (enabled)
STS?	Queries the present status register of the supply. Status conditions are stored in the status register. Each bit represents a separate condition. When the condition is true, the corresponding bit is 1. Bits remain set in the status register as long as the condition is true. See Section 3.6 Accumulated Status, Status, and Fault Registers. Response: STS <status bits> where status bits is the decimal equivalent of the total bit weights for the operating conditions as listed in the status register.
	Continued on next page.

Table 3.5-1 Command Reference (continued)

Command	Description
TRG	Implements programmed voltage and current settings which had been in hold mode. The supply operates with previous values until the TRG (trigger) command is sent.
UNMASK <mnemonics>	Enables you to select those supply's operating conditions that you are most interested in monitoring for fault occurrence. Mnemonics are separated from each other by commas, and may be sent in any order. Specifying one or more mnemonics which describe the conditions (or the decimal equivalent of their total bit weight) enables the selected conditions to set bits in the fault and status registers. A bit is set in the fault register when the corresponding bit in the status register changes from 0 to 1 and the corresponding bit in the mask register is 1. Whenever any bit is set in the fault register, the FAULT bit (position 0) is set in the serial poll register. See Section 3.6 Accumulated Status, Status, and Fault Registers. UNMASK mnemonics: CV,CC,OV,SD,ERR,FOLD (See MASK) Initial value: UNMASK NONE
UNMASK?	Queries the supply's fault conditions which are currently enabled (unmasked). Response: UNMASK <fault mask> where fault mask is the decimal equivalent of the total bit weights for the operating conditions as listed in the status and fault registers See Section 3.6.
VDATA <Vlo>,<Vhi>	Calculates the slope and offset for voltage programming. Uses VHI and VLO data. Specifies the actual high and low voltage settings (as measured by an external source) which correspond to the programmed high and low calibration voltage settings for the power supply. Set CMODE ON before using this command. <Vlo> and <Vhi> are in <voltage> format.
VHI	Sets the output voltage for the power supply to the internally-programmed high calibration voltage setting. This data is uploaded from the supply. Set CMODE ON before using this command.
VLO	Sets the output voltage for the power supply to the internally-programmed low calibration voltage setting. This data is uploaded from the supply. Set CMODE ON before using this command.
VMAX <voltage>	Sets an upper soft limit on the programmed output voltage for the supply. If the soft limit is exceeded, or if the soft limit value is lower than the present output voltage setting, the supply will ignore the command, turn on the ERR LED, and set the ERR bit in the status and serial poll registers. Range: 0 to model maximum output voltage (VMAX) Initial value: model VMAX
VMAX?	Queries the soft voltage limit setting for the supply. Response: VMAX <voltage>
VOUT?	Measures the actual voltage output for the supply using the built-in voltage readback A/D converter. Response: VOUT <voltage>
VRDAT <Vlo>,<Vhi>	Calculates the slope and offset for voltage readback. Uses VRHI and VRLO data. Specifies the actual high and low voltage settings (as measured by an external source) which correspond to the programmed high and low calibration current readback settings for the power supply. Set CMODE ON before using this command. <Vlo> and <Vhi> are in <voltage> format.

Continued on next page.

Table 3.5-1 Command Reference (continued)

Command	Description
VRHI	Sets the output current for the power supply to the internally-programmed high calibration voltage readback setting. This data is uploaded from the supply. Set CMODE ON before using this command.
VRLO	Sets the output current for the power supply to the internally-programmed low calibration voltage readback setting. This data is uploaded from the supply. Set CMODE ON before using this command.
VSET <voltage> **or** **VSET <-voltage>**	Sets the output voltage of the power supply in volts (default) or in millivolts. This programmed voltage is the actual output in CV mode or the voltage limit in CC mode. A negative value asserts the polarity signal on the rear panel J7 connector, line 2, which may be used to trip external relays to switch the output polarity. Range: 0 to model maximum output voltage (VMAX) Initial value: 0 volts
VSET?	Queries the present output voltage setting for the power supply. Does not apply to voltage settings which are being held. See HOLD command. Response: VSET <voltage>

3.6 Accumulated Status, Status, and Fault Registers

The M9B option card for the 60W and 300W power supplies uses three separate registers which are always active. They are the accumulated status, status, and fault registers. You can use the status commands shown in Table 3.4-4 to activate the registers. The bit register has eight conditions, each assigned a bit weight. When querying a register, the controller returns a response which is the sum of the weights of all relevant conditions.

Example:

ASTS? query the accumulated status register.

ASTS 771 controller response

771 = 512 + 256 + 2 + 1 = PON + REM + CC + CV

The accumulated status register shows that PON, REM, CC, and CV have all been active since the last accumulated register query.

Table 3.6-1 shows the mnemonics and bit weights which correspond to each register condition. You can control conditions in the fault and status register by using the MASK and UNMASK commands. For more information about Mask and Unmask commands, See Section 3.5 Command Reference.

Table 3.6-1 Status and Fault Registers

Condition	Mnemonic	Bit Position	Bit Weight
Constant voltage operation	**CV**	0	1
Constant current operation	**CC**	1	2
Not used	**–**	2	4
Overvoltage protection tripped	**OV**	3	8
Not used	**–**	4	16
Supply external shutdown active (J7-1)	**SD**	5	32
Foldback mode operation	**FOLD**	6	64
Remote programming error	**ERR**	7	128
Power ON (accumulated status, status registers only)	**PON**	8	256
Remote mode (accumulated status, status registers only)	**REM**	9	512

Notes:

1. Only CV, CC, OV, SD, ERR, and FOLD can be **MASK**ed or **UNMASK**ed.
2. The error (ERR) bit is reset with an error query (**ERR?**) or another error-free command in the accumulated status, status, and serial poll registers.
3. The accumulated status register is cleared with an accumulated status query (**ASTS?**).
4. A fault is cleared with a fault query (**FAULT?**).

3.7 Error Codes

If the ERR flag in the accumulated status or fault registers has been activated, an ERR? query will return an error number which corresponds to an event described in Table 3.7-1. The ERR? query will also clear the ERR bit in the register.

Table 3.7-1 Error Codes

Error #	Error Identification	Explanation
0	No Errors	
4	Unrecognized Character	A character such as **@,*,$** was received.
	Improper Number	A numeric character was received but the characters were not a proper number. Example: VSET ,±10.3 V
	Unrecognized String	An invalid command was received.
	Syntax Error	Incorrectly placed word, number, separator, or terminator was received. Example: OFF SRQ, VOUT 6V, MASK, ERR
5	Number Out of Range	A number received for the command was outside of the allowed range.
6	Attempt to Exceed Soft Limits	An attempt was made to program a voltage or current **greater than** the soft limit. Example: VMAX 500V ; VSET 550V LF
7	Improper Soft Limit	An attempt was made to program a soft limit less than the output value.
8	Data Requested without a Query Being Sent	The controller requested data from the power supply without first sending a query command.
9	OVP Set Below Output	An **OVSET** command was sent with a trip value lower than the output voltage.
10	Slave Processor Not Responding	The interface PCB slave processor did not respond.
12	Illegal Calibration	Calibration was attempted when the supply was not in calibration mode. See **CMODE** command.

4. CALIBRATION

4.1 Introduction

The GPIB Interface is calibrated in order to adjust the signal levels on the interface card to correspond to the expected signal levels on the power supply's main assembly. You may need to recalibrate the interface whenever you install a new interface board or replace parts either on the interface board or on the main power supply board, or, if the unit falls out of specification due to component aging drifts. You can calibrate the GPIB Interface for voltage program, voltage readback, current program, current readback, and overvoltage protection.

The calibration procedures in this section are designed to be performed at an ambient temperature of 25°C ± 5°C.

4.2 Voltage Mode Calibration

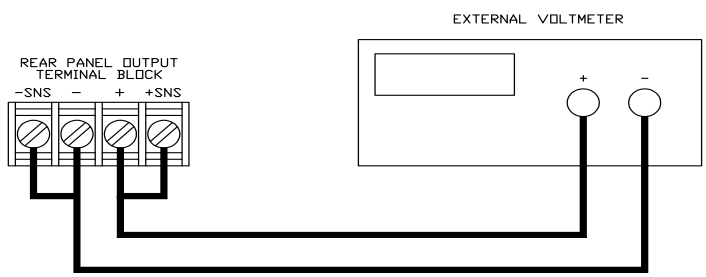


Figure 4.2-1 Voltage Calibration Setup

4.2.1 Voltage Calibration Setup

1. Disconnect the load from the power supply to be calibrated.
2. Connect a voltmeter across the load terminals of the unit under test.

Refer to Figure 4.2-1.

4.2.2 Voltage Program Calibration Procedure

1. Set up for calibration as in Section 4.2.1 Voltage Calibration Setup.
2. Send **CMODE ON** or **CMODE 1** to activate calibration mode.
3. Send **VLO; ILO** to the power supply you want to calibrate. Measure and record the output that is shown on the external meter.
4. Send **VHI; IHI** to the supply, then measure and record the output voltage as shown on the external meter.

4.2.2 Voltage Program Calibration Procedure (continued)

5. Send the command **VDATA <vlo>,<vhi>** where <vlo> and <vhi> are the values obtained with the **VLO** and **VHI** commands. When the power supply is calibrated, the low to high voltage program calibration values are stored as constants.
6. Program the supply at various levels using the **VSET** command to confirm that the calibration was successful and that linearity is observed. See the voltage program accuracy specification in Appendix A.
7. Turn off calibration mode by sending the **CMODE OFF** or **CMODE 0** command.

4.2.3 Voltage Readback Calibration Procedure

1. Set up for calibration as in Section 4.2.1 Voltage Calibration Setup.
2. Send **CMODE ON** or **CMODE 1** to activate calibration mode.
3. Send **VRLO; IRLO** to the power supply you want to calibrate. Wait for supply to settle. Measure and record the output that is shown on the external meter. Send **VRLO** again.
4. Send **VRHI; IRHI** to the supply. Wait for supply to settle. Then measure and record the output voltage as shown on the external meter. Send **VRHI** again.
5. Send the command **VRDAT <vlo>,<vhi>** where <vlo> and <vhi> are the values obtained with the **VRLO** and **VRHI** commands. The processor calculates the offset value required to calibrate the power supply. When the power supply is calibrated, the low to high voltage readback calibration values (offsets) are stored as constants.
6. Program and readback the output of the supply at various levels using the **VSET** and **VOUT?** commands to confirm that the calibration was successful and that linearity is observed. Refer to the voltage readback accuracy specification in Appendix A.
7. Turn off calibration mode by sending the **CMODE OFF** or **CMODE 0** command.

4.3 Current Mode Calibration

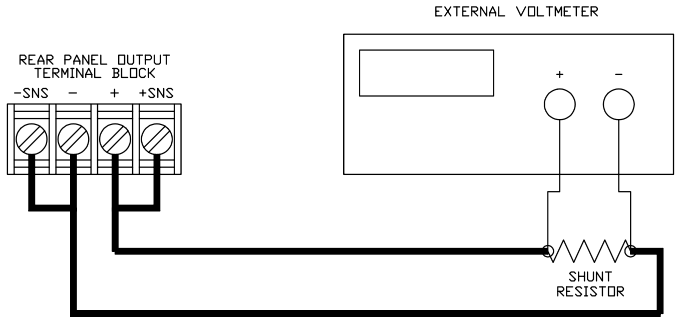


Figure 4.3-1 Current Calibration Setup

4.3.1 Current Calibration Setup

1. Disconnect the load from the power supply to be calibrated.
2. Connect a shunt across the supply's output terminals.
3. Connect a voltmeter across the shunt.

Refer to Figure 4.3-1.

4.3.2 Current Program Calibration Procedure

1. Ensure the current shunt has been connected to the power supply as shown in Section 4.3.1 Current Calibration Setup.
2. Send **CMODE ON** or **CMODE 1** to activate calibration mode.
3. Send **ILO; VLO** to the power supply you want to calibrate. Measure and record the output that is shown on the external meter.
4. Send **IHI; VHI** to the supply, then measure and record the output voltage as shown on the external meter.
5. Calculate **ILO** and **IHI** from the voltages measured.
6. Send the command **IDATA <ilo>,<ihi>** where <ilo> and <ihi> are the values obtained with the **ILO** and **IHI** commands. When the power supply is calibrated, the low to high current program calibration values are stored as constants.
7. Program the supply at various levels using the **ISET** command to confirm that the calibration was successful and that linearity is observed. Refer to the current program accuracy specification in Appendix A.
8. Turn off calibration mode by sending the **CMODE OFF** or **CMODE 0** command.

4.3.3 Current Readback Calibration Procedure

1. Ensure the current shunt has been connected to the power supply as shown in Section 4.3.1 Current Calibration Setup. Connecting a DVM is optional.
2. Send **CMODE ON** or **CMODE 1** to activate calibration mode.
3. Send **IRLO; VRLO** to the power supply you want to calibrate. Wait for supply to settle. Measure and record the output that is shown on the external meter. Send **IRLO** again.
4. Send **IRHI; VRHI** to the supply. Wait for supply to settle. Then measure and record the output voltage as shown on the external meter. Send **IRHI** again.
5. Calculate **IRLO** and **IRHI** from the voltages measured.
6. Send the command **IRDAT <ilo>,<ihi>** where <ilo> and <ihi> are the values obtained with the **IRLO** and **IRHI** commands. When the power supply is calibrated, the low to high current readback calibration values are stored as constants. Refer to the current readback accuracy specification in Appendix A.
7. Program and readback the output of the supply at various levels using the **ISET** and **IOUT?** commands to confirm that the calibration was successful and that linearity is observed.
8. Turn off calibration mode by sending the **CMODE OFF** or **CMODE 0** command.

4.4 Over Voltage Protection (OVP) Calibration

We recommend that you perform OVP calibration every six months. Connecting a digital voltmeter as in Section 4.2.1 Voltage Calibration Setup is optional.

1. Disconnect any load from the supply.
2. Ensure that jumper 217 on the interface PCB is CLOSED to enable remote OVP calibration. (Jumper 217 is closed at the factory.)
3. Send **CMODE ON** or **CMODE 1** to activate calibration mode.
4. Send the command **OVCAL**.
5. Use the **OVSET**, **OVSET?**, and **VSET** commands to trip the OVP level, confirming that the calibration was successful. The red OVP LED will light up and the voltage will drop to zero. Use **RST** to clear the OVP condition. Refer to the OVP program accuracy specification in Appendix A.
6. Turn off calibration mode by sending the **CMODE OFF** or **CMODE 0** command.

5. MAINTENANCE

5.1 Introduction

This section describes the diagnostic LEDs found on the GPIB Interface printed circuit board (PCB) and provides lists of replacement parts for the interface.

5.2 Troubleshooting

5.2.1 Diagnostic LEDs

Computer Operating Properly (COP) LEDs

The GPIB Interface provides three diagnostic LEDs, located at CR13, CR14, and CR141 on its PCB. Refer to the PCB drawing, Figure 2.2-3, for their locations. At present, these LEDS illuminate to signal COP events for the interface's microprocessors. Issue a reset (**RST**) command to clear diagnostic LEDs.

The green COP LED at circuit designation CR13 indicates that the GPIB Interface microprocessor successfully recovered from an illegal operating code. The event is transparent to the GPIB communications bus and the GPIB Interface continues to function normally.

The red COP LED at CR14 indicates that a transparent restart caused by noise in the master processor circuitry has occurred.

The red COP LED at CR141 indicates that a transparent restart caused by noise in the slave processor circuitry has occurred.

5.3 Replaceable Parts

5.3.1 Parts Replacement and Modifications

Do not use substitute parts or make any unauthorized modifications to the interface to ensure that its safety features are not degraded.

5.3.2 Ordering Parts

Order parts from the factory using the parts numbers given in this section. When ordering parts, please include the model number and serial numbers. Since microprocessor and EPROM revisions may occur, check the revision number stamped on these parts if you should need to order a replacement.

5.3.3 GPIB Interface Parts for 60W and 300W Series Supplies

Table 5.3-1 Replaceable Parts

Designation	Description	Part #
C21, 23,24,35,41,45,46, 47,51,65, 80,83,91,98, 99,103,104,114,118,119, 123,143,152,161,164, 165 ,169,183,186,190, 191,206, 207,216, 222, 228,229, 232	0.33uF 50V Z5U +80 to -20% 5.00mm Cer Rad	CC-334F-09
C26,27,28,29,31,32	Empty Location	C-EMPT
C37, 173, 199	Empty Position	C-EMPT
C52	47µF 16V Tant 20% 5.0mm	CJ-470F-16
C53	2200µF 16V El Axial 12.5x30mm	CL-222A-16
C58,59,81,92,100,106, 107,128,129,144,145, 172, 233	10µF 25V Tantalum 20% 2.5mm	CJ-100D-25
C111, 127, 160, 170	10nF 100V X7R 10% 5.0mm Cer Rad Cap	CB-103F-16
C121, 122, 166	4.7µF 2.5mm 25V Tantalum capacitor	CJ-4U7D-25
C158, 159	1nF 100V X7R 10% 5.0mm Cer Rad Cap	CB-102F-16
C187,189	1µF 35V Tantalum 10% 2.5mm	CJ-1U0D-35
C193, 194, 195	0.33µF Metallized Polyprylene Axial Cap	CD-334A-C6
C223	100pF 100V Z5F 10% 5.00mm cer Rad	CB-101F-16
C224, 225	220pF 100V X7R 10% 5.0mm Cer Rad	CB-221F-16
CR2	Red Rectangular LED 2.5 x 5.0mm	DS-5556-R6
CR3	Green Rectangular LED. 2.5 x 5mm	DS-0394-G6
CR13	T1-3/4 1.8mcd @2mA Green LED	DS-4740-G2
CR14,141	T1-3/4 2 mcd @2mA Red LED	DS-4700-R2
CR50	4 Pin DIL 200V 1A Bridge Rectifier	CR-B012
CR62, 130,131, 132, 133, 148, 149, 150, 155, 176, 185, 197, 209, 226, 231, 235	1N4148 UR D035 75V 300mA	CR-4148
F205	7A Fast Fuse 250V 3AG	F2-0700-F
J6	IEEE-488 Right Angle PC Mount Connector	MC-0488-24
For J6	#4-40 x 5/16" Phillips Pan Head, Stainless Steel	MS-4P28-05

Continued on next page.

5.3.3 GPIB Interface Parts for 60W and 300W Series Supplies (continued)

Table 5.3-1 Replaceable Parts (continued)

Designation	Description	Part #
J7,8,9	Empty Location	J-EMPT
J10	8 Position RJ45 Filtered Modular Phone Jack	MC-458B-MJ
For J10	Ferrite Block	FE-0443-CL
J86, 125, 171, 198	9 Pin Male 0.1" Friction Lock	MC-0903-MC
J95, 117, 217	2 Pin Female 0.1" Header Jumper	MC-0201-JMP
J95, 217	2x1, 0.25"SQ, 0.1" Spacing Header	MC-0201-MC
J117	3x1, 0.25"SQ, 0.1" Spacing Header	MC-0300-MC
L134,135,136	33µH Inductor	L-0330
PCB	M9B GPIB Interface PCB , Rev. D	PC-6H9B-D
Q174	IRF640 NM 200V .18Ω 18A T0220	QF-0640-IR
Q181, 196, 208	PN2222A NB 40V 500mA 500mW TO92	QM-2222-A
Q213	XX2907A PB 60V .5mA 400mW TO92	QN-2907-A
R4,33,87,94	10 Pin SIP, 4.7k x 9, 2%	RX-4701-02
R11,12,15, 16, 115	3.92k 1% 1/4W	R-3921-41
R36, 38, 55, 69, 78, 83, 180, 202	4.75k 1% 1/4W	R-4751-41
R42, 44, 56, 88, 89, 112, 227	100Ω 1% 1/4W MF	R-1000-41
R49, 79, 116, 153, 168, 212, 214, 219	10k 1% 1/4W	R-1002-41
R61	10 Pin Bussed SIP, 10k, 2%	RX-1002-02
R63, 66, 68, 77, 84	511Ω 1% 1/4W	R-5110-41
R64, 67, 76, 85, 108, 147, 184, 234	1.00kΩ 1% 1/4W MF	R-1001-41
R96	10 Pin 10kΩ Isolated SIP, 2%	RY-1002-02
R101	10 Pin 330Ω Isolated SIP, 2%	RY-3300-02
R109, 126,218	100k 1% 1/4W MF	R-1003-41
R142, 178	2k 1% 1/4W MF	R-2001-41
R146, 154, 167	20.0k 1% 1/4W	R-2002-41
R156	10 Pin 20kΩ Isolated SIP, 2%	RY-2002-02
R157	10 Pin 100Ω Isolated SIP, 2%	RY-1000-02
R162,201,203	475Ω 1% 1/4W MF	R-4750-41
R175	4Ω 5W Wire Wound, 0.7"	RW-4R00-5
R177	27.4k 1% 1/4W	R-2742-41
R179	665k 1/4W 1%	R-6653-41
R200	180Ω 5% 1/4W CF	R-1800
R204 (model-specific)	60W, 7V-30V: 82.5k	R-8252-41
	60W, 60V-250V: 825k	R-8253-41
	300W, 15V-30V: 82.5k	R-8252-41
	300W, 60V: 825k	R-8253-41
R210	Empty Position	R-EMPT
R211	2.21k 1% 1/4W MF	R-2211-41

Continued on next page.

5.3.3 GPIB Interface Parts for 60W and 300W Series Supplies (continued)

Table 5.3-1 Replaceable Parts (continued)

Designation	Description	Part #
R215 (model-specific)	60W, 7V: 84.5k	R-8452-41
	60W, 15V: 178k	R-1783-41
	60W, 20V: 237k	R-2373-41
	60W, 30V: 357k	R-3573-41
	60W, 60V: 715k	R-7153-41
	60W, 120V: 1.43M	R-1434-41
	60W, 250V: 3.01M	R-3014-41
	300W, 15V: 178k	R-1783-41
	300W, 30V: 357k	R-3573-41
	300W, 60V: 715k	R-7153-41
R220	6.34k 1% 1/4W MF	R-6341-41
R221	36.5k 1% 1/4W MF	R-3652-41
Subplate	M9B GPIB Subplate	SM-6H9B-GPIB
For Subplate	IEEE488 Connector Hardware Set	MA-0488
SW1	8 Position 5V 0.1A Piano DIP Switch	SW-8156-KA3
U18	Programmed EPROM Master M9B V1.14	UM-6H5C-M114
For U18,95	28 Pin 0.6" Machined IC Socket	MC-M628-IC
U19	Empty Position	U-EMPT
U20	GPIB Octal Transceiver for Control Lines	UI-0161-CL
U22	GPIB Octal Transceiver for DIO	UI-0160-DIO
U25	40 Pin TLC 7210 GPIB Control	US-7210-P
U30	Empty Location	U-EMPT
U34	LM2940CT 3T 5V Low Sat. Regulator TO220	UR-2940-CT
For U34	Black Heatsink TO220 0.71"L x 0.5"H	HS-6107-B
For U34, 140	#4-40 x 1/4" Kep Nut Stainless Steel	MN-440Z-08
For U34, 140	#4-40 x 5/16" Phillips Pan Head Stainless Steel	MN-4P28-05
U40,182	Quad Pos. NAND Gate w. Schmitt Trig.	UH-C132
U43, 113	8.0 MHz TTL Clock Osc. Metal Pkg.	YM-0008-5
U48,82	MC34064P Power Reset IC TO92	US-3406-4P
U57,90	68 Pin PLCC 68HC11F1 μController	US-11F1-FN
For U57,90	PLCC Socket, 68 Pin	MC-PL68-IC
U70, 71	8 Pin DIP High Speed Dual Optocoupler	UP-2630
U72,75	6 Pin DIP 4N35 Optocoupler	UP-4N35
U73,74	Dual Photo Transistor Optocoupler	UP-MCT6
U95	Programmed EPROM Slave M9B V1.11	UM-6H8B-S111
U97, 102, 105	20 Pin DIP 74HCT 574 Octal Latch	UH-T574-N
U120	Unity Gain, Precision, Diffn Amplifier	UA-AMP3-GP
U124	16 bit Resolution DAC	UD-1600-JP
U139	+12V Low Dropout Regulator TO92	UR-7512-92
U140	-12V Low Current 3T Regulator TO92 10%	UR-7912-92
U151	8 Pin DIP LF353 Dual AMP FET Input	UA-0353-N
U163,188	Quad SPST CMOS Analog Switch Logic	UI-D445-DJ
U192	Quad OP AMP Rail-Rail	UA-2274-CN
U230	TLC372 Dual Differential Comparator	UA-C372-N

A.Specifications

The specifications in this section are warranted at 25°C ±5°C unless otherwise specified. All specifications are subject to change without notice.

A.1 Electrical Specifications for XT and HPD Series Supplies (GPIB Interface Installed)

Table A-1 Electrical Specifications for XT and HPD Series DC Power Supplies									
XT & HPD Models	**XT 7-6**	**XT 15-4**	**XT 20-3**	**XT 30-2**	**XT 60-1**	**XT 120-0.5**	**HPD 15-20**	**HPD 30-10**	**HPD 60-5**
Program Resolution									
Voltage	1.1mV	2.4mV	3.1mV	4.7mV	9.3mV	17mV	2.4mV	4.7mV	9.3mV
Current	1.0mA	0.6mA	0.5mA	0.3mA	0.2mA	0.1mA	2.8mA	1.4mA	0.7mA
OVP	1.0mV	2.4mV	3.1mV	4.7mV	9.3mV	17mV	2.4mV	4.7mV	9.3mV
Program Accuracy									
Voltage	10mV ±0.1%	20mV ±0.1%	20mV ±0.15%	30mV ±0.15%	200mV ±0.15%	400mV ±0.15%	60mV ±0.1%	70mV ±0.1%	90mV ±0.12%
Current	110mA ±0.15%	70mA ±0.15%	50mA ±0.15%	40mA ±0.15%	26mA ±0.2%	13mA ±0.2%	75mA ±0.12%	50mA ±0.12%	25mA ±0.1%
OVP	70mV	150mV	200mV	300mV	600mV	1.2V	1.5V	3V	6V
Readback Resolution									
Voltage	1.1mV	2.4mV	3.1mV	4.7mV	9.3mV	17mV	2.4mV	4.7mV	9.3mV
Current	1.0mA	0.6mA	0.5mA	0.3mA	0.2mA	0.1mA	2.8mA	1.4mA	0.7mA
Readback Accuracy[1]									
Voltage	10mV ±0.15%	10mV ±0.1%	10mV ±0.1%	15mV ±0.1%	35mV ±0.15%	70mV ±0.15%	45mV ±0.3%	90mV ±0.3%	175mV ±0.3%
Current	110mA ±0.15%	70mA ±0.15%	50mA ±0.15%	40mA ±0.15%	26mA ±0.2%	13mA ±0.2%	75mA ±0.12%	40mA ±0.12%	25mA ±0.1%

[1] Apply accuracy specifications according to the following voltage program accuracy example:
Set a model XT 15-4 power supply to 10 volts. The expected result will be within the range of 10 volts ± 20mV ± 0.1%.

B. ASSEMBLY SCHEMATIC

XT/HPD GPIB INTERFACE OPTION BOARD
XS-6H9B

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