XANTREX
Power to Innovate

Technical Manual for

Internal GPIB Interface for XT and HPD Series Power Supplies

Internal GPIB Interface

for XT and HPD Series Power Supplies

TECHNICAL MANUAL

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ABOUT THIS MANUAL

This is the technical manual for the Internal GPIB Interface, a Talker-Listener card installed in XT and/or HPD Series DC power supplies. This interface permits you to operate your power supplies from a computer terminal via the IEEE-488 bus. The interface allows up to 30 connected supplies to be controlled from one IEEE-488 primary address with possible restrictions due to cable lengths.

Rear panel connectors on the GPIB Interface provide access to the IEEE-488 communications bus and to any external sources you may require. To complete the link, the computer controller connects to the IEEE-488 communications bus via one of several interfaces available within the industry. You use the computer controller to relay GPIB commands such as Local Lockout, and device-dependent commands such as Set Output Voltage Level to a designated power supply located at a specific address on the bus. You also receive status information and service requests back from the 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 network of power supplies. Error messages, calibration procedures, schematics, and parts lists are also included.

Refer to your power supply manuals for installation, configuration, and operating procedures for your XT and HPD supplies.

MANUAL CORRECTIONS

Figures moved into text and page numbers revised. 95/02/14

About This Manual text corrected to remove reference to a serial link. 95/02/17

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SCHEMATIC:

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 comunications bus. This interface is used with **XT and HPD Series DC power supplies**. See **Figure 1.1-1**.

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 14-bit resolution. Additionally, the built-in DVM and current shunt measure the actual power supply output and provide you with accurate 14-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.

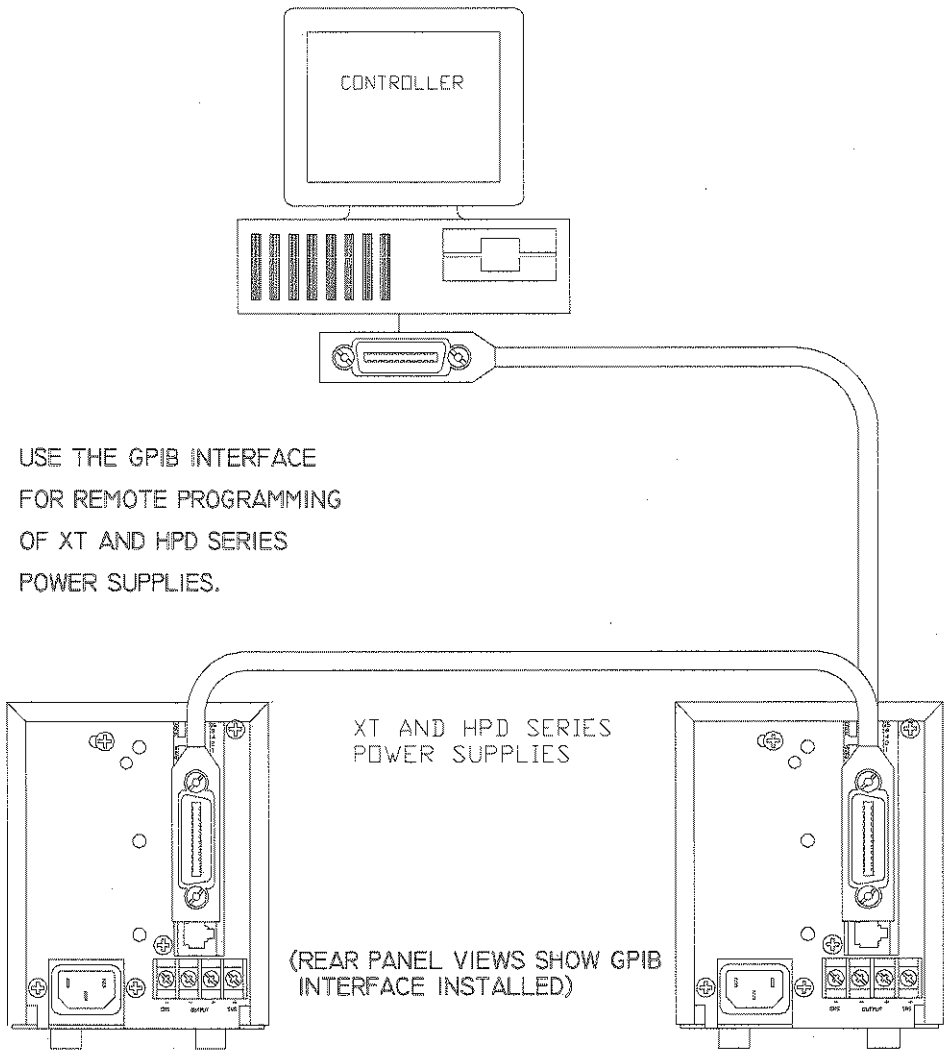


Figure 1.1-1 Sample Configuration using GPIB Interface

1.2 Features and Functions

Features

- 14-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

1.3 Specifications

1.3.1 Specifications for XT and HPD Series Supplies (GPIB Interface Installed)

(at 25°C ±5°C unless otherwise specified)

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	2.1mV	4.5mV	6mV	9mV	18mV	36mV	4.5mV	9mV	18mV
Current	1.8mA	1.2mA	0.9mA	0.6mA	0.3mA	0.15mA	6mA	3mA	1.5mA
OVP	3.5mV	7.5mV	10mV	15mV	30mV	60mV	7.5mV	15mV	30mV
Program Accuracy [1]									
Voltage	10mV	20mV	20mV	30mV	200mV	400mV	60mV	70mV	90mV
	±0.1%	±0.1%	±0.15%	±0.15%	±0.15%	±0.15%	±0.1%	±0.1%	±0.12%
Current	110mA	70mA	50mA	40mA	26mA	13mA	75mA	50mA	25mA
	±0.15%	±0.15%	±0.15%	±0.15%	±0.2%	±0.2%	±0.12%	±0.12%	±0.1%
OVP	70mV	150mV	200mV	300mV	600mV	1.2V	1.5V	3V	6V
Readback Resolution									
Voltage	2.1mV	4.5mV	6mV	9mV	18mV	36mV	4.5mV	9mV	18mV
Current	1.8mA	1.2mA	0.9mA	0.6mA	0.3mA	0.15mA	6mA	3mA	1.5mA
Readback Accuracy [1]									
Voltage	10mV	10mV	10mV	15mV	35mV	70mV	45mV	90mV	175mV
	±0.15%	±0.1%	±0.1%	±0.1%	±0.15%	±0.15%	±0.3%	±0.3%	±0.3%
Current	110mA	70mA	50mA	40mA	26mA	13mA	75mA	40mA	25mA
	±0.15%	±0.15%	±0.15%	±0.15%	±0.2%	±0.2%	±0.12%	±0.12%	±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% of the set voltage of 10 volts.

1.4 Initial Inspection

The GPIB Interface board is typically installed in the power supply at the factory and then shipped to you. If you have ordered the interface separately, your sales/service representative can ensure it is installed in your previously-purchased power supply.

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.

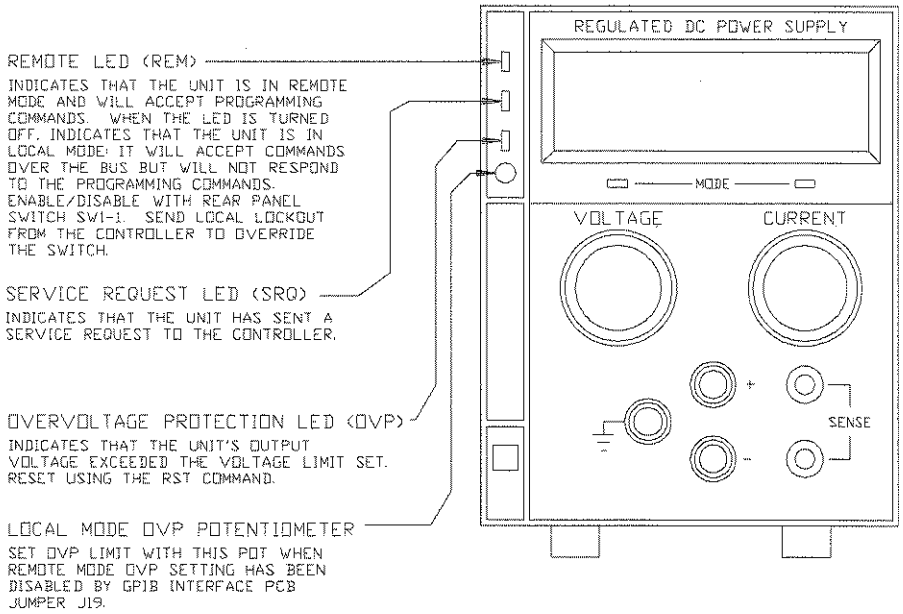
CAUTION

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

2. INSTALLATION AND CONFIGURATION

2.1 Introduction

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. However, you do need to configure the GPIB Interface-enhanced supply for your system using the Basic Setup Procedure, next.



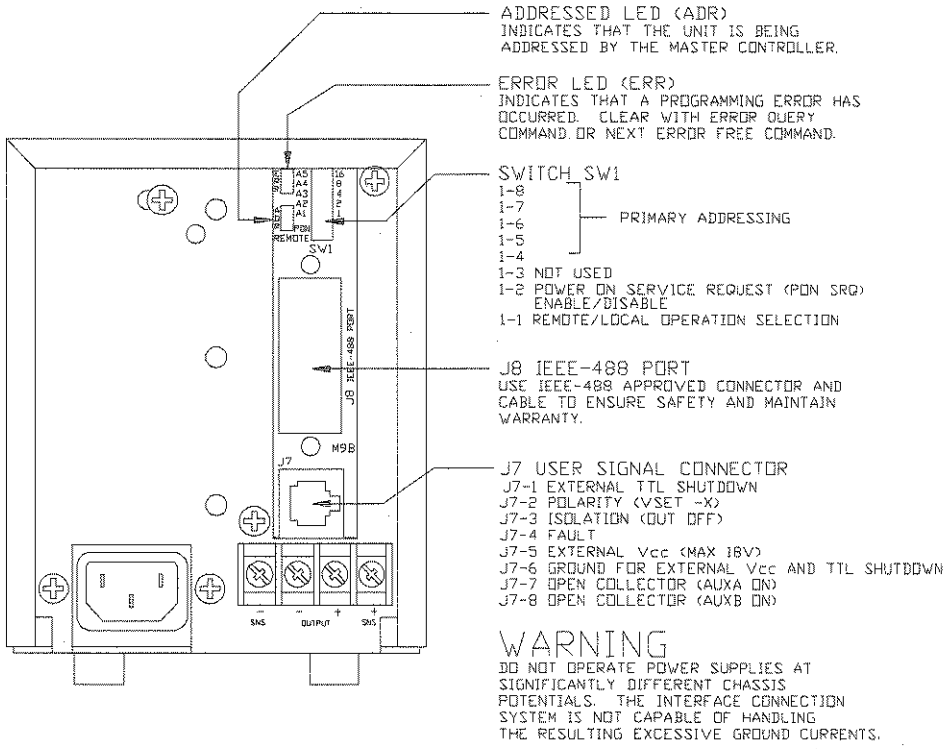


Figure 2.1-1 XT or HPD Series Supply Front and Rear Panels (GPIB Interface Installed)

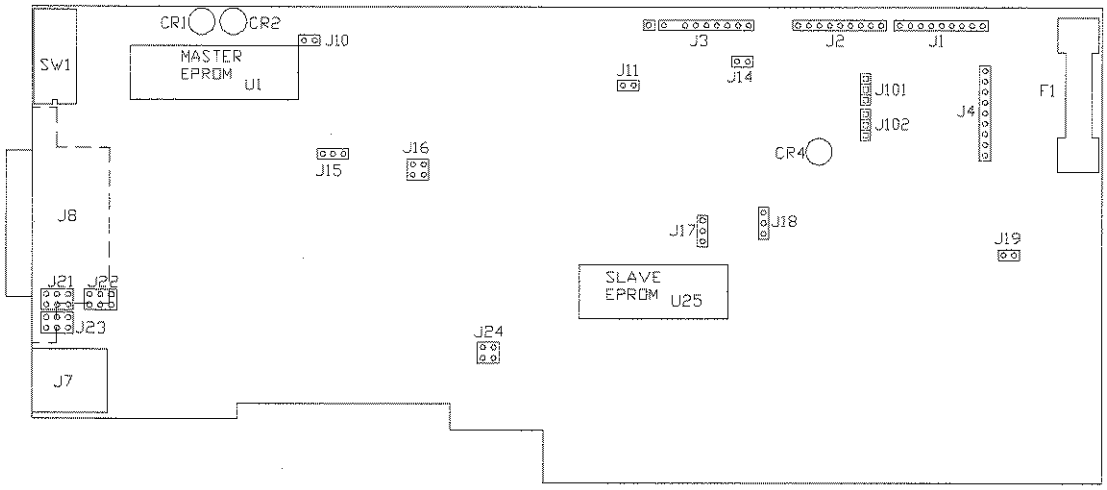
CAUTION

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

DIAGNOSTIC GREEN LED (CR1)- BUS ERROR HAS OCCURRED ON THE MASTER CIRCUITRY.

DIAGNOSTIC RED LED (CR2)- A SOFT RESTART HAS OCCURRED ON THE MASTER CIRCUITRY.

DIAGNOSTIC GREEN LED (CR4)- EITHER A BUS ERROR OR SOFT RESTART HAS OCCURRED ON THE SLAVE CIRCUITRY.



J10-NO CONNECTION. (FACTORY SET)
J11-MODEL IDENTIFICATION D EXTRA (FACTORY SET)
J14-MODEL IDENTIFICATION E EXTRA (FACTORY SET)
J15 (FACTORY SET) .
J16 (FACTORY SET) ADDRESS 16 LINE
J17-(FACTORY SET) ADDRESS 15 LINE (1-2)
J18-USER TTL SHUTDOWN (S/D) SELECTION
(1-2)- USER TTL SHUTDOWN LINE ACTIVE LOW
(2-3)- USER TTL SHUTDOWN LINE ACTIVE HIGH (DEFAULT)
J19-OVP CONTROL SELECTION.
(CLOSED) REMOTE PROGRAMMING OVP SETTINGS
(OPEN) LOCAL- FRONT PANEL POTENTIOMETER OVP SETTINGS
J24-(FACTORY SET) MODE 0/1 FOR MICROPROCESSOR
J101-XT/HPD SELECT (FACTORY SET) (1-2) FOR HPD, (2-3) FOR XT.
J102-XT/HPD SELECT (FACTORY SET) (1-2) FOR HPD, (2-3) FOR XT.

MASTER AND SLAVE EPROMS (U1 AND U25)- VERIFY REVISION LEVEL STAMPED ON EPROMS FOR TROUBLESHOOTING OR MAINTENANCE

FUSE (F1)- LOCATION GIVEN TO AID MAINTENANCE.

Figure 2.1-2 GPIB Interface PCB for XT and HPD Series Supplies

2.2 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 XT and HPD Series DC power supplies**. Refer also to **Figures 2.1-1 and 2.1-2** for drawings of the front panel, the rear panel, and the GPIB Interface printed circuit board (PCB) for XT and HPD Series supplies. The assembly schematic is inserted in **Section 5**.

1. By default, you control the over voltage protection (OVP) function via remote operation. For more information, see **Section 2.2.1 OVP Selection**.

2. Select a unique primary address to identify the power supply to the computer controller in a GPIB system. Use GPIB Interface rear panel switches S1-4 to S1-8 to set the primary address. See **Section 2.2.2 IEEE-488 Primary Address Selection**.

3. Set the unit to remote mode using rear panel switch S1-1 (Open). See also **Section 2.2.3 Remote/Local Operation** for remote Power ON conditions and information about the Local Lockout command.

4. Connect the IEEE-488 bus to the supply at connector J8. See **Section 2.2.4 IEEE-488 Controller Connection**.

5. Power on the unit. Before proceeding, check to ensure that the green REMOTE LED on the front panel is on. Refer to the front panel drawing for XT and HPD Series supplies, **Figure 2.1-1**. See also **Section 2.3 Additional Setup** and **Section 2.4 User Signals** for information about Power ON Service Request (PON SRQ), Local/Remote OVP, and auxiliary connector J7 user signals.

7. Configure the controller to match the power supply identification and characteristics using one of the available programs such as IBCONF (Interface Bus Configuration) from National Instruments. This program is used here as an example only.

8. Test the link by communicating with the power supply:

E.g.: VSET2;ISET1	This command string sets power supply voltage to 2V and its current limit to 1A.
E.g.: ibwrt "vset2;iset"	As above, using IBIC. *

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

2.2 Basic Setup Procedure (continued)

2.2.1 OVP Selection

OVP Selection for XT and HPD Supplies

Over voltage protection (OVP) for XT and HPD Series supplies with the GPIB Interface installed is set at the factory for remote, or programmed, operation by default. If you should wish to change OVP operation to local control, close jumper J19 on the GPIB Interface PCB. See **Figure 2.2-2**.

PCB JUMPER J19 POSITION	OVP PROGRAMMING SELECTION
Open	Local OVP operation selected
Closed	Remote OVP operation selected (default)

2.2.2 IEEE-488 Primary Address Selection

1. Choose an address: a number between 0 and 31 which is unique to your IEEE-488 bus, i.e., different from other device addresses on the same bus.

2. Locate switch S1 on the GPIB Interface rear panel. See **Figure 2.1-1** for the rear panel drawing.

3. Use five switch positions, S1-4 to S1-8, to set the primary address. Refer to the selection table.

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

IEEE-488 PRIMARY ADDRESS SELECTION											
Address	S1-4	S1-5	S1-6	S1-7	S1-8	Address	S1-4	S1-5	S1-6	S1-7	S1-8
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	**31**	1	1	1	1	1

2.2 Basic Setup Procedure (continued)

2.2.3 Remote/Local Operation

You can enable or disable remote or local operation of your XT or HPD Series supply in one of three ways:

- Rear panel Remote/Local switch S1-1, or
- IEEE-488 Local Lockout command, or
- Device-dependent LOC command

Remote/Local Switch

Use the rear panel Remote/Local switch S1-1 to toggle between remote and local operation without losing programmed values. To locate the switch, refer to the rear panel drawing in **Figure 2.1-1**.

REAR PANEL SWITCH S1-1 POSITION	OPERATION SELECTED
Open	Remote Operation Selected
Closed	Local Operation Selected

Powering up in remote mode will result in the following default operating conditions. See also **Section 3.5 Command Reference**.

REMOTE MODE POWER ON CONDITIONS		
Condition	**Default**	**XT Model 7-6 Defaults Example**
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 2.2.4**), you may send Local Lockout to the power supply via the IEEE-488 bus to override the REMOTE switch S1-1 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.

Example on next page.

2.2.3 Remote/Local Operation

IEEE-488 Local Lockout Command (continued)

E.g.:	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.

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**.

2.2.4 IEEE-488 Controller Connection

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 2.1-1**.

CAUTION

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

2.3 Additional Setup

2.3.1 Power On Service Request (PON SRQ)

Set the rear panel PON SRQ switch S1-2 to cause a service request to be sent to the computer controller when the power supply is turned on or when it reinitializes after a momentary power interrupt. The front panel SRQ LED will also turn on. You may 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.

REAR PANEL SWITCH S1-2 POSITION	PON SRQ STATE
Open	PON SRQ Enabled
Closed	PON SRQ Disabled

2.3.2 Local/Remote Overvoltage Protection (OVP)

Control the overvoltage protection function via remote programming by issuing settings and commands from the computer controller. Or, use local control by programming OVP from the power supply's front panel. For additional information about local OVP programming, refer to the power supply manual.

The factory-set default enables remote OVP operation of the XT and HPD Series supplies with the GPIB Interface installed. If you should wish to use the supply's front panel for OVP operation, select local OVP operation with XT/HPD GPIB Interface PCB jumper J19. See **Section 2.2.1**.

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. To locate the connector, refer to GPIB Interface rear panel drawings in **Figure 2.1-1**. See also **Section 3.5 Command Summary**.

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**)

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 switchers, 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.

IEEE-488 INTERFACE FUNCTIONS 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 GPIB Operation (continued)

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 2.2.3** and **2.3.1**.

E.g.:	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.

E.g.: Use HOLD Command to set values to be executed when triggered. See **Section 3.5**.
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.

E.g.:	ibrpp	Conduct a parallel poll, or
	PPOLL	Perform 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 2.2.3 Remote/Local Operation**.

E.g.:	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 GPIB Operation (continued)

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 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 2.3.1**.

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.

E.g.: ibrsp Return serial poll byte.

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

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>

PARAMETERS		
<current>	<float> default **A** (amps) or specify **mA** or decimal value for milliamps	
<fault mask>	a combination of **CV, CC, OV, SD, ERR,** and/or **FOLD**. **PON** if enabled.	
<float>	optional sign, e.g.: **+1.23** or **-1.23** or **1.23** integer.integer, e.g.: **1.2** .integer, e.g.: **.1** integer, e.g.: **1** integer., e.g.: **1.** optional E (scientific notation):	optional sign, e.g.: **1.23 E-1** optional integer. After the E plus a sign, you must use an integer, e.g.: **E-1** or **E+1** At least one digit must precede E. Lower case e and upper case E are treated as the same
<seconds>	<float> followed by **s** (seconds; default) or **ms** (milliseconds)	
<status bits>	a combination of **CV, CC, OV, SD, FOLD, ERR, PON,** and/or **REM**	
<voltage>	<float> followed by **V** (volts; default) or **mV** (millivolts)	
<other>	See **Section 3.5 Command Reference** for other, command-specific parameters such as **1, 0, ON, OFF, ALL,** or **NONE**	

Notes:

1. You may enter commands and parameters in upper or lower case letters.

2. 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.

   E.g.: OUT ON

   Numeric data may contain leading spaces. Embedded spaces between digits or between digits and decimal point are not accepted.

4. 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.

   E.g.: MASK CV,OV , FOLD

3.3 Command Syntax (continued)

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.

E.g.: ISET 2.0A;VSET 5V 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.

E.g.: 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.

E.g.: 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.

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.

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.

3.4 Command Summary (continued)

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.

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.

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

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 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> E.g.: ERR 0 (if no error)**
	Continued on next page.

3.5 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**. **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. **E.g.:** 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.

3.5 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 2.2.3 and 3.2.5**. **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**. 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.

3.5 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 19 on the interface PCB is connected. See **Section 2.3.2**.
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 2.3.1**. **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)**
	Continued on next page.

3.5 Command Reference (continued)

Command	Description
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 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.
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 FAU bit (position 0) is set in the serial poll register. See **Section 3.6 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>**
	Continued on next page.

3.5 Command Reference (continued)

Command	Description
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.
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 Acumulated Status, Status, and Fault Registers

To form a **status or fault mask** (i.e., **a bit mask**) individual bit weights are added and the resulting sum sent to the controller. To interpret the result, break down the sum using the component bit weight values from this table.

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

3.6 Accumulated Status, Status, and Fault Registers (continued)

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

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. **E.g.: VSET ,±10.3 V**
	Unrecognized String	An invalid command was received.
	Syntax Error	Incorrectly placed word, number, separator, or terminator was received. **E.g.: 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. **E.g.: 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 Calibration for XT and HPD Supplies

4.2.1 Voltage Mode Calibration for XT and HPD Supplies

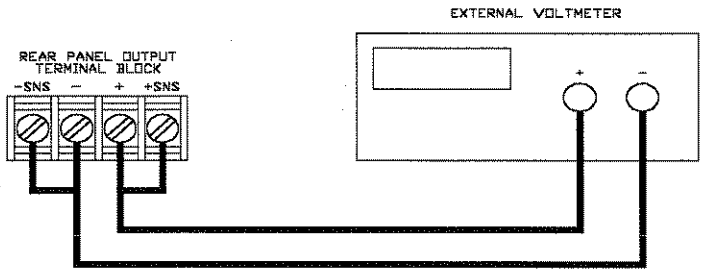


Figure 4.2-1 Voltage Calibration Setup (XT and HPD)

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**.

Voltage Program Calibration Procedure

1. Set up for calibration as in **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.
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 **Section 1**.
7. Turn off calibration mode by sending the **CMODE OFF** or **CMODE 0** command.

4.2.1 Voltage Mode Calibration for XT and HPD Supplies (continued)

Voltage Readback Calibration Procedure

1. Set up for calibration as in **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 **Section 1**.
7. Turn off calibration mode by sending the **CMODE OFF** or **CMODE 0** command.

4.2.2 Current Mode Calibration for XT and HPD Supplies

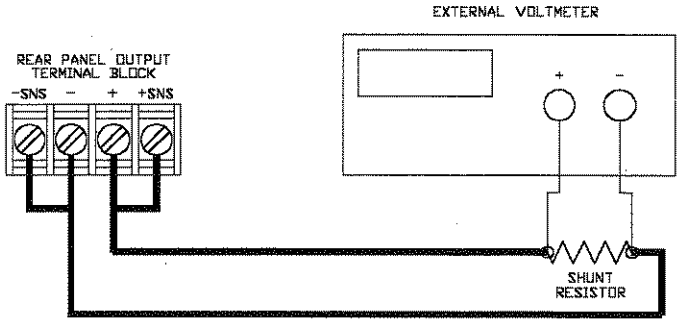


Figure 4.2-2 Current Calibration Setup (XT and HPD)

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 4.2-2**.

Current Program Calibration Procedure

1. Ensure the current shunt has been connected to the power supply as shown in **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.

➔

4.2.2 Current Mode Calibration for XT and HPD Supplies

Current Program Calibration Procedure (continued)

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 **Section 1**.
8. Turn off calibration mode by sending the **CMODE OFF** or **CMODE 0** command.

Current Readback Calibration Procedure

1. Ensure the current shunt has been connected to the power supply as shown in **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 **Section 1**.
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.

4.2.3 Over Voltage Protection (OVP) Calibration for XT and HPD Supplies

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

1. Disconnect any load from the supply.
2. Ensure that jumper 19 on the interface PCB is CLOSED to enable remote OVP calibration. (Jumper 19 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 **Section 1**.
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 CR1, CR2, and CR4 on its PCB. Refer to the PCB drawing, **Figure 2.1-2,** 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 CR1 indicates that the GPIB Interface microprocessor successfully recovered from an illegal operating code. The event is transparent to the GPIB comunications bus and the GPIB Interface continues to function normally.

The red COP LED at CR2 indicates that a transparent restart caused by noise in the master processor circuitry has occurred.

The red COP LED at CR4 indicates that a transparent restart caused by noise in the slave processor circuitry has occurred.

5.3 Replaceable Parts

In this section, you will find parts lists for the GPIB Interface assembly. Each of the parts and options listed can be ordered separately.

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 Replaceable Parts (continued)

5.3.3 GPIB Interface Parts for XT and HPD Series Supplies

Designation	Description	Part #
	#4-40 x 1/4" Philips Pan ZINC	MS-4P00-04
C1	47µF 16V Tant 20% 5.0mm	CJ-470F-16
C2,3,5,6,16,18,21,23, 25,27,28,31,37,38, 40,41,43,52-54,57, 58, 60-65,70-73,107	0.1µF 50V Z5U +80% to -20% 2.5mm Cer Rad Cap	CC-104D-09
C4,19,26	100pF 100V Z5F 10% 5.0mm Cer Rad Cap	CB-101F-16
C9,11-13,29,30, 35,36,39	10µF 25V Tantalum 20% 2.5mm	CJ-100D-25
C17	2200µF 16V El Axial 12.5x30mm	CL-222A-16
C22,32,51	0.1µF 50V Z5U +80% TO -20% 2.5mm Cer Rad	CC-104D-09
C42,59	1µF 35V Tantalum 10% 2.5mm	CJ-1U0D-35
C45-50	Empty Position	C-EMPT
C55,56,66,68,69, 74,104	4.7µF 2.5mm 25V Tantalum capacitor	CJ-4U7D-25
C67,105,106	10nF 100V X7R 10% 5.0mm Cer Rad Cap	CB-103F-16
C75,76,77	0.33µF Metallized Polyprylene Axial Cap	CD-334A-C6
C101,102,103	1nF 100V X7R 10% 5.0mm Cer Rad Cap	CB-102F-16
CR1	T1-3/4 1.8mcd @2mA Green LED	DS-4740-G2
CR2,4	T1-3/4 2 mcd @2mA Red LED	DS-4700-R2
CR3	4 Pin DIL 200V 1A Bridge Rectifier	CR-B012
CR5,8-15,17-24	1N4148 UR D035 75V 300mA	CR-4148
CR6	Red Rectangular LED 2.5 x 5.0mm	DS-5556-R6
CR7	Green Rectangular LED. 2.5 x 5mm	DS-0394-G6
F1	7A Fast Fuse 250V 3AG	F2-0700-F
For F1	3AG Silver Plate BeCu PC Mount Fuseclip	MC-3101-FC
J1,2,3	#22 x 9, 3.5" Flat Cable Assembly	WA-0922-07
J4	#22 x 9, 4.5" Flat Cable Assembly	WA-0922-09
J7	8 Position RJ45 Filtered Modular Phone Jack	MC-458B-MJ
J8	IEEE-488 Conn. Hardware	MA-0488
For J8	#6 Fiber Washer 0.312 x 0.062 Thick	MI-6410-62
For J8	IEEE-488 Rt. Angle PC Mount Connector	MC-0488-24
J10,11,14,16,19,24	2x1, 0.25"SQ, 0.1" Spacing Header	MC-0201-MC
J15	3x1, 0.25"SQ, 0.1" Spacing Header	MC-0300-MC
J17,18	3x1, 0.25"SQ, 0.1" Spacing Header	MC-0300-MC
L1,2,3	33µH Inductor	L-0330
PCB	M9B GPIB/RS232 PCB for XT/HPD REV. A	PC-6H9B-A
Q1,3,4	PN2222A NB 40V 500mA 500mW TO92	QM-2222-A
Q2	IRF640 NM 200V .18Ω 18A T0220	QF-0640-IR
For Q2	#6-32 x 1/4" Philips Pan Zinc	MS-6P00-04
Q5	XX2907A PB 60V .5mA 400mW TO92	QN-2907-A

Continued on next page.

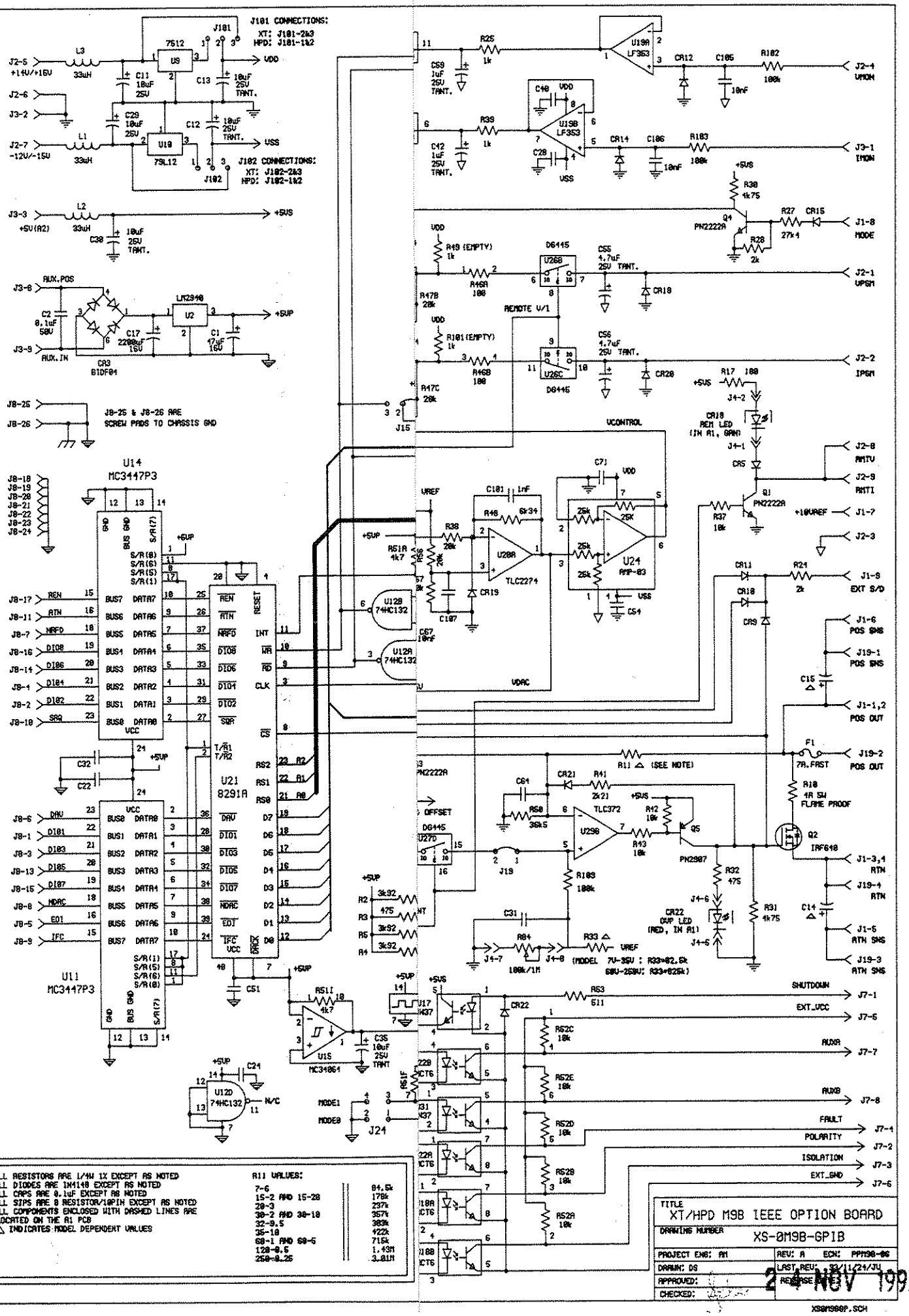
5.3.3 GPIB Interface Parts for XT and HPD Series Supplies (continued)

Designation	Description		Part #
R1,9,35,51	10 Pin SIP, 4.7k x 9, 2%		RX-4701-02
R2,4,5,15	3.92k 1% 1/4W		R-3921-41
R3,18,32	475Ω 1% 1/4W MF		R-4750-41
R6,14,21	2.15k 1% 1/4W		R-2151-41
R7,13,22,25,39,49,55, 58,101	1.00kΩ 1% 1/4W MF		R-1001-41
R8,16,37,42,43,57,110	10k 1% 1/4W		R-1002-41
R10	4Ω 5W Wire Wound, 0.7"		RW-4R00-5
R11	XT Model:	Resistor:	
	7V	84.5k	R-8452-41
	15V	178k	R-1783-41
	20V	237k	R-2373-41
	30V	357k	R-3573-41
	60V	715k	R-7153-41
	120V	1.43M	R-1434-41
	250V	3.01M	R-3014-41
R11	HPD Model:	Resistor:	
	15V	178k	R-1783-41
	30V	357k	R-3573-41
	32V	383k	R-3833-41
	35V	422k	R-4223-41
	60V	715k	R-7153-41
For R11,33	Socket .025" Comp. Lead, 0.052 Mounting Hole		MC-5315-MS
R12,19,20,108	4.75k 1% 1/4W		R-4751-41
R17	180Ω 5% 1/4W CF		R-1800
R23	1.62k 1%1/4W MF		R-1621-41
R24,28	2k 1% 1/4W MF		R-2001-41
R26,38,56	20.0k 1% 1/4W		R-2002-41
R27	27.4k 1% 1/4W		R-2742-41
R29,40	2.2MΩ 1% 1/4W		R-2204-41
R30,31,108	4.75k 1% 1/4W		R-4751-41
R33	XT Model:	Resistor:	
	7V-30V	82.5k	R-8252-41
	60V-250V	825k	R-8253-41
	HPD Model:	Resistor:	
	15V-30V	82.5k	R-8252-41
	60V	825k	R-8253-41
R41	2.21k 1% 1/4W MF		R-2211-41
R45	10k 1% 1/4W		R-1002-41
R46	10 Pin 100Ω Isolated SIP, 2%		RY-1000-02
R47	10 Pin 20kΩ Isolated SIP, 2%		RY-2002-02
R48	6.34k 1% 1/4W MF		R-6341-41
R50	36.5k 1% 1/4W MF		R-3652-41
R52	10 Pin Bussed SIP, 10k, 2%		RX-1002-02
R53	511Ω 1% 1/4W		R-5110-41
R54	10 Pin 330Ω Isolated SIP, 2%		RY-3300-02
R102,103,109	100k 1% 1/4W MF		R-1003-41
R111	10 Pin 10kΩ Isolated SIP, 2%		RY-1002-02

Continued on next page.

5.3.3 GPIB Interface Parts for XT and HPD Series Supplies (continued)

Designation	Description	Part #
Subplate	XT/HPD M9B GPIB Subplate	SM-6H9B-GPIB
SW1	8 Position 5V 0.1A Piano DIP Switch	SW-8156-KA3
U1	Programmed EPROM Master M9B V1.10	UM-6H5C-M110
For U1	32 Pin Machined Socket 0.6"	MC-M632-IC
U2	LM2940CT 3T 5V Low Sat. Regulator TO220	UR-2940-CT
For U2	Black Heatsink TO220 0.71"L x 0.5"H	HS-6107-B
For U2,Q2	#4-40 x 5/16" Philips Pan Zinc	MS-4P00-05
For U2,Q2	#4 Nylon Shoulder Washer, 0.12"SD x 0.22"	MI-0412-SW
For U2,U8,Q2	#4-40 x 1/4" KEP Nut Steel/CAD	MN-440K-08
U3,6,13	Low I/P Current High Speed Optocoupler	UP-2300
For U3,6,13,18,19, 22,24,29	8 Pin Machined IC Socket 0.3"	MC-M308-IC
U4	MC34064P Power Reset IC TO92	US-3406-4P
U5	Empty Position	UM-EMPT
U7	68 Pin PLCC 68HC11F1 µController	US-11F1-FN
For U7	68 Pin PLCC Socket	MC-PL68-IC
U9	+12V Low Dropout Regulator TO92	UR-7512-92
U10	-12V Low Current 3T Regulator TO92 10%	UR-7912-92
U11,14	24 Pin DIP GPIB Octal Transceiver SK 0.3"	UI-3447-P3
For U11,14	24 Pin Machined IC Socket 0.3"	MC-M324-IC
U12	Quad Pos. NAND Gate w. Schmitt Trig.	UH-C132
For U12	14 Pin Machined IC Socket 0.3"	MC-M314-IC
U15	MC34064P Power Reset IC TO92	US-3406-4P
U16	68 Pin PLCC 68HC11F1 µController	US-11F1-FN
For U16	68 Pin PLCC Socket	MC-PL68-IC
U17,31	6 Pin DIP 4N37 Optocoupler	UP-4N37
For U17,31	6 Pin Socket	MC-0006-IC
U18,22	Dual Photo Transistor Optocoupler	UP-MCT6
U19	8 Pin DIP LF353 Dual AMP FET Input	UA-0353-N
U20	Quad Pos. NAND Gates	UH-C132
For U20,28	14 Pin Machined IC Socket 0.3"	MC-M314-IC
U21	40 Pin DIP 8291 GPIB Talk/Listen	US-8291-AP
For U21	40 Pin Machined IC Socket 0.6"	MC-M640-IC
U23,32	20 Pin DIP 74HCT 574 Octal Latch	UH-T574-N
For U23,32	20 Pin Machined IC Socket 0.3"	MC-M320-IC
U24	Unity Gain, Precision, Diffn Amplifier	UA-AMP3-GP
U25	Programmed EPROM Slave M9B V1.10	UM-6H8B-S110
For U25	28 Pin Machined IC Socket 0.6"	MC-M628-IC
U26,27	Quad SPST CMOS Analog Switch Logic	UI-D445-DJ
For U26,27	16 Pin Machined IC Socket 0.3"	MC-M316-IC
U28	Quad OP AMP Rail-Rail	UA-2274-CN
U29	TLC372 Dual Differential Comparator	UA-C372-N
U33	16 bit Resolution DAC	UD-1600-JP
For U33	24 Pin Machined Socket 0.6"	MC-M624-IC
U34	8.0 MHz TTL Clock Osc. Metal Pkg.	YM-0008-5
U35	8.0MHz TTL Clock Osc. Metal Pkg.	YM-0008-5


J101 CONNECTIONS:
XT: J101-2&3
HPD: J101-1&2
J102 CONNECTIONS:
XT: J102-2&3
HPD: J102-1&2
J2-5 +14V/+15V
J2-6
J3-2
J2-7 -12V/-15V
J3-3 +5V(A2)
J3-8 AUX.POS
J3-9 AUX.IN
J8-25 & J8-26 ARE SCREW PADS TO CHASSIS GND
U14 MC3447P3
U11 MC3447P3
U21 8291A
U15 MC34064
U19B LF353
U26B
U26C
U24 AMP-03
U28A TLC2274
U29B TLC372
REMOTE V/I
VCONTROL
VDAC
J15
J24
MODE1
MODE0
SHUTDOWN
EXT_VCC
AUXR
AUXB
FAULT
POLARITY
ISOLATION
EXT_GND
VMON
IMON
MODE
VPGM
IPGM
AMTV
AMTI
+10VREF
EXT S/D
POS SNS
POS OUT
RTN
RTN SNS
REN LED (IN A1, GRN)
OVP LED (RED, IN A1)
FLAME PROOF
R11 (SEE NOTE)
1. ALL RESISTORS ARE 1/4W 1% EXCEPT AS NOTED
2. ALL DIODES ARE 1N4148 EXCEPT AS NOTED
3. ALL CAPS ARE 0.1uF EXCEPT AS NOTED
4. ALL SIPS ARE 8 RESISTOR/10PIN EXCEPT AS NOTED
5. ALL COMPONENTS ENCLOSED WITH DASHED LINES ARE LOCATED ON THE A1 PCB
6. △ INDICATES MODEL DEPENDENT VALUES
R11 VALUES:
7-6 84.5k
15-2 AND 15-28 178k
20-3 237k
30-2 AND 30-10 357k
32-9.5 383k
35-10 422k
60-1 AND 60-5 715k
120-9.5 1.43M
250-8.25 3.01M
TITLE
XT/HPD M9B IEEE OPTION BOARD
DRAWING NUMBER
XS-0M9B-GP1B
PROJECT ENG: AM
REV: A
ECN: PP1998-06
DRAWN: DS
LAST REV: 93/11/24/JU
APPROVED:
RELEASE:
CHECKED:
24 NOV 1993
XS0M9B0P.SCH