GPIB

GPIB-140A User Manual

Worldwide Technical Support and Product Information

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For further support information, see the *Technical Support Resources* appendix. To comment on the
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Important Information

Compliance

FCC/DOC Radio Frequency Interference Class A Compliance

This equipment generates and uses radio frequency energy and, if not installed and used in strict accordance with the instructions in this manual, may cause interference to radio and television reception. Classification requirements are the same for the Federal Communications Commission (FCC) and the Canadian Department of Communications (DOC). This equipment has been tested and found to comply with the following two regulatory agencies:

Federal Communications Commission

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Notices to User: *Changes or modifications not expressly approved by National Instruments could void the user's authority to operate the equipment under the FCC Rules.*

This device complies with the FCC rules only if used with shielded interface cables of suitable quality and construction. National Instruments used such cables to test this device and provides them for sale to the user. The use of inferior or nonshielded interface cables could void the user's authority to operate the equipment under the FCC rules.

If necessary, consult National Instruments or an experienced radio/television technician for additional suggestions. The following booklet prepared by the FCC may also be helpful: *Interference to Home Electronic Entertainment Equipment Handbook*. This booklet is available from the U.S. Government Printing Office, Washington, DC 20402.

Canadian Department of Communications

This Class A digital apparatus meets all requirements of the Canadian Interference-Causing Equipment Regulations.

Cet appareil numérique de la classe A respecte toutes les exigences du Règlement sur le matériel brouilleur du Canada.

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About This Manual

This manual describes how to install, configure, and operate the National Instruments GPIB-140A or GPIB-140A/2 bus extender.

Conventions

The following conventions appear in this manual:

This icon denotes a note, which alerts you to important information.

This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash.

bold   Bold text denotes the names of LEDs.

GPIB-140A   GPIB-140A refers to a National Instruments GPIB extender that extends the GPIB to a maximum distance of 1 km.

GPIB-140A/2   GPIB-140A/2 refers to a National Instruments GPIB extender that extends the GPIB to a maximum distance of 2 km.

GPIB extender   GPIB extender refers to the GPIB-140A and the GPIB-140A/2.

IEEE 488 and   *IEEE 488* and *IEEE 488.2* refer to the ANSI/IEEE Standard 488.1-1987
IEEE 488.2   and the ANSI/IEEE Standard 488.2-1992, respectively, which define the GPIB.

italic   Italic text denotes variables, emphasis, a cross reference, or an introduction to a key concept. This font also denotes text that is a placeholder for a word or value that you must supply.

`monospace`   Text in this font denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames and extensions, and code excerpts.

Related Documentation

The following documents contain information that you might find helpful as you read this manual:

- ANSI/IEEE Standard 488.1-1987, *IEEE Standard Digital Interface for Programmable Instrumentation*

- ANSI/IEEE Standard 488.2-1992, *IEEE Standard Codes, Formats, Protocols, and Common Commands*

1

Introduction

This chapter lists what you need to get started and briefly describes the GPIB-140A bus extender.

What You Need to Get Started

Before you connect your GPIB-140A or GPIB-140A/2, make sure you have all of the following items:

❑ One of the following GPIB-140A or GPIB-140A/2 bus extenders, which is included in your kit:

> U.S. 100–120 VAC
> Switzerland 220–240 VAC
> Australia 220–240 VAC
> Universal European 220–240 VAC
> North American 220–240 VAC
> U.K. 220–240 VAC

❑ One of the following standard 3-wire power cables, which is included in your kit:

> 100–120 VAC
> 220–240 VAC

❑ One of the following transmission cables, which you can purchase from National Instruments:

> Type T7 fiber-optic cable—up to 1 km (used with GPIB-140A)
> Type T8 fiber-optic cable—up to 2 km (used with GPIB-140A/2)

❑ One of the following shielded GPIB cables, which you can purchase from National Instruments:

> Type X1 single-shielded cables (1, 2, or 4 m)
> Type X2 double-shielded cables (1, 2, or 4 m)

⚠ **Caution** To meet FCC emission limits for this device, you must use a shielded (Type X1 or X2) GPIB cable. If you operate this equipment with a non-shielded cable, it may interfere with radio and television reception.

Hardware Overview

✎ **Note**   You cannot use the GPIB-140A or GPIB-140A/2 bus extenders to communicate with either a GPIB-140 or GPIB-140/2 bus extender. The GPIB-140A and GPIB-140A/2 bus extenders use a different protocol to communicate with each other across the fiber optic cable.

The GPIB-140A and GPIB-140A/2 are high-speed bus extenders that you can use in pairs with fiber-optic cable to connect two separate GPIB systems in a functionally transparent manner.

Although the two bus systems are physically separate, as shown in Figure 1-1, devices logically appear to be located on the same bus, as shown in Figure 1-2.
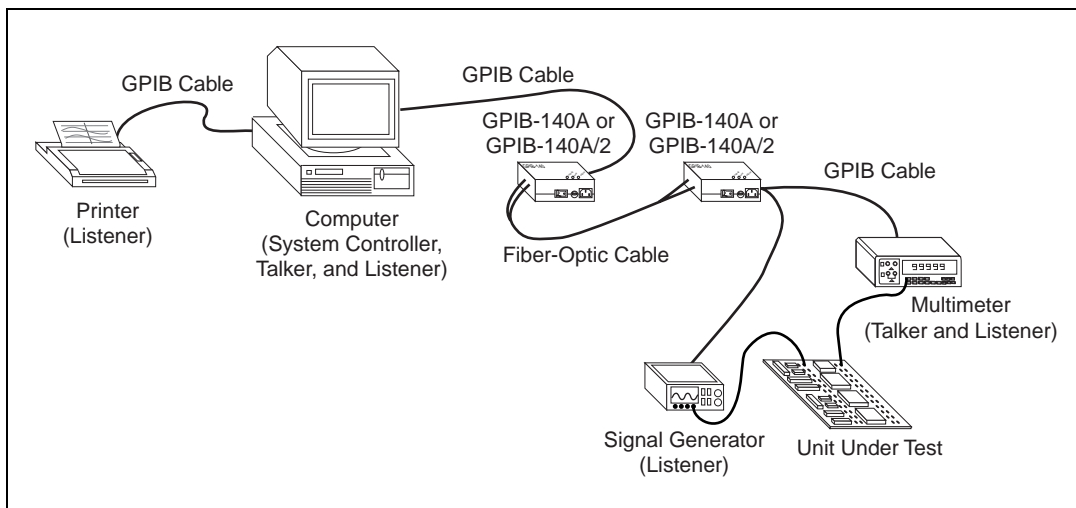
Figure 1-1. Typical Extension System (Physical Configuration)
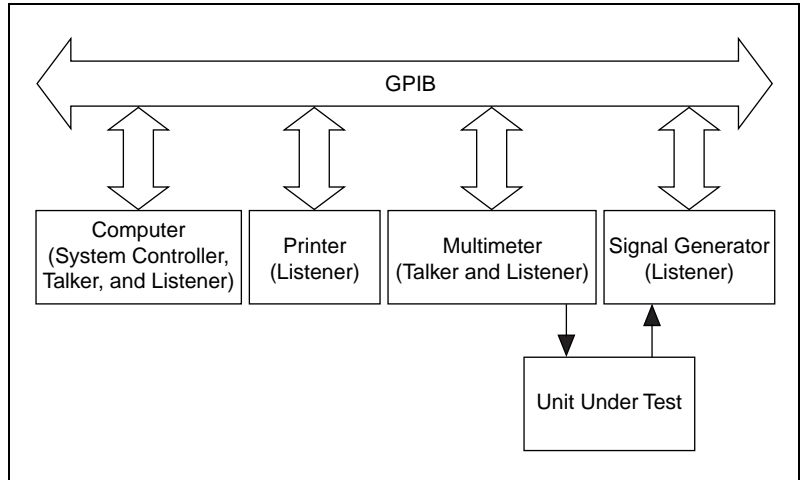
Figure 1-2. Typical Extension System (Logical Configuration)

The GPIB-140A and GPIB-140A/2 bus extenders comply with the specifications of the ANSI/IEEE Standard 488.1-1987 and the ANSI/IEEE Standard 488.2-1992, including the Find Listeners protocol. With the GPIB extenders, you can overcome the following two configuration restrictions imposed by IEEE 488:

•   A cable length limit of 20 m total per contiguous bus or 2 m per each device on the bus, whichever is smaller

•   An electrical loading limit of 15 devices per contiguous bus

Each GPIB-140A system extends the GPIB to a maximum distance of 1 km, and each GPIB-140A/2 system extends the GPIB to a maximum distance of 2 km. Both systems extend the loading limit to 28 devices (including the GPIB extenders), without sacrificing speed or performance. You can connect these point-to-point extension systems in series for longer distances or in star patterns for additional loading.

Using the HS488 protocol, the maximum data transfer rate over the extension is greater than 2.8 Mbytes/s. The GPIB extenders use a buffered transfer technique with a serial extension bus, which maximizes performance and minimizes the cabling cost. Furthermore, the extender does not affect the transfer rate between devices on the same side of the extension. The GPIB extender can also check for errors to make sure that the data transmitted successfully over the fiber-optic link.

Because the GPIB-140A and GPIB-140A/2 are functionally transparent extenders, the GPIB communications and control programs that work with an unextended system also work with an extended system. However, the *Parallel Poll Response Modes* section in Chapter 3, *Configuring and Using Your Hardware*, describes one exception to this transparency in conducting parallel polls.

Time-Saving Development Tools

Your kit includes the GPIB-140A or GPIB-140A/2 bus extender. In addition, you can order the NI-488.2, LabWindows/CVI, or LabVIEW software from National Instruments to speed your application development time and make it easier to communicate with your instruments.

The NI-488.2 software supports the concurrent use of multiple types of GPIB hardware. For example, you can communicate with GPIB devices through an AT-GPIB/TNT, a PCMCIA-GPIB, and a GPIB-ENET in the same system at the same time. The NI-488.2 software, along with the GPIB hardware, transforms your computer into a GPIB Talker/Listener/Controller with complete communications and bus management capability.

LabVIEW is an easy-to-use, graphical programming environment you can use to acquire data from thousands of different instruments, including IEEE 488.2 devices, VXI devices, serial devices, PLCs, and plug-in data acquisition boards. After you have acquired raw data, you can convert it into meaningful results using the powerful data analysis routines in LabVIEW. LabVIEW also comes with hundreds of instrument drivers, which dramatically reduce software development time, because you do not have to spend time programming the low-level control of each instrument.

LabWindows/CVI is similar to LabVIEW, except that it combines an interactive, easy-to-use development approach with the programming power and flexibility of compiled ANSI C code.

The GPIB Analyzer is another optional tool available from National Instruments that is useful in troubleshooting a variety of IEEE 488 hardware and software problems. With its built-in time-stamping capability, you can easily determine the throughput and overhead of

your GPIB systems. The GPIB Analyzer software for Windows 98/95 works with the AT-GPIB/TNT+ and PCMCIA-GPIB+ products, which provide GPIB Analyzer support along with the functionality of a high-performance GPIB Controller.

For ordering information, or to request free demonstration software, contact National Instruments.

2

Connecting Your Hardware

This chapter describes how to connect your GPIB extender and verify that it is working properly.

Step 1. Verify the DIP Switch Setting

The 3-bit DIP switch sets the operation mode of the GPIB extender. The default switch setting is for unbuffered transfer mode, latched parallel poll response (PPR), and HS488 disabled mode, as shown in Figure 2-1.
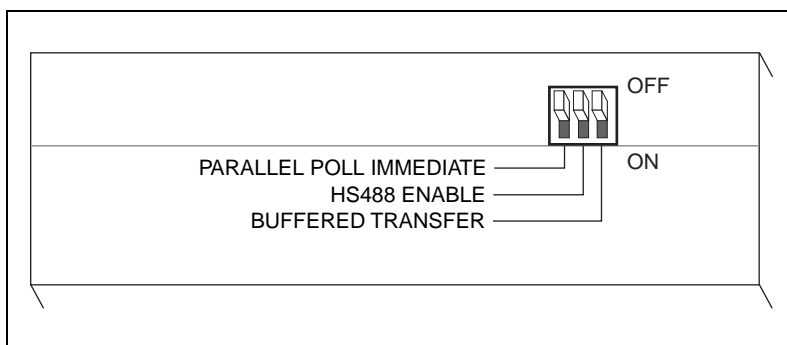
Figure 2-1. Default DIP Switch Setting

Verify that the DIP switches on your GPIB extender are in these default positions. If you need to change these settings, refer to Chapter 3, *Configuring and Using Your Hardware* for instructions on how to set the operation mode for your application.

Step 2. Connect the Cables

To connect the cables to both GPIB extenders, complete the following steps:

1. Make sure that each GPIB extender is powered off.

2. Connect the two connectors on each end of the fiber-optic cable to your GPIB extenders, as follows:

    a. As shown in Figure 2-2, align the connector marked T (transmit) with the connector marked TRANS on the side panel of the GPIB extender. Align the connector marked R (receive) with the connector marked RCVR on the side panel of the GPIB extender.
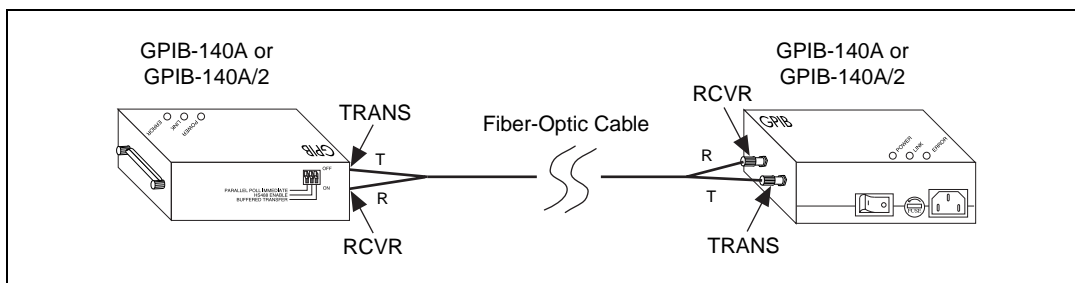
Figure 2-2. Connecting the Fiber-Optic Cable to Both GPIB Extenders

    b. Remove the caps on the connectors.

    c. Align the notch on each cable connector to the slot of the fiber-optic connector on the box.

    d. Firmly push in the cable connector and rotate the sleeve clockwise until it locks on to the side notch of the fiber-optic connector on the box.

3. Connect the end of the extender with the GPIB connector to your GPIB system. Make sure that you follow all IEEE 488 cabling restrictions. For typical restrictions, refer to the *Configuration Requirements* section in Appendix A, *GPIB Basics*.

4. Plug the utility power cord included with your GPIB extender into an AC outlet of the correct voltage.

5. Plug the other end of the utility power cord into your GPIB extender.

Step 3. Switch On Your GPIB Extender

Power on each GPIB extender. The **POWER** LED should light immediately. If the **POWER** LED does not light immediately, make sure that power is supplied to your GPIB extender.

The **LINK** LED lights only when both GPIB extenders are on and the fiber-optic cable is properly connected between them.

Step 4. Verify the Connection

Each GPIB extender has a self test that determines whether the GPIB extender receivers, transmitters, and packet transmission and reception circuitry are working properly.

To run the self test, complete the following steps:

1. Power off the GPIB extender.

2. Disconnect the fiber-optic cable from the GPIB extender.

3. Power on the GPIB extender.

    The **POWER** LED lights, indicating that power is supplied to the extender. The **LINK** LED remains off.

4. Connect the connector marked T (transmit) on one end of the fiber-optic cable to the connector marked TRANS on the side panel of the GPIB extender.

5. Connect the connector marked R (receive) on the opposite end of the fiber-optic cable to the connector marked RCVR on the side panel of the GPIB extender.
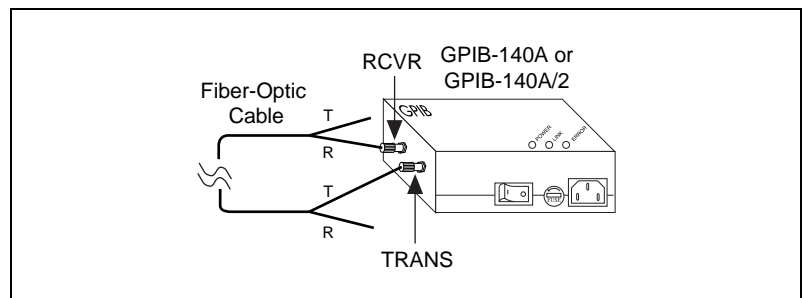
Figure 2-3. GPIB Extender Self-Test Configuration

The **LINK** LED lights, indicating that the cable is connected. The **ERROR** LED should remain off, indicating that the GPIB extender is working properly.

6. If the **ERROR** LED does not remain off, complete the following steps to solve the problem:

   a. Verify that the fiber-optic cable is connected to the GPIB extender, as described in steps 4 and 5. If the problem persists, continue to the next step.

   b. Repeat steps 4 and 5 using the unconnected ends of the fiber-optic cable. If switching the fiber-optic cable connectors solves the problem, you need to replace your fiber-optic cable. To order a new fiber-optic cable, contact National Instruments. If switching the fiber-optic cable connectors does not solve the problem, continue to the next step.

   c. If possible, repeat steps 4 and 5 using a different fiber-optic cable. If the problem persists, you might need to replace your GPIB extender. For more information, contact National Instruments.

3

Configuring and Using Your Hardware

This chapter describes how to configure and use your GPIB-140A or GPIB-140A/2 system.

Data Transfer Modes

The GPIB extender has two data transfer modes—unbuffered mode and buffered mode. The data transfer mode determines how data is transmitted across the extension.

Selecting a Data Transfer Mode

To select a data transfer mode, refer to the following descriptions of each mode.

Unbuffered Mode

In unbuffered mode, each data byte is transmitted using the GPIB double-interlocked handshaking protocol. For long data streams, transfers are slower than transfers using buffered mode. However, the GPIB extension is transparent in unbuffered mode.

Buffered Mode

In buffered mode, the GPIB extenders use FIFO (first-in-first-out) buffers to buffer data between the remote and local units. For long data streams, the data throughput is much higher than with unbuffered mode.

However, a few applications may not operate properly in buffered mode. For example, a GPIB device on the local side of the extension is addressed to talk, another device on the remote side is addressed to listen. When the Talker sources data bytes, the GPIB extenders accept the data bytes and store them in a FIFO buffer. At the same time, the GPIB extenders read data from the FIFO buffer and source data bytes to the Listener. If the FIFO buffer contains data, the number of bytes sourced by the Talker differs from the number of bytes accepted by the Listener.

GPIB command bytes are not stored in the FIFO buffers; they are transmitted using the GPIB double-interlocked handshaking protocol.

Setting the Data Transfer Mode

The two GPIB extenders in your extension system must use the same data transfer mode.

To use buffered mode, set DIP switch 1 to the ON position, as shown in Figure 3-1. To use unbuffered mode, set DIP switch 1 to the OFF position.
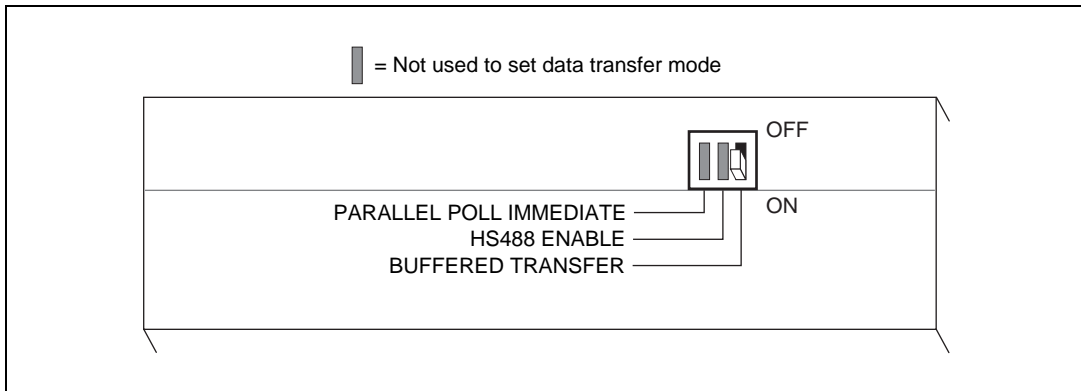
Figure 3-1. DIP Switch Setting for Buffered Mode

HS488 Mode

The GPIB extender can handle data transfers using the HS488 protocol. HS488 transfers data between two or more devices using a noninterlocked handshaking protocol. You can use HS488 to transfer data at rates higher than rates possible using the IEEE 488 protocol. For more information about HS488, refer to Appendix B, *Introduction to HS488*.

Selecting an HS488 Mode

To select an HS488 mode, refer to the following descriptions of each mode.

HS488 Disabled

If you disable HS488, the GPIB extender sources and accepts data using a three-wire handshaking protocol, even if both the Talker and Listener can transfer data using the HS488 protocol.

HS488 Enabled

After the Talker indicates that it wants to issue HS488 transfers, HS488 is enabled and the GPIB extender accepts data using the HS488 protocol. Also, when talking, the GPIB extender always tries to use the HS488 mode. In HS488 mode, FIFO buffers buffer data during HS488 transfers, even if the data transfer mode is set to unbuffered. When you use the HS488 protocol with the GPIB extender, you should set the GPIB cable length to 5 m for both the local and the remote system. To do so, use your IEEE 488.2 software configuration utility.

Setting the HS488 Mode

The two GPIB extenders in your extension system do not need to use the same HS488 mode. However, the system uses the maximum data transfer rate when both sides in your extension system use HS488.

To enable HS488, set DIP switch 2 to the ON position, as shown in Figure 3-2. To disable HS488, set DIP switch 2 to the OFF position.
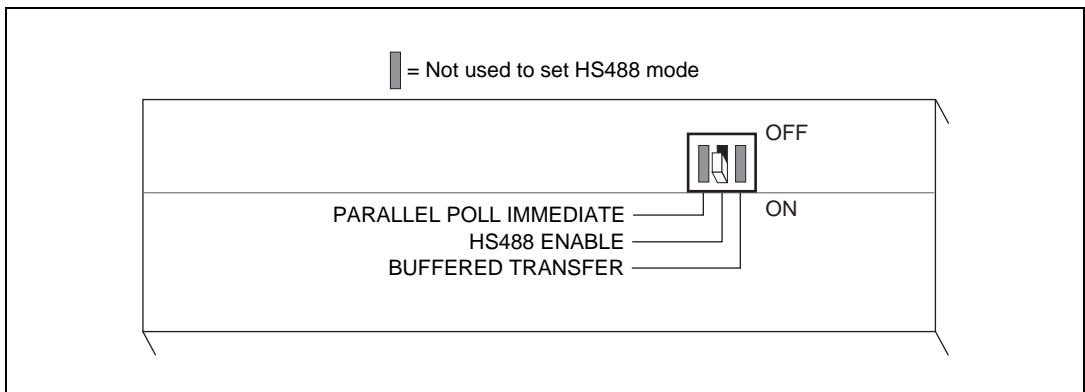
Figure 3-2. DIP Switch Setting for Enabled HS488

Parallel Poll Response Modes

According to IEEE 488, devices must respond to a parallel poll within 200 ns after the Controller-In-Charge (CIC) asserts the Identify (IDY) message—Attention (ATN) and End or Identify (EOI). The CIC waits at least 2 µs before reading the Parallel Poll Response (PPR). In many cases, a remote device on an extended system cannot respond to parallel polls this

quickly because of cable propagation delays. To solve this problem, use one of the following two solutions in your application:

*   If possible, specify in your application that the CIC must allow enough time to receive the response. For more information, refer to the following section, *Immediate PPR Mode*. If you are using the NI-488.2 software, you can use the NI-488.2 Configuration utility to set the amount of time that the CIC waits.

*   Execute two consecutive parallel polls and use the second response. For more information, refer to the *Latched PPR Mode* section later in this chapter.

Immediate PPR Mode

In immediate PPR mode, the GPIB extenders do not use the internal PPR data register. When a Controller on the local system asserts IDY, the local extender sends the IDY message to the remote bus and the response is returned as fast as propagation delays permit. Your application must allow enough time to receive the response.

Latched PPR Mode

In latched PPR mode, the GPIB extenders use an internal PPR data register. When a Controller on the local system asserts IDY, the local extender sends the contents of the PPR data register to the local data lines. At the same time, a parallel poll message is sent to the remote bus. When the local system unasserts IDY, the PPR from the remote system is loaded into the internal PPR data register. Consequently, the register always contains the response of the previous complete poll. To obtain the response of both local and remote systems, your application should execute two consecutive parallel polls and use the second response.

The software driver library of most Controllers contains an easy-to-use parallel poll function. For example, if the function is called `ibrpp` and your application is written in BASIC, the sequence to execute a poll in latched PPR mode might be similar to the following sequence:

```
CALL ibrpp (brd0%, ppr%)
CALL ibrpp (brd0%, ppr%)
IF ppr > 0 GOTO 300
```

Selecting a PPR Mode

To select a PPR mode, consider the type of Controller present in your GPIB system and the length of cable between the GPIB-140A extenders.

However, if your application does not use parallel polls, you do not need to select a PPR mode.

Some Hewlett Packard GPIB Controllers remain in a parallel poll state with IDY asserted if they are not performing another function. A change in the response interrupts the application. In some Controllers, the IDY signal is toggled on and off, and you can change the duration of the signal to accommodate delayed responses over extenders. If you are using these types of Controllers, you should set the GPIB extender to immediate PPR mode.

Most other Controllers pulse the IDY signal for approximately 2 µs and expect a response within that time. If you are using this type of Controller and if the cable between the extenders is longer than 60 m, you should set the GPIB extender to latched PPR mode. For shorter cable distances, use immediate PPR mode.

The two GPIB extenders in your extension system do not need to use the same PPR mode. Select the PPR mode of the local GPIB extender based on the Controllers on the local GPIB system. Likewise, select the PPR mode of the remote GPIB extender based on the Controllers on the remote GPIB system. If no Controllers are physically connected to one of the GPIB extenders, the PPR mode of that GPIB extender has no effect on your system.

Setting the PPR Mode

To use immediate PPR mode, set DIP switch 3 to the ON position, as shown in Figure 3-3. To use latched PPR mode, set DIP switch 3 to the OFF position.
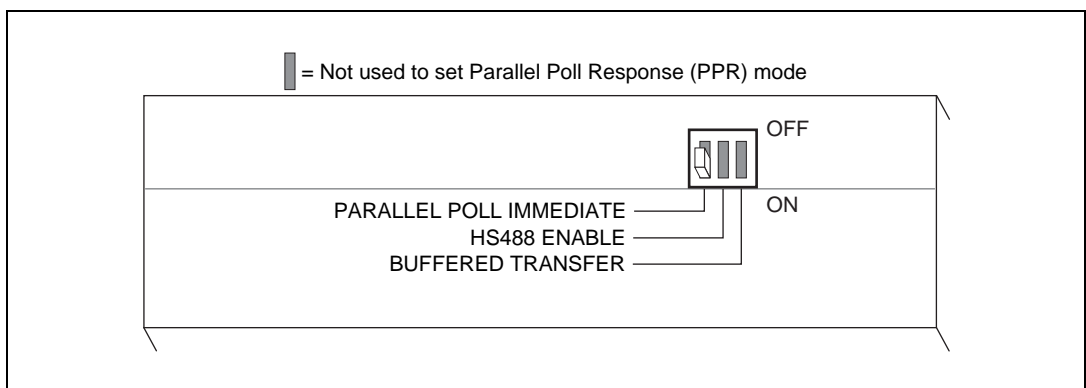

Figure 3-3. DIP Switch Setting for Immediate PPR Mode

Using Your Extension System

After you supply power to both extenders and connect the fiber-optic cable, you can use your GPIB-140A or GPIB-140A/2 extension system.

Table 3-1 lists the three LEDs that indicate the operational status of each GPIB extender.

Table 3-1. GPIB-140A LEDs

LED	Description
POWER	Lights if power is supplied to the GPIB extender and the power switch is in the on position.
LINK	Lights if both GPIB extenders are powered on and the transmission cable is properly connected to both extenders. During operation, the **LINK** LED turns off if you disconnect the cable from the receiver of the GPIB extender, or if you power off either GPIB extender.
ERROR	Lights if the GPIB extender receives corrupted data. The **ERROR** LED turns off after the GPIB extender starts re-transmission and has received the first retransmitted data byte without error.

4

Theory of Operation

This chapter describes how the GPIB extender circuitry operates.

This chapter assumes that you are familiar with GPIB. If you are a first-time user or if you would like to review the basics about GPIB, refer to Appendix A, *GPIB Basics*.

Figure 4-1 shows the five layers of a GPIB extender. To form a complete link, you can connect each layer to the corresponding layer of another extender at the remote side.
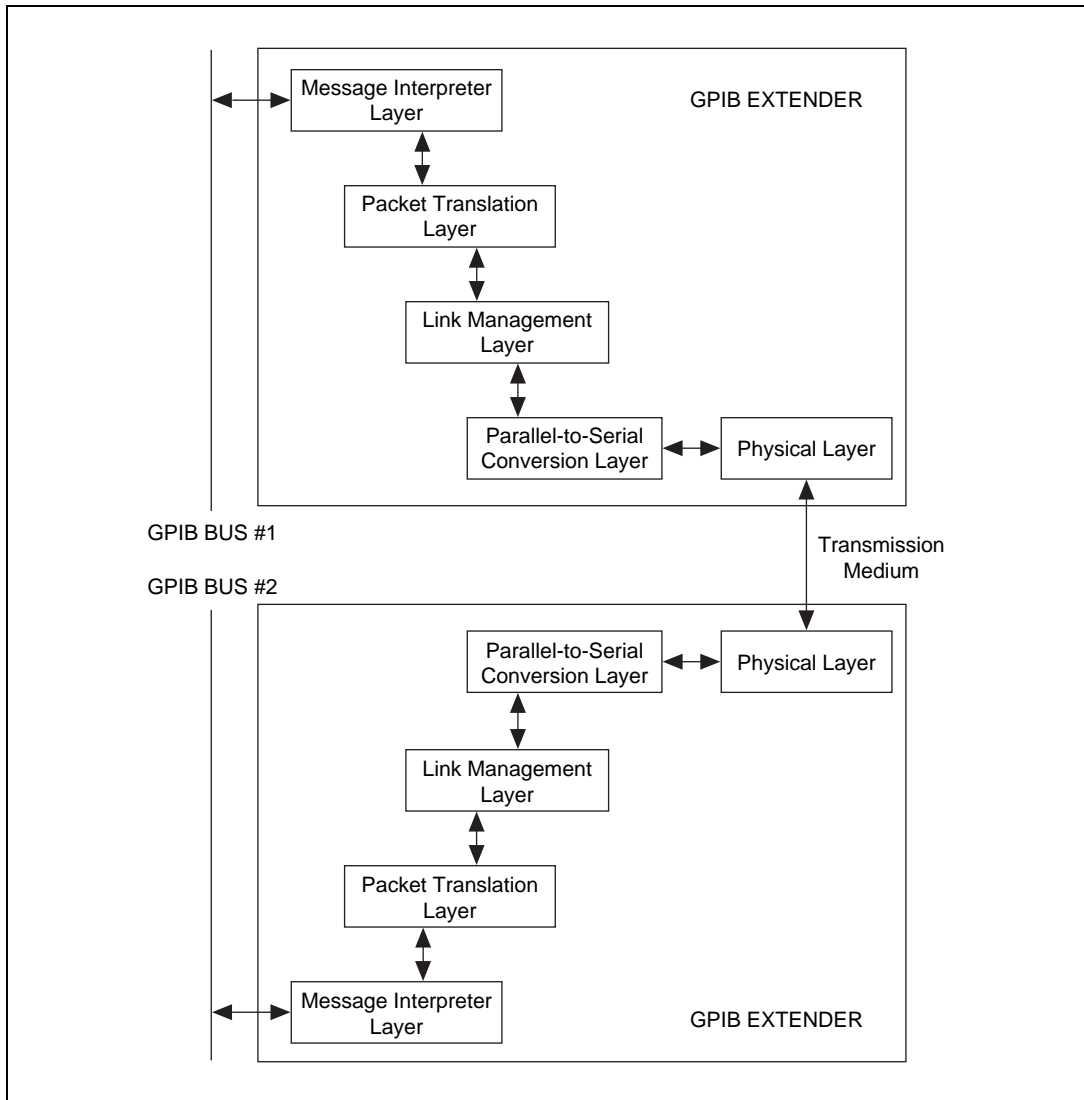
Figure 4-1. GPIB Extender Block Diagram

Message Interpreter Layer

The Message Interpreter Layer handles the handshake between the GPIB extender and other devices on the GPIB. At the same time, the layer monitors the activities that occur on the GPIB, translates them into equivalent local and remote GPIB messages, and sends these messages to the Packet Translation Layer.

Packet Translation Layer

The Packet Translation Layer converts the messages that it receives to packets and sends them to the Link Management Layer. It can also receive packets from the Link Management Layer and convert them back to local or remote GPIB messages.

Link Management Layer

The Link Management Layer receives packets from the Packet Translation Layer. It sends the packets to the Parallel-to-Serial Conversion Layer and it stores them in a local buffer. If a transmission error occurs, the Link Management Layer can re-send the packets from this local buffer. The Link Management Layer also receives packets from the Parallel-to-Serial Conversion Layer and checks the packets for transmission errors. If the Link Management Layer does not detect an error, it sends the packets to the Packet Translation Layer. However, if it detects a transmission error, the it re-transmits the packets.

Parallel-to-Serial Conversion Layer

The Parallel-to-Serial Conversion Layer accepts packets from the Link Management Layer, converts them into serial data, and sends the data to the Physical Layer. It also extracts serial bits from the Physical Layer, reconstructs them back into packets, and sends them to the Link Management Layer.

Physical Layer

The Physical Layer transmits and receives serial data over the fiber-optic link.

A

GPIB Basics

This appendix describes the basic concepts of GPIB, including its physical and electrical characteristics, and configuration requirements.

The ANSI/IEEE Standard 488.1-1987, also known as General Purpose Interface Bus (GPIB), describes a standard interface for communication between instruments and controllers from various vendors. It contains information about electrical, mechanical, and functional specifications. GPIB is a digital, 8-bit parallel communications interface with data transfer rates of 1 Mbyte/s and higher, using a three-wire handshake. The bus supports one System Controller, usually a computer, and up to 14 additional instruments. The ANSI/IEEE Standard 488.2-1992 extends IEEE 488.1 by defining a bus communication protocol, a common set of data codes and formats, and a generic set of common device commands.

Types of Messages

Interconnected GPIB devices communicate by passing messages through the interface system, including device-dependent messages and interface messages.

- Device-dependent messages, also called *data* or *data messages*, contain device-specific information, such as programming instructions, measurement results, machine status, and data files.

- Interface messages, also called *commands* or *command messages*, manage the bus itself. Interface messages initialize the bus, address and unaddress devices, and set device modes for remote or local programming.

  The term *command* as used here does not refer to device instructions, which are also called commands. Those device-specific instructions are data messages.

Talkers, Listeners, and Controllers

GPIB devices can be Talkers, Listeners, or Controllers. A Talker sends out data messages. Listeners receive data messages. The Controller, usually a computer, manages the flow of information on the bus. It defines the communication links and sends GPIB commands to devices.

Some devices are capable of playing more than one role. A digital voltmeter, for example, can be a Talker and a Listener. If your system has a National Instruments GPIB interface and software installed, it can function as a Talker, Listener, and Controller.

The GPIB is like a typical computer bus, except that the typical computer has circuit cards interconnected via a backplane bus, whereas the GPIB has standalone devices interconnected via a cable bus.

The role of the GPIB Controller is similar to the role of the CPU of a computer, but a better analogy is to the switching center of a city telephone system. The switching center (Controller) monitors the communications network (GPIB). When the center (Controller) notices that a party (device) wants to make a call (send a data message), it connects the caller (Talker) to the receiver (Listener).

The Controller addresses a Talker and a Listener before the Talker can send its message to the Listener. After the message is transmitted, the Controller may unaddress both devices.

Some bus configurations do not require a Controller. For example, one device may always be a Talker (called a Talk-only device) and there may be one or more Listen-only devices.

A Controller is necessary when the active or addressed Talker or Listener must be changed. The Controller function is usually handled by a computer.

With the GPIB interface board and its software your personal computer plays all three roles.

- Controller—to manage the GPIB
- Talker—to send data
- Listener—to receive data

Controller-In-Charge and System Controller

You can have multiple Controllers on the GPIB, but only one Controller at a time can be the active Controller, or Controller-In-Charge (CIC). The CIC can be either active or inactive (standby). Control can pass from the current CIC to an idle Controller, but only the System Controller, usually a GPIB interface, can make itself the CIC.

GPIB Signals and Lines

Devices on the bus communicate by sending messages. Signals and lines transfer these messages across the GPIB interface, which consists of 16 signal lines and 8 ground return (shield drain) lines. The 16 signal lines are discussed in the following sections.

Data Lines

Eight data lines, DIO1 through DIO8, carry both data and command messages.

Handshake Lines

Three hardware handshake lines asynchronously control the transfer of message bytes between devices. This process is a three-wire interlocked handshake, and it guarantees that devices send and receive message bytes on the data lines without transmission error. Table A-1 summarizes the GPIB handshake lines.

Table A-1. GPIB Handshake Lines

Line	Description
NRFD (not ready for data)	Listening device is ready/not ready to receive a message byte. Also used by the Talker to signal high-speed GPIB transfers.
NDAC (not data accepted)	Listening device has/has not accepted a message byte.
DAV (data valid)	Talking device indicates signals on data lines are stable (valid) data.

Interface Management Lines

Five hardware lines manage the flow of information across the bus. Table A-2 summarizes the GPIB interface management lines.

Table A-2. GPIB Interface Management Lines

Line	Description
ATN (attention)	Controller drives ATN true when it sends commands and false when it sends data messages.
IFC (interface clear)	System Controller drives the IFC line to initialize the bus and make itself CIC.
REN (remote enable)	System Controller drives the REN line to place devices in remote or local program mode.
SRQ (service request)	Any device can drive the SRQ line to asynchronously request service from the Controller.
EOI (end or identify)	Talker uses the EOI line to mark the end of a data message. Controller uses the EOI line when it conducts a parallel poll.

Physical and Electrical Characteristics

Devices are usually connected with a cable assembly consisting of a shielded 24-conductor cable with both a plug and receptacle connector at each end, as shown in Figure A-1. With this design, you can link devices in a linear configuration, a star configuration, or a combination of the two configurations. Figure A-2 shows the linear and star configurations.
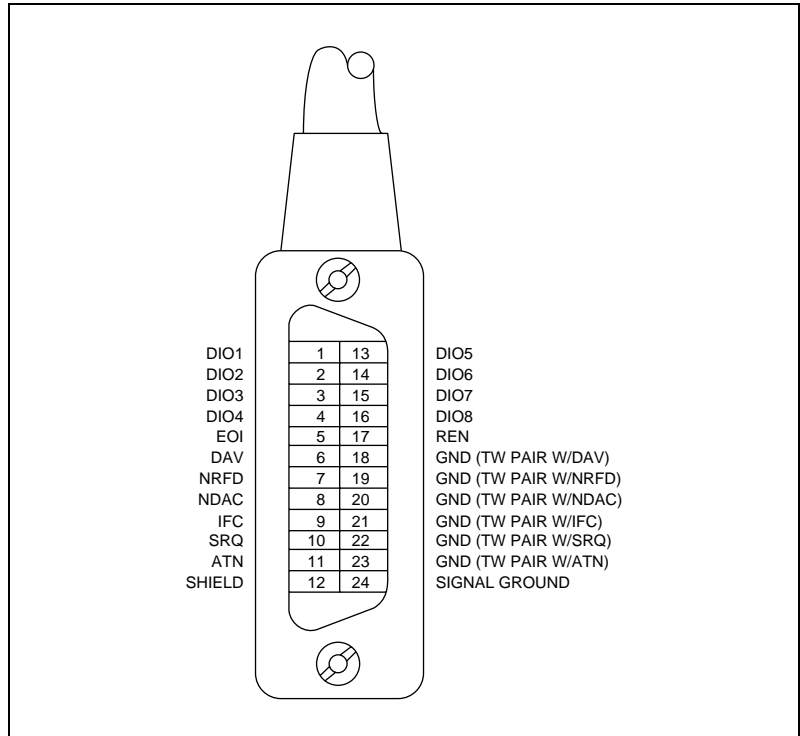
Figure A-1. GPIB Connector and the Signal Assignment
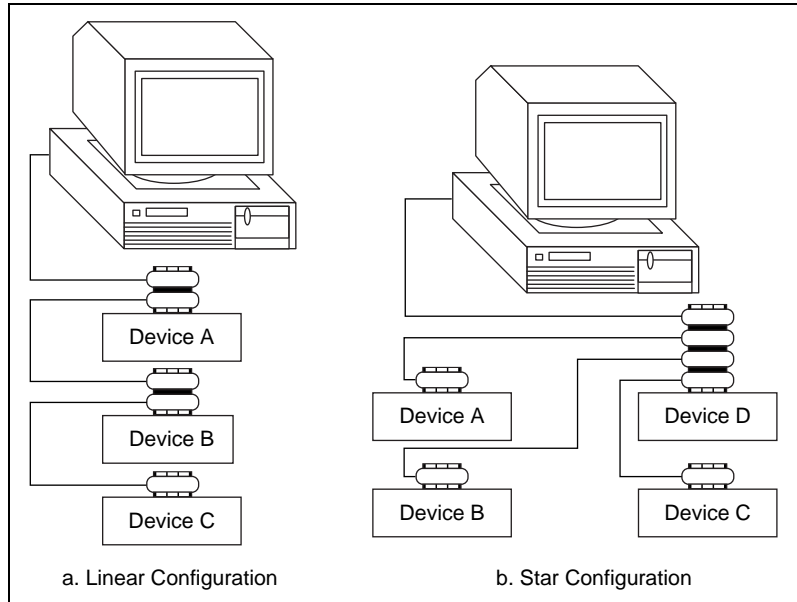
Figure A-2. Linear and Star System Configuration

The standard connector is the Amphenol or Cinch Series 57 *Microribbon* or *Amp Champ* type. For special interconnection applications, you use an adapter cable using a non-standard cable and/or connector.

The GPIB uses negative logic with standard TTL (transistor-transistor logic) level. For example, when DAV is true, it is a TTL low level (≤ 0.8 V), and when DAV is false, it is a TTL high level (≥ 2.0 V).

Configuration Requirements

To achieve the high data transfer rate that the GPIB was designed for, you must limit the number of devices on the bus and the physical distance between devices. The following restrictions are typical:

- A maximum separation of 4 m between any two devices and an average separation of 2 m over the entire bus.

- A maximum total cable length of 20 m.

- A maximum of 15 devices connected to each bus, with at least two-thirds powered on.

For high-speed operation, the following restrictions apply:

*   All devices in the system must be powered on.

*   Cable lengths must be as short as possible with up to a maximum of 15 m of cable for each system.

*   There must be at least one equivalent device load per meter of cable.

If you want to exceed these limitations, you can use a bus expander to increase the number of device loads. You can order bus expanders from National Instruments.

B

Introduction to HS488

This appendix describes HS488 and the sequence of events in high-speed data transfers.

National Instruments has designed a high-speed data transfer protocol for IEEE 488 called HS488. This protocol increases performance for GPIB reads and writes up to 8 Mbytes/s, depending on your system.

If HS488 is enabled, the TNT4882C hardware implements high-speed transfers automatically when communicating with HS488 instruments. If you attempt to enable HS488 on a GPIB interface that does not have the TNT4882C hardware, the ECAP error code is returned.

Objectives

The following sections describe the objectives of HS488.

Faster Transfer Rates

HS488 enables transfer rates that are substantially faster than the IEEE 488 standard. In small systems, the raw transfer rate can be up to 8 Mbytes/s. The faster raw transfer rates improve system throughput in systems where devices send long blocks of data. The physical limitations of the cabling system, however, limit the transfer rate.

Compatibility with IEEE 488 Devices

HS488 is a superset of the IEEE 488 standard; thus, you can mix IEEE 488.1, IEEE 488.2, and HS488 devices in the same system.

When connected to an HS488 device, the Controller does not need to be capable of HS488 noninterlocked transfers. While ATN is asserted, the Controller sources multiline messages to HS488 devices just as it sources multiline messages to any IEEE 488 devices.

Automatic HS488 Detection

Addressed HS488 devices can detect whether other addressed devices are capable of HS488 transfers without the interaction of the Controller.

Compatibility with the IEEE 488.2 Standard

The HS488 protocol requires no changes to the IEEE 488.2 standard. Also, HS488 devices do not need to be compliant with IEEE 488.2.

Same Cabling Restrictions as IEEE 488.1

Systems that meet the IEEE 488.1 requirements for high-speed operation also meet the HS488 requirements. HS488 cabling requirements are also the same as the requirements in the IEEE 488.1 standard.

However, using HS488 does not reduce software overhead. Also, system throughput increases depend on data block size.

IEEE 488.1 Requirements for High-Speed Operation (T1 Delay $\geq$ 350 ns)

The IEEE 488.1 standard requires that devices used in high-speed operation must use three-state, 48 mA drivers on most signals. Each device must add no more than 50 pF capacitance on each signal, and all devices must be powered on.

The total cable length in a system must be no more than 15 m, or 1 m times the number of devices in the system.

HS488 System Requirements

An HS488 system must meet the IEEE 488.1 requirements and it must implement the following three new interface functions:

- Talking devices must use the *Source Handshake Extended (SHE)* interface function, which is an extension of the IEEE 488.1 SH function.

- Listening devices must use the *Acceptor Handshake Extended (AHE)* interface function, which is an extension of the IEEE 488.1 AH function. Accepting devices must have a buffer of at least 3 bytes to store received data.

- HS488 devices must implement the *Configuration (CF)* interface function. At system power on, the Controller uses previously undefined multiline messages to configure HS488 devices. The CF function enables devices to interpret these multiline messages.

Sequence of Events in Data Transfers

Figure B-1 shows a typical IEEE 488.1 data transfer.
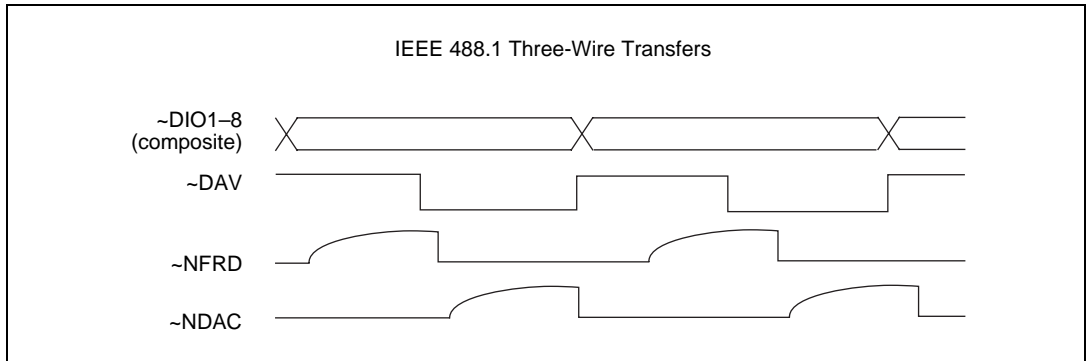
Figure B-1. IEEE 488.1 Transfers

Figure B-2 shows an HS488 data transfer. The HS488 protocol modifies the IEEE 488.1 SH and AH functions. At the beginning of each data transfer, the HS488 SHE and AHE functions determine whether all active Talkers and Listeners are capable of HS488 transfers. If the addressed devices are HS488-capable, they use the HS488 noninterlocked handshake protocol for that data transfer. If any addressed device is not HS488-capable, the transfer continues using the standard three-wire handshake.
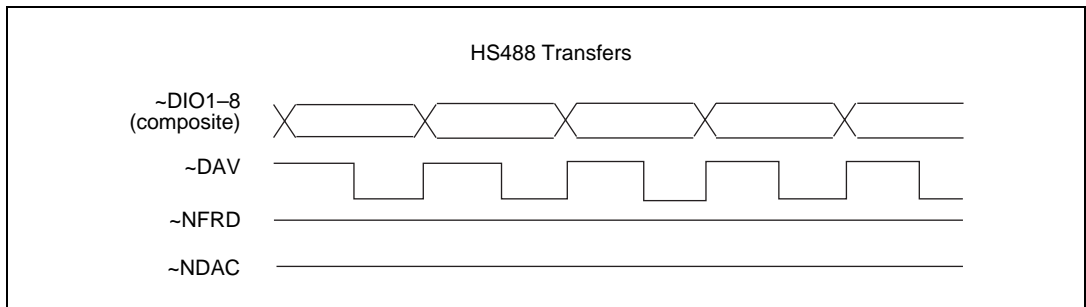
Figure B-2. HS488 Transfers

Case 1: Talker and Listener Are HS488-Capable

Figure B-3 and the following steps describe a typical sequence of events in an HS488 data transfer in which both the Talker and Listener are HS488-capable.
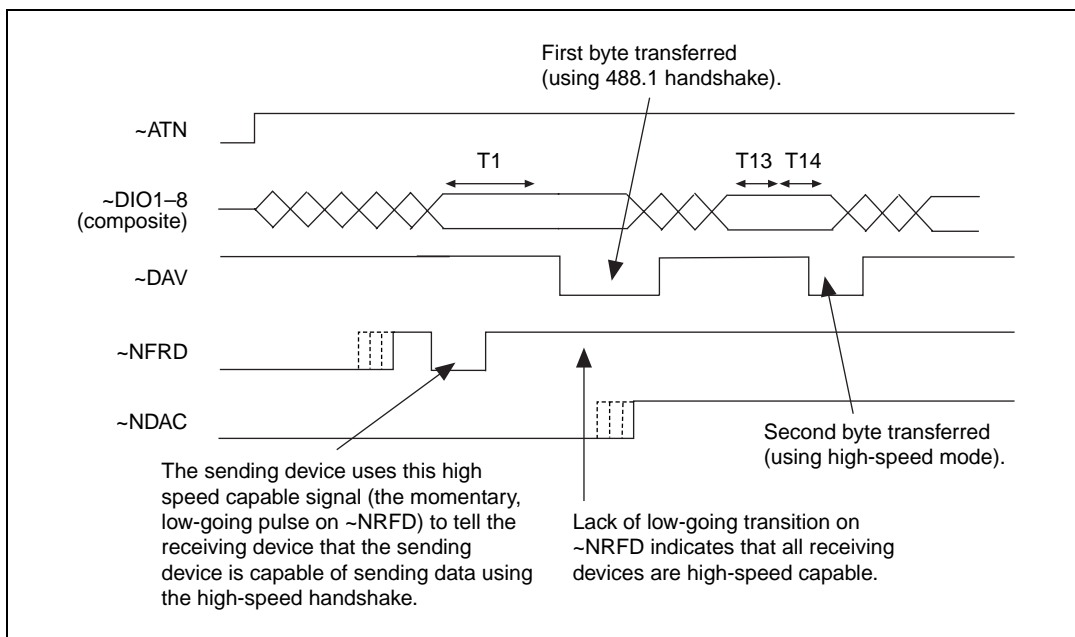
Figure B-3. HS488-Capable Talker and Listener

1. The Controller addresses devices and becomes Standby Controller by unasserting ATN.

2. The Listener asserts NDAC and NRFD.

3. The Listener unasserts NRFD as it becomes ready to accept a byte.

4. After allowing time for the Listener to detect NRFD unasserted, the Talker indicates that it is HS488-capable by sending the HSC message. To send the HSC message true, the Talker asserts the NRFD signal.

5. After allowing time for the Listener to respond to the HSC message, the Talker sends the HSC message false. To send the HSC message false, the Talker unasserts the NRFD signal.

6. When the Talker has a byte ready to send, it drives the data on the DIO signal lines, allows some settling time, and asserts DAV.

7. The Listener unasserts NDAC. HS488-capable Listeners do not assert NRFD as IEEE 488.1 devices would, so the Talker determines that the addressed Listener is HS488-capable.

8. The Talker unasserts DAV and drives the next data byte on the GPIB.

9. After allowing some settling time, the Talker asserts DAV.

10. The Listener latches the byte in response to the assertion (falling) edge of DAV.

11. After allowing some hold time, the Talker unasserts DAV and drives the next data byte on the DIO signal lines.

12. Steps 9–11 are repeated for each data byte.

Case 2: Talker Is HS488-Capable, But Listener Is Not HS488-Capable

Figure B-4 and the following steps describe a typical sequence of events in an HS488 data transfer in which the Talker is HS488-capable, but the Listener is not.
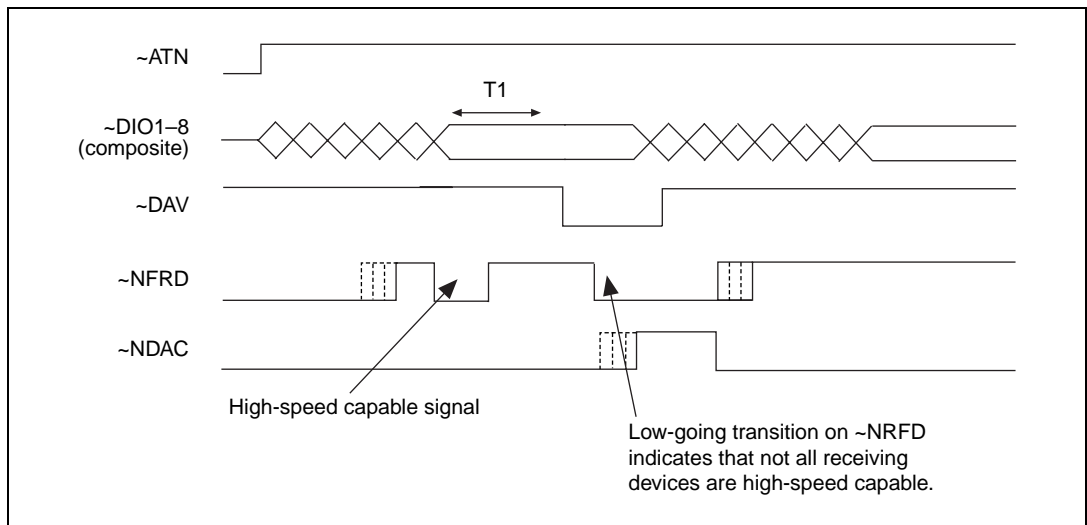
Figure B-4. HS488-Capable Talker

Steps 1–6 are identical to steps 1–6 in Case 1: Talker and Listener Are HS488-Capable. The Listener ignores the HSC message from the Talker.

Then, the IEEE 488.1 Listener enters ACDS and asserts NRFD. As a result, the Talker determines that the addressed Listener is not HS488-capable. The Talker sources bytes using the IEEE 488.1 protocol.

Case 3: Talker Is Not HS488-Capable, But Listener Is HS488-Capable

The Talker does *not* send an HSC message to the Listener, but sources bytes using the IEEE 488.1 protocol.

The addressed Listener (HS488 or IEEE 488.1) accepts bytes using the IEEE 488.1 standard three-wire handshake, as shown in Figure B-5.
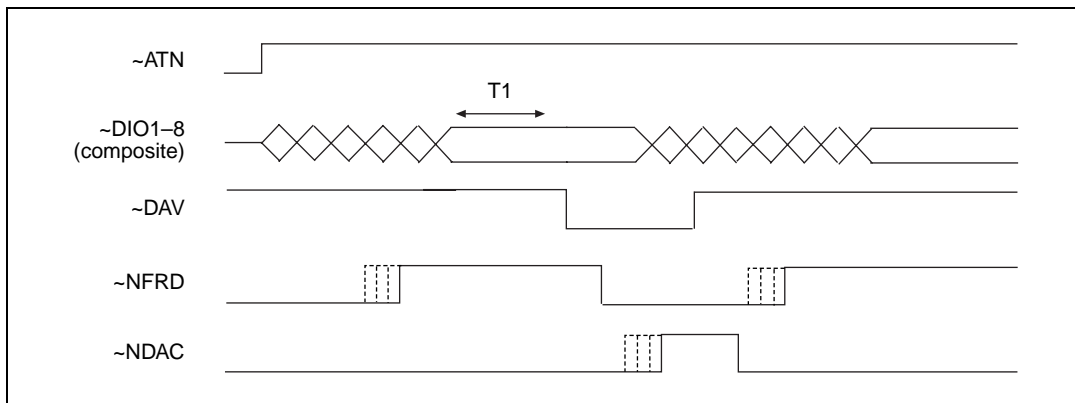
Figure B-5. Listener Is HS488-Capable

System Configuration

The HS488 AHE and SHE interface functions depend on several time delays. Some of these delays are a function of the total system cable length.

The Controller must communicate this system configuration data to HS488 devices after the system powers on. The Controller configures HS488 devices by sourcing the following two multiline messages while ATN is true:

• **Configuration Enable (CFE)**—The Controller sends the CFE message by driving a bit pattern (1E hex) that the IEEE 488.1 standard does not define on the DIO signal lines. The CFE message enables HS488 devices to interpret the SCG message that follows.

• **Secondary Command Group (SCG)**—This message contains the configuration data. The Secondary Command has the bit pattern 6*n* hex, where *n* is the meters of cable in the system. The SCG includes CFG1–CFG15 in Appendix C, *Multiline Interface Messages*.

C

Multiline Interface Messages

This appendix lists the multiline interface messages and describes the mnemonics and messages that correspond to the interface functions.

The multiline interface messages are commands defined by the IEEE 488 standard. The messages are sent and received with ATN asserted. The interface functions include initializing the bus, addressing and unaddressing devices, and setting device modes for local or remote programming. For more information about these messages, refer to the ANSI/IEEE Standard 488.1-1987, *IEEE Standard Digital Interface for Programmable Instrumentation*.

Table C-1. Multiline Interface Messages

Hex	Dec	ASCII	Message	Hex	Dec	ASCII	Message
00	0	NUL	—	20	32	SP	MLA0
01	1	SOH	GTL	21	33	!	MLA1
02	2	STX	—	22	34	"	MLA2
03	3	ETX	—	23	35	#	MLA3
04	4	EOT	SDC	24	36	$	MLA4
05	5	ENQ	PPC	25	37	%	MLA5
06	6	ACK	—	26	38	&	MLA6
07	7	BEL	—	27	39	'	MLA7
08	8	BS	GET	28	40	(	MLA8
09	9	HT	TCT	29	41	)	MLA9
0A	10	LF	—	2A	42	*	MLA10
0B	11	VT	—	2B	43	+	MLA11
0C	12	FF	—	2C	44	,	MLA12
0D	13	CR	—	2D	45	-	MLA13
0E	14	SO	—	2E	46	.	MLA14
0F	15	SI	—	2F	47	/	MLA15
10	16	DLE	—	30	48	0	MLA16
11	17	DC1	LLO	31	49	1	MLA17
12	18	DC2	—	32	50	2	MLA18
13	19	DC3	—	33	51	3	MLA19
14	20	DC4	DCL	34	52	4	MLA20
15	21	NAK	PPU	35	53	5	MLA21
16	22	SYN	—	36	54	6	MLA22
17	23	ETB	—	37	55	7	MLA23
18	24	CAN	SPE	38	56	8	MLA24
19	25	EM	SPD	39	57	9	MLA25
1A	26	SUB	—	3A	58	:	MLA26
1B	27	ESC	—	3B	59	;	MLA27
1C	28	FS	—	3C	60	<	MLA28
1D	29	GS	—	3D	61	=	MLA29
1E	30	RS	—	3E	62	>	MLA30
1F	31	US	CFE	3F	63	?	UNL

Table C-1. Multiline Interface Messages (Continued)

Hex	Dec	ASCII	Message	Hex	Dec	ASCII	Message
40	64	@	MTA0	60	96	`	MSA0, PPE
41	65	A	MTA1	61	97	a	MSA1, PPE, CFG1
42	66	B	MTA2	62	98	b	MSA2, PPE, CFG2
43	67	C	MTA3	63	99	c	MSA3, PPE, CFG3
44	68	D	MTA4	64	100	d	MSA4, PPE, CFG4
45	69	E	MTA5	65	101	e	MSA5, PPE, CFG5
46	70	F	MTA6	66	102	f	MSA6, PPE, CFG6
47	71	G	MTA7	67	103	g	MSA7, PPE, CFG7
48	72	H	MTA8	68	104	h	MSA8, PPE, CFG8
49	73	I	MTA9	69	105	i	MSA9, PPE, CFG9
4A	74	J	MTA10	6A	106	j	MSA10, PPE, CFG10
4B	75	K	MTA11	6B	107	k	MSA11, PPE, CFG11
4C	76	L	MTA12	6C	108	l	MSA12, PPE, CFG12
4D	77	M	MTA13	6D	109	m	MSA13, PPE, CFG13
4E	78	N	MTA14	6E	110	n	MSA14, PPE, CFG14
4F	79	O	MTA15	6F	111	o	MSA15, PPE, CFG15
50	80	P	MTA16	70	112	p	MSA16, PPD
51	81	Q	MTA17	71	113	q	MSA17, PPD
52	82	R	MTA18	72	114	r	MSA18, PPD
53	83	S	MTA19	73	115	s	MSA19, PPD
54	84	T	MTA20	74	116	t	MSA20, PPD
55	85	U	MTA21	75	117	u	MSA21, PPD
56	86	V	MTA22	76	118	v	MSA22, PPD
57	87	W	MTA23	77	119	w	MSA23, PPD
58	88	X	MTA24	78	120	x	MSA24, PPD
59	89	Y	MTA25	79	121	y	MSA25, PPD
5A	90	Z	MTA26	7A	122	z	MSA26, PPD
5B	91	[	MTA27	7B	123	{	MSA27, PPD
5C	92	\	MTA28	7C	124	|	MSA28, PPD
5D	93	]	MTA29	7D	125	}	MSA29, PPD
5E	94	^	MTA30	7E	126	~	MSA30, PPD
5F	95	_	UNT	7F	127	DEL	—

Multiline Interface Message Definitions

CFE †	Configuration Enable	P P D	Parallel Poll Disable
CFG †	Configure	P P E	Parallel Poll Enable
DCL	Device Clear	P P U	Parallel Poll Unconfigure
GET	Group Execute Trigger	S D C	Selected Device Clear
GTL	Go To Local	S P D	Serial Poll Disable
LLO	Local Lockout	S P E	Serial Poll Enable
MLA	My Listen Address	T C T	Take Control
MSA	My Secondary Address	U N L	Unlisten
MTA	My Talk Address	U N T	Untalk
PPC	Parallel Poll Configure		

† This multiline interface message is a proposed extension to the IEEE 488 specification to support the HS488 protocol.

D

Specifications

This appendix lists the specifications and characteristics of the GPIB extender.

System Configuration

Distance per extension

GPIB-140A .... Up to 1 km

GPIB-140A/2 .... Up to 2 km

Loading per extension .... Up to 13 additional devices
(28 total devices in the extension system, including the extenders)

Multiple extensions .... Permitted in any combination of star or linear pattern

Performance Characteristics

Maximum transfer rate

Buffered mode, non-HS488 .... > 1.1 Mbytes/s

HS488 handshake .... > 2.8 Mbytes/s

Unbuffered mode .... > 200 kbytes/s

Functionality .... Transparent GPIB operation except for latched parallel polls

Interlocked IEEE 488 handshake .... Maintained across the extension in unbuffered mode

IEEE 488 capability identification codes

SH1 .... Complete Source Handshake

AH1 .... Complete Acceptor Handshake

T5, TE5 .... Complete Talker

L3, LE3 .... Complete Listener

SR1 .... Complete Service Request

RL1 ....Complete Remote Local

PP1, 2...Complete Parallel Poll

DC1..Complete Device Clear

DT1..Complete Device Trigger

C1–5 ....Complete Controller

E2...Tri-state GPIB driver

HS488 capability identification codes

SHE..HS488 Source Handshake

AHE..HS488 Acceptor Handshake

Operational Characteristics

Architecture ....Point-to-point (not multi-drop) transmission

Operating modes...................................Buffered or unbuffered (interlocked) mode

HS488 modes..Enabled HS488 or disabled HS488 mode

Parallel Poll Response modes................Immediate Parallel Poll Response mode or latched Parallel Poll Response mode

Electrical Characteristics

Transmission interface unit

GPIB-140A....................................Optical transmitter and receiver (HFBR1414, HFBR2416, or equivalent) with ST-style optical cable connectors

GPIB-140A/2.................................Optical transmitter and receiver (HFBR1312, HFBR1316, or equivalent) with ST-style optical cable connectors

GPIB interface load ....Two standard loads, AC and DC

Power supply unit

100–120 VAC ....50–60 Hz

220–240 VAC ....50–60 Hz

Maximum current requirement

      100–120 VAC.................................. 120 mA

      220–240 VAC.................................. 80 mA

Fuse rating and type

      100–120 VAC.................................. 300 mA, UL/CSA approved

      220–240 VAC.................................. 500 mA, IEC approved

Environmental Characteristics

Operating temperature............................ 0 to 40 °C

Storage temperature .... –20 to 70 °C

Relative humidity................................... 10% to 90%, noncondensing

EMI .... FCC Class A Verified

Physical Characteristics

Overall case size (dimensions)............... 3.5 by 5.65 by 1.62 in.
(8.89 by 14.35 by 4.11 cm)

Case material... All metal enclosure

Weight... 0.55 lb (0.25 kg)

GPIB cable .... Type X1 or X2 shielded[1]

Transmission cable

      GPIB-140A .... 3.0 by 6.5 mm cable diameter
62.5/125 micron core/clad
with NA=0.275
850 nm operating wavelength
3.0 dB/km attenuation
Duplex style, terminated
with ST-style connectors

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[1] To meet FCC emission limits for this device, you must use a shielded (Type X1 or X2) GPIB cable. If you operate this equipment with a non-shielded cable, it may interfere with radio and television reception.

GPIB-140A/2...................................3.0 by 6.5 mm cable diameter
62.5/125 micron core/clad
with NA=0.275
1300 nm operating wavelength
1 dB/km attenuation
Duplex style, terminated
with ST-style connectors

E

Technical Support Resources

This appendix describes the comprehensive resources available to you in the Technical Support section of the National Instruments Web site and provides technical support telephone numbers for you to use if you have trouble connecting to our Web site or if you do not have internet access.

NI Web Support

To provide you with immediate answers and solutions 24 hours a day, 365 days a year, National Instruments maintains extensive online technical support resources. They are available to you at no cost, are updated daily, and can be found in the Technical Support section of our Web site at `www.natinst.com/support`.

Online Problem-Solving and Diagnostic Resources

- **KnowledgeBase**—A searchable database containing thousands of frequently asked questions (FAQs) and their corresponding answers or solutions, including special sections devoted to our newest products. The database is updated daily in response to new customer experiences and feedback.

- **Troubleshooting Wizards**—Step-by-step guides lead you through common problems and answer questions about our entire product line. Wizards include screen shots that illustrate the steps being described and provide detailed information ranging from simple getting started instructions to advanced topics.

- **Product Manuals**—A comprehensive, searchable library of the latest editions of National Instruments hardware and software product manuals.

- **Hardware Reference Database**—A searchable database containing brief hardware descriptions, mechanical drawings, and helpful images of jumper settings and connector pinouts.

- **Application Notes**—A library with more than 100 short papers addressing specific topics such as creating and calling DLLs, developing your own instrument driver software, and porting applications between platforms and operating systems.

Software-Related Resources

- **Instrument Driver Network**—A library with hundreds of instrument drivers for control of standalone instruments via GPIB, VXI, or serial interfaces. You also can submit a request for a particular instrument driver if it does not already appear in the library.

- **Example Programs Database**—A database with numerous, non-shipping example programs for National Instruments programming environments. You can use them to complement the example programs that are already included with National Instruments products.

- **Software Library**—A library with updates and patches to application software, links to the latest versions of driver software for National Instruments hardware products, and utility routines.

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Glossary

Prefix	Meaning	Value
p-	pico-	10^{-12}
n-	nano-	10^{-9}
μ-	micro-	10^{-6}
m-	milli-	10^{-3}
c-	centi-	10^{-2}
k-	kilo-	10^{3}
M-	mega-	10^{6}

°	degrees
%	percent
A	amperes
AC	alternating current
AHE	HS488 Acceptor Handshake Extended interface function
ANSI	American National Standards Institute
ASCII	American Standards Code for Information Interchange
ASIC	application-specific integrated circuit
ATN	Attention
C	Celsius
CIC	Controller-In-Charge
CPU	central processing unit
CSA	Canadian Standards Association
DAV	data valid
dB	decibels
DC	direct current

DIO	digital input/output
DIP	dual inline package
EOI	End or Identify
EOS	End of String
F	Farads
FCC	Federal Communications Commission
FIFO	first-in-first-out
g	grams
GPIB	General Purpose Interface Bus
hex	hexadecimal
Hz	hertz
IDY	Identify
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
IFC	Interface Clear
in.	inches
lb	pounds
LED	light-emitting diode
m	meters
s	seconds
SHE	HS488 Source Handshake Extended interface function
TTL	transistor-transistor logic
UL	Underwriter's Laboratories
V	volts
VAC	volts alternating current