NI-488.2™

NI-488.2 User Manual for Windows

NATIONAL INSTRUMENTS™

June 1999 Edition
Part Number 321819D-01

Worldwide Technical Support and Product Information

`www.natinst.com`

National Instruments Corporate Headquarters

11500 North Mopac Expressway   Austin, Texas 78759-3504   USA   Tel: 512 794 0100

Worldwide Offices

Australia 03 9879 5166, Austria 0662 45 79 90 0, Belgium 02 757 00 20, Brazil 011 284 5011,
Canada (Ontario) 905 785 0085, Canada (Québec) 514 694 8521, China 0755 3904939, Denmark 45 76 26 00,
Finland 09 725 725 11, France 01 48 14 24 24, Germany 089 741 31 30, Hong Kong 2645 3186,
India 91805275406, Israel 03 6120092, Italy 02 413091, Japan 03 5472 2970, Korea 02 596 7456,
Mexico (D.F.) 5 280 7625, Mexico (Monterrey) 8 357 7695, Netherlands 0348 433466, Norway 32 27 73 00,
Singapore 2265886, Spain (Madrid) 91 640 0085, Spain (Barcelona) 93 582 0251, Sweden 08 587 895 00,
Switzerland 056 200 51 51, Taiwan 02 2377 1200, United Kingdom 01635 523545

For further support information, see the *Technical Support Resources* appendix. To comment on the documentation, send e-mail to `techpubs@natinst.com`.

Important Information

Contents

Chapter 7
NI-488.2 Programming Techniques

About This Manual

This manual describes the features and functions of the NI-488.2 software for Windows. You can use the NI-488.2 software for Windows with Windows 95, Windows 98, Windows NT version 4.0, or Windows 2000. This manual assumes that you are already familiar with Windows.

Using the NI-488.2 Documentation

The following NI-488.2 documentation is available on your *NI-488.2 for Windows* CD:

- The *Getting Started* card briefly describes how to install the NI-488.2 software and your GPIB hardware.
- This manual, *NI-488.2 User Manual for Windows*, describes the features and functions of the NI-488.2 software for Windows.
- The *NI-488.2 Function Reference Manual for Windows* describes the NI-488.2 API.
- The *GPIB Hardware Guide* contains detailed instructions on how to install and configure your GPIB hardware. This guide also includes hardware and software specifications and compliance information.

To view these documents online, insert your *NI-488.2 for Windows* CD. When the **NI-488.2 Software for Windows** screen appears, select the **View Documentation** option. The View Documentation Wizard helps you find the documentation that you want to view. You can also view these documents at `http://www.natinst.com/manuals/`.

Accessing the NI-488.2 Online Help

The *NI-488.2 for Windows Online Help* addresses questions you might have about NI-488.2, includes troubleshooting information, and describes the NI-488.2 API. You can access the NI-488.2 online help as follows:

1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB**.
2. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.
3. Right-click on your GPIB interface and select **NI-488.2 Help** from the drop-down menu that appears.

Conventions

The following conventions appear in this manual:

»	The » symbol leads you through nested menu items and dialog box options to a final action. The sequence **File»Page Setup»Options** directs you to pull down the **File** menu, select the **Page Setup** item, and select **Options** from the last dialog box.
✎	This icon denotes a note, which alerts you to important information.
bold	Bold text denotes items that you must select or click on in the software, such as menu items and dialog box options. Bold text also denotes parameter names.
IEEE 488 and IEEE 488.2	*IEEE 488* and *IEEE 488.2* refer to the ANSI/IEEE Standard 488.1-1987 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.
`monospace bold`	Bold text in this font denotes the messages and responses that the computer automatically prints to the screen. This font also emphasizes lines of code that are different from the other examples.

Related Documentation

The following documents contain information that you may 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 describes how to set up your GPIB system.

Setting up and Configuring Your System

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. With this design, you can link devices in a linear configuration, a star configuration, or a combination of the two configurations. Figure 1-1 shows the linear and star configurations.

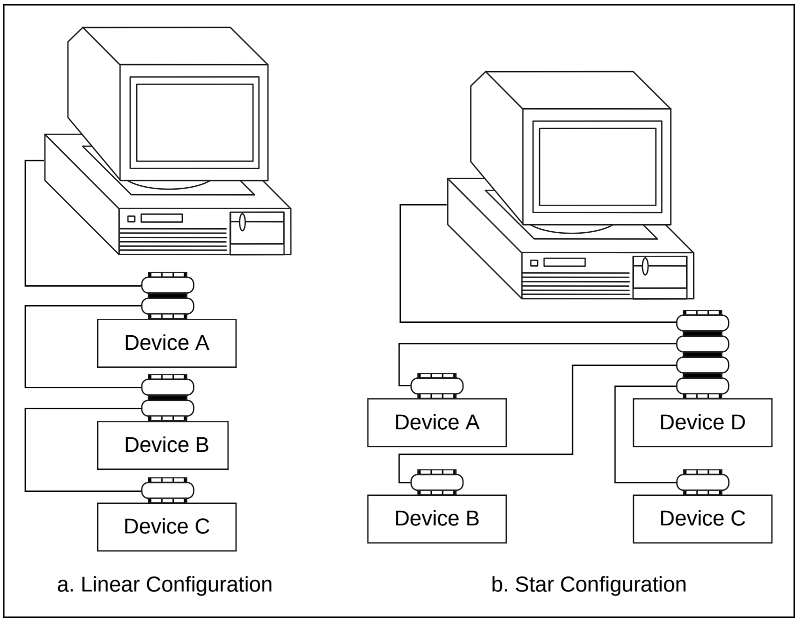


Figure 1-1. Linear and Star System Configuration

Controlling More Than One Interface

Figure 1-2 shows an example of a multiboard system configuration. `gpib0` is the access interface for the voltmeter, and `gpib1` is the access interface for the plotter and printer. The control functions of the devices automatically access their respective interfaces.

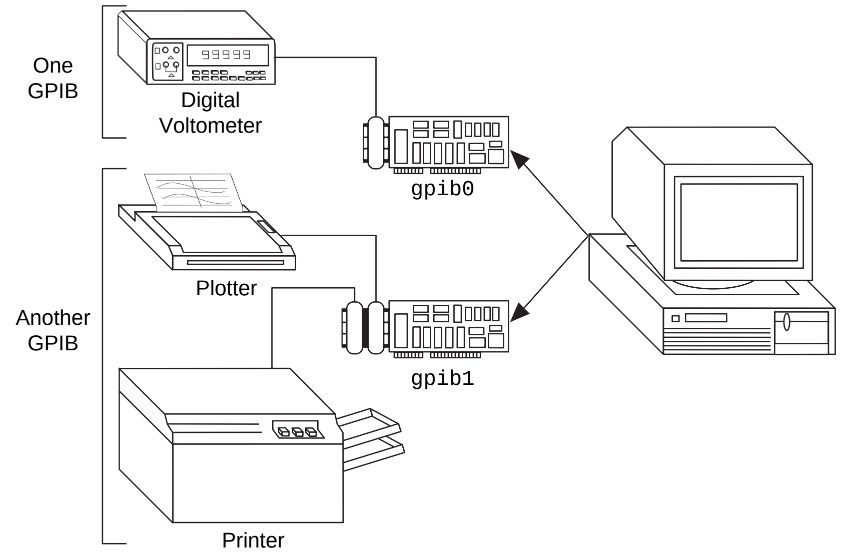


Figure 1-2. Example of Multiboard System Configuration

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 extender to increase the cable length or a bus expander to increase the number of device loads. You can order bus extenders and expanders from National Instruments.

2 Measurement & Automation Explorer

This chapter describes Measurement & Automation Explorer, an interactive utility you can use with the NI-488.2 software.

To start Measurement & Automation Explorer, select **Start»Programs»National Instruments NI-488.2»Explore GPIB**.

Overview

You can perform the following GPIB-related tasks in Measurement & Automation Explorer:

- Establish basic communication with your GPIB instruments.
- Scan for instruments connected to your GPIB interface.
- Launch the NI-488.2 Getting Started Wizard to get started with GPIB instrument communication.
- Launch the NI-488.2 Troubleshooting Wizard to troubleshoot GPIB and NI-488.2 problems.
- Launch NI Spy to monitor NI-488.2 or VISA API calls to GPIB interfaces.
- View information about your GPIB hardware and NI-488.2 software.
- Reconfigure the GPIB interface settings.
- Locate additional help resources for GPIB and NI-488.2.

Starting Measurement & Automation Explorer

To start Measurement & Automation Explorer, select **Start»Programs»National Instruments NI-488.2»Explore GPIB**. Figure 2-1 shows Measurement & Automation Explorer.

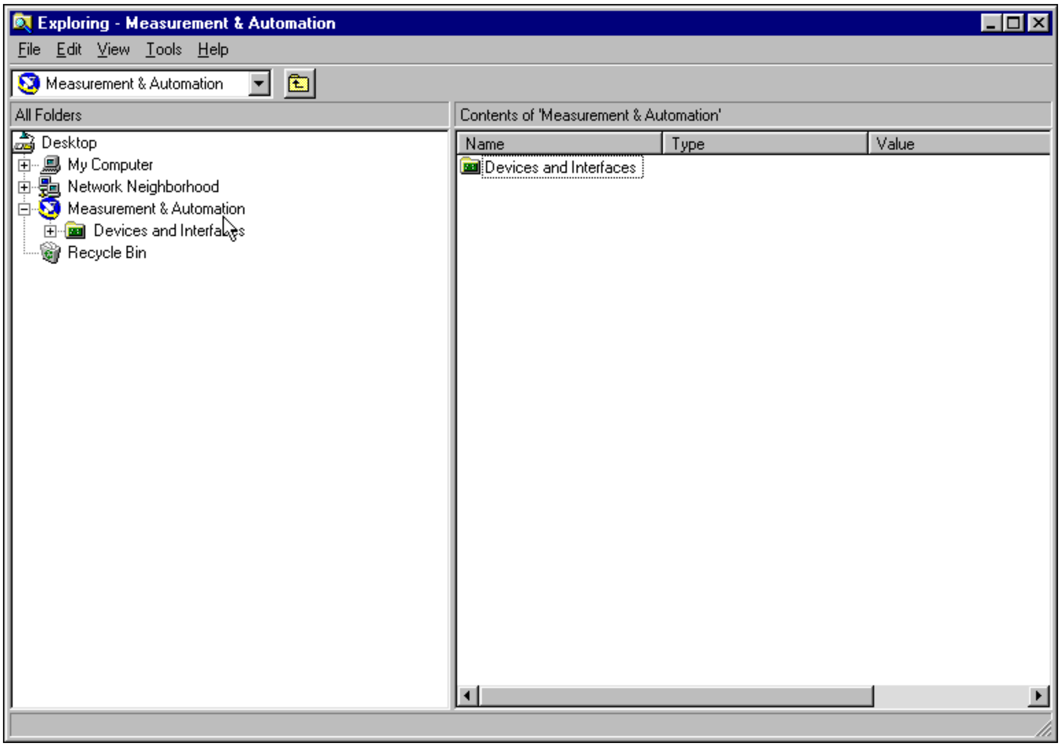


Figure 2-1. Measurement & Automation Explorer

Getting Started with NI-488.2

To get started with GPIB instrument communication using Measurement & Automation Explorer, complete the following steps:

1. Refer to your *Getting Started* card and install the NI-488.2 software and your GPIB hardware.

   If you do not have a *Getting Started* card, complete the following steps to view your getting started documentation:

   a. Insert the *NI-488.2 for Windows* CD.

b. When the **NI-488.2 Software for Windows** screen appears, select the **View Documentation** option, as shown in Figure 2-2.

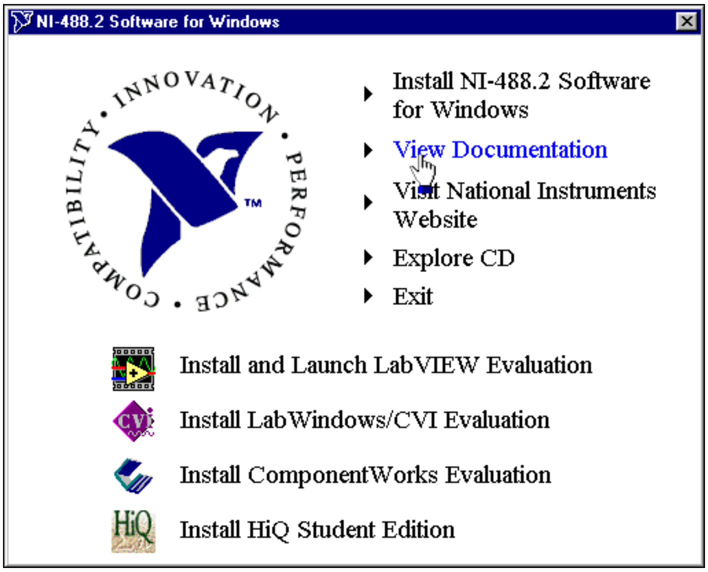

NI-488.2 Software for Windows
INNOVATION • PERFORMANCE • COMPATIBILITY •
Install NI-488.2 Software for Windows
View Documentation
Visit National Instruments Website
Explore CD
Exit
Install and Launch LabVIEW Evaluation
Install LabWindows/CVI Evaluation
Install ComponentWorks Evaluation
Install HiQ Student Edition

Figure 2-2. Viewing Documentation on Your CD

The View Documentation Wizard helps you find the documentation that you want to view.

2. Use the NI-488.2 Getting Started Wizard to verify the installation and establish basic communication with your GPIB instruments.

Note After you install the NI-488.2 software and restart your system, the NI-488.2 Getting Started Wizard runs automatically. To start it within Measurement & Automation Explorer, select **Measurement & Automation** in the left window pane and select **Help»Getting Started»NI-488.2 Getting Started Wizard**.

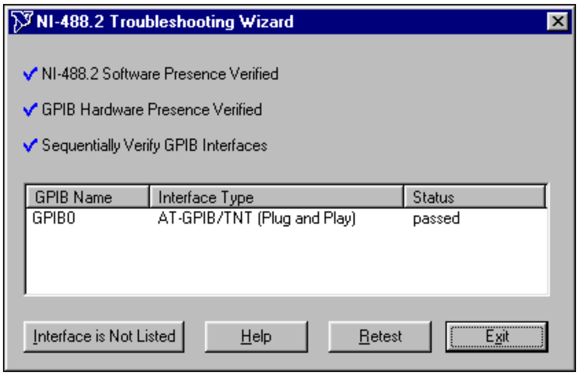
After you install the NI-488.2 software and your GPIB hardware, you can run an existing NI-488.2 application or develop a new NI-488.2 application.

Troubleshoot NI-488.2 Problems

To troubleshoot NI-488.2 problems, run the NI-488.2 Troubleshooting Wizard, as follows:

1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
2. Select **Help»Troubleshooting»NI-488.2 Troubleshooting Wizard**.

   The Troubleshooting Wizard tests your GPIB interface and displays the results, as shown in Figure 2-3.



✓ NI-488.2 Software Presence Verified
✓ GPIB Hardware Presence Verified
✓ Sequentially Verify GPIB Interfaces

GPIB Name	Interface Type	Status
GPIB0	AT-GPIB/TNT (Plug and Play)	passed

Figure 2-3. NI-488.2 Troubleshooting Wizard

To view online help for the Troubleshooting Wizard, click on the **Help** button.

Add a New GPIB Interface

To add a new GPIB interface to your system, complete the following steps:

1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
2. Select the **Devices and Interfaces** folder.
3. In the right window pane, double-click on the **Add Device or Interface** icon.

   The **Insert New** dialog box appears.
4. Double-click on the **GPIB Interface** item.

   If you are using Windows 98/95, the Add GPIB Hardware Wizard appears. If you are using Windows 2000/NT, the NI-488.2 Configuration utility appears.

5. Use either the Add GPIB Hardware Wizard or the NI-488.2 Configuration utility to add your interface.

Delete a GPIB Interface

Before you physically remove a GPIB interface from your system, you must remove the hardware information, as follows:

Note If your interface is a PCMCIA-GPIB, click on the **PC Card** icon on the taskbar to stop the PC Card. When you stop the PC Card, the system removes the hardware information from the Device Manager.

1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
2. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.
3. Right-click on your GPIB interface and select **Delete Interface** from the drop-down menu that appears.
4. When prompted, click on the **Yes** button to confirm the removal of your interface.

Scan for GPIB Instruments

To scan for instruments connected to your GPIB interface or to add a new instrument to your system, complete the following steps:

1. Make sure that your instrument is powered on and connected to your GPIB interface.
2. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
3. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.
4. Right-click on your GPIB interface and select **Scan for Instruments** from the drop-down menu that appears.

   Measurement & Automation Explorer displays the connected instruments in the right window pane.

Instruments Not Found

If the **`Instruments not Found`** message appears in the right window pane, Measurement & Automation Explorer did not find any instruments. To solve this problem, make sure that your GPIB instruments are powered on and properly connected to the GPIB interface with a GPIB cable. Then, scan for instruments again, as described in the previous section, *Scan for GPIB Instruments*.

Instruments Enumeration Failed

If the **`Instruments Enumeration Failed`** message appears in the right window pane, Measurement & Automation Explorer found too many Listeners on the GPIB. To solve this problem, refer to the following possible solutions:

- If you have a running GPIB Analyzer with the GPIB handshake option enabled, disable the GPIB handshake option in the GPIB Analyzer.
- If you have a GPIB extender in your system, Measurement & Automation Explorer cannot detect any instruments connected to your GPIB interface. Instead, you can verify communication with your instruments using the Interactive Control utility. To do so, select **Tools»NI-488.2 Utilities»Interactive Control**. For more information about verifying instrument communication, type `help "Interactive Control:getting started"` at the Interactive Control command prompt.

Communicate with Your Instrument

To establish basic or advanced communication with your instruments, refer to the following sections.

For more information about instrument communication and a list of the commands that your instrument understands, refer to the documentation that came with your GPIB instrument. Most instruments respond to the `*IDN?` command by returning an identification string.

Basic Communication (Query/Write/Read)

To establish basic communication with your instrument, use the NI-488.2 Communicator, as follows:

1. If you have not already done so, scan for connected instruments as described in the previous section, *Scan for GPIB Instruments*.
2. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.

3. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.
4. Select your GPIB interface.

   Measurement & Automation Explorer displays the connected instruments in the right window pane.
5. Right-click on your GPIB instrument and select **Communicate with Instrument** from the drop-down menu that appears.

   The **NI-488.2 Communicator** dialog box appears, as shown in Figure 2-4.

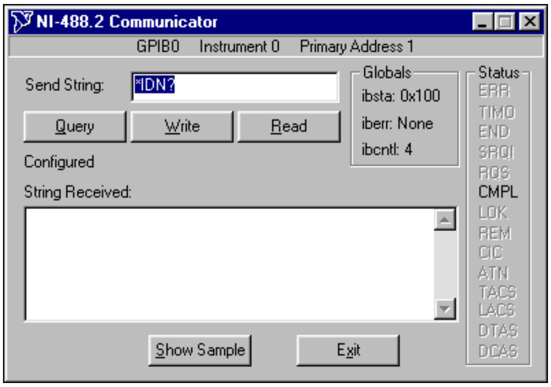


Figure 2-4. NI-488.2 Communicator

6. Type a command in the **Send String** field and do one of the following:
   - To write a command to the instrument then read a response back, click on the **Query** button.
   - To write a command to the instrument, click on the **Write** button.
   - To read a response from the instrument, click on the **Read** button.

To view sample C/C++ code that performs a simple query of a GPIB instrument, click on the **Show Sample** button.

Advanced Communication

For advanced interactive communication with GPIB instruments, use the Interactive Control utility, as follows:

1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
2. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.

3. Right-click on your GPIB interface and select **Interactive Control** from the drop-down menu that appears.
4. At the command prompt, type NI-488.2 API calls to communicate interactively with the your instrument. For example, you might use `ibdev`, `ibclr`, `ibwrt`, `ibrd`, and `ibonl`.

To view the online help for Interactive Control, type `help` at the Interactive Control command prompt.

View NI-488.2 Software Version

To view the NI-488.2 software version, complete the following steps:

1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
2. Select **Help»About Measurement & Automation Explorer**.

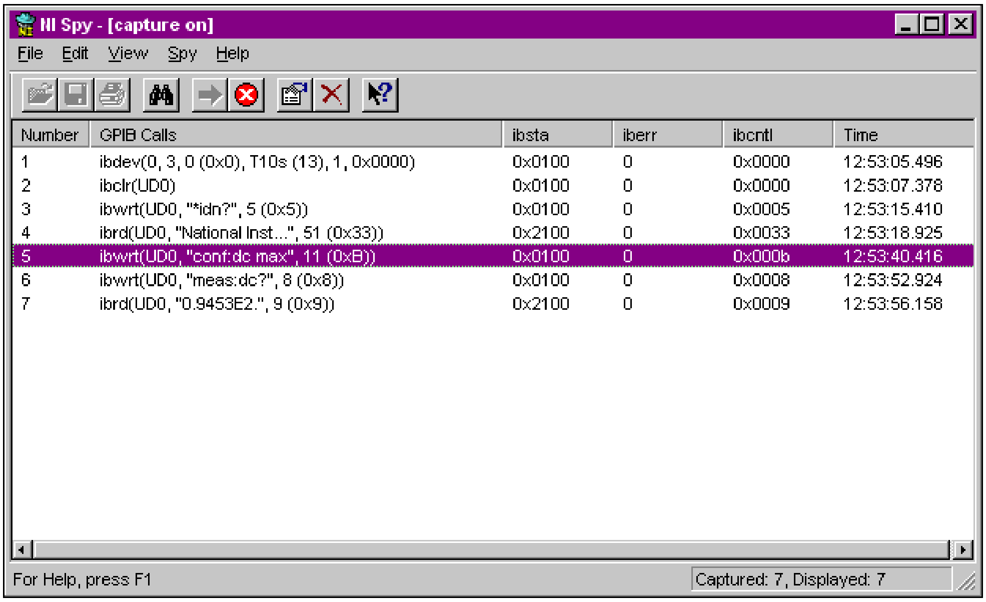
   The **Value** column in the **About Measurement & Automation Explorer** dialog box displays the version number of the NI-488.2 software.

Monitor, Record, and Display NI-488.2 Calls

To monitor NI-488.2 calls, use NI Spy, as follows:

1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
2. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.
3. Right-click on your GPIB interface and select **NI Spy** from the drop-down menu that appears.
4. On the NI Spy toolbar, click on the blue arrow button to start a capture.
5. Start the NI-488.2 application that you want to monitor.

NI Spy records and displays all NI-488.2 calls, as shown in Figure 2-5.



Number	GPIB Calls	ibsta	iberr	ibcntl	Time
1	ibdev(0, 3, 0 (0x0), T10s (13), 1, 0x0000)	0x0100	0	0x0000	12:53:05.496
2	ibclr(UD0)	0x0100	0	0x0000	12:53:07.378
3	ibwrt(UD0, "*idn?", 5 (0x5))	0x0100	0	0x0005	12:53:15.410
4	ibrd(UD0, "National Inst...", 51 (0x33))	0x2100	0	0x0033	12:53:18.925
5	ibwrt(UD0, "conf:dc max", 11 (0xB))	0x0100	0	0x000b	12:53:40.416
6	ibwrt(UD0, "meas:dc?", 8 (0x8))	0x0100	0	0x0008	12:53:52.924
7	ibrd(UD0, "0.9453E2.", 9 (0x9))	0x2100	0	0x0009	12:53:56.158

For Help, press F1

Captured: 7, Displayed: 7

Figure 2-5. NI-488.2 Calls Recorded by NI Spy

For more information about using NI Spy, select **Help»Help Topics** in NI Spy or refer to Chapter 5, *NI Spy Utility*.

View or Change GPIB Interface Settings

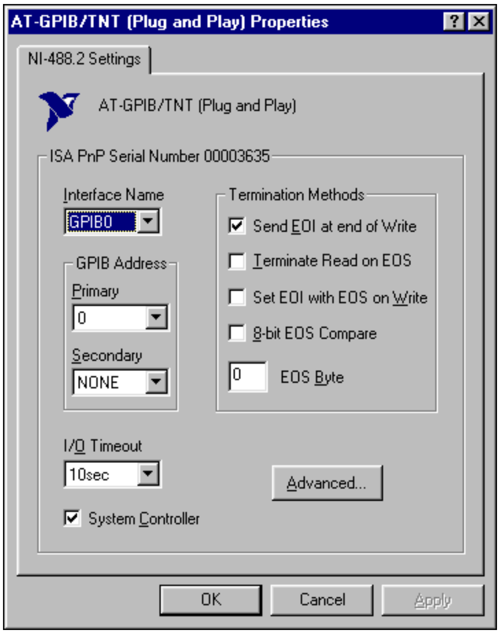
To view or change the settings of your GPIB interface, refer to one of the following sections.

Windows 98/95

To view or change your interface settings in Windows 98/95, complete the following steps:

1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
2. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.
3. Right-click on your GPIB interface and select **Properties** from the drop-down menu that appears.

The **Properties** dialog box appears. Figure 2-6 shows the **Properties** dialog box for an AT-GPIB/TNT (Plug and Play) interface.



AT-GPIB/TNT (Plug and Play) Properties

NI-488.2 Settings

AT-GPIB/TNT (Plug and Play)

ISA PnP Serial Number 00003635

Interface Name: GPIB0

GPIB Address
- Primary: 0
- Secondary: NONE

Termination Methods
- [✓] Send EOI at end of Write
- [ ] Terminate Read on EOS
- [ ] Set EOI with EOS on Write
- [ ] 8-bit EOS Compare
- EOS Byte: 0

I/O Timeout: 10sec

[✓] System Controller

Figure 2-6. Properties Dialog Box in Windows 98/95

If you need more information about a field in the **Properties** dialog box, click on the **?** button in the upper-right corner of the dialog box, then click on the field.

4. (Optional) Change the settings for your interface.

Windows 2000/NT

To view or change GPIB interface information, complete the following steps:

1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
2. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.
3. Right-click on your GPIB interface and select **Properties** from the drop-down menu that appears.

The **GPIB Configuration** dialog box appears. Figure 2-7 shows the **GPIB Configuration** dialog box for an AT-GPIB/TNT (Plug and Play) interface in Windows NT.

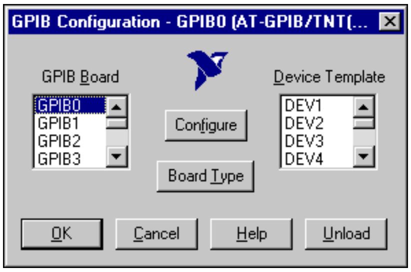


Figure 2-7. GPIB Configuration Utility in Windows NT

4. Select your **GPIB Board** and click on the **Configure** button.
5. (Optional) Change the settings for your interface.

For more information about changing the settings for your interface, click on the **Help** button.

View GPIB Instrument Information

To view information about your GPIB instruments, complete the following steps:

1. If you have not already done so, scan for connected instruments as described in the *Scan for GPIB Instruments* section earlier in this chapter.
2. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
3. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.
4. Select your GPIB interface.

   Measurement & Automation Explorer displays the connected instruments in the right window pane. Table 2-1 describes the instrument information that Measurement & Automation Explorer displays.

Table 2-1. Measurement & Automation Explorer Instrument Information

Column	Description
Name	Logical instrument name assigned by Measurement & Automation Explorer
Type	Instrument's response to the identification query (`*IDN?`)
Value	Primary (PAD) and secondary (SAD) addresses of the instrument
Description	Identifies the instrument as a GPIB instrument

Change GPIB Device Templates

For older NI-488.2 applications, you might need to modify one of the device templates to find a given GPIB instrument by name, for example, `ibfind("fluke45")`. Older applications still use `ibfind` instead of the preferred `ibdev` to obtain a device handle. In new applications, avoid using `ibfind` to obtain device handles and use `ibdev` instead. You can use `ibdev` to dynamically configure your GPIB device handle. `ibdev` also eliminates unneccessary device name requirements.

If you must modify a device template, refer to one of the following sections.

Windows 98/95

To reconfigure GPIB device templates in Windows 98/95, complete the following steps:

1. Select **Start»Settings»Control Panel**.
2. Double-click on the **System** icon.
3. Select the **Device Manager** tab and click on the **View devices by type** button.
4. Click on the **National Instruments GPIB Interfaces** icon.
5. Click on the **Properties** button.
6. Select the **Device Templates** tab and rename the template as described in your application documentation.
7. Click on the **OK** button twice to save your changes and exit.

Windows 2000/NT

To reconfigure GPIB device templates in Windows 2000/NT, complete the following steps:

1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
2. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.
3. Right-click on any GPIB interface and select **Properties** from the drop-down menu that appears.
4. Select the device template that you want to modify, such as **DEV1**.
5. Click on the **Configure** button and rename the device template as described in your application documentation.
6. Click on the **OK** button twice to save your changes and exit.

Enable/Disable NI-488.2 DOS Support

To enable or disable DOS support for your NI-488.2 application, refer to one of the following sections.

Windows 98/95

To enable or disable NI-488.2 DOS support in Windows 98/95, complete the following steps:

1. Make sure that no older version of the NI-488.2 DOS device driver is being loaded from your `config.sys` file. To do so, complete the following steps:
   a. Locate your `config.sys` file and open it for editing.
   b. Find the following line:
      ```
      device=<path>\gpib.com
      ```
      where <*path*> refers to the drive and directory where `gpib.com` is located.
   c. If that line appears, type `REM` at the beginning of the line, as follows:
      ```
      REM device=<path>\gpib.com
      ```
   d. Save your `config.sys` file and close it.
2. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.

3. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.
4. Click on your GPIB interface and select **Tools»Settings»NI-488.2** from the Explorer menu.
5. Enable or disable DOS support in the **NI-488.2 Settings** dialog box and click on the **OK** button.
6. If you are prompted to do so, restart your system.

Windows 2000/NT

To enable NI-488.2 DOS support in Windows 2000/NT, complete the following steps:

1. Open your `config.nt` file, located in the Windows NT system32 directory (for example, `c:\windows\system32`).
2. Find the following lines:

   ```
   REM ***To run DOS GPIB applications, uncomment the
   REM ***following line
   REM device=<path>\doswin16\gpib-nt.com
   ```

   where <*path*> is the directory in which you installed the NI-488.2 software.
3. Remove `REM` from the last line so that it reads as follows:

   ```
   device=<path>\doswin16\gpib-nt.com
   ```

To disable DOS support, add `REM` back to the line where it was removed.

Access Additional Help and Resources

To access additional help and resources for the NI-488.2 software and your GPIB hardware, refer to the following sections.

NI-488.2 Online Help

The *NI-488.2 for Windows Online Help* addresses questions you might have about NI-488.2, includes troubleshooting information, and describes the NI-488.2 API. You can access the NI-488.2 online help as follows:

1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
2. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.

3. Right-click on your GPIB interface and select **NI-488.2 Help** from the drop-down menu that appears.

National Instruments GPIB Web Site

To access the National Instruments Web site for GPIB, select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer. Then, select **Help»National Instruments on the Web»GPIB Home Page**.

View or Change GPIB-ENET Network Settings (Windows 98/95 Only)

To view or change the network settings of your GPIB-ENET, refer to the following sections. For more information about your GPIB-ENET network settings, refer to the *Getting Started with Your GPIB-ENET and the NI-488.2 Software for Windows 98/95* manual.

Assign IP Address

You can run the Assign IP Address utility in Measurement & Automation Explorer, as follows:

1. Contact your network administrator to determine whether you should use the Assign IP Address utility to assign the IP address manually.
2. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
3. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.
4. Right-click on your GPIB-ENET interface and select **Assign IP Address** from the drop-down menu that appears.

To view the built-in, context-sensitive help for the Assign IP Address utility, click on the **Help** button.

Configure Advanced IP Settings

You can run the Advanced IP Settings utility in Measurement & Automation Explorer, as follows:

1. Contact your network administrator.
2. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.

3. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.
4. Right-click on your GPIB-ENET interface and select **Advanced IP Settings** from the drop-down menu that appears.

To view the built-in, context-sensitive help for the Advanced IP Settings utility, click on the **Help** button.

Update GPIB-ENET Firmware

You can run the Update Firmware utility in Measurement & Automation Explorer, as follows:

1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
2. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.
3. Right-click on your GPIB-ENET interface and select **Update Firmware** from the drop-down menu that appears.

To view the built-in, context-sensitive help for the Update Firmware utility, click on the **Help** button.

3 Developing Your NI-488.2 Application

This chapter describes how to develop an NI-488.2 application using the NI-488.2 API.

Simple Instrument Control

To establish basic communication with your instrument, use the NI-488.2 Communicator, as follows:

1. If you have not already done so, scan for connected instruments as described in the *Scan for GPIB Instruments* section in Chapter 2, *Measurement & Automation Explorer*.
2. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
3. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.
4. Select your GPIB interface.

   Measurement & Automation Explorer displays the connected instruments in the right window pane.
5. Right-click on your GPIB instrument and select **Communicate with Instrument** from the drop-down menu that appears.

The **NI-488.2 Communicator** dialog box appears, as shown in Figure 3-1.

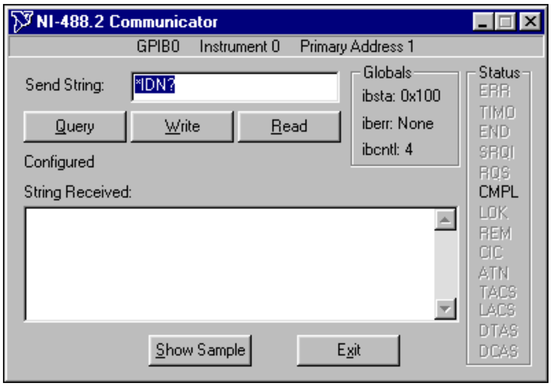


Figure 3-1. NI-488.2 Communicator

6. Type a command in the **Send String** field and do one of the following:
   - To write a command to the instrument then read a response back, click on the **Query** button.
   - To write a command to the instrument, click on the **Write** button.
   - To read a response from the instrument, click on the **Read** button.

To view sample C/C++ code that performs a simple query of a GPIB instrument, click on the **Show Sample** button.

Interactive Instrument Control

Before you write your NI-488.2 application, you might want to use the Interactive Control utility to communicate with your instruments interactively by typing individual commands rather than issuing them from an application. You can also use the Interactive Control utility to learn to communicate with your instruments using the NI-488.2 API. For specific device communication instructions, refer to the documentation that came with your instrument. For information about using the Interactive Control utility and detailed examples, refer to Chapter 6, *Interactive Control Utility*.

For advanced interactive communication with GPIB instruments, use the Interactive Control utility, as follows:

1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
2. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.
3. Right-click on your GPIB interface and select **Interactive Control** from the drop-down menu that appears.
4. At the command prompt, type NI-488.2 API calls to communicate interactively with the your instrument. For example, you might use `ibdev`, `ibclr`, `ibwrt`, `ibrd`, and `ibonl`.

To view the online help for Interactive Control, type `help` at the Interactive Control command prompt. For more information, refer to Chapter 6, *Interactive Control Utility*.

Choosing Your Programming Methodology

Based on your development environment, you can select a method for accessing the driver, and based on your NI-488.2 programming needs, you can choose how to use the NI-488.2 API.

Choosing a Method to Access the NI-488.2 Driver

Applications can access the NI-488.2 dynamic link library (DLL), `gpib-32.dll`, either by using an NI-488.2 language interface or by direct access.

NI-488.2 Language Interfaces

You can use a language interface if your program is written in Microsoft Visual C/C++ (2.0 or later), Borland C/C++ (4.0 or later), or Microsoft Visual Basic (4.0 or later). Otherwise, you must access `gpib-32.dll` directly.

Direct Entry Access

You can access the DLL directly from any programming environment that allows you to request addresses of variables and functions that a DLL exports. `gpib-32.dll` exports pointers to each of the global variables and all the NI-488.2 calls.

Choosing How to Use the NI-488.2 API

The NI-488.2 API has two subsets of calls to meet your application needs. Both of these sets, the traditional calls and the multi-device calls, are compatible across computer platforms and operating systems, so you can port programs to other platforms with little or no source code modification. For most applications, the traditional NI-488.2 calls are sufficient. If you have a complex configuration with one or more interfaces and multiple devices, use the multi-device NI-488.2 calls. Whichever option you choose, bus management operations necessary for device communication are performed automatically.

The following sections describe some differences between the traditional NI-488.2 calls and the multi-device NI-488.2 calls.

Communicating with a Single GPIB Device

If your system has only one device attached to each interface, the traditional NI-488.2 calls are probably sufficient for your programming needs. A typical NI-488.2 application with a single device has three phases:

- Initialization: use `ibdev` to get a handle and use `ibclr` to clear the device.
- Device Communication: use `ibwrt`, `ibrd`, `ibtrg` , `ibrsp`, and `ibwait` to communicate with the device.
- Cleanup: use `ibonl` to put the handle offline.

Refer to the sample applications that are installed with the NI-488.2 software to see detailed examples for different GPIB device types.

For NI-488.2 applications that need to control the GPIB in non-typical ways, for example, to communicate with non-compliant GPIB devices, there are a set of low-level functions that perform rudimentary GPIB applications. If you use these functions, you need to understand GPIB management details like how to address talkers and listeners. Refer to Appendix A, *GPIB Basics*, for some details on GPIB management.

The set of low-level functions are called board-level functions. They access the interface directly and require you to handle the addressing and bus management protocol. These functions give you the flexibility and control to handle situations such as the following:

- Communicating with non-compliant (non-IEEE 488.2) devices.
- Altering various low-level interface configurations.
- Managing the bus in non-typical ways.

Board-level functions that an NI-488.2 application might use include the following—`ibcmd`, `ibrd`, `ibwrt`, and `ibconfig`. For a detailed list, refer to the NI-488.2 online help. For instructions on accessing the online help, refer to the *Using the NI-488.2 Documentation* section in *About This Manual*.

Using Multiple Interfaces and/or Multiple Devices

When your system includes an interface that must access multiple devices, use the multi-device NI-488.2 calls, which can perform the following tasks with a single call:

- Find the Listeners on the bus using `FindLstn`.
- Find a device requesting service using `FindRQS`.
- Determine the state of the SRQ line, or wait for SRQ to be asserted using `TestSRQ` or `WaitSRQ`.
- Address multiple devices to receive a command using `SendList`.

You can mix board-level traditional NI-488.2 calls with the multi-device NI-488.2 calls to have access to all the NI-488.2 functionality.

Checking Status with Global Variables

Each NI-488.2 API call updates four global variables to reflect the status of the device or interface that you are using. These global status variables are the status word (`ibsta`), the error variable (`iberr`), and the count variables (`ibcnt` and `ibcntl`). They contain useful information about the performance of your application. Your application should check these variables after each NI-488.2 call. The following sections describe each of these global variables and how you can use them in your application.

Note If your application is a multithreaded application, refer to the section *Writing Multithreaded Win32 NI-488.2 Applications* in Chapter 7, *NI-488.2 Programming Techniques*.

Status Word (ibsta)

All NI-488.2 calls update a global status word, `ibsta`, which contains information about the state of the GPIB and the GPIB hardware. The value stored in `ibsta` is the return value of all the traditional NI-488.2 calls, except `ibfind` and `ibdev`. You can examine various status bits in `ibsta` and use that information to make decisions about continued processing. If you check for possible errors after each call using the `ibsta` ERR bit, debugging your application is much easier.

`ibsta` is a 16-bit value. A bit value of one (1) indicates that a certain condition is in effect. A bit value of zero (0) indicates that the condition is not in effect. Each bit in `ibsta` can be set for device-level traditional NI-488.2 calls (dev), board-level traditional NI-488.2 calls and multi-device NI-488.2 calls (brd), or all (dev, brd).

Table 3-1 shows the condition that each bit position represents, the bit mnemonics, and the type of calls for which the bit can be set. For a detailed explanation of each status condition, refer to Appendix B, *Status Word Conditions*.

Table 3-1. Status Word Layout

Mnemonic	Bit Pos	Hex Value	Type	Description
ERR	15	8000	dev, brd	NI-488.2 error
TIMO	14	4000	dev, brd	Time limit exceeded
END	13	2000	dev, brd	END or EOS detected
SRQI	12	1000	brd	SRQ interrupt received
RQS	11	800	dev	Device requesting service
CMPL	8	100	dev, brd	I/O completed
LOK	7	80	brd	Lockout State
REM	6	40	brd	Remote State
CIC	5	20	brd	Controller-In-Charge
ATN	4	10	brd	Attention is asserted
TACS	3	8	brd	Talker
LACS	2	4	brd	Listener
DTAS	1	2	brd	Device Trigger State
DCAS	0	1	brd	Device Clear State

The language header file defines each of the `ibsta` status bits. You can test for an `ibsta` status bit being set using the bitwise `and` operator (`&` in C/C++). For example, the `ibsta` ERR bit is bit 15 of `ibsta`.

To check for an NI-488.2 error, use the following statement after each NI-488.2 call:

```
if (ibsta & ERR)
   printf("NI-488.2 error encountered");
```

Error Variable (iberr)

If the ERR bit is set in `ibsta`, an NI-488.2 error has occurred. When an error occurs, the error type is specified by `iberr`. To check for an NI-488.2 error, use the following statement after each NI-488.2 call:

```
if (ibsta & ERR)
   printf("NI-488.2 error %d encountered", iberr);
```

Note The value in `iberr` is meaningful as an error type only when the ERR bit is set in `ibsta`, indicating that an error has occurred.

For more information about error codes and solutions, refer to Chapter 4, *Debugging Your Application*, or Appendix C, *Error Codes and Solutions*.

Count Variables (ibcnt and ibcntl)

The count variables are updated after each read, write, or command function. In Win32 applications, `ibcnt` and `ibcntl` are 32-bit integers. On some systems, like MS-DOS, `ibcnt` is a 16-bit integer, and `ibcntl` is a 32-bit integer. For cross-platform compatibility, all applications should use `ibcntl`. If you are reading data, the count variables indicate the number of bytes read. If you are sending data or commands, the count variables reflect the number of bytes sent.

Using Interactive Control to Communicate with Devices

Before you begin writing your application, you might want to use the Interactive Control utility to communicate with your instruments interactively by typing in commands from the keyboard rather than from an application. You can use the Interactive Control utility to learn to communicate with your instruments using the NI-488.2 API. For specific device communication instructions, refer to the user manual that came with your instrument. For information about using the Interactive Control utility and detailed examples, refer to Chapter 6, *Interactive Control Utility*.

Programming Models

Applications That Communicate with a Single GPIB Device

This section describes items you should include in your application and provides general program steps with an NI-488.2 example.

Items to Include

Include the following items in your application:

- Header files—In a C application, include the header files `windows.h` and `decl-32.h`. The standard Windows header file, `windows.h`, contains definitions used by `decl-32.h`, and `decl-32.h` contains prototypes for the NI-488.2 calls and constants that you can use in your application.
- Error checking—Check for errors after each NI-488.2 call.
- Error handling—Declare and define a function to handle NI-488.2 errors. This function takes the device offline and closes the application. If the function is declared as:

  ```
  void gpiberr (char * msg); /*function prototype*/
  ```

  Then, your application invokes it as follows:

  ```
  if (ibsta & ERR) {
     gpiberr("NI-488.2 error");
  }
  ```

General Program Steps and Examples

The following steps show you how to use the device-level traditional NI-488.2 calls in your application. The NI-488.2 software includes the source code for an example written in C, `devquery.c`, and the source code for the example written to use direct entry to access `gpib-32.dll`, `dlldevquery.c`. The NI-488.2 software also includes a sample program written in Visual Basic, `devquery.frm`.

Initialization

Step 1. Open a Device

Use `ibdev` to open a device handle. The `ibdev` function requires the following parameters:

- Connect board index (typically 0, for `GPIB0`).
- Primary address for the GPIB instrument (refer to the instrument user manual or use the `FindLstn` function to dynamically determine the

GPIB address of your GPIB device, as described in *Step 2. Determine the GPIB Address of Your Device* in the section *Applications That Use Multiple Interfaces or Communicate with Multiple GPIB Devices* later in this chapter).

- Secondary address for the GPIB instrument (0 if the GPIB instrument does not use secondary addressing).
- Timeout period (typically set to T10s, which is 10 seconds).
- End-of-transfer mode (typically set to 1 so that EOI is asserted with the last byte of writes).
- EOS detection mode (typically 0 if the GPIB instrument does not use EOS characters).

A successful `ibdev` call returns a device handle, `ud`, that is used for all device-level traditional NI-488.2 calls that communicate with the GPIB instrument.

Step 2. Clear the Device

Use `ibclr` to clear the device. This resets the device's internal functions to the default state.

Device Communication

Step 3. Communicate with the Device

Communicate with the device by sending it the `"*IDN?"` query and then reading back the response. Many devices respond to this query by returning a description of the device. Refer to the documentation that came with your GPIB device to see specific instructions on the proper way to communicate with it.

Step 3a.

Use `ibwrt` to send the `"*IDN?"` query command to the device.

Step 3b.

Use `ibrd` to read the response from the device.

Continue communicating with the GPIB device until you are finished.

Cleanup

Step 4. Place the Device Offline before Exiting Your Application

Use `ibonl` to put the device handle offline before you exit the application.

Applications That Use Multiple Interfaces or Communicate with Multiple GPIB Devices

This section describes items you should include in your application and provides general program steps with an NI-488.2 example.

Items to Include

Include the following items in your application:

- Header files—In a C application, include the header files `windows.h` and `decl-32.h`. The standard Windows header file, `windows.h`, contains definitions used by `decl-32.h`, and `decl-32.h` contains prototypes for the NI-488.2 calls and constants that you can use in your application.
- Error checking—Check for errors after each NI-488.2 call.
- Error handling—Declare and define a function to handle NI-488.2 errors. This function takes the device offline and closes the application. If the function is declared as:

  ```
  void gpiberr (char * msg); /*function prototype*/
  ```

  Then your application invokes it as follows:

  ```
  if (ibsta & ERR) {
     gpiberr("NI-488.2 error");
  }
  ```

General Program Steps and Examples

The following steps show you how to use the multi-device NI-488.2 calls in your application. The NI-488.2 software includes the source code for an example written in C, `4882query.c`, and the source code for the example written to use direct entry to access the `gpib-32.dll`, `dll4882query.c`. The NI-488.2 software also includes a sample program written in Visual Basic, `query4882.frm`.

Initialization

Step 1. Become Controller-In-Charge (CIC)

Use `SendIFC` to initialize the bus and the GPIB interface so that the GPIB interface is Controller-In-Charge (CIC). The only argument of `SendIFC` is the GPIB interface number, typically 0 for `GPIB0`.

Step 2. Determine the GPIB Address of Your Device

Use `FindLstn` to find all the devices attached to the GPIB. The `FindLstn` function requires the following parameters:

- Interface number (typically 0, for `GPIB0`).
- A list of primary addresses, terminated with the `NOADDR` constant.
- A list for reported GPIB addresses of devices found listening on the GPIB.
- Limit, which is the number of the GPIB addresses to report.

Use `FindLstn` to test for the presence of all of the primary addresses that are passed to it. If a device is present at a particular primary address, then the primary address is stored in the GPIB addresses list. Otherwise, all secondary addresses of the given primary address are tested, and the GPIB address of any devices found are stored in the GPIB addresses list. When you have the list of GPIB addresses, you can determine which one corresponds to your instrument and use it for subsequent calls.

Alternately, if you already know your GPIB device's primary and secondary address, you can create an appropriate GPIB address to use in subsequent NI-488.2 calls, as follows: a GPIB address is a 16-bit value that contains the primary address in the low byte and the secondary address in the high byte. If you are not using secondary addressing, the secondary address is 0. For example, if the primary address is 1, then the 16-bit value is 0x01; otherwise, if the primary address is 1 and the secondary address is 0x67, then the 16-bit value is 0x6701.

Step 3. Initialize the Devices

Use `DevClearList` to clear the devices on the GPIB. The first argument is the GPIB interface number. The second argument is the list of GPIB addresses that were found to be listening as determined in Step 2.

Device Communication

Step 4. Communicate with the Devices

Communicate with the devices by sending them the `"*IDN?"` query and then reading back the responses. Many devices respond to this query by returning a description of the device. Refer to the documentation that came with your GPIB devices to see specific instruction on the proper way to communicate with them.

Step 4a.

Use `SendList` to send the `"*IDN?"` query command to multiple GPIB devices. The address is the list of GPIB devices to be queried. The buffer that you pass to `SendList` is the command message to the device.

Step 4b.

Use `Receive` for each device to read the responses from each device.

Continue communicating with the GPIB devices until you are finished.

Cleanup

Step 5. Place the Interface Offline before Exiting Your Application

Use `ibonl` to put the interface offline before you exit the application.

Language-Specific Programming Instructions

The following sections describe how to develop, compile, and link your Win32 NI-488.2 applications using various programming languages.

Microsoft Visual C/C++ (Version 2.0 or Later)

Before you compile your Win32 C application, make sure that the following lines are included at the beginning of your program:

```
#include <windows.h>
#include "decl-32.h"
```

To compile and link a Win32 console application named `cprog` in a DOS shell, type the following on the command line:

```
cl cprog.c gpib-32.obj
```

Borland C/C++ (Version 4.0 or Later)

Before you compile your Win32 C application, make sure that the following lines are included at the beginning of your program:

```
#include <windows.h>
#include "decl-32.h"
```

To compile and link a Win32 console application named `cprog` in a DOS shell, type the following on the command line:

```
bcc32 -w32 cprog.c borlandc_gpib-32.obj
```

Visual Basic (Version 4.0 or Later)

With Visual Basic, you can access the traditional NI-488.2 calls as subroutines, using the BASIC keyword `CALL` followed by the traditional NI-488.2 call name, or you can access them using the `il` set of functions. With some of the NI-488.2 calls (for example `ibrd` and `Receive`), the length of the string buffer is automatically calculated within the actual function or subroutine, which eliminates the need to pass in the length as an extra parameter. For more information about function syntax for Visual Basic, refer to the NI-488.2 online help. For instructions on accessing the online help, refer to the *Using the NI-488.2 Documentation* section in *About This Manual*.

Before you run your Visual Basic application, include the `niglobal.bas` and `vbib-32.bas` files in your application project file.

Direct Entry with C

The following sections describe how to use direct entry with C.

gpib-32.dll Exports

`gpib-32.dll` exports pointers to the global variables and all of the NI-488.2 calls. Pointers to the global variables (`ibsta`, `iberr`, `ibcnt`, and `ibcntl`) are accessible through these exported variables:

```
int *user_ibsta;
int *user_iberr;
int *user_ibcnt;
long *user_ibcntl;
```

Except for the functions `ibbna`, `ibfind`, `ibrdf`, and `ibwrtf`, all the NI-488.2 call names are exported from `gpib-32.dll`. Thus, to use direct entry to access a particular function and to get a pointer to the exported function, you just need to call `GetProcAddress` passing the name of the function as a parameter. For more information about the parameters to use when you invoke the function, refer to the NI-488.2 online help. For instructions on accessing the online help, refer to the *Using the NI-488.2 Documentation* section in *About This Manual*.

The functions `ibbna`, `ibfind`, `ibrdf`, and `ibwrtf` all require an argument that is a name. `ibbna` requires an interface name, `ibfind` requires an interface or device name, and `ibrdf` and `ibwrtf` require a file name. Because Windows 2000/NT supports both normal (8-bit) and Unicode (16-bit) characters, `gpib-32.dll` exports both normal and Unicode versions of these functions. Because Windows 98/95 does not support 16-bit wide characters, use only the 8-bit ASCII versions, named `ibbnaA`, `ibfindA`, `ibrdfA`, and `ibwrtfA`. The Unicode versions are named `ibbnaW`, `ibfindW`, `ibrdfW`, and `ibwrtfW`. You can use either the Unicode or ASCII versions of these functions with Windows 2000/NT, but only the ASCII versions with Windows 98/95.

In addition to pointers to the status variables and a handle to the loaded `gpib-32.dll`, you must define the direct entry prototypes for the functions you use in your application. For the prototypes for each function exported by `gpib-32.dll`, refer to the NI-488.2 online help. For instructions on accessing the online help, refer to the *Using the NI-488.2 Documentation* section in *About This Manual*.

The direct entry sample programs illustrate how to use direct entry to access `gpib-32.dll`. For more information about direct entry, refer to the online help for your development environment.

Directly Accessing the gpib-32.dll Exports

Make sure that the following lines are included at the beginning of your application:

```
#ifdef __cplusplus
extern "C"{
#endif

#include <windows.h>
#include "decl-32.h"

#ifdef __cplusplus
}
#endif
```

In your Win32 application, you need to load `gpib-32.dll` before accessing the `gpib-32.dll` exports. The following code fragment shows you how to call the `LoadLibrary` function to load `gpib-32.dll` and check for an error:

```
HINSTANCE Gpib32Lib = NULL;
Gpib32Lib=LoadLibrary("GPIB-32.DLL");
if (Gpib32Lib == NULL) {
   return FALSE;
}
```

For the prototypes for each function, refer to the NI-488.2 online help. For instructions on accessing the online help, refer to the *Using the NI-488.2 Documentation* section in *About This Manual*.

For functions that return an integer value, like `ibdev` or `ibwrt`, the pointer to the function needs to be cast as follows:

```
int (_stdcall *Pname)
```

where `*Pname` is the name of the pointer to the function. For functions that do not return a value, like `FindLstn` or `SendList`, the pointer to the function needs to be cast as follows:

```
void (_stdcall *Pname)
```

where `*Pname` is the name of the pointer to the function. They are followed by the function's list of parameters as described in the NI-488.2 online help. For instructions on accessing the online help, refer to the *Using the NI-488.2 Documentation* section in *About This Manual*.

Following is an example of how to cast the function pointer and how the parameter list is set up for `ibdev` and `ibonl` functions:

```
int (_stdcall *Pibdev)(int ud, int pad, int sad, int tmo,
int eot, int eos);
```

```
int (_stdcall *Pibonl)(int ud, int v);
```

Next, your Win32 application needs to use `GetProcAddress` to get the addresses of the global status variables and functions your application needs. The following code fragment shows you how to get the addresses of the pointers to the status variables and any functions your application needs:

```
/* Pointers to NI-488.2 global status variables */
int *Pibsta;
int *Piberr;
long *Pibcntl;
static int(__stdcall *Pibdev)
   (int ud, int pad, int sad, int tmo, int eot,
    int eos);

static int(__stdcall *Pibonl)
   (int ud, int v);
Pibsta = (int *) GetProcAddress(Gpib32Lib,
      (LPCSTR)"user_ibsta");
Piberr = (int *) GetProcAddress(Gpib32Lib,
      (LPCSTR)"user_iberr");
```

```
Pibcntl = (long *) GetProcAddress(Gpib32Lib,
       (LPCSTR)"user_ibcnt");
```

```
Pibdev = (int (__stdcall *)
    (int, int, int, int, int, int))
    GetProcAddress(Gpib32Lib, (LPCSTR)"ibdev");
Pibonl = (int (__stdcall *)(int, int))
GetProcAddress(Gpib32Lib, (LPCSTR)"ibonl");
```

If `GetProcAddress` fails, it returns a NULL pointer. The following code fragment shows you how to verify that none of the calls to `GetProcAddress` failed:

```
if ((Pibsta  == NULL) ||
    (Piberr  == NULL) ||
    (Pibcntl == NULL) ||
    (Pibdev  == NULL) ||
    (Pibonl  == NULL)) {

   /* Free the GPIB library */
   FreeLibrary(Gpib32Lib);
   printf("GetProcAddress failed.");
}
```

Your Win32 application needs to dereference the pointer to access either the status variables or function. The following code shows you how to call a function and access the status variable from within your application:

```
dvm = (*Pibdev) (0, 1, 0, T10s, 1, 0);
if (*Pibsta & ERR) {
   printf("Call failed");
}
```

Before exiting your application, you need to free `gpib-32.dll` with the following command:

```
FreeLibrary(Gpib32Lib);
```

For more examples of directly accessing `gpib-32.dll`, refer to the direct entry sample programs `dlldevquery.c` and `dll4882query.c`, installed with the NI-488.2 software. For more information about direct entry, refer to the online help for your development environment.

Running Existing NI-488.2 Applications

Running Existing Win32 and Win16 NI-488.2 Applications

The NI-488.2 software includes the necessary components to allow existing Win32 and Win16 NI-488.2 applications to run properly.

Running Existing DOS NI-488.2 Applications Under Windows 98/95

To configure the NI-488.2 software to run existing DOS NI-488.2 applications, complete the following steps:

1. Make sure that no older version of the NI-488.2 DOS device driver is being loaded from your `config.sys` file. To do so, complete the following steps:
   a. Locate your `config.sys` file and open it for editing.
   b. Find the following line:

      `device=<`*`path`*`>\gpib.com`

      where <*`path`*> refers to the drive and directory where `gpib.com` is located.
   c. If that line appears, type `REM` at the beginning of the line, as follows:

      `REM device=<`*`path`*`>\gpib.com`
   d. Save your `config.sys` file and close it.
2. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
3. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.
4. Select your GPIB interface and select **Tools»Settings»NI-488.2** from the Explorer menu.
5. Enable or disable DOS support in the **NI-488.2 Settings** dialog box and click on the **OK** button.
6. If you are prompted to do so, restart your system.

Running Existing DOS NI-488.2 Applications under Windows 2000/NT

To run DOS NI-488.2 applications, you must enable NI-488.2 DOS support under Windows 2000/NT. To enable NI-488.2 DOS support in Windows 2000/NT, complete the following steps:

1. Open your `config.nt` file, located in the Windows 2000/NT system32 directory (for example, `c:\windows\system32`).
2. Find the following lines:

   ```
   REM ***To run DOS GPIB applications, uncomment the
   REM ***following line
   REM device=<path>\doswin16\gpib-nt.com
   ```

   where <*path*> is the directory in which you installed the NI-488.2 software.
3. Remove `REM` from the last line so that it reads as follows:

   ```
   device=<path>\doswin16\gpib-nt.com
   ```

To disable DOS support, add `REM` back to the line where it was removed.

4

Debugging Your Application

This chapter describes several ways to debug your application.

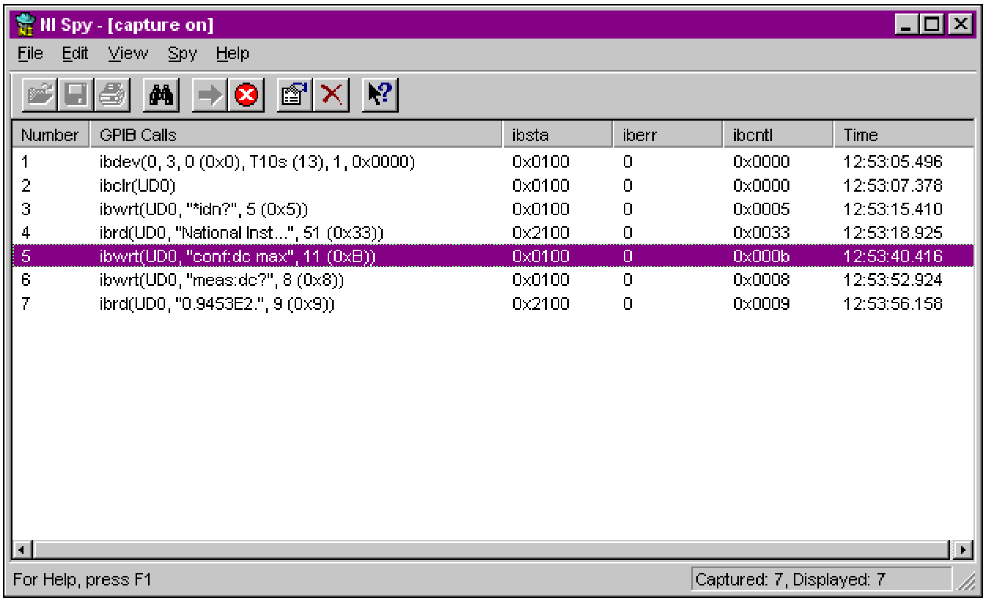
NI Spy

The NI Spy utility monitors NI-488.2 API calls made by NI-488.2 applications. It records NI-488.2 API input and output values from all Win32, Win16, and DOS NI-488.2 applications.

To start NI Spy, complete the following steps:

1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
2. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.
3. Right-click on your GPIB interface and select **NI Spy** from the drop-down menu that appears.
4. On the NI Spy toolbar, click on the blue arrow button to start a capture.
5. Start the NI-488.2 application that you want to monitor.

NI Spy records and displays all NI-488.2 calls, as shown in Figure 4-1.



Number	GPIB Calls	ibsta	iberr	ibcntl	Time
1	ibdev(0, 3, 0 (0x0), T10s (13), 1, 0x0000)	0x0100	0	0x0000	12:53:05.496
2	ibclr(UD0)	0x0100	0	0x0000	12:53:07.378
3	ibwrt(UD0, "*idn?", 5 (0x5))	0x0100	0	0x0005	12:53:15.410
4	ibrd(UD0, "National Inst...", 51 (0x33))	0x2100	0	0x0033	12:53:18.925
5	ibwrt(UD0, "conf:dc max", 11 (0xB))	0x0100	0	0x000b	12:53:40.416
6	ibwrt(UD0, "meas:dc?", 8 (0x8))	0x0100	0	0x0008	12:53:52.924
7	ibrd(UD0, "0.9453E2.", 9 (0x9))	0x2100	0	0x0009	12:53:56.158

For Help, press F1

Captured: 7, Displayed: 7

Figure 4-1. NI-488.2 Calls Recorded by NI Spy

For more information about using NI Spy, select **Help»Help Topics** in NI Spy or refer to Chapter 5, *NI Spy Utility*.

Global Status Variables

At the end of each NI-488.2 call, the global status variables (`ibsta`, `iberr`, `ibcnt`, and `ibcntl`) are updated. If you are developing an NI-488.2 application, you should check for errors after each NI-488.2 call. If a NI-488.2 call failed, the high bit of `ibsta` (the `ERR` bit) is set. For a failed NI-488.2 call, `iberr` contains a value that defines the error. In some error cases, the value in `ibcntl` contains even more error information.

You can use NI Spy to determine which NI-488.2 call is failing. Once you know which NI-488.2 call fails, refer to Appendix B, *Status Word Conditions*, and Appendix C, *Error Codes and Solutions*, for help understanding why the NI-488.2 call failed. This information is also available in the NI-488.2 online help. For instructions on accessing the online help, refer to the *Using the NI-488.2 Documentation* section in *About This Manual*.

Existing Applications

If the application does not have built-in error detection handling, you can use NI Spy to determine which NI-488.2 call is failing.

To start NI Spy, refer to the *NI Spy* section earlier in this chapter.

After you have an NI Spy capture file, you can use NI Spy to search for failed NI-488.2 calls by searching for calls with the ERR bit set. Once you know which NI-488.2 call fails, refer to Appendix B, *Status Word Conditions*, and Appendix C, *Error Codes and Solutions*, for help understanding why the NI-488.2 call failed. This information is also available in the NI-488.2 online help. For instructions on accessing the online help, refer to the *Using the NI-488.2 Documentation* section in *About This Manual*.

NI-488.2 Error Codes

The error variable is meaningful only when the ERR bit in the status variable, `ibsta`, is set. For a detailed description of each error and possible solutions, refer to Appendix C, *Error Codes and Solutions*.

Configuration Errors

Several applications require customized configuration of the NI-488.2 driver. For example, you might want to terminate reads on a special end-of-string character, or you might require secondary addressing. In these cases, you can either reconfigure from your application using the `ibconfig` function or reconfigure using the NI-488.2 Configuration utility.

Note National Instruments recommends using `ibconfig` to modify the configuration.

If your application uses `ibconfig`, it works properly regardless of the previous configuration. For more information about using `ibconfig`, refer to the description of `ibconfig` in the NI-488.2 online help. For instructions on accessing the online help, refer to the *Using the NI-488.2 Documentation* section in *About This Manual*.

Timing Errors

If your application fails, but the same calls issued interactively in the Interactive Control utility are successful, your program might be issuing the NI-488.2 calls too quickly for your device to process and respond to them. This problem can also result in corrupted or incomplete data. This should only be a problem with older, non-standard GPIB devices.

To check if your interactively issued NI-488.2 calls succeed, use the Interactive Control utility. To start the Interactive Control utility, complete the following steps:

1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
2. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.
3. Right-click on your GPIB interface and select **Interactive Control** from the drop-down menu that appears.
4. At the command prompt, type NI-488.2 API calls to communicate interactively with the your instrument. For example, you might use `ibdev`, `ibclr`, `ibwrt`, `ibrd`, and `ibonl`.

To view the online help for Interactive Control, type `help` at the Interactive Control command prompt.

A well-behaved IEEE 488 device does not experience timing errors. If your device is not well-behaved, you can test for and resolve the timing error by single-stepping through your program and inserting finite delays between each NI-488.2 call. One way to do this is to have your device communicate its status whenever possible. Although this method is not possible with many devices, it is usually the best option. Your delays are controlled by the device and your application can adjust itself and work independently on any platform. Other delay mechanisms probably exhibit differing behaviors on different platforms and thus might not eliminate timing errors.

Communication Errors

The following sections describe communication errors you might encounter in your application.

Repeat Addressing

Devices adhering to the IEEE 488.2 standard should remain in their current state until specific commands are sent across the GPIB to change their state. However, some devices require GPIB addressing before any GPIB activity. Therefore, you might need to configure your NI-488.2 driver to perform repeat addressing if your device does not remain in its currently addressed state. You can either reconfigure from your application using `ibconfig`, or reconfigure using the NI-488.2 Configuration utility.

Note National Instruments recommends using `ibconfig` to modify the configuration.

If your application uses `ibconfig`, it works properly regardless of the previous configuration. For more information about `ibconfig`, refer to the description of `ibconfig` in the NI-488.2 online help. For instructions on accessing the online help, refer to the *Using the NI-488.2 Documentation* section in *About This Manual*.

Termination Method

You should be aware of the data termination method that your device uses. By default, your NI-488.2 software is configured to send EOI on writes and terminate reads on EOI or a specific byte count. If you send a command string to your device and it does not respond, it might not be recognizing the end of the command. In that case, you need to send a termination message, such as <CR> <LF>, after a write command, as follows:

```
ibwrt(dev,"COMMAND\x0A\x0D",9);
```

Other Errors

If you experience other errors in your application, refer to the NI-488.2 online help. It includes extensive troubleshooting information and the answers to frequently asked questions. For instructions on accessing the online help, refer to the *Using the NI-488.2 Documentation* section in *About This Manual*.

5 NI Spy Utility

This chapter introduces you to NI Spy, a utility that monitors and records multiple National Instruments APIs (for example, NI-488.2 and VISA).

Overview

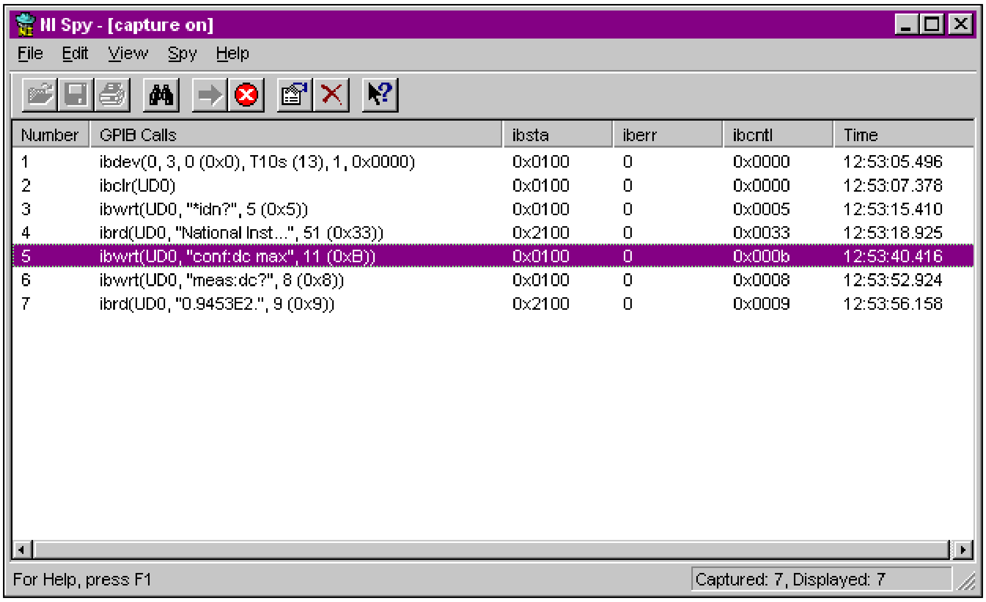
NI Spy monitors, records, and displays the NI-488.2 calls made from Win32, Win16, and DOS NI-488.2 applications. It is a useful tool for troubleshooting errors in your application and for verifying that the communication with your GPIB instrument is correct.

Starting NI Spy

To start NI Spy, complete the following steps:

1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
2. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.
3. Right-click on your GPIB interface and select **NI Spy** from the drop-down menu that appears.
4. On the NI Spy toolbar, click on the blue arrow button to start a capture.
5. Start the NI-488.2 application that you want to monitor.

NI Spy records and displays all NI-488.2 calls, as shown in Figure 5-1.



Number	GPIB Calls	ibsta	iberr	ibcntl	Time
1	ibdev(0, 3, 0 (0x0), T10s (13), 1, 0x0000)	0x0100	0	0x0000	12:53:05.496
2	ibclr(UD0)	0x0100	0	0x0000	12:53:07.378
3	ibwrt(UD0, "*idn?", 5 (0x5))	0x0100	0	0x0005	12:53:15.410
4	ibrd(UD0, "National Inst...", 51 (0x33))	0x2100	0	0x0033	12:53:18.925
5	ibwrt(UD0, "conf:dc max", 11 (0xB))	0x0100	0	0x000b	12:53:40.416
6	ibwrt(UD0, "meas:dc?", 8 (0x8))	0x0100	0	0x0008	12:53:52.924
7	ibrd(UD0, "0.9453E2.", 9 (0x9))	0x2100	0	0x0009	12:53:56.158

For Help, press F1 Captured: 7, Displayed: 7

Figure 5-1. NI-488.2 Calls Recorded by NI Spy

Using the NI Spy Online Help

To view the built-in, context-sensitive online help for the NI Spy utility, select **Help»Help Topics** in NI Spy. You can also view the online help by clicking on the question mark button on the NI Spy toolbar, and then clicking on the area of the screen about which you have a question.

Locating Errors with NI Spy

All NI-488.2 calls returned with an error are displayed in red within the main NI Spy window.

Viewing Properties for Recorded Calls

To see the detailed properties of any call recorded in the main NI Spy window, double-click on the call. The **Call Properties** window appears. It contains general, input, output, and buffer information.

Exiting NI Spy

When you exit NI Spy, its current configuration is saved and used to configure NI Spy when you start it again. Unless you save the data captured in NI Spy before you exit, that information is lost.

To save the captured data, click on the red circled X button on the toolbar and select **File»Save As** to save the data in a `.spy` file. After you save your data, select **File»Exit** to exit the NI Spy utility.

Performance Considerations

NI Spy can slow down the performance of your NI-488.2 application, and certain configurations of NI Spy have a larger impact on performance than others. For example, configuring NI Spy to record calls to an output file or to use full buffers might have a significant impact on the performance of both your application and your system. For this reason, use NI Spy only while you are debugging your application or in situations where performance is not critical.

6 Interactive Control Utility

This chapter introduces you to the Interactive Control utility, which lets you communicate with GPIB devices interactively.

Overview

With the Interactive Control utility, you communicate with the GPIB devices through functions you interactively type in at the keyboard. For specific information about communicating with your particular device, refer to the documentation that came with the device. You can use the Interactive Control utility to practice communication with the instrument, troubleshoot problems, and develop your application.

The Interactive Control utility helps you to learn about your instrument and to troubleshoot problems by displaying the following information on your screen after you enter a command:

- Results of the status word (`ibsta`) in hexadecimal notation.
- Mnemonic constant of each bit set in `ibsta.`
- Mnemonic value of the error variable (`iberr`) if an error exists (the ERR bit is set in `ibsta`).
- Count value for each read, write, or command function.
- Data received from your instrument.

Getting Started with Interactive Control

This section shows you how to use the Interactive Control utility to test a sequence of NI-488.2 calls.

To start the Interactive Control utility, complete the following steps:

1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
2. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.

3. Right-click on your GPIB interface and select **Interactive Control** from the drop-down menu that appears.

   For help on any Interactive Control command, type `help` followed by the command. For example, type `help ibdev` or `help set`.

4. Open either an interface handle or device handle to use for further NI-488.2 calls. Use `ibdev` to open a device handle, `ibfind` to open an interface handle, or the `set 488.2` command to switch to a 488.2 prompt.

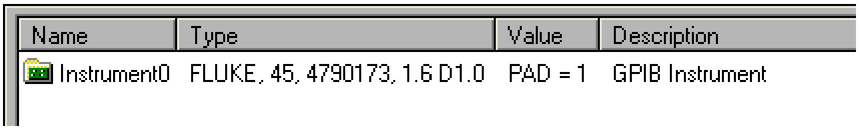
   The following example uses `ibdev` to open a device, assigns it to access interface `gpib0`, chooses a primary address of 6 with no secondary address, sets a timeout of 10 seconds, enables the END message, and disables the EOS mode:

```
:ibdev
    enter board index: 0
    enter primary address: 6
    enter secondary address: 0
    enter timeout: 13
    enter 'EOI on last byte' flag: 1
    enter end-of-string mode/byte: 0
ud0:
```

Note If you type a command and no parameters, Interactive Control prompts you for the necessary arguments. If you already know the required arguments, you can type them at the command prompt, as follows:

```
:ibdev 0 6 0 13 1 0
ud0:
```

Note If you do not know the primary and secondary address of your GPIB instrument, right-click on your GPIB interface in Measurement & Automation Explorer and select **Scan for Instruments**. After Explorer scans your interface, it displays your instrument address in the right window pane. The instrument shown in Figure 6-1 has a primary address of `1` and no secondary address.



Name	Type	Value	Description
Instrument0	FLUKE, 45, 4790173, 1.6 D1.0	PAD = 1	GPIB Instrument

Figure 6-1. Instrument Address in Measurement & Automation Explorer

5. After you successfully complete `ibdev`, you have a `ud` prompt. The new prompt, `ud0`, represents a device-level handle that you can use for further NI-488.2 calls. To clear the device, use `ibclr`, as follows:

   ```
   ud0: ibclr
   [0100] (cmpl)
   ```

6. To write data to the device, use `ibwrt`. Make sure that you refer to the documentation that came with your GPIB instrument for recognized command messages.

   ```
   ud0: ibwrt
      enter string: "*IDN?"
   [0100] (cmpl)
   count: 5
   ```

   Or, equivalently:

   ```
   ud0: ibwrt "*IDN?"
   [0100] (cmpl)
   count: 5
   ```

7. To read data from your device, use `ibrd`. The data that is read from the instrument is displayed. For example, to read 29 bytes, enter the following:

   ```
   ud0: ibrd
      enter byte count: 29
   [0100] (cmpl)
   count: 29
   46 4C 55 4B 45 2C 20 34     FLUKE, 4
   35 2C 20 34 37 39 30 31     5, 47901
   37 33 2C 20 31 2E 36 20     73, 1.6
   44 31 2E 30 0A              D.10.
   ```

   Or, equivalently:

   ```
   ud0: ibrd 29
   [0100] (cmpl)
   count: 29
   46 4C 55 4B 45 2C 20 34     FLUKE, 4
   35 2C 20 34 37 39 30 31     5, 47901
   37 33 2C 20 31 2E 36 20     73, 1.6
   44 31 2E 30 0A              D.10.
   ```

8. When you finish communicating with the device, make sure you put it offline using the `ibonl` command, as follows:

   ```
   ud0: ibonl 0
   [0100] (cmpl)
   :
   ```

The `ibonl` command properly closes the device handle and the `ud0` prompt is no longer available.

9. To exit Interactive Control, type `q`.

Interactive Control Syntax

The following special rules apply to making calls from the Interactive Control utility:

- The `ud` or `BoardId` parameter is implied by the Interactive Control prompt, therefore it is never included in the call.
- The `count` parameter to functions is unnecessary because buffer lengths are automatically determined by Interactive Control.
- Function return values are handled automatically by Interactive Control. In addition to printing out the return `ibsta` value for the function, it also prints other return values.
- If you do not know what parameters are appropriate to pass to a given function call, type in the function name and press <Enter>. The Interactive Control utility then prompts you for each required parameter.

Number Syntax

You can enter numbers in either hexadecimal or decimal format.

Hexadecimal numbers—You must prefix hexadecimal numbers with `0x`. For example, `ibpad 0x16` sets the primary address to 16 hexadecimal (22 decimal).

Decimal numbers—Enter the number only. For example, `ibpad 22` sets the primary address to 22 decimal.

String Syntax

You can enter strings as an ASCII character sequence, hex bytes, or special symbols.

ASCII character sequence—You must enclose the entire sequence in quotation marks.

Hex byte—You must use a backslash character and an `x`, followed by the hex value. For example, hex 40 is represented by `\x40`.

Special symbols—Some instruments require special termination or end-of-string (EOS) characters that indicate to the device that a transmission has ended. The two most common EOS characters are `\r` and `\n`. `\r` represents a carriage return character and `\n` represents a linefeed character. You can use these special characters to insert the carriage return and linefeed characters into a string, as in `"*IDN?\r\n"`.

Address Syntax

Some of the NI-488.2 calls have an address or address list parameter. An address is a 16-bit representation of the GPIB device address. The primary address is stored in the low byte and the secondary address, if any, is stored in the high byte. For example, a device at primary address 6 and secondary address 0x67 has an address of 0x6706. A `NULL` address is represented as 0xffff. An address list is represented by a comma-separated list of addresses, such as `1,2,3`.

Interactive Control Commands

Tables 6-1 and 6-2 summarize the syntax of the traditional NI-488.2 calls in the Interactive Control utility. Table 6-3 summarizes the syntax of the multi-device NI-488.2 calls in the Interactive Control utility. Table 6-4 summarizes the auxiliary functions that you can use in the Interactive Control utility. For more information about the function parameters, use the online help, available by typing in `help`. If you enter only the function name, the Interactive Control utility prompts you for parameters.

Table 6-1. Syntax for Device-Level Traditional NI-488.2 Calls in Interactive Control

Syntax	Description
`ibask option`	Return configuration information where `option` is a mnemonic for a configuration parameter
`ibbna bname`	Change access interface of device where `bname` is symbolic name of new interface
`ibclr`	Clear specified device
`ibconfig option value`	Alter configurable parameters where `option` is mnemonic for a configuration parameter
`ibdev BdIndx pad sad tmo eot eos`	Open an unused device; `ibdev` parameters are `BdIndx pad sad tmo eot eos`

Table 6-1. Syntax for Device-Level Traditional NI-488.2 Calls in Interactive Control (Continued)

Syntax	Description
`ibeos v`	Change/disable EOS message
`ibeot v`	Enable/disable END message
`ibln pad sad`	Check for presence of device on the GPIB at `pad`, `sad`
`ibloc`	Go to local
`ibonl v`	Place device online or offline
`ibpad v`	Change primary address
`ibpct`	Pass control
`ibppc v`	Parallel poll configure
`ibrd count`	Read data where `count` is the bytes to read
`ibrda count`	Read data asynchronously where `count` is the bytes to read
`ibrdf flname`	Read data to file where `flname` is pathname of file to read
`ibrpp`	Conduct a parallel poll
`ibrsp`	Return serial poll byte
`ibsad v`	Change secondary address
`ibstop`	Abort asynchronous operation
`ibtmo v`	Change/disable time limit
`ibtrg`	Trigger selected device
`ibwait mask`	Wait for selected event where `mask` is a hex or decimal integer or a list of mask bit mnemonics, such as `ibwait TIMO CMPL`
`ibwrt wrtbuf`	Write data
`ibwrta wrtbuf`	Write data asynchronously
`ibwrtf flname`	Write data from a file where `flname` is pathname of file to write

Table 6-2. Syntax for Board-Level Traditional NI-488.2 Calls in Interactive Control

Syntax	Description
`ibask option`	Return configuration information where `option` is a mnemonic for a configuration parameter
`ibcac v`	Become active Controller
`ibcmd cmdbuf`	Send commands
`ibcmda cmdbuf`	Send commands asynchronously
`ibconfig option value`	Alter configurable parameters where `option` is mnemonic for a configuration parameter
`ibdma v`	Enable/disable DMA
`ibeos v`	Change/disable EOS message
`ibeot v`	Enable/disable END message
`ibfind udname`	Return unit descriptor where `udname` is the symbolic name of interface (for example, `gpib0`)
`ibgts v`	Go from Active Controller to standby
`ibist v`	Set/clear `ist`
`iblines`	Read the state of all GPIB control lines
`ibln pad sad`	Check for presence of device on the GPIB at `pad`, `sad`
`ibloc`	Go to local
`ibonl v`	Place device online or offline
`ibpad v`	Change primary address
`ibppc v`	Parallel poll configure
`ibrd count`	Read data where `count` is the bytes to read
`ibrda count`	Read data asynchronously where `count` is the bytes to read
`ibrdf flname`	Read data to file where `flname` is pathname of file to read
`ibrpp`	Conduct a parallel poll
`ibrsc v`	Request/release system control
`ibrsv v`	Request service
`ibsad v`	Change secondary address

Table 6-2. Syntax for Board-Level Traditional NI-488.2 Calls in Interactive Control (Continued)

Syntax	Description
`ibsic`	Send interface clear
`ibsre v`	Set/clear remote enable line
`ibstop`	Abort asynchronous operation
`ibtmo v`	Change/disable time limit
`ibwait mask`	Wait for selected event where `mask` is a hex or decimal integer or a list of mask bit mnemonics, such as `ibwait TIMO CMPL`
`ibwrt wrtbuf`	Write data
`ibwrta wrtbuf`	Write data asynchronously
`ibwrtf flname`	Write data from a file where `flname` is pathname of file to write

Table 6-3. Syntax for Multi-Device NI-488.2 Calls in Interactive Control

Syntax	Description
`AllSpoll addrlist`	Serial poll multiple devices
`DevClear address`	Clear a device
`DevClearList addrlist`	Clear multiple devices
`EnableLocal addrlist`	Enable local control
`EnableRemote addrlist`	Enable remote control
`FindLstn padlist limit`	Find all Listeners
`FindRQS addrlist`	Find device asserting SRQ
`PassControl address`	Pass control to a device
`PPoll`	Parallel poll devices
`PPollConfig address dataline lineSense`	Configure device for parallel poll
`PPollUnconfig addrlist`	Unconfigure device for parallel poll
`RcvRespMsg count termination`	Receive response message
`ReadStatusByte address`	Serial poll a device
`Receive address count termination`	Receive data from a device

Table 6-3. Syntax for Multi-Device NI-488.2 Calls in Interactive Control (Continued)

Syntax	Description
`ReceiveSetup address`	Receive setup
`ResetSys addrlist`	Reset multiple devices
`Send address buffer eotmode`	Send data to a device
`SendCmds buffer`	Send command bytes
`SendDataBytes buffer eotmode`	Send data bytes
`SendIFC`	Send interface clear
`SendList addrlist buffer eotmode`	Send data to multiple devices
`SendLLO`	Put devices in local lockout
`SendSetup addrlist`	Send setup
`SetRWLS addrlist`	Put devices in remote with lockout state
`TestSRQ`	Test for service request
`TestSys addrlist`	Cause multiple devices to perform self-tests
`Trigger address`	Trigger a device
`TriggerList addrlist`	Trigger multiple devices
`WaitSRQ`	Wait for service request

Table 6-4. Auxiliary Functions in Interactive Control

Function	Description
`set udname`	Select active device or interface where `udname` is the symbolic name of the new device or interface (for example, `dev1` or `gpib0`). Call `ibfind` or `ibdev` initially to open each device or interface.
`set 488.2 v`	Start using multi-device NI-488.2 calls for interface `v`.
`help`	Display the Interactive Control utility online help.
`help option`	Display help information about `option`, where `option` is any NI-488.2 or auxiliary call (for example, `help ibwrt` or `help set`).
`!`	Repeat previous function.
`-`	Turn OFF display.

Table 6-4. Auxiliary Functions in Interactive Control (Continued)

Function	Description
`+`	Turn ON display.
`n * function`	Execute function `n` times where `function` represents the correct Interactive Control function syntax.
`n * !`	Execute previous function `n` times.
`$ filename`	Execute indirect file where `filename` is the pathname of a file that contains Interactive Control functions to be executed.
`buffer option`	Set type of display used for buffers. Valid options are `full`, `brief`, `ascii`, and `off`. Default is `full`.
`q`	Exit or quit.

Status Word

In the Interactive Control utility, all NI-488.2 calls (except `ibfind` and `ibdev`) return the status word `ibsta` in two forms: a hex value in square brackets and a list of mnemonics in parentheses. In the following example, the status word is on the second line, showing that the write operation completed successfully:

```
ud0: ibwrt "*IDN?"
[0100] (cmpl)
count: 5

ud0:
```

For more information about `ibsta`, refer to Chapter 3, *Developing Your NI-488.2 Application*.

Error Information

If an NI-488.2 call completes with an error, the Interactive Control utility displays the relevant error mnemonic. In the following example, an error condition EBUS has occurred during a data transfer:

```
ud0: ibwrt "*IDN?"
[8100] (err cmpl)
error: EBUS
count: 1

ud0:
```

In this example, the addressing command bytes could not be transmitted to the device. This indicates that either the GPIB device is powered off or the GPIB cable is disconnected.

For a detailed list of the error codes and their meanings, refer to Chapter 4, *Debugging Your Application*.

Count Information

When an I/O function completes, the Interactive Control utility displays the actual number of bytes sent or received, regardless of the existence of an error condition.

If one of the addresses in an address list is invalid, then the error is EARG and the Interactive Control utility displays the index of the invalid address as the count.

The count has a different meaning depending on which NI-488.2 call is made. For the correct interpretation of the count return, refer to the function descriptions in the NI-488.2 online help. For instructions on accessing the online help, refer to the *Using the NI-488.2 Documentation* section in *About This Manual*.

7 NI-488.2 Programming Techniques

This chapter describes techniques for using some NI-488.2 calls in your application.

For more information about each function, refer to the NI-488.2 online help. For instructions on accessing the online help, refer to the *Using the NI-488.2 Documentation* section in *About This Manual*.

Termination of Data Transfers

GPIB data transfers are terminated either when the GPIB EOI line is asserted with the last byte of a transfer or when a preconfigured end-of-string (EOS) character is transmitted. By default, EOI is asserted with the last byte of writes and the EOS modes are disabled.

You can use the `ibeot` function to enable or disable the end of transmission (EOT) mode. If EOT mode is enabled, the GPIB EOI line is asserted when the last byte of a write is sent out on the GPIB. If it is disabled, the EOI line is *not* asserted with the last byte of a write.

You can use the `ibeos` function to enable, disable, or configure the EOS modes. EOS mode configuration includes the following information:

- A 7-bit or 8-bit EOS byte.
- EOS comparison method—This indicates whether the EOS byte has seven or eight significant bits. For a 7-bit EOS byte, the eighth bit of the EOS byte is ignored.
- EOS write method—If this is enabled, the GPIB EOI line is automatically asserted when the EOS byte is written to the GPIB. If the buffer passed into an `ibwrt` call contains five occurrences of the EOS byte, the EOI line is asserted as each of the five EOS bytes are written to the GPIB. If an `ibwrt` buffer does not contain an occurrence of the EOS byte, the EOI line is not asserted (unless the EOT mode is enabled, in which case the EOI line is asserted with the last byte of the write).

- EOS read method—If this is enabled, `ibrd`, `ibrda`, and `ibrdf` calls are terminated when the EOS byte is detected on the GPIB, when the GPIB EOI line is asserted, or when the specified count is reached. If the EOS read method is disabled, `ibrd`, `ibrda`, and `ibrdf` calls terminate only when the GPIB EOI line is asserted or the specified count has been read.

You can use the `ibconfig` function to configure the software to indicate whether the GPIB EOI line was asserted when the EOS byte was read in. Use the `IbcEndBitIsNormal` option to configure the software to report only the END bit in `ibsta` when the GPIB EOI line is asserted. By default, END is reported in `ibsta` when either the EOS byte is read in or the EOI line is asserted during a read.

High-Speed Data Transfers (HS488)

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.

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. 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.

Enabling HS488

To enable HS488 for your GPIB interface, use the `ibconfig` function (option `IbcHSCableLength`). The value passed to `ibconfig` should specify the number of meters of cable in your GPIB configuration. If you specify a cable length that is much smaller than what you actually use, the transferred data could become corrupted. If you specify a cable length longer than what you actually use, the data is transferred successfully, but more slowly than if you specified the correct cable length.

In addition to using `ibconfig` to configure your GPIB interface for HS488, the Controller-In-Charge must send out GPIB command bytes (interface messages) to configure other devices for HS488 transfers.

If you are using device-level calls, the NI-488.2 software automatically sends the HS488 configuration message to devices. If you enabled the HS488 protocol in the NI-488.2 Configuration utility, the NI-488.2 software sends out the HS488 configuration message when you use `ibdev` to bring a device online. If you call `ibconfig` to change the GPIB cable length, the NI-488.2 software sends out the HS488 message again, the next time you call a device-level function.

If you are using board-level traditional NI-488.2 calls or multi-device NI-488.2 calls and you want to configure devices for high-speed, you must send the HS488 configuration messages using `ibcmd` or `SendCmds`. The HS488 configuration message is made up of two GPIB command bytes. The first byte, the Configure Enable (CFE) message (hex 1F), places all HS488 devices into their configuration mode. Non-HS488 devices should ignore this message. The second byte is a GPIB secondary command that indicates the number of meters of cable in your system. It is called the Configure (CFGn) message. Because HS488 can operate only with cable lengths of 1 to 15 m, only CFGn values of 1 through 15 (hex 61 through 6F) are valid. If the cable length was configured properly in the NI-488.2 Configuration utility, you can determine how many meters of cable are in your system by calling `ibask` (option `IbaHSCableLength`) in your application. For more information about CFE and CFGn messages, refer to the *Multiline Interface Messages* topic in the NI-488.2 online help. For instructions on accessing the online help, refer to the *Using the NI-488.2 Documentation* section in *About This Manual*.

System Configuration Effects on HS488

Maximum HS488 data transfer rates can be limited by your host computer and GPIB system setup. For example, when using a PC-compatible computer with PCI bus, the maximum obtainable transfer rate is 8 Mbytes/s, but when using a PC-compatible computer with ISA bus, the maximum transfer rate obtainable is only 2 Mbytes/s. The same IEEE 488 cabling constraints for a 350 ns T1 delay apply to HS488. As you increase the amount of cable in your GPIB configuration, the maximum data transfer rate using HS488 decreases. For example, two HS488 devices connected by two meters of cable can transfer data faster than four HS488 devices connected by 4 m of cable.

Waiting for GPIB Conditions

You can use the `ibwait` function to obtain the current `ibsta` value or to suspend your application until a specified condition occurs on the GPIB. If you use `ibwait` with a parameter of zero, it immediately updates `ibsta` and returns. If you want to use `ibwait` to wait for one or more events to occur, pass a wait mask to the function. The wait mask should always include the TIMO event; otherwise, your application is suspended indefinitely until one of the wait mask events occurs.

Asynchronous Event Notification in Win32 NI-488.2 Applications

Win32 NI-488.2 applications can asynchronously receive event notifications using the `ibnotify` function. This function is useful if you want your application to be notified asynchronously about the occurrence of one or more GPIB events. For example, you might choose to use `ibnotify` if your application only needs to interact with your GPIB device when it is requesting service. After calling `ibnotify`, your application does not need to check the status of your GPIB device. Then, when your GPIB device requests service, the NI-488.2 driver automatically notifies your application that the event has occurred by invoking a callback function. The callback function is registered with the NI-488.2 driver when the `ibnotify` call is made.

Calling the ibnotify Function

`ibnotify` has the following function prototype:

```
ibnotify (
    int ud,// unit descriptor
    int mask,// bit mask of GPIB events
    GpibNotifyCallback_t Callback,
    // callback function
    void * RefData// user-defined reference data
    )
```

Both board-level and device-level `ibnotify` calls are supported by the NI-488.2 driver. If you are using device-level calls, you call `ibnotify` with a device handle for `ud` and a `mask` of RQS, CMPL, END, or TIMO. If you are using board-level calls, you call `ibnotify` with a board handle for `ud` and a `mask` of any values except RQS or ERR. The `ibnotify` mask bits are identical to the `ibwait` mask bits. In the example of waiting for your

GPIB device to request service, you might choose to pass `ibnotify` a `mask` with RQS (for device-level) or SRQI (for board-level).

The callback function that you register with the `ibnotify` call is invoked by the NI-488.2 driver when one or more of the mask bits passed to `ibnotify` is TRUE. The function prototype of the callback is as follows:

```
int __stdcall Callback (
    int ud,// unit descriptor
    int ibsta,// ibsta value
    int iberr,// iberr value
    long ibcntl,// ibcntl value
    void * RefData// user-defined reference data
    )
```

The callback function is passed a unit descriptor, the current values of the NI-488.2 global variables, and the user-defined reference data that was passed to the original `ibnotify` call. The NI-488.2 driver interprets the return value for the callback as a mask value that is used to automatically rearm the callback if it is non-zero. For a complete description of `ibnotify`, refer to the NI-488.2 online help. For instructions on accessing the online help, refer to the *Using the NI-488.2 Documentation* section in *About This Manual*.

Note The `ibnotify` callback is executed in a separate thread of execution from the rest of your application. If your application will be performing other NI-488.2 operations while it is using `ibnotify`, use the per-thread NI-488.2 globals that are provided by the `ThreadIbsta`, `ThreadIberr`, `ThreadIbcnt`, and `ThreadIbcntl` functions described in the *Writing Multithreaded Win32 NI-488.2 Applications* section of this chapter. In addition, if your application needs to share global variables with the callback, use a synchronization primitive (for example, a semaphore) to protect access to any globals. For more information about the use of synchronization primitives, refer to the documentation about using Win32 synchronization objects that came with your development tools.

ibnotify Programming Example

The following code is an example of how you can use `ibnotify` in your application. Assume that your GPIB device is a multimeter that you program it to acquire a reading by sending `"SEND DATA"`. The multimeter requests service when it has a reading ready, and each reading is a floating point value.

In this example, globals are shared by the `Callback` thread and the main thread, and the access of the globals is not protected by synchronization. In this case, synchronization of access to these globals is not necessary because of the way they are used in the application: only a single thread is writing the global values and that thread only adds information (increases the count or adds another reading to the array of floats).

```
int __stdcall MyCallback (int ud, int LocalIbsta, int LocalIberr,
                          long LocalIbcntl, void *RefData);
int ReadingsTaken = 0;
float Readings[1000];
BOOL DeviceError = FALSE;
char expectedResponse = 0x43;

int main()
{
     int ud;

     // Assign a unique identifier to the device and store it in the
     // variable ud. ibdev opens an available device and assigns it to
     // access GPIB0 with a primary address of 1, a secondary address of 0,
     // a timeout of 10 seconds, the END message enabled, and the EOS mode
     // disabled. If ud is less than zero, then print an error message
     // that the call failed and exit the program.
     ud = ibdev         (0,// connect board
           1,           // primary address of GPIB device
           0,           // secondary address of GPIB device
           T10s,        // 10 second I/O timeout
           1,           // EOT mode turned on
           0);          // EOS mode disabled

     if (ud < 0)  {
          printf ("ibdev failed.\n");
          return 0;
     }

     // Issue a request to the device to send the data. If the ERR bit
     // is set in ibsta, then print an error message that the call failed
     // and exit the program.
     ibwrt (ud, "SEND DATA", 9L);
     if (ibsta & ERR)  {
          printf ("unable to write to device.\n");
          return 0;
     }

     // set up the asynchronous event notification on RQS
     ibnotify (ud, RQS, MyCallback, NULL);
     if (ibsta & ERR)  {
          printf ("ibnotify call failed.\n");
          return 0;
     }

     while ((ReadingsTaken < 1000) && !(DeviceError))  {
          // Your application does useful work here. For example, it
          // might process the device readings or do any other useful work.
     }

     // disable notification
     ibnotify (ud, 0, NULL, NULL);

     // Call the ibonl function to disable the hardware and software.
     ibonl (ud, 0);
     return 1;

}

int __stdcall MyCallback (int LocalUd, int LocalIbsta, int LocalIberr,
          long LocalIbcntl, void *RefData)
{
     char SpollByte;
     char ReadBuffer[40];

     // If the ERR bit is set in LocalIbsta, then print an error
     // message and return.
     if (LocalIbsta & ERR)  {
          printf ("GPIB error %d has occurred. No more callbacks.\n",
                         LocalIberr);
          DeviceError = TRUE;
          return 0;
     }
     // Read the serial poll byte from the device. If the ERR bit is set
     // in ibsta, then print an error message and return.
     LocalIbsta = ibrsp (LocalUd, &SpollByte);
     if (LocalIbsta & ERR)  {
          printf ("ibrsp failed. No more callbacks.\n");
          DeviceError = TRUE;
          return 0;
     }

     // If the returned status byte equals the expected response, then
     // the device has valid data to send; otherwise it has a fault
```

```
    // condition to report.
    if (SpollByte != expectedResponse)   {
         printf("Device returned invalid response. Status byte = 0x%x\n",
                           SpollByte);
         DeviceError = TRUE;
         return 0;
    }

    // Read the data from the device. If the ERR bit is set in ibsta,
    // then print an error message and return.
    LocalIbsta = ibrd (LocalUd, ReadBuffer, 40L);
    if (LocalIbsta & ERR)  {
         printf ("ibrd failed. No more callbacks.\n");
         DeviceError = TRUE;
         return 0;
    }

    // The string returned by ibrd is a binary string whose length is
    // specified by the byte count in ibcntl. However, many GPIB
    // instruments return ASCII data strings and this example makes this
    // assumption. Because of this, it is possible to add a NULL
    // character to the end of the data received and use the printf()
    // function to display the ASCII data. The following code
    // illustrates that.
    ReadBuffer[ibcntl] = ‘\0’;

    // Convert the data into a numeric value.
    sscanf (ReadBuffer, "%f", &Readings[ReadingsTaken]);

    // Display the data.
    printf(“Reading : %f\n”, Readings[ReadingsTaken]);

    ReadingsTaken += 1;
    if (ReadingsTaken >= 1000)  {
         return 0;
    }

    else  {
         // Issue a request to the device to send the data and rearm
         // callback on RQS.
         LocalIbsta = ibwrt (LocalUd, "SEND DATA", 9L);
         if (LocalIbsta & ERR)  {
                        printf ("ibwrt failed. No more callbacks.\n");
                        DeviceError = TRUE;
                        return 0;
            }

            else  {
                        return RQS;
            }
      }
}
```

Writing Multithreaded Win32 NI-488.2 Applications

If you are writing a multithreaded NI-488.2 application and you plan to make all of your NI-488.2 calls from a single thread, you can safely continue to use the traditional NI-488.2 global variables (`ibsta`, `iberr`, `ibcnt`, `ibcntl`). The NI-488.2 global variables are defined on a per-process basis, so each process accesses its own copy of the NI-488.2 globals.

If you are writing a multithreaded NI-488.2 application and you plan to make NI-488.2 calls from more than a single thread, you cannot safely continue to use the traditional NI-488.2 global variables without some form of synchronization (for example, a semaphore). To understand why, refer to the following example.

Assume that a process has two separate threads that make NI-488.2 calls, thread #1 and thread #2. Just as thread #1 is about to examine one of the NI-488.2 globals, it gets preempted and thread #2 is allowed to run. Thread #2 proceeds to make several NI-488.2 calls that automatically update the NI-488.2 globals. Later, when thread #1 is allowed to run, the NI-488.2 global that it is ready to examine is no longer in a known state and its value is no longer reliable.

The previous example illustrates a well-known multithreading problem. It is unsafe to access process-global variables from multiple threads of execution. You can avoid this problem in two ways:

- Use synchronization to protect access to process-global variables.
- Do not use process-global variables.

If you choose to implement the synchronization solution, you must ensure that the code making NI-488.2 calls and examining the NI-488.2 globals modified by a NI-488.2 call is protected by a synchronization primitive. For example, each thread might acquire a semaphore before making a NI-488.2 call and then release the semaphore after examining the NI-488.2 globals modified by the call. For more information about the use of synchronization primitives, refer to the documentation about using Win32 synchronization objects that came with your development tools.

If you choose not to use process-global variables, you can access per-thread copies of the NI-488.2 global variables using a special set of NI-488.2 calls. Whenever a thread makes a NI-488.2 call, the driver keeps a private copy of the NI-488.2 globals for that thread. The driver keeps a separate private copy for each thread. The following code shows the set of functions you can use to access these per-thread NI-488.2 global variables:

```
int ThreadIbsta();    // return thread-specific ibsta
int ThreadIberr();    // return thread-specific iberr
int ThreadIbcnt();    // return thread-specific ibcnt
long ThreadIbcntl();  // return thread-specific ibcntl
```

In your application, instead of accessing the per-process NI-488.2 globals, substitute a call to get the corresponding per-thread NI-488.2 global. For example, the following line of code,

```
if (ibsta & ERR)
```

could be replaced by,

```
if (ThreadIbsta() & ERR)
```

A quick way to convert your application to use per-thread NI-488.2 globals is to add the following `#define` lines at the top of your C file:

```
#define ibsta  ThreadIbsta()
#define iberr  ThreadIberr()
#define ibcnt  ThreadIbcnt()
#define ibcntl ThreadIbcntl()
```

Note If you are using `ibnotify` in your application (see the *Asynchronous Event Notification in Win32 NI-488.2 Applications* section of this chapter), the `ibnotify` callback is executed in a separate thread that is created by the NI-488.2 driver. Therefore, if your application makes NI-488.2 calls from the `ibnotify` callback function and makes NI-488.2 calls from other places, you must use the `ThreadIbsta`, `ThreadIberr`, `ThreadIbcnt`, and `ThreadIbcntl` functions described in this section, instead of the per-process NI-488.2 globals.

Device-Level Calls and Bus Management

The device-level traditional NI-488.2 calls are designed to perform all of the GPIB management for your application. However, the NI-488.2 driver can handle bus management only when the GPIB interface is CIC (Controller-In-Charge). Only the CIC is able to send command bytes to the devices on the bus to perform device addressing or other bus management activities.

Use one of the following methods to make your GPIB interface the CIC:

- If your GPIB interface is configured as the System Controller (default), it automatically makes itself the CIC by asserting the IFC line the first time you make a device-level call.
- If your setup includes more than one Controller, or if your GPIB interface is not configured as the System Controller, use the CIC Protocol method. To use the protocol, issue the `ibconfig` function (option `IbcCICPROT`) or use the NI-488.2 Configuration utility to activate the CIC protocol. If the interface is not CIC, and you make a device-level call with the CIC protocol enabled, the following sequence occurs:
    1. The GPIB interface asserts the SRQ line.
    2. The current CIC serial polls the interface.
    3. The interface returns a response byte of hex 42.
    4. The current CIC passes control to the GPIB interface.

If the current CIC does not pass control, the NI-488.2 driver returns the ECIC error code to your application. This error can occur if the current CIC does not understand the CIC protocol. If this happens, you could send a device-specific command requesting control for the GPIB interface. Then, use a board-level `ibwait` command to wait for CIC.

Talker/Listener Applications

Although designed for Controller-In-Charge applications, you can also use the NI-488.2 software in most non-Controller situations. These situations are known as Talker/Listener applications because the interface is not the GPIB Controller.

A Talker/Listener application typically uses `ibwait` with a mask of 0 to monitor the status of the interface. Then, based on the status bits set in `ibsta`, the application takes whatever action is appropriate. For example, the application could monitor the status bits TACS (Talker Active State) and LACS (Listener Active State) to determine when to send data to or receive data from the Controller. The application could also monitor the DCAS (Device Clear Active State) and DTAS (Device Trigger Active State) bits to determine if the Controller has sent the device clear (DCL or SDC) or trigger (GET) messages to the interface. If the application detects a device clear from the Controller, it might reset the internal state of message buffers. If it detects a trigger message from the Controller, the application might begin an operation, such as taking a voltage reading if the application is actually acting as a voltmeter.

Serial Polling

You can use serial polling to obtain specific information from GPIB devices when they request service. When the GPIB SRQ line is asserted, it signals the Controller that a service request is pending. The Controller must then determine which device asserted the SRQ line and respond accordingly. The most common method for SRQ detection and servicing is the serial poll. This section describes how to set up your application to detect and respond to service requests from GPIB devices.

Service Requests from IEEE 488 Devices

IEEE 488 devices request service from the GPIB Controller by asserting the GPIB SRQ line. When the Controller acknowledges the SRQ, it serial polls each open device on the bus to determine which device requested service. Any device requesting service returns a status byte with bit 6 set and then unasserts the SRQ line. Devices not requesting service return a status byte with bit 6 cleared. Manufacturers of IEEE 488 devices use lower order bits to communicate the reason for the service request or to summarize the state of the device.

Service Requests from IEEE 488.2 Devices

The IEEE 488.2 standard refined the bit assignments in the status byte. In addition to setting bit 6 when requesting service, IEEE 488.2 devices also use two other bits to specify their status. Bit 4, the Message Available bit (MAV), is set when the device is ready to send previously queried data. Bit 5, the Event Status bit (ESB), is set if one or more of the enabled IEEE 488.2 events occurs. These events include power-on, user request, command error, execution error, device dependent error, query error, request control, and operation complete. The device can assert SRQ when ESB or MAV are set, or when a manufacturer-defined condition occurs.

Automatic Serial Polling

You can enable automatic serial polling if you want your application to conduct a serial poll automatically when the SRQ line is asserted. The autopolling procedure occurs as follows:

1. To enable autopolling, use the configuration function, `ibconfig`, with option `IbcAUTOPOLL`, or the NI-488.2 Configuration utility. (Autopolling is enabled by default.)
2. When the SRQ line is asserted, the driver automatically serial polls the open devices.
3. Each positive serial poll response (bit 6 or hex 40 is set) is stored in a queue associated with the device that sent it. The RQS bit of the device status word, `ibsta`, is set.
4. The polling continues until SRQ is unasserted or an error condition is detected.
5. To empty the queue, use the `ibrsp` function. `ibrsp` returns the first queued response. Other responses are read in first-in-first-out (FIFO) fashion. If the RQS bit of the status word is not set when `ibrsp` is called, a serial poll is conducted and returns the response received. Empty the queue as soon as an automatic serial poll occurs, because responses might be discarded if the queue is full.
6. If the RQS bit of the status word is still set after `ibrsp` is called, the response byte queue contains at least one more response byte. If this happens, continue to call `ibrsp` until RQS is cleared.

Stuck SRQ State

If autopolling is enabled and the GPIB interface detects an SRQ, the driver serial polls all open devices connected to that interface. The serial poll continues until either SRQ unasserts or all the devices have been polled.

If no device responds positively to the serial poll, or if SRQ remains in effect because of a faulty instrument or cable, a *stuck SRQ* state is in effect. If this happens during an `ibwait` for RQS, the driver reports the ESRQ error. If the stuck SRQ state happens, no further polls are attempted until an `ibwait` for RQS is made. When `ibwait` is issued, the stuck SRQ state is terminated and the driver attempts a new set of serial polls.

Autopolling and Interrupts

If autopolling and interrupts are both enabled, the NI-488.2 software can perform autopolling after any device-level NI-488.2 call provided that no GPIB I/O is currently in progress. In this case, an automatic serial poll can occur even when your application is not making any calls to the NI-488.2 software. Autopolling can also occur when a device-level `ibwait` for RQS is in progress. Autopolling is not allowed when an application calls a board-level traditional or multi-device NI-488.2 call, or the stuck SRQ (ESRQ) condition occurs.

Windows 98/95

In Windows 98/95, you can use your GPIB interface without interrupts, but the NI-488.2 software performance is significantly slower without interrupts. For example, transfer sizes between 1 and 10 bytes transfer at a rate of only 2% of the transfer rate with enabled interrupts. As the transfer size increases, the performance degradation decreases slightly, but it remains a significant problem for all transfers under 1 Mbyte. For instructions on how to assign an interrupt to your GPIB interface if one was not assigned, refer to the *Enabling Interrupts* section in Appendix D, *Windows 98/95: Troubleshooting and Common Questions*.

Windows 2000/NT

The NI-488.2 software for Windows 2000/NT does not function properly if interrupts are disabled.

SRQ and Serial Polling with Device-Level Traditional NI-488.2 Calls

You can use the device-level traditional NI-488.2 call `ibrsp` to conduct a serial poll. `ibrsp` conducts a single serial poll and returns the serial poll response byte to the application. If automatic serial polling is enabled, the application can use `ibwait` to suspend program execution until RQS appears in the status word, `ibsta`. The program can then call `ibrsp` to obtain the serial poll response byte.

The following example shows you how to use the `ibwait` and `ibrsp` functions in a typical SRQ servicing situation when automatic serial polling is enabled:

```
#include "decl-32.h"
char GetSerialPollResponse ( int DeviceHandle )
{
```

```
char SerialPollResponse = 0;
ibwait ( DeviceHandle, TIMO | RQS );
if ( ibsta & RQS )  {
printf ( "Device asserted SRQ.\n" );
/* Use ibrsp to retrieve the serial poll response. */
ibrsp ( DeviceHandle, &SerialPollResponse );
}
return SerialPollResponse;
}
```

SRQ and Serial Polling with Multi-Device NI-488.2 Calls

The NI-488.2 software includes a set of multi-device NI-488.2 calls that you can use to conduct SRQ servicing and serial polling. Calls pertinent to SRQ servicing and serial polling are `AllSpoll`, `ReadStatusByte`, `FindRQS`, `TestSRQ`, and `WaitSRQ`. Following are descriptions of each of the calls:

- `AllSpoll` can serial poll multiple devices with a single call. It places the status bytes from each polled instrument into a predefined array. Then, you must check the RQS bit of each status byte to determine whether that device requested service.
- `ReadStatusByte` is similar to `AllSpoll`, except that it only serial polls a single device. It is also similar to the device-level NI-488.2 `ibrsp` function.
- `FindRQS` serial polls a list of devices until it finds a device that is requesting service or until it has polled all of the devices on the list. The call returns the index and status byte value of the device requesting service.
- `TestSRQ` determines whether the SRQ line is asserted and returns to the program immediately.
- `WaitSRQ` is similar to `TestSRQ`, except that `WaitSRQ` suspends the application until either SRQ is asserted or the timeout period is exceeded.

The following examples use these calls to detect SRQ and then determine which device requested service. In these examples, three devices are present on the GPIB at addresses 3, 4, and 5, and the GPIB interface is designated as bus index 0. The first example uses `FindRQS` to determine which device is requesting service, and the second example uses `AllSpoll` to serial poll all three devices. Both examples use `WaitSRQ` to wait for the GPIB SRQ line to be asserted.

Example 1: Using FindRQS

This example shows you how to use `FindRQS` to find the first device that is requesting service:

```
void GetASerialPollResponse ( char *DevicePad,
                              char *DeviceResponse )
{
   char SerialPollResponse = 0;
   int WaitResult;
   Addr4882_t Addrlist[4] = {3,4,5,NOADDR};
   WaitSRQ (0, &WaitResult);
   if (WaitResult) {
      printf ("SRQ is asserted.\n");
      FindRQS ( 0, AddrList, &SerialPollResponse );
      if (!(ibsta & ERR))  {
         printf ("Device at pad %x returned byte
            %x.\n", AddrList[ibcnt],(int)
            SerialPollResponse);
         *DevicePad = AddrList[ibcnt];
         *DeviceResponse = SerialPollResponse;
      }
   }
   return;
}
```

Example 2: Using AllSpoll

This example shows you how to use `AllSpoll` to serial poll three devices with a single call:

```
void GetAllSerialPollResponses ( Addr4882_t AddrList[],
short ResponseList[] )
{
   int WaitResult;
   WaitSRQ (0, &WaitResult);
   if ( WaitResult ) {
      printf ( "SRQ is asserted.\n" );
      AllSpoll ( 0, AddrList, ResponseList );
      if (!(ibsta & ERR))  {
         for (i = 0; AddrList[i] != NOADDR; i++)  {
            printf ("Device at pad %x returned byte
               %x.\n", AddrList[i], ResponseList[i] );
         }
      }
   }
```

```
    return;
}
```

Parallel Polling

Although parallel polling is not widely used, it is a useful method for obtaining the status of more than one device at the same time. The advantage of parallel polling is that a single parallel poll can easily check up to eight individual devices at once. In comparison, eight separate serial polls would be required to check eight devices for their serial poll response bytes. The value of the individual status bit (`ist`) determines the parallel poll response.

Implementing a Parallel Poll

You can implement parallel polling with either the traditional or multi-device NI-488.2 calls. If you use multi-device NI-488.2 calls to execute parallel polls, you do not need extensive knowledge of the parallel polling messages. However, you should use the traditional NI-488.2 calls for parallel polling when the GPIB interface is not the Controller, and the interface must configure itself for a parallel poll and set its own individual status bit (`ist`).

Parallel Polling with Traditional NI-488.2 Calls

Complete the following steps to implement parallel polling using traditional NI-488.2 calls. Each step contains example code.

1. Configure the device for parallel polling using the `ibppc` function, unless the device can configure itself for parallel polling.

   `ibppc` requires an 8-bit value to designate the data line number, the `ist` sense, and whether the function configures the device for the parallel poll. The bit pattern is as follows:

   0 1 1 E S D2 D1 D0

   E is 1 to disable parallel polling and 0 to enable parallel polling for that particular device.

   S is 1 if the device is to assert the assigned data line when `ist` is 1, and 0 if the device is to assert the assigned data line when `ist` is 0.

   D2 through D0 determine the number of the assigned data line. The physical line number is the binary line number plus one. For example, DIO3 has a binary bit pattern of 010.

The following example code configures a device for parallel polling using traditional NI-488.2 calls. The device asserts DIO7 if its `ist` is 0.

In this example, the `ibdev` command opens a device that has a primary address of 3, has no secondary address, has a timeout of 3 s, asserts EOI with the last byte of a write operation, and has EOS characters disabled.

The following call configures the device to respond to the poll on DIO7 and to assert the line in the case when its `ist` is 0. Pass the binary bit pattern, 0110 0110 or hex 66, to `ibppc`.

```
#include "decl-32.h"
char ppr;
dev = ibdev(0,3,0,T3s,1,0);
ibppc(dev, 0x66);
```

If the GPIB interface configures itself for a parallel poll, you should still use the `ibppc` function. Pass the interface index or an interface unit descriptor value as the first argument in `ibppc`. Also, if the individual status bit (`ist`) of the interface needs to be changed, use the `ibist` function.

In the following example, the GPIB interface is to configure itself to participate in a parallel poll. It asserts DIO5 when `ist` is 1 if a parallel poll is conducted.

```
ibppc(0, 0x6C);
ibist(0, 1);
```

2. Conduct the parallel poll using `ibrpp` and check the response for a certain value. The following example code performs the parallel poll and compares the response to hex 10, which corresponds to DIO5. If that bit is set, the `ist` of the device is 1.

   ```
   ibrpp(dev, &ppr);
   if (ppr & 0x10) printf("ist = 1\n");
   ```

3. Unconfigure the device for parallel polling with `ibppc`. Notice that any value having the parallel poll disable bit set (bit 4) in the bit pattern disables the configuration, so you can use any value between hex 70 and 7E.

   ```
   ibppc(dev, 0x70);
   ```

Parallel Polling with Multi-Device NI-488.2 Calls

Complete the following steps to implement parallel polling the using multi-device NI-488.2 calls. Each step contains example code.

1. Configure the device for parallel polling using the `PPollConfig` call, unless the device can configure itself for parallel polling. The following example configures a device at address 3 to assert data line 5 (DIO5) when its `ist` value is 1.

   ```
   #include "decl-32.h"
   char response;
   Addr4882_t AddressList[2];
   /* The following command clears the GPIB. */

   SendIFC(0);
   /* The value of sense is compared with the ist bit
      of the device and determines whether the data
      line is asserted.*/

   PPollConfig(0,3,5,1);
   ```

2. Conduct the parallel poll using `PPoll`, store the response, and check the response for a certain value. In the following example, because DIO5 is asserted by the device if `ist` is 1, the program checks bit 4 (hex 10) in the response to determine the value of `ist`.

   ```
   PPoll(0, &response);
   /* If response has bit 4 (hex 10) set, the ist bit
      of the device at that time is equal to 1. If
      it does not appear, the ist bit is equal to 0.
      Check the bit in the following statement. */

   if (response & 0x10) {
      printf("The ist equals 1.\n");
   }
   else {
      printf("The ist equals 0.\n");

   }
   ```

3. Unconfigure the device for parallel polling using `PPollUnconfig`, as shown in the following example. In this example, the `NOADDR` constant must appear at the end of the array to signal the end of the address list. If `NOADDR` is the only value in the array, all devices receive the parallel poll disable message.

   ```
   AddressList[0] = 3;
   AddressList[1] = NOADDR;
   PPollUnconfig(0, AddressList);
   ```

A

GPIB Basics

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.

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.

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 Addressing

All GPIB devices and interfaces must be assigned a unique GPIB address. A GPIB address is made up of two parts: a primary address and an optional secondary address.

The primary address is a number in the range 0 to 30. The Controller uses this address to form a talk or listen address that is sent over the GPIB when communicating with a device.

A talk address is formed by setting bit 6, the TA (Talk Active) bit of the GPIB address. A listen address is formed by setting bit 5, the LA (Listen Active) bit of the GPIB address. For example, if a device is at address 1, the Controller sends hex 41 (address 1 with bit 6 set) to make the device a Talker. Because the Controller is usually at primary address 0, it sends hex 20 (address 0 with bit 5 set) to make itself a Listener. Figure A-1 shows the configuration of the GPIB address bits.

Bit Position	7	6	5	4	3	2	1	0
Meaning	0	TA	LA	GPIB Primary Address (range 0–30)				

Figure A-1. GPIB Address Bits

With some devices, you can use secondary addressing. A secondary address is a number in the range hex 60 to hex 7E. When you use secondary addressing, the Controller sends the primary talk or listen address of the device followed by the secondary address of the device.

Sending Messages across the GPIB

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.

B

Status Word Conditions

This appendix gives a detailed description of the conditions reported in the status word, `ibsta`.

For information about how to use `ibsta` in your application program, refer to the NI-488.2 online help. For instructions on accessing the online help, refer to the *Using the NI-488.2 Documentation* section in *About This Manual*.

Each bit in `ibsta` can be set for device calls (dev), board calls (brd), or both (dev, brd). Table B-1 shows the status word layout.

Table B-1. Status Word Layout

Mnemonic	Bit Position	Hex Value	Type	Description
ERR	15	8000	dev, brd	NI-488.2 error
TIMO	14	4000	dev, brd	Time limit exceeded
END	13	2000	dev, brd	END or EOS detected
SRQI	12	1000	brd	SRQ interrupt received
RQS	11	800	dev	Device requesting service
CMPL	8	100	dev, brd	I/O completed
LOK	7	80	brd	Lockout State
REM	6	40	brd	Remote State
CIC	5	20	brd	Controller-In-Charge
ATN	4	10	brd	Attention is asserted
TACS	3	8	brd	Talker
LACS	2	4	brd	Listener
DTAS	1	2	brd	Device Trigger State
DCAS	0	1	brd	Device Clear State

ERR (dev, brd)

ERR is set in the status word following any call that results in an error. You can determine the particular error by examining the error variable `iberr`. Appendix C, *Error Codes and Solutions*, describes error codes that are recorded in `iberr` along with possible solutions. ERR is cleared following any call that does not result in an error.

TIMO (dev, brd)

TIMO indicates that the timeout period has expired. TIMO is set in the status word following any synchronous I/O functions (for example, `ibcmd`, `ibrd`, `ibwrt`, `Receive`, `Send`, and `SendCmds`) if the timeout period expires before the I/O operation has completed. TIMO is also set in the status word following an `ibwait` or `ibnotify` call if the TIMO bit is set in the `mask` parameter and the timeout period expires before any other specified `mask` bit condition occurs. TIMO is cleared in all other circumstances.

END (dev, brd)

END indicates either that the GPIB EOI line has been asserted or that the EOS byte has been received, if the software is configured to terminate a read on an EOS byte. If the GPIB interface is performing a shadow handshake as a result of the `ibgts` function, any other function can return a status word with the END bit set if the END condition occurs before or during that call. END is cleared when any I/O operation is initiated.

Some applications might need to know the exact I/O read termination mode of a read operation—EOI by itself, the EOS character by itself, or EOI plus the EOS character. You can use the `ibconfig` function (option `IbcEndBitIsNormal`) to enable a mode in which the END bit is set only when EOI is asserted. In this mode, if the I/O operation completes because of the EOS character by itself, END is not set. The application should check the last byte of the received buffer to see if it is the EOS character.

SRQI (brd)

SRQI indicates that a GPIB device is requesting service. SRQI is set whenever the GPIB interface is CIC, the GPIB SRQ line is asserted, and the automatic serial poll capability is disabled. SRQI is cleared either when the GPIB interface ceases to be the CIC or when the GPIB SRQ line is unasserted.

RQS (dev)

RQS appears in the status word only after a device-level call and indicates that the device is requesting service. RQS is set whenever one or more positive serial poll response bytes have been received from the device. A positive serial poll response byte always has bit 6 asserted. Automatic serial polling must be enabled (it is enabled by default) for RQS to automatically appear in `ibsta`. You can also wait for a device to request service regardless of the state of automatic serial polling by calling `ibwait` with a mask that contains RQS. Do not issue an `ibwait` call on RQS for a device that does not respond to serial polls. Use `ibrsp` to acquire the serial poll response byte that was received. RQS is cleared when all of the stored serial poll response bytes have been reported to you through the `ibrsp` function.

CMPL (dev, brd)

CMPL indicates the condition of I/O operations. It is set whenever an I/O operation is complete. CMPL is cleared while the I/O operation is in progress.

LOK (brd)

LOK indicates whether the interface is in a lockout state. While LOK is set, the `EnableLocal` or `ibloc` call is inoperative for that interface. LOK is set whenever the GPIB interface detects that the Local Lockout (LLO) message has been sent either by the GPIB interface or by another Controller. LOK is cleared when the System Controller unasserts the Remote Enable (REN) GPIB line.

REM (brd)

REM indicates whether the interface is in the remote state. REM is set whenever the Remote Enable (REN) GPIB line is asserted and the GPIB interface detects that its listen address has been sent either by the GPIB interface or by another Controller. REM is cleared in the following situations:

- When REN becomes unasserted.
- When the GPIB interface as a Listener detects that the Go to Local (GTL) command has been sent either by the GPIB interface or by another Controller.
- When the `ibloc` function is called while the LOK bit is cleared in the status word.

CIC (brd)

CIC indicates whether the GPIB interface is the Controller-In-Charge. CIC is set when the `SendIFC` or `ibsic` call is executed either while the GPIB interface is System Controller or when another Controller passes control to the GPIB interface. CIC is cleared either when the GPIB interface detects Interface Clear (IFC) from the System Controller or when the GPIB interface passes control to another device.

ATN (brd)

ATN indicates the state of the GPIB Attention (ATN) line. ATN is set whenever the GPIB ATN line is asserted, and it is cleared when the ATN line is unasserted.

TACS (brd)

TACS indicates whether the GPIB interface is addressed as a Talker. TACS is set whenever the GPIB interface detects that its talk address (and secondary address, if enabled) has been sent either by the GPIB interface itself or by another Controller. TACS is cleared whenever the GPIB interface detects the Untalk (UNT) command, its own listen address, a talk address other than its own talk address, or Interface Clear (IFC).

LACS (brd)

LACS indicates whether the GPIB interface is addressed as a Listener. LACS is set whenever the GPIB interface detects that its listen address (and secondary address, if enabled) has been sent either by the GPIB interface itself or by another Controller. LACS is also set whenever the GPIB interface shadow handshakes as a result of the `ibgts` function. LACS is cleared whenever the GPIB interface detects the Unlisten (UNL) command, its own talk address, Interface Clear (IFC), or that the `ibgts` function has been called without shadow handshake.

DTAS (brd)

DTAS indicates whether the GPIB interface has detected a device trigger command. DTAS is set whenever the GPIB interface, as a Listener, detects that the Group Execute Trigger (GET) command has been sent by another Controller. DTAS is cleared on any call immediately following an `ibwait` call, if the DTAS bit is set in the `ibwait` mask parameter.

DCAS (brd)

DCAS indicates whether the GPIB interface has detected a device clear command. DCAS is set whenever the GPIB interface detects that the Device Clear (DCL) command has been sent by another Controller, or whenever the GPIB interface as a Listener detects that the Selected Device Clear (SDC) command has been sent by another Controller.

If you use the `ibwait` or `ibnotify` function to wait for DCAS and the wait is completed, DCAS is cleared from `ibsta` after the next NI-488.2 call. The same is true of reads and writes. If you call a read or write function such as `ibwrt` or `Send`, and DCAS is set in `ibsta`, the I/O operation is aborted. DCAS is cleared from `ibsta` after the next NI-488.2 call.

Appendix C
Error Codes and Solutions

This appendix lists a description of each error, some conditions under which it might occur, and possible solutions.

Table C-1 lists the GPIB error codes.

Table C-1. GPIB Error Codes

Error Mnemonic	iberr Value	Meaning
EDVR	0	System error
ECIC	1	Function requires GPIB interface to be CIC
ENOL	2	No Listeners on the GPIB
EADR	3	GPIB interface not addressed correctly
EARG	4	Invalid argument to function call
ESAC	5	GPIB interface not System Controller as required
EABO	6	I/O operation aborted (timeout)
ENEB	7	Nonexistent GPIB interface
EDMA	8	DMA error
EOIP	10	Asynchronous I/O in progress
ECAP	11	No capability for operation
EFSO	12	File system error
EBUS	14	GPIB bus error
ESTB	15	Serial poll status byte queue overflow
ESRQ	16	SRQ stuck in ON position
ETAB	20	Table problem

EDVR (0)

EDVR is returned when the interface or device name passed to `ibfind`, or the interface index passed to `ibdev`, cannot be accessed. The global variable `ibcntl` contains an error code. This error occurs when you try to access an interface or device that is not installed or configured properly.

EDVR is also returned if an invalid unit descriptor is passed to any traditional NI-488.2 call.

Solutions

Possible solutions for this error are as follows:

- Use `ibdev` to open a device without specifying its symbolic name.
- Use only device or interface names that are configured in the NI-488.2 Configuration utility as parameters to the `ibfind` function.
- Use the NI-488.2 Troubleshooting Wizard to ensure that each interface you want to access is working properly, as follows:
  1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB**.
  2. Select **Help»Troubleshooting»NI-488.2 Troubleshooting Wizard**.

     The Troubleshooting Wizard tests your GPIB interface and displays the results.
- Use the unit descriptor returned from `ibdev` or `ibfind` as the first parameter in subsequent traditional NI-488.2 calls. Examine the variable before the failing function to make sure its value has not been corrupted.
- For more troubleshooting information, refer to the *Troubleshooting EDVR Error Conditions* section in Appendix D, *Windows 98/95: Troubleshooting and Common Questions*.

ECIC (1)

ECIC is returned when one of the following board functions is called while the interface is not CIC:

- Any device-level traditional NI-488.2 calls that affect the GPIB.
- Any board-level traditional NI-488.2 calls that issue GPIB command bytes: `ibcmd`, `ibcmda`, `ibln`, and `ibrpp`.

- `ibcac` and `ibgts`.
- Any NI-488.2 multi-device calls that issue GPIB command bytes: `SendCmds`, `PPoll`, `Send`, and `Receive`.

Solutions

Possible solutions for this error are as follows:

- Use `ibsic` or `SendIFC` to make the GPIB interface become CIC on the GPIB.
- Use `ibrsc 1` to make sure your GPIB interface is configured as System Controller.
- In multiple CIC situations, always be certain that the CIC bit appears in the status word `ibsta` before attempting these calls. If it does not appear, you can perform an `ibwait` (for CIC) call to delay further processing until control is passed to the interface.

ENOL (2)

ENOL usually occurs when a write operation is attempted with no Listeners addressed. For a device write, ENOL indicates that the GPIB address configured for that device in the software does not match the GPIB address of any device connected to the bus, that the GPIB cable is not connected to the device, or that the device is not powered on.

ENOL can occur in situations where the GPIB interface is not the CIC and the Controller asserts ATN before the write call in progress has ended.

Solutions

Possible solutions for this error are as follows:

- Make sure that the GPIB address of your device matches the GPIB address of the device to which you want to write data.
- Use the appropriate hex code in `ibcmd` to address your device.
- Check your cable connections and make sure at least two-thirds of your devices are powered on.
- Call `ibpad` (or `ibsad`, if necessary) to match the configured address to the device switch settings.

EADR (3)

EADR occurs when the GPIB interface is CIC and is not properly addressing itself before read and write functions. This error is usually associated with board-level functions.

EADR is also returned by the function `ibgts` when the shadow-handshake feature is requested and the GPIB ATN line is already unasserted. In this case, the shadow handshake is not possible and the error is returned to notify you of that fact.

Solutions

Possible solutions for this error are as follows:

- Make sure that the GPIB interface is addressed correctly before calling `ibrd`, `ibwrt`, `RcvRespMsg`, or `SendDataBytes`.
- Avoid calling `ibgts` except immediately after an `ibcmd` call. (`ibcmd` causes ATN to be asserted.)

EARG (4)

EARG results when an invalid argument is passed to a function call. The following are some examples:

- `ibtmo` called with a value not in the range 0 through 17.
- `ibeos` called with meaningless bits set in the high byte of the second parameter.
- `ibpad` or `ibsad` called with invalid addresses.
- `ibppc` called with invalid parallel poll configurations.
- A board-level traditional NI-488.2 call made with a valid device descriptor, or a device-level traditional NI-488.2 call made with a board descriptor.
- A multi-device NI-488.2 call made with an invalid address.
- `PPollConfig` called with an invalid data line or sense bit.

Solutions

Possible solutions for this error are as follows:

- Make sure that the parameters passed to the NI-488.2 call are valid.
- Do not use a device descriptor in a board function or vice-versa.

ESAC (5)

ESAC results when `ibsic`, `ibsre`, `SendIFC`, or `EnableRemote` is called when the GPIB interface does not have System Controller capability.

Solutions

Give the GPIB interface System Controller capability by calling `ibrsc 1` or by using the NI-488.2 Configuration utility to configure that capability into the software.

EABO (6)

EABO indicates that an I/O operation has been canceled, usually due to a timeout condition. Other causes are calling `ibstop` or receiving the Device Clear message from the CIC while performing an I/O operation. Frequently, the I/O is not progressing (the Listener is not continuing to handshake or the Talker has stopped talking), or the byte count in the call which timed out was more than the other device was expecting.

Solutions

Possible solutions for this error are as follows:

- Use the correct byte count in input functions or have the Talker use the END message to signify the end of the transfer.
- Lengthen the timeout period for the I/O operation using `ibtmo`.
- Make sure that you have configured your device to send data before you request data.

ENEB (7)

ENEB occurs when no GPIB interface exists at the I/O address specified in the configuration program. This problem happens when the interface is not physically plugged into the system, the I/O address specified during configuration does not match the actual interface setting, or there is a system conflict with the base I/O address.

Solutions

Make sure there is a GPIB interface in your computer that is properly configured both in hardware and software using a valid base I/O address by running the NI-488.2 Troubleshooting Wizard, as follows:

1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB**.
2. Select **Help»Troubleshooting»NI-488.2 Troubleshooting Wizard**.

   The Troubleshooting Wizard tests your GPIB interface and displays the results.

EDMA (8)

EDMA occurs if a system DMA error is encountered when the NI-488.2 software attempts to transfer data over the GPIB using DMA.

Solutions

Possible solutions for this error are as follows:

- You can correct the EDMA problem in the hardware by using the NI-488.2 Configuration utility to reconfigure the hardware to not use a DMA resource.
- You can correct the EDMA problem in the software by using `ibdma` to disable DMA.

EOIP (10)

EOIP occurs when an asynchronous I/O operation has not finished before some other call is made. During asynchronous I/O, you can only use `ibstop`, `ibnotify`, `ibwait`, and `ibonl` or perform other non-GPIB operations. If any other call is attempted, EOIP is returned.

Solutions

Resynchronize the driver and the application before making any further NI-488.2 calls. Resynchronization is accomplished by using one of the following functions:

`ibnotify`	If the `ibsta` value passed to the `ibnotify` callback contains CMPL, the driver and application are resynchronized.

`ibwait`	If the returned `ibsta` contains CMPL, the driver and application are resynchronized.
`ibstop`	The I/O is canceled; the driver and application are resynchronized.
`ibonl`	The I/O is canceled and the interface is reset; the driver and application are resynchronized.

ECAP (11)

ECAP results when your GPIB interface lacks the ability to carry out an operation or when a particular capability has been disabled in the software and a call is made that requires the capability.

Solutions

Check the validity of the call, or make sure your GPIB interface and the driver both have the needed capability.

EFSO (12)

EFSO results when an `ibrdf` or `ibwrtf` call encounters a problem performing a file operation. Specifically, this error indicates that the function is unable to open, create, seek, write, or close the file being accessed. The specific operating system error code for this condition is contained in `ibcntl`.

Solutions

Possible solutions for this error are as follows:

- Make sure the filename, path, and drive that you specified are correct.
- Make sure that the access mode of the file is correct.
- Make sure there is enough room on the disk to hold the file.

EBUS (14)

EBUS results when certain GPIB bus errors occur during device functions. All device functions send command bytes to perform addressing and other bus management. Devices are expected to accept these command bytes within the time limit specified by the default configuration or the `ibtmo` function. EBUS results if a timeout occurred while sending these command bytes.

Solutions

Possible solutions for this error are as follows:

- Verify that the instrument is operating correctly.
- Check for loose or faulty cabling or several powered-off instruments on the GPIB.
- If the timeout period is too short for the driver to send command bytes, increase the timeout period.

ESTB (15)

ESTB is reported only by the `ibrsp` function. ESTB indicates that one or more serial poll status bytes received from automatic serial polls have been discarded because of a lack of storage space. Several older status bytes are available; however, the oldest is being returned by the `ibrsp` call.

Solutions

Possible solutions for this error are as follows:

- Call `ibrsp` more frequently to empty the queue.
- Disable autopolling with the `ibconfig` function (option `IbcAUTOPOLL`) or the NI-488.2 Configuration utility, as follows:
  1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
  2. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.
  3. Right-click on your GPIB interface and select **Properties** from the drop-down menu that appears.

ESRQ (16)

ESRQ can only be returned by a device-level `ibwait` call with RQS set in the mask. ESRQ indicates that a wait for RQS is not possible because the GPIB SRQ line is stuck on. This situation can be caused by the following events:

- Usually, a device unknown to the software is asserting SRQ. Because the software does not know of this device, it can never serial poll the device and unassert SRQ.
- A GPIB bus tester or similar equipment might be forcing the SRQ line to be asserted.
- A cable problem might exist involving the SRQ line.

Although the occurrence of ESRQ warns you of a definite GPIB problem, it does not affect GPIB operations, except that you cannot depend on the `ibsta` RQS bit while the condition lasts.

Solutions

Check to see if other devices not used by your application are asserting SRQ. Disconnect them from the GPIB if necessary.

ETAB (20)

ETAB occurs only during the `FindLstn` and `FindRQS` functions. ETAB indicates that there was some problem with a table used by these functions:

- In the case of `FindLstn`, ETAB means that the given table did not have enough room to hold all the addresses of the Listeners found.
- In the case of `FindRQS`, ETAB means that none of the devices in the given table were requesting service.

Solutions

In the case of `FindLstn`, increase the size of result arrays. In the case of `FindRQS`, check to see if other devices not used by your application are asserting SRQ. Disconnect them from the GPIB if necessary.

D

Windows 98/95: Troubleshooting and Common Questions

This appendix describes how to troubleshoot problems and answers some common questions about the NI-488.2 software for Windows 98/95.

Troubleshooting EDVR Error Conditions

In some cases, NI-488.2 calls may return with the ERR bit set in `ibsta` and the value EDVR in `iberr`. The value stored in `ibcntl` is useful in troubleshooting the error condition.

EDVR Error Condition with ibcntl Set to 0xE028002C (–534249428)

If a call is made with an interface number that is within the range of allowed interface numbers (typically 0 to 3), but which has not been assigned to a GPIB interface, an EDVR error condition occurs with `ibcntl` set to 0xE028002C. You can assign an interface number to a GPIB interface by configuring the NI-488.2 software and selecting an interface name. For information about how to configure the NI-488.2 software, refer to the online help in the NI-488.2 Configuration utility, as follows:

1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
2. Expand the **Devices and Interfaces** directory by clicking on the + next to the folder.
3. Right-click on your GPIB interface and select **Properties** from the drop-down menu that appears.

EDVR Error Condition with ibcntl Set to 0xE0140025 (–535560155)

If a call is made with an interface number that is not within the range of allowed interface numbers (typically 0 to 3), an EDVR error condition occurs with `ibcntl` set to 0xE0140025.

EDVR Error Condition with ibcntl Set to 0xE0140035 (–535560139)

If a call is made with a device name that is not listed in the logical device templates that are part of the NI-488.2 Configuration utility, an EDVR error condition occurs with `ibcntl` set to 0xE0140035.

EDVR Error Condition with ibcntl Set to 0xE0320029 (–533594071) or 0xE1050029 (–519765975)

If a call is made with an interface number that is assigned to a GPIB interface that is unusable because of a resource conflict, an EDVR error condition occurs with `ibcntl` set to 0xE0320029 or 0xE1050029.

This error is also returned if you remove a PCMCIA-GPIB or PCMCIA-GPIB+ while the driver is accessing it or if you try to access a PCMCIA-GPIB when 32-bit PCMCIA drivers are not enabled. To enable the 32-bit PCMCIA drivers, complete the following steps:

1. Select **Start»Settings»Control Panel**.
2. Double-click on the **System** icon.
3. Select the **Performance** tab.
4. If the **PC Cards (PCMCIA)** line does not read **32-bit**, select **Start»Settings»Control Panel** and double-click on the **PC Card (PCMCIA)** icon.

   The PC Card (PCMCIA) Wizard enables the 32-bit PCMCIA drivers.
5. Shut down your system and restart it.

   Your system should detect your PCMCIA-GPIB or PCMCIA-GPIB+ interface.

EDVR Error Condition with ibcntl Set to 0xE0140004 (–535560188)

This error might occur if the GPIB interface has not been correctly installed and detected by Windows. For instructions on how to install the GPIB hardware, refer to the *GPIB Hardware Guide* on the *NI-488.2 for Windows* CD. For instructions on accessing this manual, refer to the *Using the NI-488.2 Documentation* section in *About This Manual*.

EDVR Error Condition with ibcntl set to 0xE1030043 (–519897021)

This error occurs if you have enabled DOS NI-488.2 support and attempted to run an existing NI-488.2 DOS application that was compiled with an older, unsupported DOS language interface.

Troubleshooting Device Manager Problems

If you are having trouble with your GPIB interface, use the Windows Device Manager to troubleshoot your problems. To do so, complete the following steps:

1. Select **Start»Settings»Control Panel**.
2. Double-click on the **System** icon.
3. Select the **Device Manager** tab and click on the **View devices by type** button.
4. Check to see if the interface listing in the Device Manager appears with an exclamation point or X by it. If it does, click on the interface listing and then click on the **Properties** button to display the **General** property tab for the interface.
5. In the **Device Status** section, look for the status description and status code number. Use the status code descriptions and numbers in Table D-1 to troubleshoot your problem.

Table D-1. Device Manager Status Codes

Code	Problem	Solution
9	Windows had a problem reading information from the GPIB interface. This problem can occur if you are using an older revision of the AT-GPIB/TNT+ or AT-GPIB/TNT (PnP) interface.	Contact National Instruments to upgrade your GPIB interface.
22	The GPIB interface is disabled.	To enable the GPIB interface, check the appropriate configuration checkbox in the **Device Usage** section of the **General** tab.
24	The GPIB interface is not present, or the Device Manager is unaware that the GPIB interface is present.	Select the interface in the Device Manager, and click on the **Remove** button. Next, click on the **Refresh** button. At this point, the system rescans the installed hardware, and the GPIB interface should show up without any problems. If the problem persists, contact National Instruments.
27	Windows was unable to assign the GPIB interface any resources.	Free up system resources by disabling other unnecessary hardware so that enough resources are available for the GPIB interface.

Enabling Interrupts

In Windows 98/95, you can use your GPIB interface without interrupts, but the NI-488.2 software performance is significantly slower without interrupts. For example, transfer sizes between 1 and 10 bytes transfer at a rate of only 2% of the transfer rate with enabled interrupts. As the transfer size increases, the performance degradation decreases slightly, but it remains a significant problem for all transfers under 1 Mbyte.

If you find the diminished performance unacceptable, complete the following steps to free up an interrupt resource and configure your GPIB interface to use the available interrupt resource.

Step 1. Free up an Interrupt Resource

To free up an interrupt resource, you must remove or disable one of the other devices in your system. If possible, remove a device in your system. However, your system typically does not have any devices that can be removed. In this case, you should disable a device that you do not use, such as LPT1 or COM1. To do so, complete the following steps:

1. Select **Start»Settings»Control Panel**.
2. Double-click on the **System** icon.
3. Select the **Device Manager** tab and click on the **View devices by type** button.

   If you do not use your LPT port, you can disable the LPT1 device and if you do not use your COM port, you can disable the COM1 device. However, do not disable a device that your system is using. You only need to disable one device—either LPT1 or COM1.
4. Double-click on the **Ports (COM & LPT)** item.

   If the device you want to disable has a yellow exclamation mark (!) overlaid on it, the device is not working properly and does not have assigned resources. Disabling a device that is not working properly does not free up an interrupt resource.
5. Double-click on the device that you want to disable—**Communications Port (COM1)** or **Printer Port (LPT1)**.
6. In the **Properties** dialog box, check the **Disable in this hardware profile** checkbox. If you are using Windows 95 version A, uncheck the **Original Configuration (Current)** checkbox.

7. Click on the **OK** button to save your changes.

   On the **Device Manager** tab, the disabled device has a red X overlaid on it. The red X indicates that the device is disabled.

Step 2. Remove Your GPIB Interface from the Device Manager

To remove your GPIB interface from the Device Manager, complete the following steps:

1. On the **Device Manager** tab, double-click on the **National Instruments GPIB Interfaces** item. If you are removing a PCMCIA-GPIB+ interface, double-click on the **Multifunction Adapters** item.
2. Click on the GPIB interface that does not have an interrupt resource and click on the **Remove** button. If you are removing a PCMCIA-GPIB+ interface, click on the **NI PCMCIA-GPIB+ Multifunction Parent** item and click on the **Remove** button.

Step 3. Refresh the Device Manager or Reinstall Your GPIB interface

On the **Device Manager** tab, click on the **Refresh** button.

If your GPIB interface does not appear under **National Instruments GPIB Interfaces**, your GPIB interface is not Plug and Play. In this case, you must use the Add GPIB Hardware Wizard to reinstall your interface. To start the wizard, select **Start»Programs»National Instruments NI-488.2»Add GPIB Hardware** and follow the instructions on the screen.

Common Questions

How do I get started?

To get started with your GPIB hardware and the NI-488.2 software, use the NI-488.2 Getting Started Wizard. To do so, select **Start»Programs» National Instruments NI-488.2»Getting Started Wizard**.

How do I troubleshoot problems?

Run the NI-488.2 Troubleshooting Wizard. To do so, select **Start»Programs»National Instruments NI-488.2»Explore GPIB**. Then, select **Help»Troubleshooting»NI-488.2 Troubleshooting Wizard**.

How can I determine which version of the NI-488.2 software I have installed?

To view the NI-488.2 software version, complete the following steps:

1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
2. Select **Help»About Measurement & Automation Explorer**.

   The **Value** column in the **About Measurement & Automation Explorer** dialog box displays the version number of the NI-488.2 software.

What do I do if my GPIB hardware is listed in the Windows Device Manager with a circled X or an exclamation point (!) overlaid on it?

Refer to the *Troubleshooting Device Manager Problems* section of this appendix for information about what might cause this problem. If you already completed the troubleshooting steps, contact National Instruments.

How can I determine which type of GPIB hardware I have installed?

Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** and expand the **Devices and Interfaces** directory by clicking on the + next to the folder.

Measurement & Automation Explorer lists your installed GPIB hardware under **Devices and Interfaces**.

How many GPIB interfaces can I configure for use with the NI-488.2 software?

You can configure the NI-488.2 software to communicate with up to 100 GPIB interfaces.

How many devices can I configure for use with the NI-488.2 software?

You can configure the NI-488.2 software to use up to 1,024 logical devices. The default number of devices is 32. The maximum number of physical devices you should connect to a single GPIB interface is 14, or fewer, depending on your system configuration.

Are interrupts and DMA required for the NI-488.2 software?

Neither interrupts nor DMA are required. However, if you are using a GPIB interface with Analyzer capability (PCMCIA-GPIB+ or AT-GPIB/TNT+), at least one interrupt level is required for the GPIB Analyzer driver.

In Windows 98/95, you can use your GPIB interface without interrupts, but the NI-488.2 software performance is significantly slower without interrupts. For example, transfer sizes between 1 and 10 bytes transfer at a rate of only 2% of the transfer rate with enabled interrupts. As the transfer size increases, the performance degradation decreases slightly, but it remains a significant problem for all transfers under 1 Mbyte. For instructions on how to assign an interrupt to your GPIB interface if one was not assigned, refer to the *Enabling Interrupts* section earlier in this appendix.

How can I determine if my GPIB hardware and the NI-488.2 software are installed properly?

Run the NI-488.2 Troubleshooting Wizard. To do so, select **Start»Programs»National Instruments NI-488.2»Explore GPIB**. Then, select **Help»Troubleshooting»NI-488.2 Troubleshooting Wizard**.

When should I use the Interactive Control utility?

You can use the Interactive Control utility to test and verify instrument communication, troubleshoot problems, and develop your application. For more information, refer to Chapter 6, *Interactive Control Utility*.

How do I use an NI-488.2 language interface?

For information about using NI-488.2 language interfaces, refer to Chapter 3, *Developing Your NI-488.2 Application*.

What do I need to know to communicate properly with my GPIB instrument?

Refer to the documentation that came with your instrument. The command sequences that you use depend on the specific instrument. The documentation for each instrument should include the GPIB commands that you need to communicate with your instrument. In most cases, device-level traditional NI-488.2 calls are sufficient for communicating with instruments. For more information, refer to Chapter 3, *Developing Your NI-488.2 Application*.

How can I start communicating with my GPIB instrument?

For simple instrument communication, use the NI-488.2 Communicator. For instructions on how to use the NI-488.2 Communicator, refer to the *Basic Communication (Query/Write/Read)* section in Chapter 2, *Measurement & Automation Explorer*.

How do I check for errors in my NI-488.2 application?

Examine the value of `ibsta` after each NI-488.2 call. If a call fails, the ERR bit of `ibsta` is set and an error code is stored in `iberr`. For more information about global status variables, refer to Chapter 4, *Debugging Your Application*.

What information should I have before I call National Instruments?

Before you call National Instruments, record the results of the NI-488.2 Troubleshooting Wizard. To start the NI-488.2 Troubleshooting Wizard, select **Start»Programs»National Instruments NI-488.2»Explore GPIB**. Then, select **Help»Troubleshooting»NI-488.2 Troubleshooting Wizard**.

E

Windows 2000/NT: Common Questions

This appendix answers some common questions about the NI-488.2 software for Windows 2000/NT.

Common Questions

How do I get started?

To get started with your GPIB hardware and the NI-488.2 software, use the NI-488.2 Getting Started Wizard. To do so, select **Start»Programs» National Instruments NI-488.2»Getting Started Wizard**.

How do I troubleshoot problems?

Run the NI-488.2 Troubleshooting Wizard. To do so, select **Start»Programs»National Instruments NI-488.2»Explore GPIB**. Then, select **Help»Troubleshooting»NI-488.2 Troubleshooting Wizard**.

How can I determine which version of the NI-488.2 software I have installed?

To view the NI-488.2 software version, complete the following steps:

1. Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** to start Measurement & Automation Explorer.
2. Select **Help»About Measurement & Automation Explorer**.

   The **Value** column in the **About Measurement & Automation Explorer** dialog box displays the version number of the NI-488.2 software.

How can I determine which type of GPIB hardware I have installed?

Select **Start»Programs»National Instruments NI-488.2»Explore GPIB** and expand the **Devices and Interfaces** directory by clicking on the + next to the folder.

Measurement & Automation Explorer lists your installed GPIB hardware under **Devices and Interfaces**.

How many GPIB interfaces can I configure for use with the NI-488.2 software?

You can configure the NI-488.2 software to communicate with up to four GPIB interfaces.

How many devices can I configure for use with the NI-488.2 software?

You can configure the NI-488.2 software to use up to 100 logical devices. The default number of devices is 32.

Are interrupts and DMA required with the NI-488.2 software?

Interrupts are required, but DMA is not.

How can I determine if my GPIB hardware and the NI-488.2 software are installed properly?

Run the NI-488.2 Troubleshooting Wizard. To do so, select **Start» Programs»National Instruments NI-488.2»Explore GPIB**. Then, select **Help»Troubleshooting»NI-488.2 Troubleshooting Wizard**.

How can I start communicating with my GPIB instrument?

For simple instrument communication, use the NI-488.2 Communicator. For instructions on how to use the NI-488.2 Communicator, refer to the *Basic Communication (Query/Write/Read)* section in Chapter 2, *Measurement & Automation Explorer*.

When should I use the Interactive Control utility?

You can use the Interactive Control utility to test and verify instrument communication, troubleshoot problems, and develop your application. For more information, refer to Chapter 6, *Interactive Control Utility*.

How do I use an NI-488.2 language interface?

For information about using NI-488.2 language interfaces, refer to Chapter 3, *Developing Your NI-488.2 Application*.

What do I need to know to communicate properly with my GPIB instrument?

Refer to the documentation that came with your instrument. The command sequences that you use depend on the specific instrument. The documentation for each instrument should include the GPIB commands that you need to communicate with your instrument. In most cases, device-level traditional NI-488.2 calls are sufficient for communicating with instruments. For more information, refer to Chapter 3, *Developing Your NI-488.2 Application*.

How do I check for errors in my NI-488.2 application?

Examine the value of `ibsta` after each NI-488.2 call. If a call fails, the ERR bit of `ibsta` is set and an error code is stored in `iberr`. For more information about global status variables, refer to Chapter 4, *Debugging Your Application*.

What information should I have before I call National Instruments?

Before you call National Instruments, record the results of the NI-488.2 Troubleshooting Wizard. To start the NI-488.2 Troubleshooting Wizard, select **Start»Programs»National Instruments NI-488.2»Explore GPIB**. Then, select **Help»Troubleshooting»NI-488.2 Troubleshooting Wizard**.

F

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.

Worldwide Support

National Instruments has offices located around the globe. Many branch offices maintain a Web site to provide information on local services. You can access these Web sites from `www.natinst.com/worldwide`.

If you have trouble connecting to our Web site, please contact your local National Instruments office or the source from which you purchased your National Instruments product(s) to obtain support.

For telephone support in the United States, dial 512 795 8248. For telephone support outside the United States, contact your local branch office:

Australia 03 9879 5166, Austria 0662 45 79 90 0, Belgium 02 757 00 20, Brazil 011 284 5011, Canada (Ontario) 905 785 0085, Canada (Québec) 514 694 8521, China 0755 3904939, Denmark 45 76 26 00, Finland 09 725 725 11, France 01 48 14 24 24, Germany 089 741 31 30, Hong Kong 2645 3186, India 91805275406, Israel 03 6120092, Italy 02 413091, Japan 03 5472 2970, Korea 02 596 7456, Mexico (D.F.) 5 280 7625, Mexico (Monterrey) 8 357 7695, Netherlands 0348 433466, Norway 32 27 73 00, Singapore 2265886, Spain (Madrid) 91 640 0085, Spain (Barcelona) 93 582 0251, Sweden 08 587 895 00, Switzerland 056 200 51 51, Taiwan 02 2377 1200, United Kingdom 01635 523545

Glossary

Prefix	Meaning	Value
n-	nano-	10^{-9}
m-	milli-	10^{-3}
M-	mega-	10^{6}

A

acceptor handshake	Listeners use this GPIB interface function to receive data, and all devices use it to receive commands. *See* source handshake and handshake.
access board	The GPIB board that controls and communicates with the devices on the bus that are attached to it.
ANSI	American National Standards Institute.
API	Application Programming Interface
ASCII	American Standard Code for Information Interchange.
asynchronous	An action or event that occurs at an unpredictable time with respect to the execution of a program.
automatic serial polling	A feature of the GPIB software in which serial polls are executed automatically by the driver whenever a device asserts the GPIB SRQ line. Also called autopolling.

B

base I/O address	*See* I/O address.
BIOS	Basic Input/Output System.
board-level function	A rudimentary function that performs a single operation.

C

CFE	Configuration Enable. The GPIB command which precedes CFGn and is used to place devices into their configuration mode.
CFGn	These GPIB commands (CFG1 through CFG15) follow CFE and are used to configure all devices for the number of meters of cable in the system so HS488 transfers occur without errors.
CIC	Controller-In-Charge. The device that manages the GPIB by sending interface messages to other devices.
CPU	Central processing unit.

D

DAV	Data Valid. One of the three GPIB handshake lines. *See* handshake.
DCL	Device Clear. The GPIB command used to reset the device or internal functions of all devices. *See* SDC.
device-level function	A function that combines several rudimentary board operations into one function so that the user does not have to be concerned with bus management or other GPIB protocol matters.
DIO1 through DIO8	The GPIB lines that are used to transmit command or data bytes from one device to another.
DLL	Dynamic link library.
DMA	Direct memory access. High-speed data transfer between the GPIB board and memory that is not handled directly by the CPU. Not available on some systems. *See* programmed I/O.
driver	Device driver software installed within the operating system.

E

END or END Message	A message that signals the end of a data string. END is sent by asserting the GPIB End or Identify (EOI) line with the last data byte.
EOI	A GPIB line that signals either the last byte of a data message (END) or the parallel poll Identify (IDY) message.

EOS or EOS Byte	A 7- or 8-bit end-of-string character that is sent as the last byte of a data message.
EOT	End of transmission.
ESB	The Event Status bit. Part of the IEEE 488.2-defined status byte which is received from a device responding to a serial poll.

F

FIFO	First-in-first-out.

G

GET	Group Execute Trigger. The GPIB command used to trigger a device or internal function of an addressed Listener.
GPIB	General Purpose Interface Bus is the common name for the communications interface system defined in ANSI/IEEE Standard 488.1-1987 and ANSI/IEEE Standard 488.2-1992.
GPIB address	The address of a device on the GPIB, composed of a primary address (MLA and MTA) and perhaps a secondary address (MSA). The GPIB board has both a GPIB address and an I/O address.
GPIB board	Refers to the National Instruments family of GPIB interfaces.
GTL	Go To Local. The GPIB command used to place an addressed Listener in local (front panel) control mode.

H

handshake	The mechanism used to transfer bytes from the source handshake function of one device to the acceptor handshake function of another device. DAV, NRFD, and NDAC, three GPIB lines, are used in an interlocked fashion to signal the phases of the transfer, so that bytes can be sent asynchronously (for example, without a clock) at the speed of the slowest device. For more information about handshaking, refer to the ANSI/IEEE Standard 488.1-1987.

hex	Hexadecimal; a number represented in base 16. For example, decimal 16 is hex 10.
high-level function	*See* device-level function.
HS488	A high-speed data transfer protocol for IEEE 488. This protocol increases performance for GPIB reads and writes up to 8 Mbytes/s, depending on your system.
Hz	Hertz.

I

`ibcnt`	After each NI-488.2 I/O call, this global variable contains the actual number of bytes transmitted. On systems with a 16-bit integer, such as MS-DOS, `ibcnt` is a 16-bit integer, and `ibcntl` is a 32-bit integer. For cross-platform compatibility, use `ibcntl`.
`ibcntl`	After each NI-488.2 I/O call, this global variable contains the actual number of bytes transmitted. On systems with a 16-bit integer, such as MS-DOS, `ibcnt` is a 16-bit integer, and `ibcntl` is a 32-bit integer. For cross-platform compatibility, use `ibcntl`.
`iberr`	A global variable that contains the specific error code associated with a function call that failed.
`ibsta`	At the end of each function call, this global variable (status word) contains status information.
IEEE	Institute of Electrical and Electronic Engineers.
interface message	A broadcast message sent from the Controller to all devices and used to manage the GPIB.
I/O	Input/output. In this manual, it is the transmission of commands or messages between the system via the GPIB board and other devices on the GPIB.
I/O address	The address of the GPIB board from the point of view of the CPU, as opposed to the GPIB address of the GPIB board. Also called port address or board address.

ISA	Industry Standard Architecture.
`ist`	An Individual Status bit of the status byte used in the Parallel Poll Configure function.

L

LAD	Listen Address. *See* MLA.
language interface	Code that enables an application program that uses NI-488.2 calls to access the driver.
Listener	A GPIB device that receives data messages from a Talker.
LLO	Local Lockout. The GPIB command used to tell all devices that they may or should ignore remote (GPIB) data messages or local (front panel) controls, depending on whether the device is in local or remote program mode.
low-level function	A rudimentary board or device function that performs a single operation.

M

m	Meters.
MAV	The Message Available bit is part of the IEEE 488.2-defined status byte which is received from a device responding to a serial poll.
MLA	My Listen Address. A GPIB command used to address a device to be a Listener. It can be any one of the 31 primary addresses.
MSA	My Secondary Address. The GPIB command used to address a device to be a Listener or a Talker when extended (two-byte) addressing is used. The complete address is a MLA or MTA address followed by an MSA address. There are 31 secondary addresses for a total of 961 distinct listen or talk addresses for devices.
MTA	My Talk Address. A GPIB command used to address a device to be a Talker. It can be any one of the 31 primary addresses.
multitasking	The concurrent processing of more than one program or task.

N

NDAC	Not Data Accepted. One of the three GPIB handshake lines. *See* handshake.
NRFD	Not Ready For Data. One of the three GPIB handshake lines. *See* handshake.

P

parallel poll	The process of polling all configured devices at once and reading a composite poll response. *See* serial poll.
PC	Personal computer.
PCI	Peripheral Component Interconnect.
PIO	*See* programmed I/O.
PPC	Parallel Poll Configure. The GPIB command used to configure an addressed Listener to participate in polls.
PPD	Parallel Poll Disable. The GPIB command used to disable a configured device from participating in polls. There are 16 PPD commands.
PPE	Parallel Poll Enable. The GPIB command used to enable a configured device to participate in polls and to assign a DIO response line. There are 16 PPE commands.
PPU	Parallel Poll Unconfigure. The GPIB command used to disable used to disable any device from participating in polls.
programmed I/O	Low-speed data transfer between the GPIB interface and memory in which the CPU moves each data byte according to program instructions. *See* DMA.

R

resynchronize	The GPIB software and the user application must resynchronize after asynchronous I/O operations have completed.
RQS	Request Service.

S

s	Seconds.
SDC	Selected Device Clear. The GPIB command used to reset internal or device functions of an addressed Listener. *See* DCL.
semaphore	An object that maintains a count between zero and some maximum value, limiting the number of threads that are simultaneously accessing a shared resource.
serial poll	The process of polling and reading the status byte of one device at a time. *See* parallel poll.
service request	*See* SRQ.
source handshake	The GPIB interface function that transmits data and commands. Talkers use this function to send data, and the Controller uses it to send commands. *See* acceptor handshake and handshake.
SPD	Serial Poll Disable. The GPIB command used to cancel an SPE command.
SPE	Serial Poll Enable. The GPIB command used to enable a specific device to be polled. That device must also be addressed to talk. *See* SPD.
SRQ	Service Request. The GPIB line that a device asserts to notify the CIC that the device needs servicing.
status byte	The IEEE 488.2-defined data byte sent by a device when it is serially polled.
status word	*See* `ibsta`.
synchronous	Refers to the relationship between the GPIB driver functions and a process when executing driver functions is predictable; the process is blocked until the driver completes the function.
System Controller	The single designated Controller that can assert control (become CIC of the GPIB) by sending the Interface Clear (IFC) message. Other devices can become CIC only by having control passed to them.

T

TAD	Talk Address. *See* MTA.
Talker	A GPIB device that sends data messages to Listeners.
TCT	Take Control. The GPIB command used to pass control of the bus from the current Controller to an addressed Talker.
timeout	A feature of the GPIB driver that prevents I/O functions from hanging indefinitely when there is a problem on the GPIB.
TLC	An integrated circuit that implements most of the GPIB Talker, Listener, and Controller functions in hardware.

U

`ud`	Unit descriptor. A variable name and first argument of each function call that contains the unit descriptor of the GPIB interface or other GPIB device that is the object of the function.
UNL	Unlisten. The GPIB command used to unaddress any active Listeners.
UNT	Untalk. The GPIB command used to unaddress an active Talker.

Index