

NI-488.2MTM

User Manual for Windows NT

January 1996 Edition

Part Number 320646B-01

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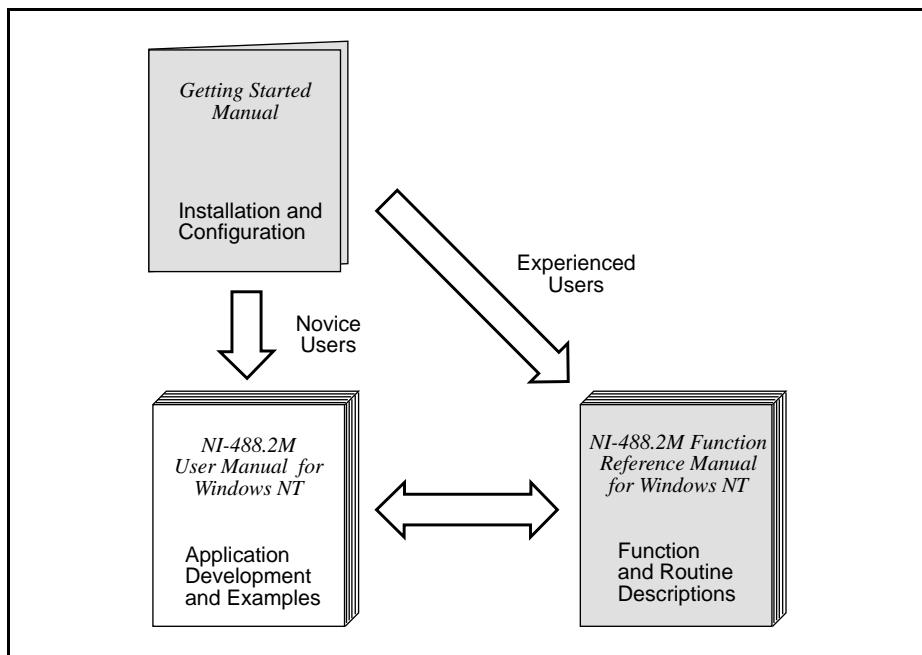
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About This Manual

This manual describes the features and functions of the NI-488.2M software for Windows NT. The NI-488.2M software is meant to be used with the Microsoft Windows NT operating system version 3.1 or higher, and the Microsoft Windows NT Advanced Server version 3.1 or higher. This manual assumes that you are already familiar with Windows NT.

How to Use This Manual Set



Use the getting started manual to install and configure your GPIB hardware and NI-488.2M software for Windows NT.

Use the *NI-488.2M User Manual for Windows NT* to learn the basics of GPIB and how to develop an application program. The user manual also contains debugging information and detailed examples.

Use the *NI-488.2M Function Reference Manual for Windows NT* for specific NI-488 function and NI-488.2 routine information, such as format, parameters, and possible errors.

Organization of This Manual

This manual is organized as follows:

- Chapter 1, *Introduction*, gives an overview of GPIB and the NI-488.2M software.
- Chapter 2, *Application Examples*, contains nine sample applications designed to illustrate specific GPIB concepts and techniques that can help you write your own applications. The description of each example includes the programmer's task, a program flowchart, and numbered steps which correspond to the numbered blocks on the flowchart.
- Chapter 3, *Developing Your Application*, explains how to develop a GPIB application program using NI-488 functions and NI-488.2 routines.
- Chapter 4, *Debugging Your Application*, describes several ways to debug your application program.
- Chapter 5, *ibic-Interface Bus Interactive Control Utility*, introduces you to *ibic*, the interactive control program that you can use to communicate with GPIB devices interactively.
- Chapter 6, *GPIB Programming Techniques*, describes techniques for using some NI-488 functions and NI-488.2 routines in your application program.
- Chapter 7, *ibconf-Interface Bus Configuration Utility*, contains a description of *ibconf*, the software configuration program you can use to configure the NI-488.2M software.
- Appendix A, *Status Word Conditions*, gives a detailed description of the conditions reported in the status word, *ibsta*.
- Appendix B, *Error Codes and Solutions*, lists a description of each error, some conditions under which it might occur, and possible solutions.
- Appendix C, *Customer Communication*, contains forms you can use to request help from National Instruments or to comment on our products and manuals.
- The *Glossary* contains an alphabetical list and description of terms used in this manual, including abbreviations, acronyms, metric prefixes, mnemonics, and symbols.
- The *Index* contains an alphabetical list of key terms and topics in this manual, including the page where you can find each one.

Conventions Used in This Manual

The following conventions are used in this manual.

bold	Bold text denotes menu items and dialog box buttons or options.
<i>bold italic</i>	Bold italic text denotes a note, caution, or warning.
<i>italic</i>	Italic text denotes emphasis, cross references, field names, or an introduction to a key concept.
<i>monospace</i>	Text in this font denotes text or characters that you enter from the keyboard. Sections of code, programming examples, and syntax examples also appear in this font. This font is also used for the proper name of disk drives, paths, directories, device names, variables, and for statements taken from program code.
<i>bold monospace</i>	Bold text in this font denotes the messages and responses that the computer automatically prints to the screen.
<i>italic monospace</i>	Italic text in this font denotes that you must supply the appropriate words or values in the place of these items.
<>	Angle brackets enclose the name of a key on the keyboard—for example, <PageDown>.
-	A hyphen between two or more key names enclosed in angle brackets denotes that you should simultaneously press the named keys—for example, <Control-C>.
IEEE 488 and IEEE 488.2	<i>IEEE 488</i> and <i>IEEE 488.2</i> are used throughout this manual to refer to the ANSI/IEEE Standard 488.1-1987 and the ANSI/IEEE Standard 488.2-1992, respectively, which define the GPIB.

Abbreviations, acronyms, metric prefixes, mnemonics, symbols, and terms are listed in the *Glossary*.

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*
- *Microsoft Windows NT System Guide*
- *Microsoft Win 32 Software Development Kit for Windows NT: Tools*

Customer Communication

National Instruments wants to receive your comments on our products and manuals. We are interested in the applications you develop with our products, and we want to help if you have problems with them. To make it easy for you to contact us, this manual contains comment and configuration forms for you to complete. These forms are in Appendix C, *Customer Communication*, at the end of this manual.

Chapter 1

Introduction

This chapter gives an overview of GPIB and the NI-488.2M software.

GPIB Overview

The ANSI/IEEE Standard 488.1-1987, also known as GPIB (General Purpose Interface Bus), describes a standard interface for communication between instruments and controllers from various vendors. It contains information about electrical, mechanical, and functional specifications. The GPIB is a digital, 8-bit parallel communications interface with data transfer rates of 1 Mbytes/s and above, using a 3-wire handshake. The bus supports one System Controller, usually a computer, and up to 14 additional instruments. The ANSI/IEEE Standard 488.2-1987 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 personal computer has a National Instruments GPIB interface board and NI-488.2M 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 either be active or inactive (Standby) Controller. Control can pass from the current CIC to an idle Controller, but only the System Controller, usually a GPIB interface board, can make itself the CIC.

GPIB Addressing

All GPIB devices and boards 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 GPIB 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 1-1 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 to 30)				

Figure 1-1. 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 secondary addressing is in use, 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 eight 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 1-1 summarizes the GPIB handshake lines.

Table 1-1. 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 GPIB hardware lines manage the flow of information across the bus. Table 1-2 summarizes the GPIB interface management lines.

Table 1-2. 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.

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. Figure 1-2 shows the linear and star configurations.

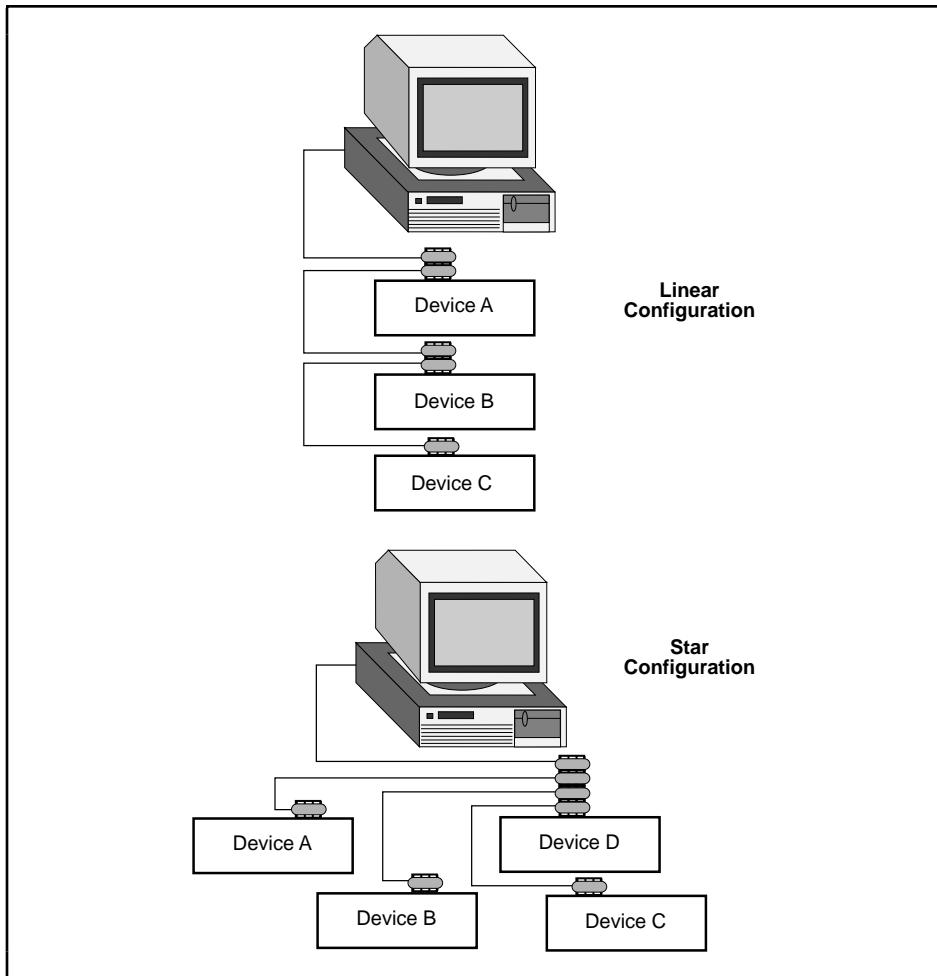


Figure 1-2. Linear and Star System Configuration

Controlling More Than One Board

The NI-488.2M driver can control up to 10 GPIB boards. Figure 1-3 shows an example of a multiboard system configuration. `gpib0` is the access board for the voltmeter, and `gpib1` is the access board for the plotter and printer. The control functions of the devices automatically access their respective boards.

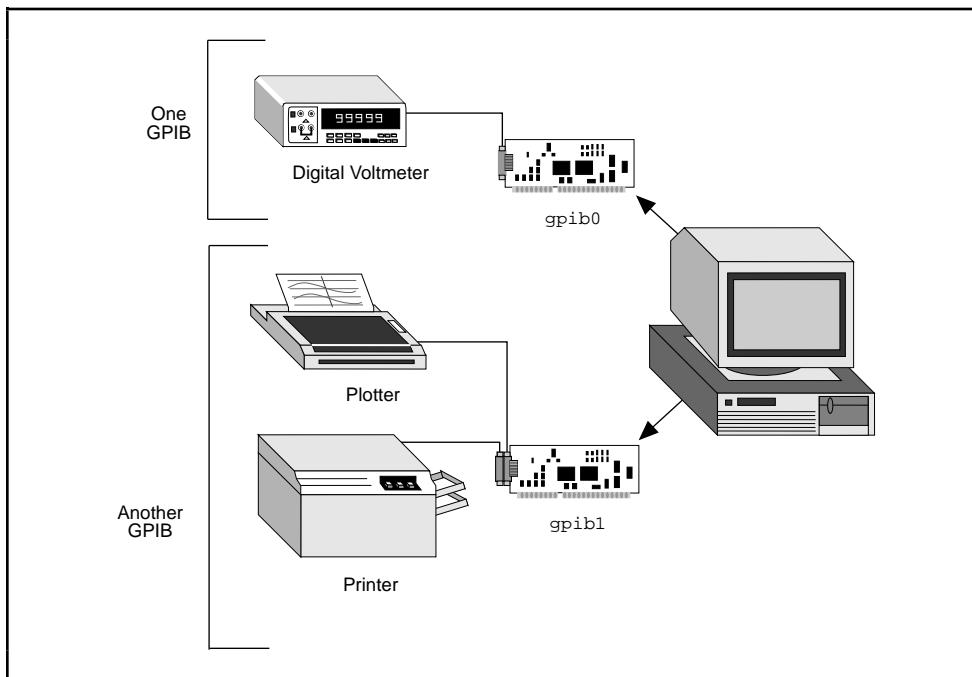


Figure 1-3. Example of Multiboard System Setup

Configuration Requirements

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

- A maximum separation of four meters between any two devices and an average separation of two meters 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 as short as possible up to a maximum of 15 m of cable for each system.
- With at least one equivalent device load per meter of cable.

If you want to exceed these limitations, you can use bus extenders to increase the cable length or expander to increase the number of device loads. Extenders and expanders are available from National Instruments.

The following sections describe the NI-488.2M software, which controls the flow of communication on the GPIB.

The NI-488.2M Software Elements

The following section highlights important elements of the NI-488.2M software for Windows NT and describes the function of each element.

NI-488.2M Driver and Driver Utilities

The distribution disk contains the following driver and utility files:

- `readme.txt` is a documentation file that contains important information about the NI-488.2M software and a description of any new features. Before you use the software, read this file for the most recent information.
- `gpibclsd.sys` is the Windows NT kernel driver that implements the NI-488.2 device-level functions.
- `gpibclsb.sys` is the Windows NT kernel driver that implements the NI-488.2 board-level functions.
- `gpibxxxx.sys` (where `xxxx` represents a particular type of GPIB hardware—for example, `gpib-mc.sys` for the MC-GPIB board or `gpibatnt.sys` for the AT-GPIB/TNT board) is the Windows NT kernel driver that implements hardware-specific features of the NI-488.2M software.
- `gpib-32.dll` is a 32-bit dynamic link library that acts as the interface between all applications and the kernel mode GPIB driver.
- `ibic.exe` is an interactive control program that you use to communicate with the GPIB devices interactively using NI-488.2 functions and routines. It helps you to learn the NI-488.2 routines and to program your instrument or other GPIB devices.

- `ibconf.cpl` is a control panel application that you use to modify the software configuration parameters of the NI-488.2M software.
- `ibconf.hlp` is a Windows help file that is used by the `ibconf` application.
- `ibtest.exe` is the NI-488.2M software installation diagnostic test.
- `gpibinfo.exe` is a utility you can use to obtain information about your GPIB hardware and software, such as the version of the NI-488.2M software and the type of interface board you are using.

DOS and 16-bit Windows Support Files

- `readme.txt` is a documentation file that contains information about using existing DOS and 16-bit Windows applications under Windows NT.
- `gpib-vdd.dll` is the virtual device driver that allows existing NI-488.2 for DOS and 16-bit Windows applications to access the NI-488.2M software.
- `gpib-nt.com` is the DOS device driver. When you run an existing NI-488.2 application for DOS in the Windows NT environment, this file replaces the `gpib.com` driver that you used in the DOS environment.
- `gpib.dll` is the 16-bit Windows dynamic link library. When you run an existing NI-488.2 application for Windows in the Windows NT environment, this file replaces the GPIB DLL that you used in the Windows (16-bit) environment.

C Language Files

- `readme.txt` is a documentation file that contains information about the C language interface.
- `decl-32.h` is a 32-bit include file. It contains NI-488 function and NI-488.2 routine prototypes and various predefined constants.
- `gpib-32.obj` is a 32-bit C language interface file. An application links with this file in order to access the 32-bit DLL.

Sample Application Files

The NI-488.2M software includes nine sample applications along with source code for each language supported by the NI-488.2M software. For a detailed description of the sample application files, refer to Chapter 2, *Application Examples*.

How the NI-488.2M Software Works with Windows NT

The main components of the NI-488.2M software are a dynamic link library that runs in user mode and a layered NT device driver that runs in kernel mode. The layered NT device driver consists of three drivers: a device class driver that handles device-level calls, a board class driver that handles board-level calls, and a GPIB port driver that uses the Hardware Abstraction Layer (HAL) to communicate with the GPIB hardware. The top two layers of the layered NT device driver are accessed from user mode by `gpib-32.dll`, a 32-bit Windows NT dynamic link library.

GPIB applications access the NI-488.2M software through `gpib-32.dll` as follows:

- A 32-bit Windows application can either link with the language interface (`gpib-32.obj`) or directly access the functions exported by the DLL.
- If you already have an existing 16-bit Windows applications, use the 16-bit DLL (`gpib.dll`) to access the GPIB virtual device driver (`gpib-vdd.dll`).
- If you have an existing DOS application, use the DOS device driver (`gpib-nt.com`) to access the GPIB virtual device driver.

Figure 1-4 shows how you can use the NI-488.2M software with Windows NT and your GPIB application programs.

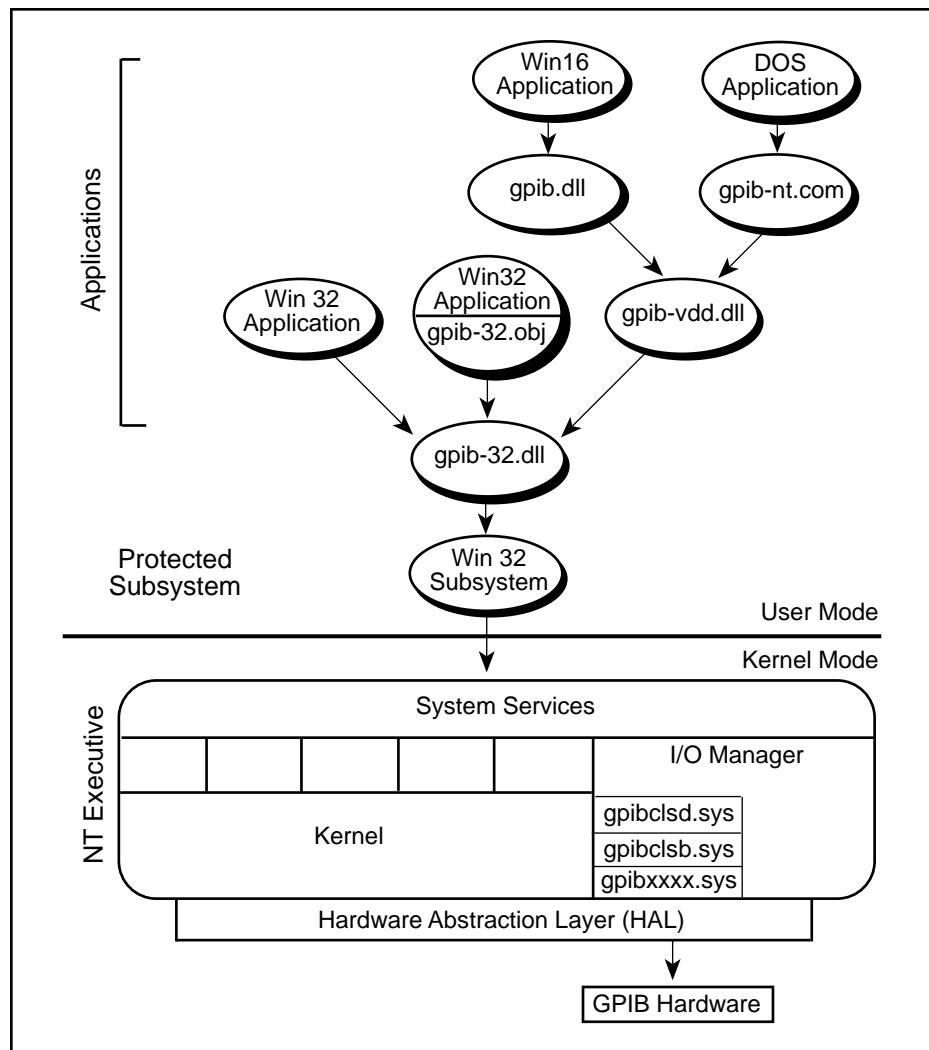


Figure 1-4. How the NI-488.2M Software Works with Windows NT

Unloading and Reloading the NI-488.2M Driver

You can unload and restart the NI-488.2M driver using the `ibconf` utility. The icon for `ibconf` is located in the **Control Panel** window in the **Program Manager**. Double-click on the `ibconf` icon to start it. The main `ibconf` window has an **Unload** button and a **Restart** button. If you click on the **Unload** button, the NI-488.2M driver is unloaded. If you click on the **Restart** button, the NI-488.2M driver is automatically unloaded and then reloaded. Refer to Chapter 7, *ibconf—Interface Bus Configuration Utility*, for a more complete description.

Chapter 2

Application Examples

This chapter contains nine sample applications designed to illustrate specific GPIB concepts and techniques that can help you write your own applications. The description of each example includes the programmer's task, a program flowchart, and numbered steps which correspond to the numbered blocks on the flowchart.

Use this chapter along with your NI-488.2M software, which includes the C source code for each of the nine examples. The programs are listed in order of increasing complexity. If you are new to GPIB programming, you might want to study the contents and concepts of the first sample, `simple.c`, before moving on to more complex examples.

The following example programs are included with your NI-488.2 software:

- `simple.c` is the source code file for Example 1. It illustrates how you can establish communication between a host computer and a GPIB device.
- `clr_trg.c` is the source code file for Example 2. It illustrates how you can clear and trigger GPIB devices.
- `asynch.c` is the source code file for Example 3. It illustrates how you can perform non-GPIB tasks while data is being transferred over the GPIB.
- `eos.c` is the source code file for Example 4. It illustrates the concept of the end-of-string (EOS) character.
- `rqs.c` is the source code file for Example 5. It illustrates how you can communicate with GPIB devices that use the GPIB SRQ line to request service. This sample is written using NI-488 functions.
- `easy4882.c` is the source code file for Example 6. It is an introduction to NI-488.2 routines.
- `rqs4882.c` is the source code file for Example 7. It uses NI-488.2 routines to communicate with GPIB devices that use the GPIB SRQ line to request service.
- `ppoll.c` is the source code file for Example 8. It uses NI-488.2 routines to conduct parallel polls.
- `non_cic.c` is the source code file for Example 9. It illustrates how you can use the NI-488.2M driver in a non-Controller application.

Example 1: Basic Communication

This example focuses on the basics of establishing communication between a host computer and a GPIB device.

A technician needs to monitor voltage readings using a GPIB multimeter. His computer is equipped with an IEEE 488.2 interface board. The NI-488.2M software is installed, and a GPIB cable runs from the computer to the GPIB port on the multimeter.

The technician is familiar with the multimeter remote programming command set. This list of commands is specific to his multimeter and is available from the multimeter manufacturer.

He sets up the computer to direct the multimeter to take measurements and record each measurement as it occurs. To do this, he has written an application that uses some simple high-level GPIB commands. The following steps correspond to the program flowchart in Figure 2-1.

1. The application initializes the GPIB by bringing the interface board in the computer online.
2. The application sends the multimeter an instruction, setting it up to take voltage measurements in autorange mode.
3. The application sends the multimeter an instruction to take a voltage measurement.
4. The application tells the multimeter to transmit the data it has acquired to the computer.

The process of requesting a measurement and reading from the multimeter (Steps 3 and 4) is repeated as long as there are readings to be obtained.

5. As a cleanup step before exiting, the application returns the interface board to its original state by taking it offline.

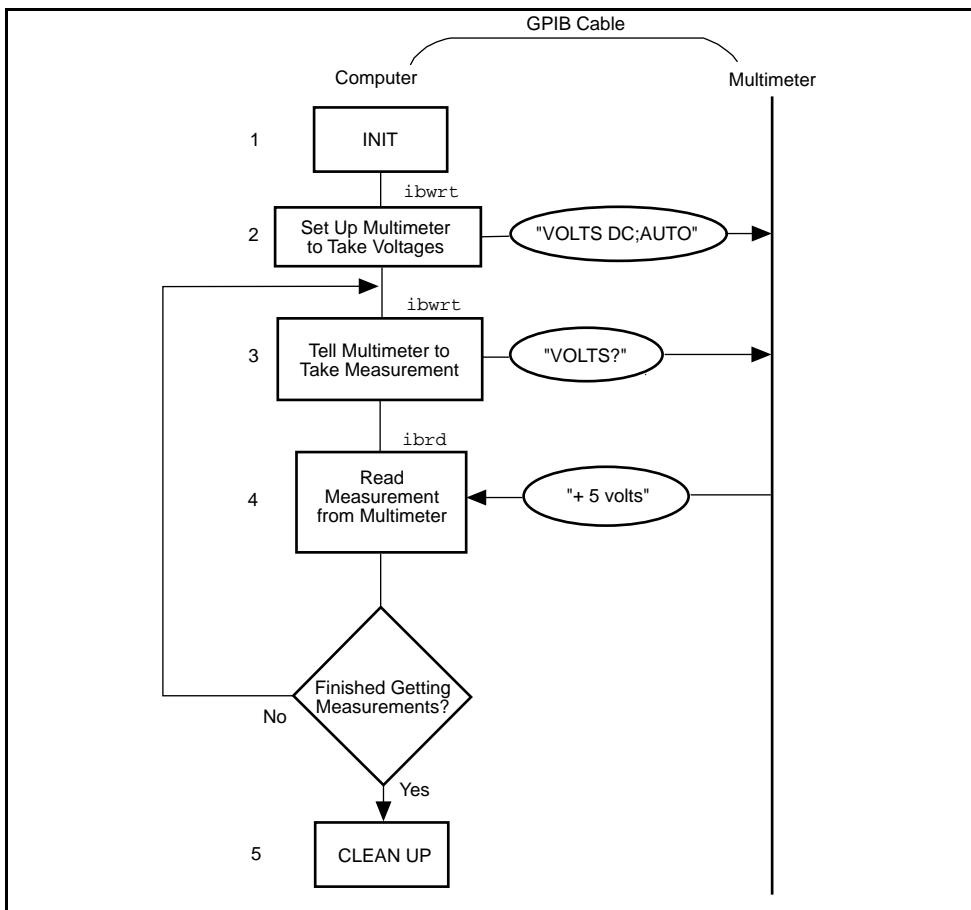


Figure 2-1. Program Flowchart for Example 1

Example 2: Clearing and Triggering Devices

This example illustrates how you can clear and trigger GPIB devices.

Two freshman physics lab partners are learning how to use a GPIB digital oscilloscope. They have successfully loaded the NI-488.2M software on a personal computer and connected their GPIB board to a GPIB digital oscilloscope. Their current lab assignment is to write a small application to practice using the oscilloscope and its command set using high-level GPIB commands. The following steps correspond to the program flowchart in Figure 2-2.

1. The application initializes the GPIB by bringing the interface board in the computer online.
2. The application sends a GPIB clear command to the oscilloscope. This command clears the internal registers of the oscilloscope, reinitializing it to default values and settings.
3. The application sends a command to the oscilloscope telling it to read a waveform each time it is triggered. Predefining the task in this way decreases the execution time required. Each trigger of the oscilloscope is now sufficient to get a new run.
4. The application sends a GPIB trigger command to the oscilloscope which causes it to acquire data.
5. The application queries the oscilloscope for the acquired data. The oscilloscope sends the data.
6. The application reads the data from the oscilloscope.
7. The application calls an external graphics routine to display the acquired waveform.

Steps 4, 5, 6, and 7 are repeated until all of the desired data has been acquired by the oscilloscope and received by the computer.

8. As a cleanup step before exiting, the application returns the interface board to its original state by taking it offline.

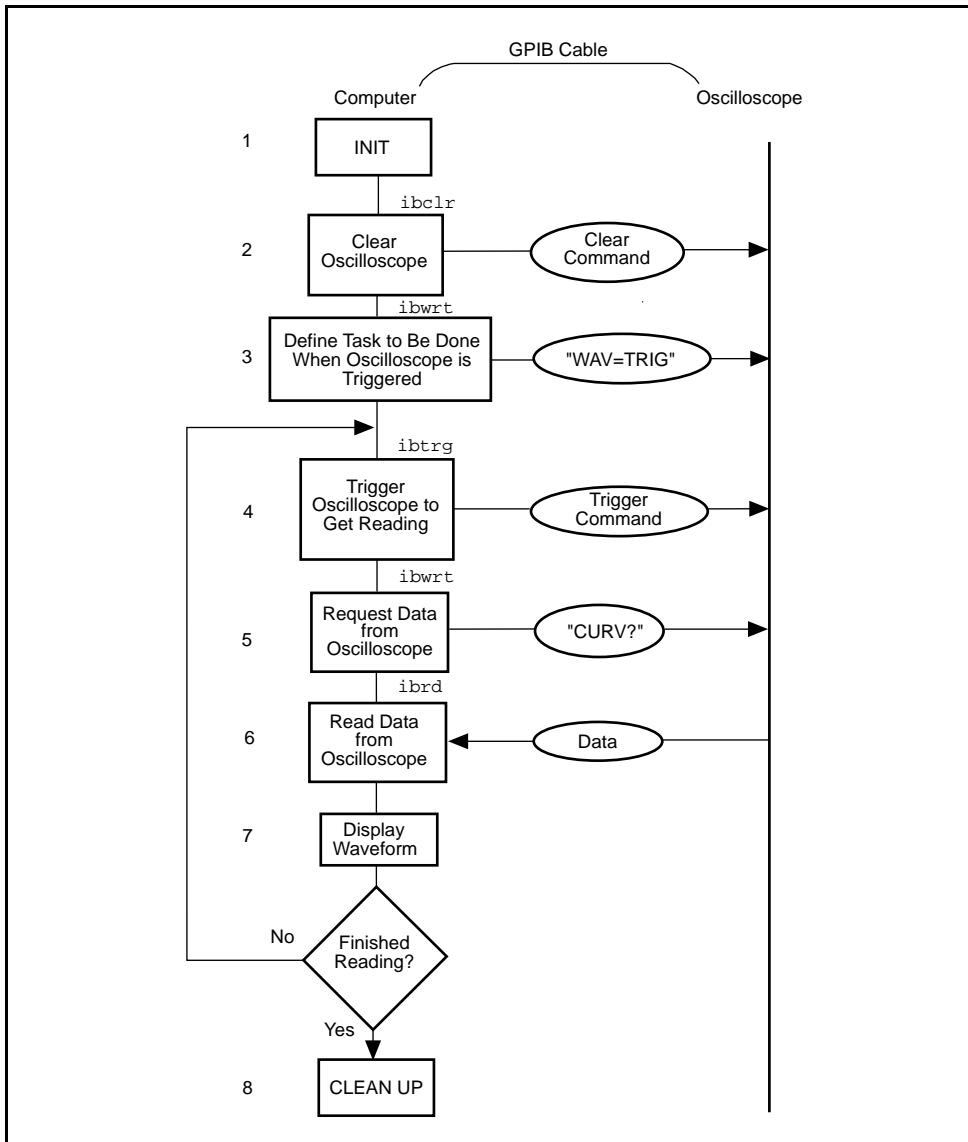


Figure 2-2. Program Flowchart for Example 2

Example 3: Asynchronous I/O

This example illustrates how an application conducts data transfers with a GPIB device and immediately returns to perform other non-GPIB related tasks while GPIB I/O is occurring in the background. This asynchronous mode of operation is particularly useful when the requested GPIB activity may take some time to complete.

In this example, a research biologist is trying to obtain accurate CAT scans of a laboratory animal's liver. She will print out a color copy of each scan as it is acquired. The entire operation is computer-controlled. The CAT scan machine sends the images it acquires to a computer that has the NI-488.2M software installed and is connected to a GPIB color printer. The biologist is familiar with the command set of her color printer, as described in the user manual provided by the manufacturer. She acquires and prints images with the aid of an application program she wrote using high-level GPIB commands. The following steps correspond to the program flowchart in Figure 2-3.

1. The application initializes the GPIB by bringing the interface board in the computer online.
2. An image is scanned in.
3. The application sends the GPIB printer a command to print the new image and immediately returns without waiting for the I/O operation to be completed.
4. The application saves the image obtained to a file.
5. The application inquires as to whether the printing operation has completed by issuing a GPIB wait command. If the status reported by the wait command indicates completion (CMPL is in the status returned) and more scans need to be acquired, Steps 2 through 5 are repeated until the scans have all been acquired. If the status reported by the wait command in Step 5 does not indicate that printing is finished, statistical computations are performed on the scan obtained and Step 5 is repeated.
6. As a cleanup step before exiting, the application returns the interface board to its original state by taking it offline.

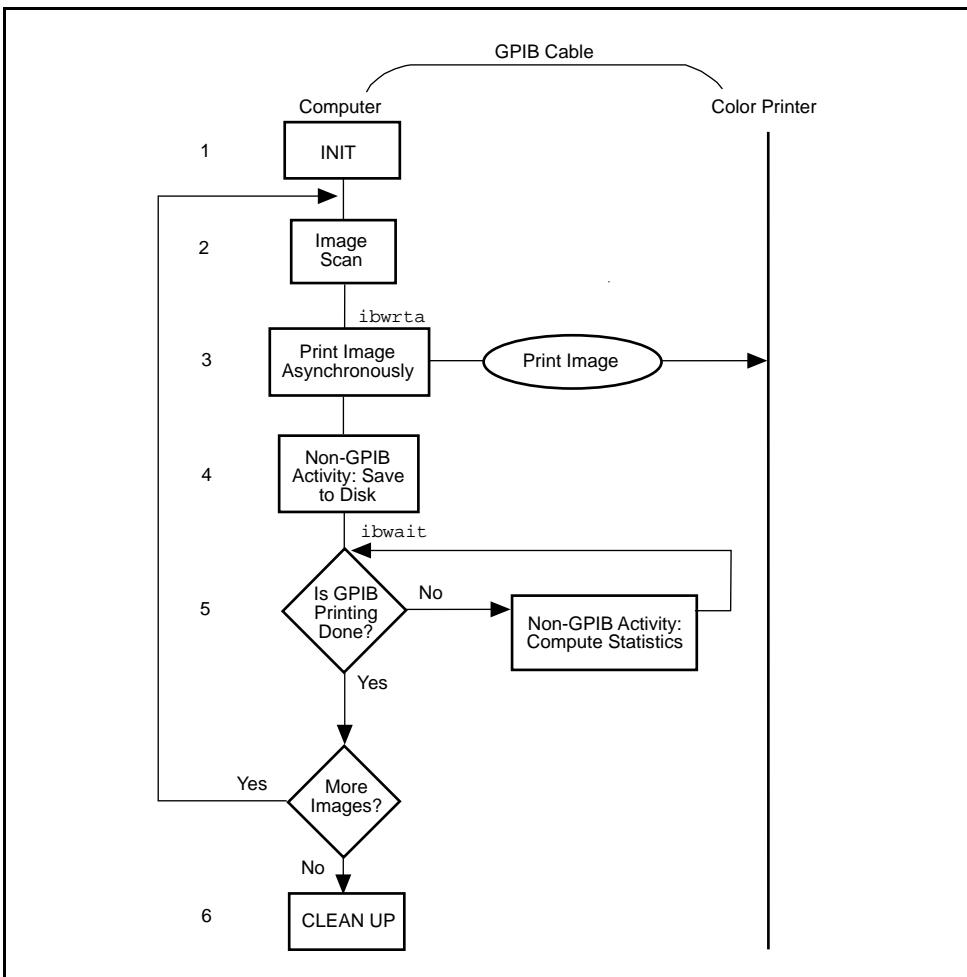


Figure 2-3. Program Flowchart for Example 3

Example 4: End-of-String Mode

This example illustrates how to use the end-of-string modes to detect that the GPIB device has finished sending data.

A journalist is using a GPIB scanner to scan some pictures into his personal computer for a news story. A GPIB cable runs between the scanner and the computer. He is using an application written by an intern in the department who has read the scanner's instruction manual and is familiar with the scanner's programming requirements. The following steps correspond to the program flowchart in Figure 2-4.

1. The application initializes the GPIB by bringing the interface board in the computer online.
2. The application sends a GPIB clear message to the scanner, initializing it to its power-on defaults.
3. The scanner needs to detect a delimiter indicating the end of a command. In this case, the scanner expects the commands to be terminated with <CR><LF> (carriage return, \r, and linefeed, \n). The application sets its end-of-string (EOS) byte to <LF>. The linefeed code indicates to the scanner that no more data is coming, and is called the end-of-string byte. It flags an end-of-string condition for this particular GPIB scanner. The same effect could be accomplished by asserting the EOI line when the command is sent.
4. With the exception of the scan resolution, all the default settings are appropriate for the task at hand. The application changes the scan resolution by writing the appropriate command to the scanner.
5. The scanner sends back information describing the status of the *change resolution* command. This is a string of bytes terminated by the end-of-string character to tell the application it is done changing the resolution.
6. The application starts the scan by writing the scan command to the scanner.
7. The application reads the scan data into the computer.
8. As a cleanup step before exiting, the application returns the interface board to its original state by taking it offline.

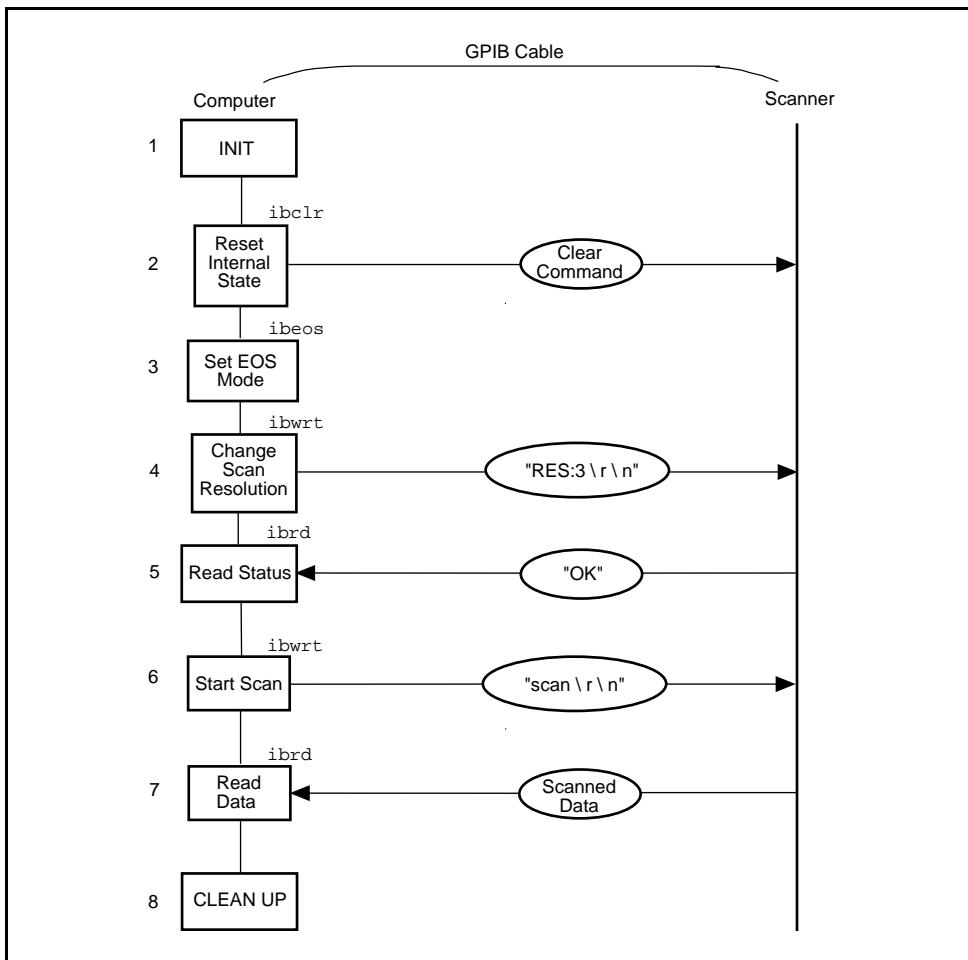


Figure 2-4. Program Flowchart for Example 4

Example 5: Service Requests

This example illustrates how an application communicates with a GPIB device that uses the GPIB service request (SRQ) line to indicate that it needs attention.

A graphic arts designer is transferring digital images stored on her computer to a roll of color film, using a GPIB digital film recorder. A GPIB cable connects the GPIB port on the film recorder to the IEEE 488.2 interface board installed in her computer. She has installed the NI-488.2M software on the host computer and is familiar with the programming instructions for the film recorder, as described in the user manual provided by the manufacturer. She places a fresh roll of film in the camera and launches a simple application she has written using high-level GPIB commands. With the aid of the application, she records a few images on film. The following steps correspond to the program flowchart in Figure 2-5.

1. The application initializes the GPIB by bringing the interface board in the computer online.
2. The application brings the film recorder to a ready state by issuing a device clear instruction. The film recorder is now set up for operation using its default values. (The graphic arts designer has previously established that the default values for the film recorder are appropriate for the type of film she is using).
3. The application advances the new roll of film into position so the first image can be exposed on the first frame of film. This is done by sending the appropriate instructions as described in the film recorder programming guide.
4. The application waits for the film recorder to signify that it is done loading the film, by waiting for RQS (request for service). The film recorder asserts the GPIB SRQ line when it has finished loading the film.
5. As soon as the film recorder asserts the GPIB SRQ line, the application's wait for the RQS event completes. The application conducts a serial poll by sending a special command message to the film recorder that directs it to return a response in the form of a serial poll status byte. This byte contains information indicating what kind of service the film recorder is requesting or what condition it is flagging. In this example, it indicates the completion of a command.
6. A color image transfers to the digital film recorder in three consecutive passes—one pass each for the red, green and blue components of the image. Sub-steps 6a, 6b, and 6c are repeated for each of the passes:
 - 6a. The application sends a command to the film recorder directing it to accept data to create a single pass image. The film recorder asserts the SRQ line as soon as a pass is completed.
 - 6b. The application waits for RQS.

- 6c. When the SRQ line is asserted, the application serial polls the film recorder to see if it requested service, as in Step 5.
7. The application issues a command to the film recorder to advance the film by one frame. The advance occurs successfully unless the end of film is reached.
8. The application waits for RQS, which completes when the film recorder asserts the SRQ line to signal it is done advancing the film.
9. As soon as the application's wait for RQS completes, the application serial polls the film recorder to see if it requested service, as in Step 5. The returned serial poll status byte indicates either of two conditions—the film recorder finished advancing the film as requested or the end of film was reached and it can no longer advance. Steps 6 through 9 are repeated as long as film is in the camera and more images need to be recorded.
10. As a cleanup step before exiting, the application returns the interface board to its original state by taking it offline.

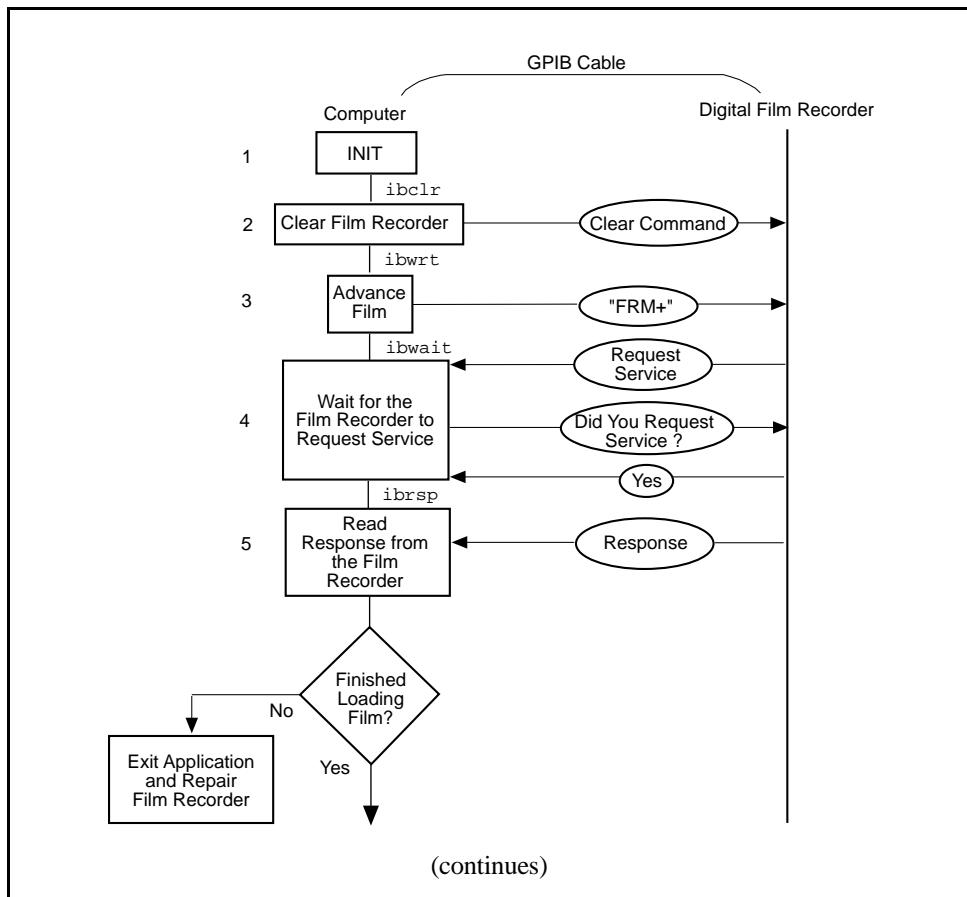


Figure 2-5. Program Flowchart for Example 5

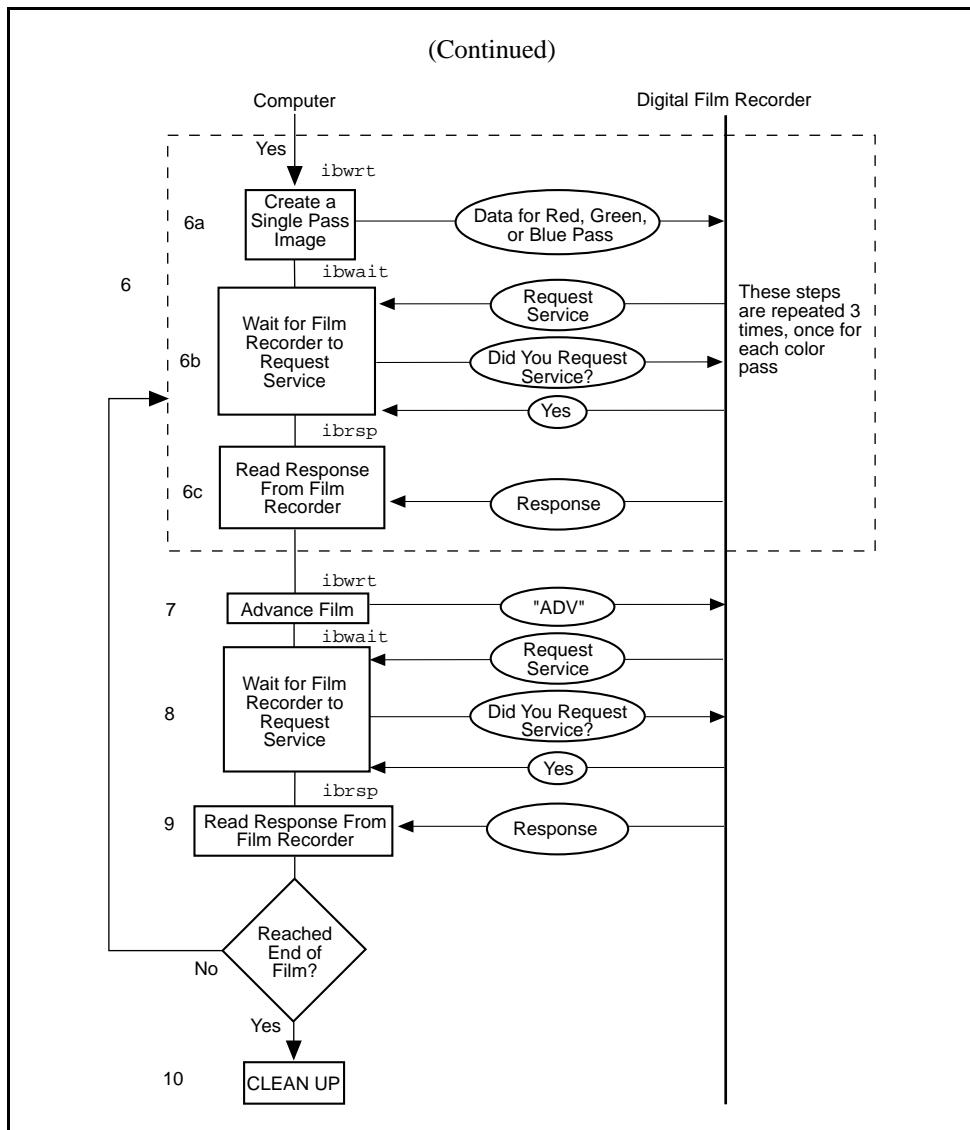


Figure 2-5. Program Flowchart for Example 5 (Continued)

Example 6: Basic Communication with IEEE 488.2-Compliant Devices

This example provides an introduction to communicating with IEEE 488.2-compliant devices.

A test engineer in a metal factory is using IEEE 488.2-compliant tensile testers to find out the strength of metal rods as they come out of production. There are several tensile testers and they are all connected to a central computer equipped with an IEEE 488.2 interface board. These machines are fairly voluminous and it is difficult for the engineer to reach the address switches of each machine. For the purposes of his future work with these tensile testers, he needs to determine what GPIB addresses they have been set to. He can do so with the aid of a simple application he has written. The following steps correspond to the program flowchart in Figure 2-6.

1. The application initializes the GPIB by bringing the interface board in the computer online.
2. The application issues a command to detect the presence of listening devices on the GPIB and compiles a list of the addresses of all such devices.
3. The application sends an identification query (" *IDN? ") all of the devices detected on the GPIB in Step 2.
4. The application reads the identification information returned by each of the devices as it responds to the query in Step 3.
5. As a cleanup step before exiting, the application returns the interface board to its original state by taking it offline.

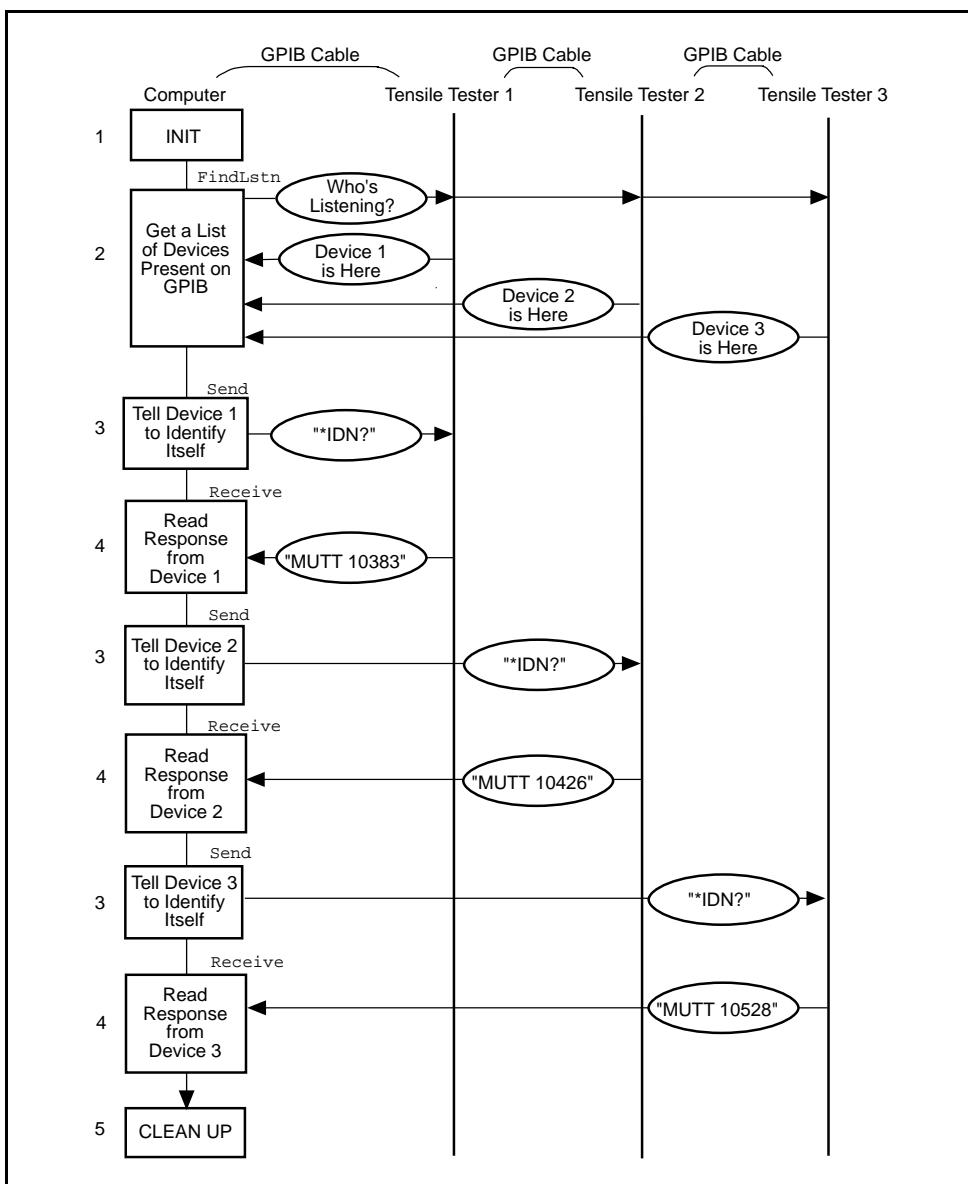


Figure 2-6. Program Flowchart for Example 6

Example 7: Serial Polls Using NI-488.2 Routines

This example illustrates how you can take advantage of the NI-488.2 routines to reduce the complexity of performing serial polls of multiple devices.

A candy manufacturer is using GPIB strain gauges to measure the consistency of the syrup used to make candy. The plant has four big mixers containing syrup. The syrup has to reach a certain consistency to make good quality candy. This is measured by strain gauges that monitor the amount of pressure used to move the mixer arms. When a certain consistency is reached, the mixture is removed and a new batch of syrup is poured in the mixer. The GPIB strain gauges are connected to a computer with an IEEE 488.2 interface board and the NI-488.2M software installed. The process is controlled by an application that uses NI-488.2 routines to communicate with the IEEE 488.2-compliant strain gauges. The following steps correspond to the program flowchart in Figure 2-7.

1. The application initializes the GPIB by bringing the interface board in the computer online.
2. The application configures the strain gauges to request service when they have a significant pressure reading or a mechanical failure occurs. They signal their request for service by asserting the SRQ line.
3. The application waits for one or more of the strain gauges to indicate that they have a significant pressure reading. This wait event ends as soon as the SRQ line is asserted.
4. The application serial polls each of the strain gauges to see if it requested service.
5. Once the application has determined which one of the strain gauges requires service, it takes a reading from that strain gauge.
6. If the reading matches the desired consistency, a dialog window appears on the computer screen and prompts the mixer operator to remove the mixture and start a new batch. Otherwise, a dialog window prompts the operator to service the mixer in some other way.

Steps 3 through 6 are repeated as long as the mixers are in operation.

7. After the last batch of syrup has been processed, the application returns the interface board to its original state by taking it offline.

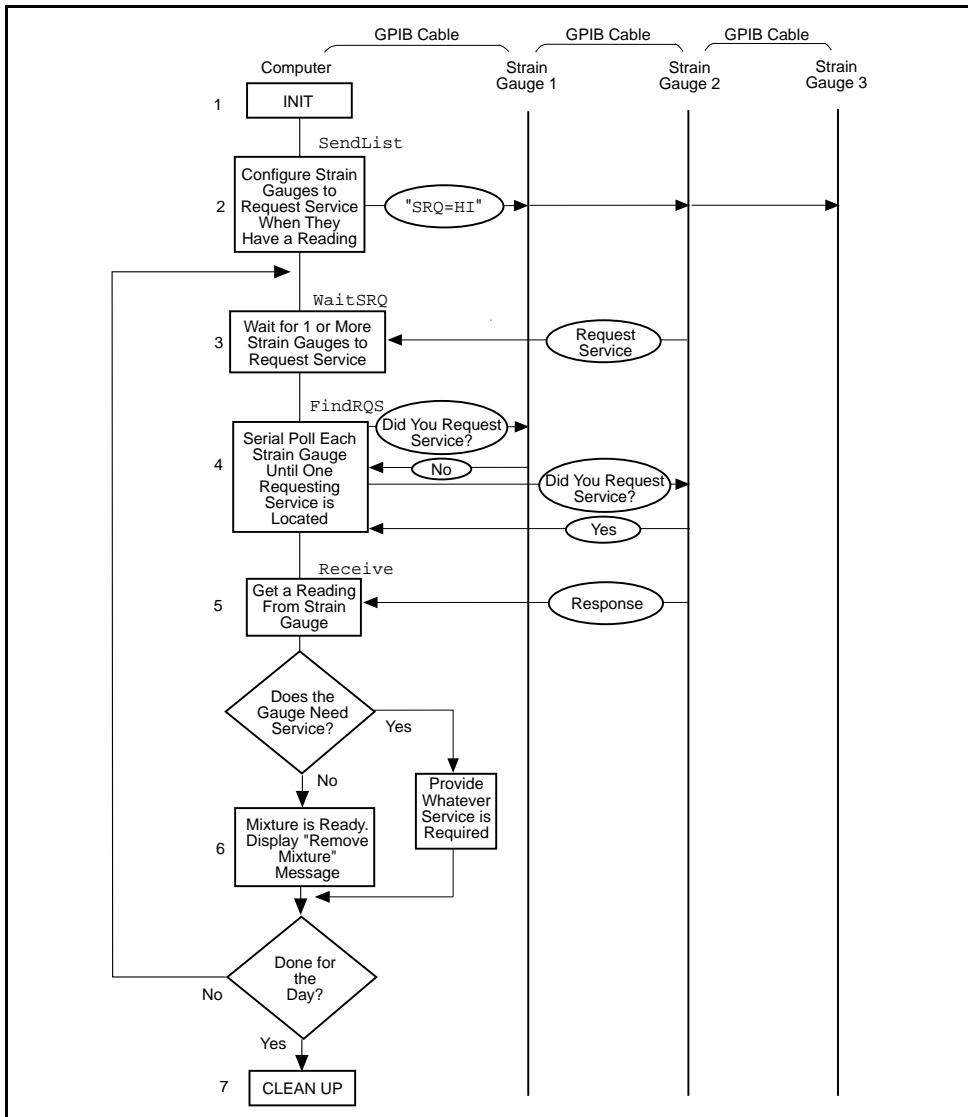


Figure 2-7. Program Flowchart for Example 7

Example 8: Parallel Polls

This example illustrates how you can use NI-488.2 routines to obtain information from several IEEE 488.2-compliant devices at once using a procedure called parallel polling.

The process of manufacturing a particular alloy involves bringing three different metals to specific temperatures before mixing them to form the alloy. Three vats are used, each containing a different metal. Each is monitored by a GPIB ore monitoring unit. The monitoring unit consists of a GPIB temperature transducer and a GPIB power supply. The temperature transducer is used to probe the temperature of each metal. The power supply is used to start a motor to pour the metal into the mold when it reaches a predefined temperature. The three monitoring units are connected to the IEEE 488.2 interface board of a computer that has the NI-488.2M software installed. An application using NI-488.2 routines operates the three monitoring units. The application will obtain information from the multiple units by conducting a parallel poll, and will then determine when to pour the metals into the mixture tank. The following steps correspond to the program flowchart in Figure 2-8.

1. The application initializes the GPIB by bringing the interface board in the computer online.
2. The application configures the temperature transducer in the first monitoring unit by choosing which of the eight GPIB data lines the transducer uses to respond when a parallel poll is conducted. The application also sets the temperature threshold. The transducer manufacturer has defined the individual status (*ist*) bit to be true when the temperature threshold is reached, and the configured status mode of the transducer is *assert the data line*. When a parallel poll is conducted, the transducer asserts its data line if the temperature has exceeded the threshold.
3. The application configures the temperature transducer in the second monitoring unit for parallel polls.
4. The application configures the temperature transducer in the third monitoring unit for parallel polls.
5. The application conducts non-GPIB activity while the metals are heated.
6. The application conducts a parallel poll of all three temperature transducers to determine whether the metals have reached the appropriate temperature. Each transducer asserts its data line during the configuration step if its temperature threshold has been reached.
7. If the response to the poll indicates that all three metals are at the appropriate temperature, the application sends a command to each of the three power supplies, directing them to power on. Then the motors start and the metals pour into the mold.

If only one or two of the metals is at the appropriate temperature, Steps 5 and 6 are repeated until the metals can be successfully mixed.

8. The application unconfigures all of the transducers so that they no longer participate in parallel polls.
9. As a cleanup step before exiting, the application returns the interface board to its original state by taking it offline.

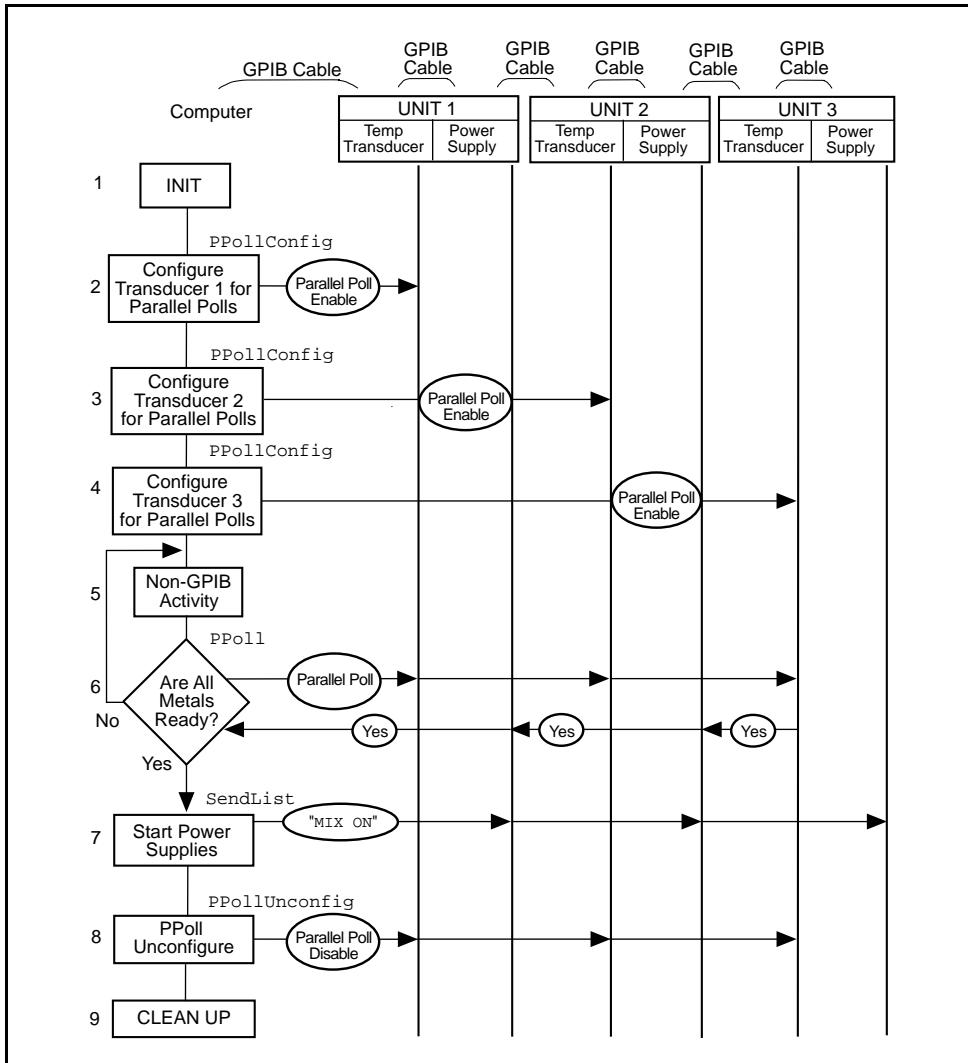


Figure 2-8. Program Flowchart for Example 8

Example 9: Non-Controller Example

This example illustrates how you can use the NI-488.2M software to emulate a GPIB device that is not the GPIB Controller.

A software engineer has written firmware to emulate a GPIB device for a research project and is testing it using an application that makes simple GPIB calls. The following steps correspond to the program flowchart in Figure 2-9.

1. The application brings the device online.
2. The application waits for any of three events to occur: the device to become listen-addressed, become talk-addressed, or receive a GPIB clear message.
3. As soon as one of the events occurs, the application takes an action based upon the event that occurred. If the device was cleared, the application resets the internal state of the device to default values. If the device was talk-addressed, it writes data back to the Controller. If the device was listen-addressed, it reads in new data from the Controller.

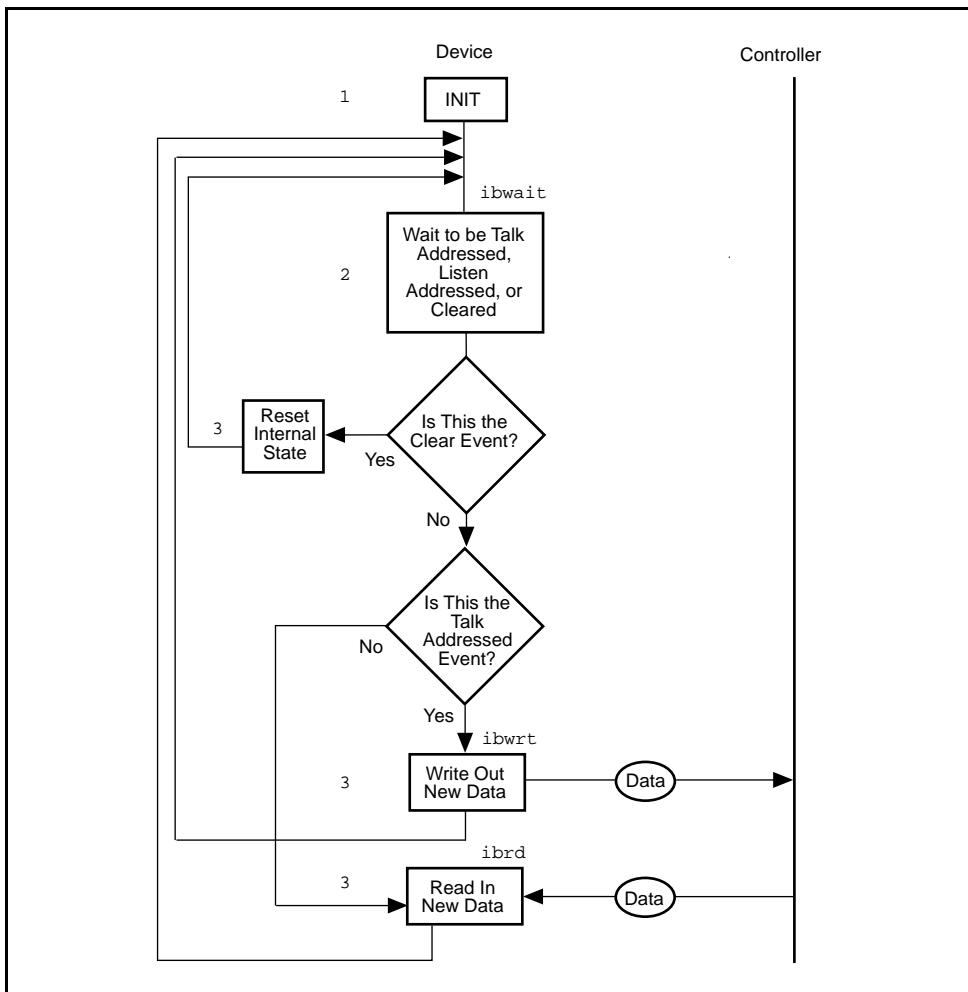


Figure 2-9. Program Flowchart for Example 9

Chapter 3

Developing Your Application

This chapter explains how to develop a GPIB application program using NI-488 functions and NI-488.2 routines.

Choosing How to Access the NI-488.2M DLL

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

If you need to access the `gpib-32.dll` from a language other than C, you must directly access the `gpib-32.dll`. You can directly access the DLL from any programming environment that allows you to request addresses of variables and functions that a DLL exports. The `gpib-32.dll` exports pointers to each of the global variables:

- `user_ibsta` is a pointer to `ibsta`
- `user_iberr` is a pointer to `iberr`
- `user_ibcntl` is a pointer to `ibcntl`

The `gpib-32.dll` also exports pointers to all of the NI-488 and NI-488.2 calls. For example, it exports a pointer to the NI-488 `ibwrt` function. For a detailed example showing how to use direct access, refer to the sample program `dlldev.c` that came with your NI-488.2M software.

Choosing Between NI-488 Functions and NI-488.2 Routines

Your distribution disk contains two distinct sets of subroutines to meet your application needs. Both of these sets, the NI-488 functions and the NI-488.2 routines, 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 application programs, the NI-488 functions are sufficient. You should use the NI-488.2 routines if you have a complex configuration with one or more interface boards and multiple devices. Regardless of which option you choose, the driver automatically addresses and performs other bus management operations necessary for device communication.

The following sections discuss some differences between NI-488 functions and NI-488.2 routines.

Using NI-488 Functions: One Device for Each Board

If your system has only one device attached to each board, the NI-488 functions are probably sufficient for your programming needs. Some other factors that make the NI-488 functions more convenient include the following:

- With NI-488 asynchronous I/O functions (`ibcmda`, `ibrda`, and `ibwrt`), you can initiate an I/O sequence while maintaining control over the CPU for non-GPIB tasks.
- NI-488 functions include built-in file transfer functions (`ibrdf` and `ibwrtf`).
- With NI-488 functions, you can control the bus in non-typical ways or communicate with non-compliant devices.

The NI-488 functions consist of high-level (or device) functions that hide much of the GPIB management operations and low-level (or board) functions that offer you more control over the GPIB than NI-488.2 routines. The following sections describe these different function types.

NI-488 Device Functions

Device functions are high-level functions that automatically execute commands that handle bus management operations such as reading from and writing to devices or polling them for status. If you use device functions, you do not need to understand GPIB protocol or bus management. For information about device-level calls and how they manage the GPIB, refer to *Device-Level Calls and Bus Management*, in Chapter 6, *GPIB Programming Techniques*.

NI-488 Board Functions

Board functions are low-level functions that perform rudimentary GPIB operations. Board functions access the interface board directly and require you to handle the addressing and bus management protocol. In cases when the high-level device functions might not meet your needs, low-level board 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 board configurations
- Managing the bus in non-typical ways

The NI-488 board functions are compatible with, and can be interspersed within, sequences of NI-488.2 routines. When you use board functions within a sequence of NI-488.2 routines, you do not need a prior call to `ibfind` to obtain a board descriptor. You simply substitute the board index as the first parameter of the board function call. With this flexibility, you can handle non-standard or unusual situations that you cannot resolve using NI-488.2M routines only.

Using NI-488.2 Routines: Multiple Boards and/or Multiple Devices

When your system includes a board that must access multiple devices, use the NI-488.2 routines. NI-488.2 routines can perform the following tasks with a single call:

- Find all of the Listeners on the bus
- Find a device requesting service
- Determine the state of the SRQ line, or wait for SRQ to be asserted
- Address multiple devices to listen

Checking Status with Global Variables

Each NI-488 function and NI-488.2 routine updates four global variables to reflect the status of the device or board that you are using. The status word (`ibsta`), the error variable (`iberr`) and the count variables (`ibcnt` and `ibcntl`) contain useful information about the performance of your application program. Your program should check these variables frequently. The following sections describe each of these global variables and how you can use them in your application program.

Status Word – `ibsta`

All functions 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 of the NI-488 functions except `ibfind` and `ibdev`. You can test for the conditions reported in `ibsta` and use that information to make decisions about continued processing. If you check for possible errors after each call, 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 NI-488 device calls (dev), NI-488 board calls (brd) and NI-488.2 calls, 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 of the status conditions, refer to Appendix A, *Status Word Conditions*.

Table 3-1. Status Word (ibsta) Layout

Mnemonic	Bit Pos.	Hex Value	Type	Description
ERR	15	8000	dev, brd	GPIB 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
SPOLL	10	400	brd	Board has been serial polled by the Controller
EVENT	9	200	brd	A DCAC, DTAS, or IFC event has occurred
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 included on your distribution disk contains the mnemonic constants for `ibsta`. You can check a bit position in `ibsta` by using its numeric value or its mnemonic constant. For example, bit position 15 (hex 8000) detects a GPIB error. The mnemonic for this bit is `ERR`. To check for a GPIB error, use either of the following statements after each NI-488 function and NI-488.2 routine as shown:

```
if (ibsta & ERR) gpiberr();
```

or

```
if (ibsta & 0x8000) gpiberr();
```

where `gpiberr()` is an error-handling routine.

Error Variable – `iberr`

If the `ERR` bit is set in the status word (`ibsta`), a GPIB error has occurred. When an error occurs, the error type is specified by the value in `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 on error codes and solutions refer to Chapter 4, *Debugging Your Application*, or Appendix B, *Error Codes and Solutions*.

Count Variables – `ibcnt` and `ibcntl`

The count variables are updated after each read, write, or command function. `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.

In your application program, you can use the count variables to null-terminate an ASCII string of data received from an instrument. For example, if data is received in an array of characters, you can use `ibcntl` to null-terminate the array and print the measurement on the screen as follows:

```
char rdbuf[512];
ibrd (ud, rdbuf, 20L);
if (!(ibsta & ERR)){
    rdbuf[ibcntl] = '\0';
    printf ("Read: %s\n", rdbuf);
}
else {
    error();
}
```

`ibcnt1` is the number of bytes received. Data begins in the array at index zero (0); therefore, `ibcnt1` is the position for the null character that marks the end of the string.

Using ibic to Communicate with Devices

Before you begin writing your application program, you might want to use the `ibic` utility. With `ibic` (Interface Bus Interactive Control), you communicate with your instruments from the keyboard rather than from an application program. You can use `ibic` to learn to communicate with your instruments using the NI-488 functions or NI-488.2 routines. For specific device communication instructions, refer to the user manual that came with your instrument. For information about using `ibic` and for detailed examples, refer to Chapter 5, *ibic—Interface Bus Interactive Control Utility*.

Writing Your NI-488 Application

This section discusses items you should include in your application program, general program steps, and an NI-488 example. In this manual the example code is presented in C using the standard C language interface. The NI-488.2M software includes the source code for this example written in C (`devsamp.c`) and the source code for this example written to use direct entry to access the `gpib-32.dll` (`dlldev.c`).

The NI-488.2M software also includes the source code for nine application examples, which are described in Chapter 2, *Application Examples*.

Items to Include

- Include the appropriate GPIB header file. This file contains prototypes for the NI-488 functions and constants that you can use in your application program.
- Check for errors after each NI-488 function call.
- Declare and define a function to handle GPIB 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("GPIB error");  
}
```

NI-488 Program Shell

Figure 3-1 is a flowchart of the steps to create your application program using NI-488 functions. The flowchart is for device-level calls.

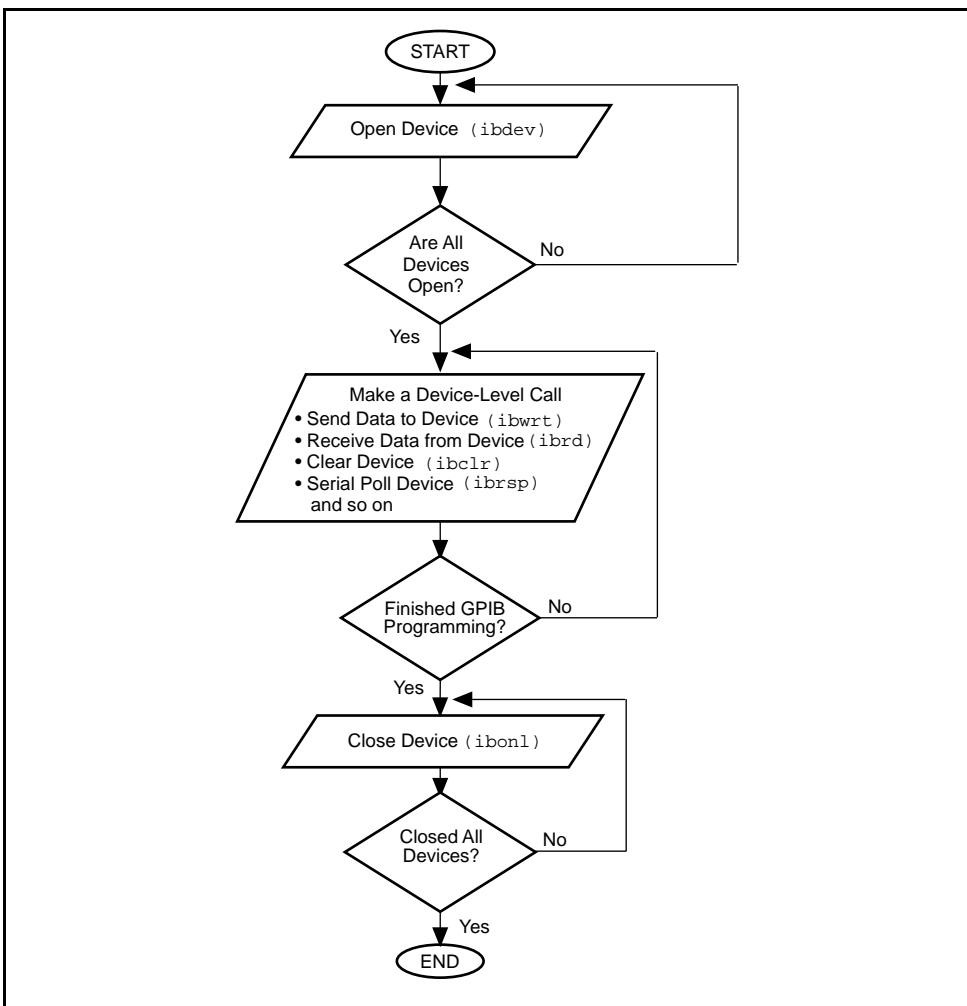


Figure 3-1. General Program Shell Using NI-488 Device Functions

General Program Steps and Examples

The following steps demonstrate how to use the NI-488 device functions in your program. This example configures a digital multimeter, reads 10 voltage measurements, and computes the average of these measurements.

Step 1. Open a Device

Your first NI-488 function call should be to `ibdev` to open a device.

```
ud = ibdev(0, 1, 0, T10s, 1, 0);

if (ibsta & ERR) {
    gpiberr("ibdev error");
}
```

The input arguments of the `ibdev` function are as follows:

- 0 - board index for GPIB0
- 1 - primary GPIB address of the device
- 0 - no secondary GPIB address for the device
- T10s - I/O timeout value (10 s)
- 1 - send END message with the last byte when writing to device
- 0 - disable EOS detection mode

When you call `ibdev`, the driver automatically initializes the GPIB by sending an Interface Clear (IFC) message and placing the device in remote programming state.

Step 2. Clear the Device

Clear the device before you configure the device for your application. Clearing the device resets its internal functions to a default state.

```
ibclr(ud);
if (ibsta & ERR) {
    gpiberr("ibclr error");
}
```

Step 3. Configure the Device

After you open and clear the device, it is ready to receive commands. To configure the instrument, you send device-specific commands using the `ibwrt` function. Refer to the instrument user manual for the command bytes that work with your instrument.

```
ibwrt(ud, "*RST; VAC; AUTO; TRIGGER 2; *SRE 16", 35L);
if (ibsta & ERR) {
    gpiberr("ibwrt error");
}
```

The programming instruction in this example resets the multimeter (*RST). The meter is instructed to measure the volts alternating current (VAC) using auto-ranging (AUTO), to wait for a trigger from the GPIB interface board before starting a measurement (TRIGGER 2), and to assert the SRQ line when the measurement completes and the multimeter is ready to send the result (*SRE 16).

Step 4. Trigger the Device

If you configure the device to wait for a trigger, you must send a trigger command to the device before reading the measurement value. Then instruct the device to send the next triggered reading to its GPIB output buffer.

```
ibtrg(ud);
if (ibsta & ERR) {
    gpiberr("ibtrg error");
}
ibwrt(ud, "VAL1?", 5L);
if (ibsta & ERR) {
    gpiberr("ibwrt error");
}
```

Step 5. Wait for the Measurement

After you trigger the device, the RQS bit is set when the device is ready to send the measurement. You can detect RQS by using the `ibwait` function. The second parameter indicates what you are waiting for. Notice that the `ibwait` function also returns when the I/O timeout value is exceeded.

```
printf("Waiting for RQS...\n");
ibwait (ud, TIMO|RQS);
if (ibsta & (ERR|TIMO)) {
    gpiberr("ibwait error");
}
```

When SRQ has been detected, serial poll the instrument to determine if the measured data is valid or if a fault condition exists. For IEEE 488.2 instruments, you can find out by checking the message available (MAV) bit, bit 4 in the status byte that you receive from the instrument.

```
ibrsp (ud, &StatusByte);
if (ibsta & ERR) {
    gpiberr("ibrsp error");
}

if ( !(StatusByte & MAVbit)) {
    gpiberr("Improper Status Byte");
    printf("    Status Byte = 0x%x\n", StatusByte);
}
```

Step 6. Read the Measurement

If the data is valid, read the measurement from the instrument. (AsciiToFloat is a function that takes a null-terminated string as input and outputs the floating point number it represents.)

```
ibrd (ud, rdbuf, 10L);
if (ibsta & ERR) {
    gpiberr("ibrd error");
}

rdbuf[ibcntl] = '\0';
printf("Read: %s\n", rdbuf);
/* Output ==> Read: +10.98E-3 */

sum += AsciiToFloat(rdbuf);
```

Step 7. Process the Data

Repeat Steps 4 through 6 in a loop until 10 measurements have been read. Then print the average of the readings as shown:

```
printf("The average of the 10 readings is %f\n", sum/10.0);
```

Step 8. Place the Device Offline

As a final step, take the device offline using the ibonl function.

```
ibonl (ud, 0);
```

Writing Your NI-488.2 Application

This section discusses items you should include in an application program that uses NI-488.2 routines, general program steps, and an NI-488.2 example. In this manual the example code is presented in C using the standard C language interface. The NI-488.2M software includes the source code for this example written in C (`samp4882.c`) and the code for this example written to use direct entry to access the `gpib-32.dll` (`dll4882.c`).

The NI-488.2M software also includes the source code for nine application examples, which are described in Chapter 2, *Application Examples*.

Items to Include

- Include the appropriate GPIB header file. This file contains prototypes for the NI-488.2 routines and constants that you can use in your application program.
- Check for errors after each NI-488.2 routine call.
- Declare and define a function to handle GPIB 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("GPIB error");  
}
```

NI-488.2 Program Shell

Figure 3-2 is a flowchart of the steps to create your application program using NI-488.2 routines.

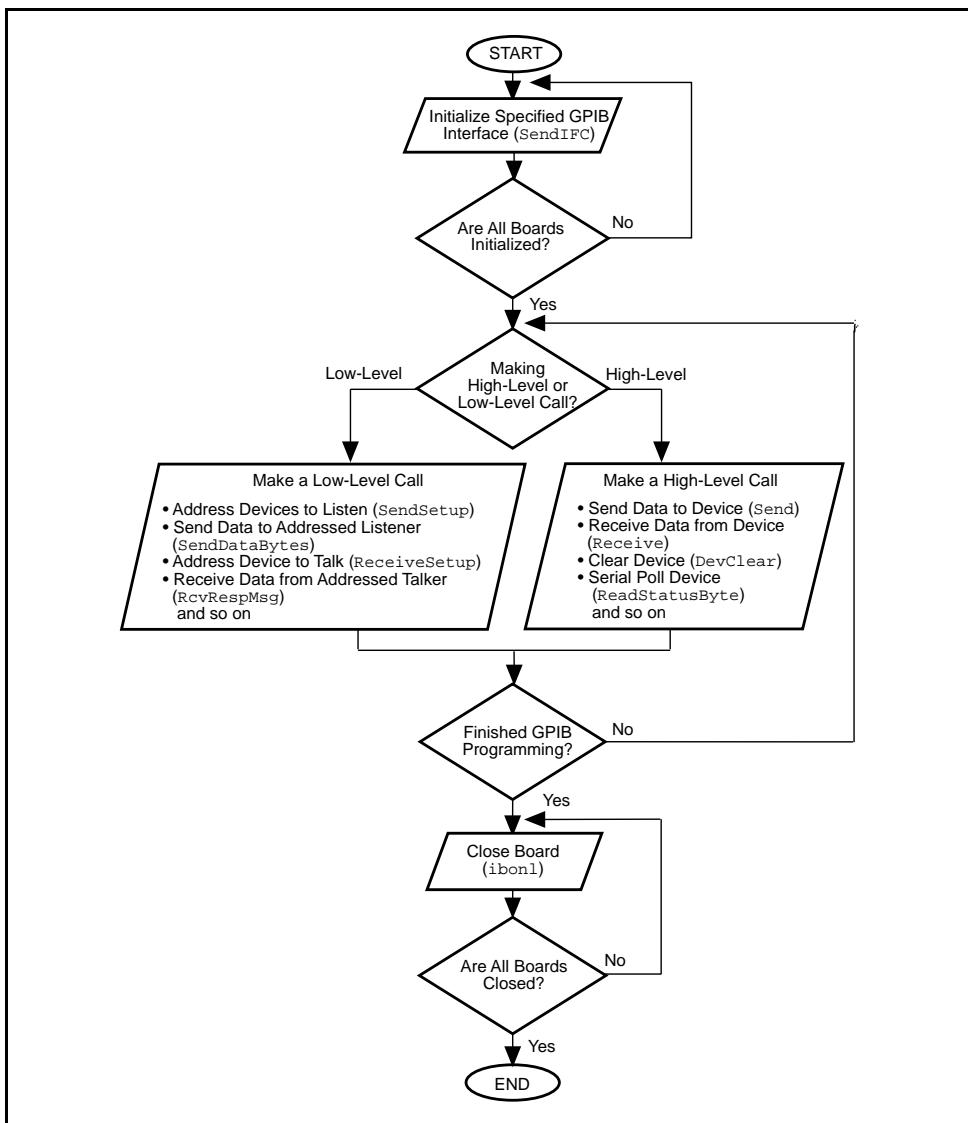


Figure 3-2. General Program Shell Using NI-488.2 Routines

General Program Steps and Examples

The following steps demonstrate how to use the NI-488.2 routines in your program. This example configures a digital multimeter, reads 10 voltage measurements, and computes the average of these measurements.

Step 1. Initialization

Use the `SendIFC` routine to initialize the bus and the GPIB interface board so that the GPIB board is Controller-In-Charge (CIC). The only argument of `SendIFC` is the GPIB interface board number.

```
SendIFC(0);
if (ibsta & ERR) {
    gpiberr("SendIFC error");
}
```

Step 2. Find All Listeners

Use the `FindLstn` routine to create an array of all of the instruments attached to the GPIB. The first argument is the interface board number, the second argument is the list of instruments that was created, the third argument is a list of instrument addresses that the procedure actually found, and the last argument is the maximum number of devices that the procedure can find (that is, it must stop if it reaches the limit). The end of the list of addresses must be marked with the `NOADDR` constant, which is defined in the header file that you included at the beginning of the program.

```
for (loop = 0; loop <=30; loop++){
    instruments[loop] = loop;
}
instruments[31] = NOADDR;

printf("Finding all Listeners on the bus...\n");

FindLstn(0, instruments, result, 30);
if (ibsta & ERR) {
    gpiberr("FindLstn error");
}
```

Step 3. Identify the Instrument

Send an identification query to each device for identification. For this example, assume that all of the instruments are IEEE 488.2-compatible and can accept the identification query, `*IDN?`. In addition, assume that `FindLstn` found the GPIB interface board at primary address 0 (default) and, therefore, you can skip the first entry in the `result` array.

```

for (loop = 1; loop <= num_Listeners; loop++) {
    Send(0, result[loop], "*IDN?", 5L, NLend);
    if (ibsta & ERR) {
        gpiberr("Send error");
    }

    Receive(0, result[loop], buffer, 10L, STOPend);
    if (ibsta & ERR) {
        gpiberr("Receive error");
    }

    buffer[ibcntl] = '\0';
    printf("The instrument at address %d is a %s\n",
           result[loop], buffer);
    if (strncmp(buffer, "Fluke, 45", 9) == 0) {
        fluke = result[loop];
        printf("**** Found the Fluke ****\n");
        break;
    }
}

if (loop > num_Listeners) {
    printf("Did not find the Fluke!\n");
    ibonl(0,0);
    exit(1);
}

```

The constant NLend signals that the new line character with EOI is automatically appended to the data to be sent.

The constant STOPend indicates that the read is stopped when EOI is detected.

Step 4. Initialize the Instrument

After you find the multimeter, use the DevClear routine to clear it. The first argument is the GPIB board number. The second argument is the GPIB address of the multimeter. Then send the IEEE 488.2 Reset command to the meter.

```

DevClear(0, fluke);
if (ibsta & ERR) {
    gpiberr("DevClear error")
}

Send(0, fluke, "*RST", 4L, NLend);
if (ibsta & ERR) {
    gpiberr("Send *RST error");
}
sum = 0.0;
for(m = 0; m<10; m++) {
    /* start of loop for Steps 5 through 8 */

```

Step 5. Configure the Instrument

After initialization, the instrument is ready to receive instructions. To configure the multimeter, use the `Send` routine to send device-specific commands. The first argument is the number of the access board. The second argument is the GPIB address of the multimeter. The third argument is a string of bytes to send to the multimeter.

The bytes in this example instruct the meter to measure volts alternating current (VAC) using auto-ranging (AUTO), to wait for a trigger from the Controller before starting a measurement (TRIGGER 2), and to assert SRQ when the measurement has been completed and the meter is ready to send the result (*SRE 16). The fourth argument represents the number of bytes to be sent. The last argument, `NLend`, is a constant defined in the header file which tells `Send` to append a linefeed character, with EOI asserted, to the end of the message sent to the multimeter.

```
Send (0, fluke, "VAC; AUTO; TRIGGER 2; *SRE 16", 29L, NLend);
if (ibsta & ERR) {
    gpiberr("Send setup error");
}
```

Step 6. Trigger the Instrument

In the previous step, the multimeter was instructed to wait for a trigger before conducting a measurement. Now send a trigger command to the multimeter. You could use the `Trigger` routine to accomplish this, but because the Fluke 45 is IEEE 488.2-compatible, you can just send it the trigger command, *TRG. The `VAL1?` command instructs the meter to send the next triggered reading to its output buffer.

```
Send(0, fluke, "*TRG; VAL1?", 11L, NLend);
if (ibsta & ERR) {
    gpiberr("Send trigger error");
}
```

Step 7. Wait for the Measurement

After the meter is triggered, it takes a measurement and displays it on its front panel and then asserts SRQ. You can detect the assertion of SRQ using either the `TestSRQ` or `WaitSRQ` routine. If you have a process that you want to execute while you are waiting for the measurement, use `TestSRQ`. For this example, you can use the `WaitSRQ` routine. The first argument in `WaitSRQ` is the GPIB board number. The second argument is a flag returned by `WaitSRQ` that indicates whether or not SRQ is asserted.

```
WaitSRQ(0, &SRQasserted);
if (!SRQasserted) {
    gpiberr("WaitSRQ error");
}
```

After you have detected SRQ, use the `ReadStatusByte` routine to poll the meter and determine its status. The first argument is the GPIB board number, the second argument is the GPIB address of the instrument, and the last argument is a variable that `ReadStatusByte` uses to store the status byte of the instrument.

```
ReadStatusByte(0, fluke, &statusByte);
if (ibsta & ERR) {
    gpiberr("ReadStatusByte error");
}
```

After you have obtained the status byte, you must check to see if the meter has a message to send. You can do this by checking the message available (MAV) bit, bit 4, in the status byte.

```
if (!(statusByte & MAVbit) {
    gpiberr("Improper Status Byte");
    printf("Status Byte = 0x%x\n", statusByte);
}
```

Step 8. Read the Measurement

Use the `Receive` function to read the measurement over the GPIB. The first argument is the GPIB interface board number, and the second argument is the GPIB address of the multimeter. The third argument is a string into which the `Receive` function places the data bytes from the multimeter. The fourth argument represents the number of bytes to be received. The last argument indicates that the `Receive` message terminates upon receiving a byte accompanied with the END message.

```
Receive(0, fluke, buffer, 10L, STOPEnd);
if (ibsta & ERR) {
    gpiberr("Receive error");
}

buffer[ibcntl] = '\0';
printf (Reading : %s\n", buffer);
sum += AsciiToFloat(buffer);
} /* end of loop started in Step 5 */
```

Step 9. Process the Data

Repeat Steps 5 through 8 in a loop until 10 measurements have been read. Then print the average of the readings as shown:

```
printf ("The average of the 10 readings is : %f\n", sum/10);
```

Step 10. Place the Board Offline

Before ending your application program, take the board offline using the `ibonl` function.

```
ibonl(0,0);
```

Compiling, Linking, and Running Your GPIB Win32 Application

The following sections describe how to compile, link, and run your Win32 GPIB application.

Microsoft Visual C/C++

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

```
#include "decl-32.h"
```

After you have written your C application program, you must compile the application program using Microsoft Visual C/C++ (version 2.0 or higher). Next, link the application with the C language interface, `gpib-32.obj`. 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
```

To run your application from the Windows environment, select the **Run...** option from the **Start** menu. Enter the name of the compiled program in the dialog box that appears. To run your application from a DOS shell, type the name of your compiled program on the DOS command line.

Direct Entry with C

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

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

#include "decl-32.h"
```

```

/* Global variable for the handle to the loaded gpib-32.dll. */
HINSTANCE Gpib32Lib = NULL;
/* Pointers to NI-488.2 global status variables */
int *Pibsta;
int *Piberr;
long *Pibcntl;

#ifndef __cplusplus
}
#endif

```

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. The prototypes for each function that `gpib-32.dll` exports can be found in the *NI-488.2M Function Reference Manual for Windows NT*. The NI-488.2M direct entry sample programs illustrate how to use direct entry to access `gpib-32.dll`. Use the `LoadLibrary` and `GetProcAddress` functions to load the `gpib-32.dll` and get pointers to its exported functions. For more information on direct entry, refer to the Win32 SDK (Software Development Kit) documentation.

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

```

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

```

Next, your Win32 application must use `GetProcAddress`. The following code fragment demonstrates how to retrieve the addresses of the pointers to the status variables and any functions your application needs:

```

Pibsta = (int *) GetProcAddress(Gpib32Lib, (LPCSTR)"user_ibsta");
Piberr = (int *) GetProcAddress(Gpib32Lib, (LPCSTR)"user_iberr");
Pibcntl = (long *) GetProcAddress(Gpib32Lib,
(LPCSTR)"user_ibcntl");

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 demonstrates how to verify that none of the calls to `GetProcAddress` failed:

```

if ((Pibsta == NULL) ||
    (Piberr == NULL) ||
    (Pibcntl == NULL) ||
    (Pibdev == NULL) ||
    (Pibonl == NULL)) {
    // ERROR!
}

```

```
}
```

Your Win32 application dereferences the pointer to access either the status variables or function. The following code demonstrates 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 must free `gpib-32.dll` with the following command:

```
FreeLibrary(Gpib32Lib);
```

For more information on direct entry, refer to the Win32 SDK (Software Development Kit) documentation.

Microsoft Visual C/C++

After you have written your Win32 application, you must compile the application using Microsoft Visual C/C++ (version 2.0 or higher). To compile and link a Win32 console application named `cprog` in a DOS shell, type the following on the command line:

```
cl cprog.c
```

To run your application from the Windows environment, select the **Run...** option from the **Start** menu. Enter the path and name of the compiled program in the dialog box that appears. To run your application from a DOS shell, type the name of your compiled program on the DOS command line.

Borland C/C++

After you have written your Win32 Borland C/C++ (version 4.0 or higher) application, compile it using the `-w32` option to create a console application. From the command line in a DOS shell, type the following command to compile and link a Win32 application named `cprog`:

```
bcc32 -w32 cprog.c
```

To run your application from the Windows environment, select the **Run...** option from the **Start** menu. Enter the name of the compiled program in the dialog box that appears. To run your application from a DOS shell, type the name of your compiled program on the DOS command line.

Running Existing DOS and Windows GPIB Applications

You can run existing DOS and Windows GPIB applications under Windows NT by using the GPIB Virtual Device Driver, `gpib-vdd.dll`, which is included with your NI-488.2M software.

To run DOS GPIB applications, load the special GPIB device driver `gpib-nt.com` instead of `gpib.com`, which you normally use with DOS. When you install the NI-488.2M software, `gpib-nt.com` is copied into a new subdirectory called `doswin16`. To use `gpib-nt.com`, you must modify your `config.nt` file to load `gpib-nt.com` whenever a DOS application is executed. The `config.nt` file is located in your `<winnt>\system32` directory, where `<winnt>` is your Windows NT directory, for example `c:\windows`. To load `gpib-nt.com`, add the following line to your `config.nt` file:

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

where `<path>` is the directory where you installed the GPIB software (the default installation directory is `c:\gpib-nt`).

To run 16-bit Windows GPIB applications, the system uses the special GPIB dynamic link library, `gpib.dll`. When you install the NI-488.2M software, `gpib.dll` is copied into the `<winnt>\system32` directory, where `<winnt>` is your Windows NT directory, for example `c:\windows`). As long as `gpib.dll` is in that directory, it is automatically accessed whenever you launch a 16-bit Windows GPIB application.

Chapter 4

Debugging Your Application

This chapter describes several ways to debug your application program.

Running the Software Diagnostic Test

Before you run your application program, you should run the software diagnostic test, `ibtest`, that was installed with your NI-488.2M software. The `ibtest` program is an NI-488.2M application that makes calls to the driver. If `ibtest` passes, your GPIB hardware and NI-488.2M software are interacting correctly. The following paragraphs describe the messages you might receive while running `ibtest`, and how to resolve each problem.

Presence Test of Driver

The `ibtest` program tests for the presence of the NI-488.2M driver. `ibtest` displays the following message if it detects a problem:

```
<<< IBTEST was unable to access the NI-488.2M driver. Please be
sure that the installation completed successfully, the hardware is
installed correctly without conflicts, and the software is
configured correctly. See your Getting Started manual for more
information. >>>
```

There are several reasons why `ibtest` might be unable to access the NI-488.2M driver. If the software is not properly installed or if there is a conflict between the GPIB hardware and the other hardware in the system, the NI-488.2M driver fails to start. Two Windows NT utilities are useful in determining the source of the problem: the **Devices** applet in the **Control Panel** in the **Main** group, and the **Event Viewer** in the **Administrative Tools** group. The information available through each utility is described in the following sections.

Examining NT Devices to Verify the NI-488.2M Installation

To verify whether the NI-488.2M devices are installed correctly (that is, that the devices are started), run the **Devices** applet in the **Control Panel** window in the **Program Manager**. This utility lists all of the devices known to Windows NT. Each device has a status associated with it. If the NI-488.2M driver is installed correctly, the following lines appear in the list of NT devices:

<u>Device</u>	<u>Status</u>	<u>Started</u>
GPIB Board Class Driver	Started	Automatic
GPIB Device Class Driver	Started	Automatic

You should also see one or more lines similar to the following:

<u>Device</u>	<u>Status</u>	<u>Started</u>
GPIB Port Driver (AT-GPIB)	****	System
GPIB Port Driver (MC-GPIB)	****	System

The **GPIB Board Class Driver** and the **GPIB Device Class Driver** should both have a status of **Started**. If not, refer to the next section, *Examining the NT System Log Using the Event Viewer*.

At least one of the GPIB Port Drivers listed by the **Devices** applet should have a status of **Started**. If not, refer to the next section, *Examining the NT System Log Using the Event Viewer*.

If the GPIB Class Driver lines are not present or at least one GPIB Port Driver line is not present, the NI-488.2M software is not installed properly. You must reinstall the NI-488.2M software.

Examining the NT System Log Using the Event Viewer

Windows NT maintains a system log. If the NI-488.2M driver is unable to start, it records entries in the system log explaining why it failed to start. You can examine the system log by running the **Event Viewer** utility in the **Administrative Tools** window of the **Program Manager**. Events that might appear in the system log include the following:

- The system is unable to locate the device file for one or more of the devices that make up the NI-488.2M driver and an event is logged that **The system cannot find the file specified**. In this case, the NI-488.2M software is incorrectly installed. You should reinstall the software.
- A conflict exists between the GPIB hardware and the other hardware in the system. If this is the case, an event is logged that indicates the nature of the resource conflict. To correct this conflict, reconfigure the GPIB hardware and NI-488.2M software. Refer to the getting started manual that came with your GPIB board.

GPIB Cables Connected

The following error messages appear if a GPIB cable is connected to the board when you run `ibtest`.

```
Call(25) 'ibcmd" "' failed, ibsta (0x134) not what was expected
(0x8130)
```

```
Call(25) 'ibcmd" "' failed, expected ibsta (0x100) to have the
ERR bit set.
```

Disconnect all GPIB cables before trying the test again.

Running GPIBInfo

The `GPIBInfo` utility program is a simple diagnostic tool you can use to obtain information about the NI-488.2M software you are using and any GPIB interface boards in your system. This information helps you determine the capabilities of your NI-488.2M software and is also helpful if you need to call National Instruments for technical support.

Run `GPIBInfo` with no parameters. The program displays software information such as the name and version of your GPIB software, the type of GPIB interface board and functions that you can use with the software, and whether or not you can use the HS488 high-speed protocol. `GPIBInfo` also displays information about each GPIB interface board installed in your system, including the name of the board, the type of Controller chip it uses, the hardware settings, the type of functions that the board can use, and whether or not the board can use the HS488 high-speed communication protocol. The typical `GPIBInfo` output is as follows:

```
GPIBInfo (Sep 29 1993)
Copyright 1993 National Instruments Corp. All rights reserved.
```

Software Information:

```
The NI-488.2M Software for Windows NT is loaded.
You are running Version 1.0 for the AT-GPIB/TNT board.
It supports both the NI-488 functions and the NI-488.2 routines.
It supports the HS488 high-speed protocol.
```

Hardware Information:

```
GPIB0: an AT-GPIB/TNT board using the TNT4882C chip.
It supports both the NI-488 functions and NI-488.2
routines.
It supports the HS488 high-speed protocol.
It uses base I/O address 0x2C0.
It uses interrupt level 11.
It uses DMA channel 5.
```

Debugging with the Global Status Variables

After each function call to your NI-488.2M driver, `ibsta`, `iberr`, `ibcnt`, and `ibcntl` are updated before the call returns to your application. You should check for an error after each GPIB call. Refer to Chapter 3, *Developing Your Application*, for more information about how to use these variables within your program to automatically check for errors.

After you determine which GPIB call is failing and note the corresponding values of the global variables, refer to Appendix A, *Status Word Conditions*, and Appendix B, *Error Codes and Solutions*. These appendixes can help you interpret the state of the driver.

Debugging with `ibic`

If your application does not automatically check for and display errors, you can locate an error by using `ibic`. Simply issue the same functions or routines, one at a time as they appear in your application program. Because `ibic` returns the status values and error codes after each call, you should be able to determine which GPIB call is failing. For more information about `ibic`, refer to Chapter 5, *ibic—Interface Bus Interactive Control Utility*.

After you determine which GPIB call is failing and note the corresponding values of the global variables, refer to Appendix A, *Status Word Conditions*, and Appendix B, *Error Codes and Solutions*. These appendixes can help you interpret the state of the driver.

GPIB Error Codes

Table 4-1 lists the GPIB error codes. Remember that the error variable is meaningful only when the ERR bit in the status variable is set. For a detailed description of each error and possible solutions, refer to Appendix B, *Error Codes and Solutions*.

Table 4-1. GPIB Error Codes

Error Mnemonic	<code>iberr</code> Value	Meaning
EDVR	0	System error
ECIC	1	Function requires GPIB board to be CIC
ENOL	2	No Listeners on the GPIB
EADR	3	GPIB board not addressed correctly
EARG	4	Invalid argument to function call
ESAC	5	GPIB board not System Controller as required
EABO	6	I/O operation aborted (timeout)
ENEB	7	Nonexistent GPIB board
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

Configuration Errors

Several applications require customized configuration of the GPIB 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 use either the `ibconf` utility to permanently reconfigure the driver, or you can use the dynamic configuration function call `ibconfig` to modify the driver while your application is running.

`ibconfig` does not change the state of the driver permanently. Using dynamic configuration automatically configures the driver as necessary.

Note: *To change settings other than base I/O address, interrupt level, or DMA channel, National Instruments recommends using `ibconfig` instead of running the `ibconf` utility.*

If your program uses dynamic configuration, it will always work regardless of the previous configuration of the driver. Refer to the description of `ibconfig` in the *NI-488.2M Function Reference Manual for Windows NT* for more information.

To test the configuration of your hardware, you can use the `ibdiag` program as described in your getting started manual.

Timing Errors

If your application fails, but the same calls issued in `ibic` 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.

A well behaved IEEE 488 device should hold off handshaking and set the appropriate transfer rate. 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 GPIB 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 will be controlled by the device and your application can adjust itself and work independently on any platform. Other delay mechanisms will probably cause varying delay times on different platforms.

Communication Errors

Repeat Addressing

Some devices require GPIB addressing before any GPIB activity. 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. You might need to configure your NI-488.2M driver to perform repeat addressing if your device does not remain in its currently

addressed state. Refer to Chapter 7, *ibconf—Interface Bus Configuration Utility*, or to the description of `ibconfig` (option `IbcREADDR`) in the *NI-488.2M Function Reference Manual for Windows NT* for more information about reconfiguring your software.

Termination Method

You should be aware of the data termination method that your device uses. By default, your NI-488.2M 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 be because it does not recognize the end of the command. You might need to send a termination message such as `<CR> <LF>` after a write command as follows:

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

Common Questions

What do I do if `ibtest` fails with an error?

Refer to the *Running the Software Diagnostic Test* section of this manual or the section about `ibdiag` in the getting started manual for specific information about what might cause these tests to fail.

How do I communicate with my instrument over the GPIB?

Refer to the documentation that came from the instrument manufacturer. The command sequences you use are totally dependent on the specific instrument. The documentation for each instrument should include the GPIB commands you need to communicate with it. In most cases, NI-488 device-level calls are sufficient for communicating with instruments. Refer to Chapter 3, *Developing Your Application*, for more information.

Can I use the NI-488 and NI-488.2 calls together in the same application?

Yes, you can mix NI-488 functions and NI-488.2 routines.

Can I use the same name for my application and a GPIB device listed in `ibconf`?

No. Devices share the same name space that file and directory names use. Windows NT might not operate properly if you have a file or a directory name that conflicts with one of the GPIB device names. By default, the names used by the DOS driver are `gpib0`, `gpib1`, `gpib2`, `gpib3`, and `dev1`, `dev2`, `dev3`, and so on through `dev32`.

What can I do to check for errors in my GPIB application?

Examine the value of `ibsta` after each NI-488 or NI-488.2 call. If a call fails, the `ERR` bit of `ibsta` is set and an error code is stored in `ibcnt1`. For more information about global status variables, refer to Chapter 3, *Developing Your Application*.

How do I use `ibic`?

You can use `ibic` to practice communication with your instrument, troubleshoot problems, and develop your application program. For instructions, refer to Chapter 5, *ibic—Interface Bus Interactive Control Utility*.

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

Run the `GPIBInfo` utility. It returns information about the GPIB boards currently configured for use in your system.

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

Run the `GPIBInfo` utility. It provides information about the version of the NI-488.2M software currently installed.

What information should I have before I call National Instruments?

When you call National Instruments, you should have the results of the diagnostic tests `ibdiag` and `ibtest` along with the output from the `GPIBInfo` utility. Also, make sure you have filled out the technical support form in Appendix C, *Customer Communication*.

Chapter 5

ibic—Interface Bus Interactive Control Utility

This chapter introduces you to `ibic`, the interactive control program that you can use to communicate with GPIB devices interactively.

Overview

With the Interface Bus Interactive Control (`ibic`) program, you communicate with the GPIB devices through functions you enter at the keyboard. For specific information about how to communicate with your particular device, refer to the manual that came with the device. You can use `ibic` to practice communication with the instrument, troubleshoot problems, and develop your application program.

One way `ibic` helps you to learn about your instrument and to troubleshoot problems is by displaying the following information on your screen whenever you enter a command:

- The results of the status word (`ibsta`) in hexadecimal notation
- The mnemonic constant of each bit set in `ibsta`
- The mnemonic value of the error variable (`iberr`) if an error exists (the ERR bit is set in `ibsta`)
- The count value for each read, write, or command function
- The data received from your instrument

Example Using NI-488 Functions

This section shows how you might use `ibic` to test a sequence of NI-488 device function calls. You do not need to remember the parameters that each function takes. If you enter the function name only, `ibic` prompts you for the necessary parameters.

1. To run **ibic**, change to the appropriate drive and directory (c:\gpib-nt in this example). Then enter the command **ibic**. Your screen should appear as follows:

```
National Instruments
IEEE 488 Interface Bus Interactive Control Program (IBIC)
Copyright 1993 National Instruments Corp. Version 3.0 (Win32)
Version Date: May 28 1993 Version Time: 09:42:25
All rights reserved
```

```
Type 'help' for help or 'q' to quit
```

```
:
```

2. Use **ibdev** to find the device name which is assigned to your device in the **ibconf** program. The following example shows how you could use **ibdev** to open a device, assign it to access board **gpib0**, choose a primary address of 6 with no secondary address, set a timeout of 10 s, enable the END message, and disable 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
id = 32256
```

```
ud0:
```

You could also input all the same information with the **ibdev** command as follows:

```
:ibdev 0 6 0 13 1 0
id = 32256
```

```
ud0:
```

3. Clear the device as follows:

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

4. Write the function, range, and trigger source instructions to your device. Refer to the instrument user manual for the command bytes that work with your instrument.

```
ud0: ibwrt
    enter string: "F3R7T3"
[0100] (cmp1)
count: 6
```

or

```
ud0: ibwrt "F3R7T3"
[0100] (cmp1)
count: 6
```

5. Trigger the device as follows:

```
ud0: ibtrg
[0100] (cmp1)
```

6. Wait for a timeout or for your device to request service. If the current timeout limit is too short, use ibtmo to change it. Use the ibwait command as follows:

```
ud0: ibwait
    enter wait mask: TIMO RQS
[0900] (rqc cmp1)
```

or

```
ud0: ibwait TIMO RQS
[0900] (rqc cmp1)
```

7. Read the serial poll status byte. This serial poll status byte varies depending on the device used.

```
ud0: ibrsp
[0100] (cmp1)
Poll: 0x40 (decimal : 64)
```

8. Use the read command to display the data on the screen both in hex values and their ASCII equivalents.

```
ud0: ibrd
      enter byte count: 18
[0100] (cmp1)
count: 18
4e 44 43 56 20 30 30 30      N D C V  0 0 0
2e 30 30 34 37 45 2b 30      . 0 0 4 7 E + 0
0a 0a                          . .
```

or

```
ud0: ibrd 18
[0100] (cmp1)
count: 18
4e 44 43 56 20 30 30 30      N D C V  0 0 0
2e 30 30 34 37 45 2b 30      . 0 0 4 7 E + 0
0a 0a                          . .
```

9. Place the device offline as follows:

```
ud0: ibonl
      enter value: 0
[0100] (cmp1)
```

or

```
ud0: ibonl 0
[0100] (cmp1)
```

10. Terminate the `ibic` program by entering `q` at the prompt.

ibic Syntax

When you enter commands in `ibic`, you can either include the parameters, or the program prompts you for values. Some commands require numbers as input values. Others might require you to input a string.

Number Syntax

You can enter numbers as hexadecimal, octal, or decimal integer.

Hexadecimal numbers—You must precede hex numbers by zero and x (for example, 0xD).

Octal numbers—You must precede octal numbers by zero only (for example, 015).

Decimal numbers—Enter the number only.

String Syntax

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

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

Octal bytes—You must use a backslash character followed by the octal value. For example, octal 40 is represented by `\40`.

Hex bytes—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 `"F3R5T1\r\n"`.

Address Syntax

Many of the NI-488.2 routines have an address or address list parameter. An address is a 16-bit representation of the GPIB address of a device. 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.

ibic Syntax for NI-488 Functions

Table 5-1 and Table 5-2 summarize the syntax of NI-488 functions in `ibic.c`. `v` represents a number that you input. `string` represents a string that you input. For more information about the function parameters, use the `ibic` help feature or refer to the *NI-488.2M Function Reference Manual for Windows NT*.

Table 5-1. Syntax for Device-Level NI-488 Functions in ibic

Syntax	Description
ibask mn	Return configuration information where mn is a mnemonic for a configuration parameter or equivalent integer value
ibbna brdname	Change access board of device where brdname is symbolic name of new board
ibclr	Clear specified device
ibconfig mn v	Alter configurable parameters where mn is mnemonic for a configuration parameter or equivalent integer value
ibdev v vvvvv	Open an unused device ibdev parameters are board id, pad, sad, tmo, eos, eot
ibeos v	Change/disable EOS message
ibeot v	Enable/disable END message
ibln v v	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 v	Read data where v is the bytes to read
ibrda v	Read data asynchronously where v is the bytes to read
ibrdf fname	Read data to file where fname 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, octal, or decimal integer or a mask bit mnemonic
ibwrt string	Write data
ibwrta string	Write data asynchronously
ibwrtf fname	Write data from a file where fname is pathname of file to write

Table 5-2. Syntax for Board-Level NI-488 Functions in ibic

Syntax	Description
ibask mn	Return configuration information where mn is a mnemonic for a configuration parameter or equivalent integer value
ibcac v	Become active Controller
ibcmd string	Send commands
ibcmda string	Send commands asynchronously
ibconfig mn v	Alter configurable parameters where mn is mnemonic for a configuration parameter or equivalent integer value
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 board (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 v v	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 v	Read data where v is the bytes to read
ibrda v	Read data asynchronously where v is the bytes to read
ibrdf fname	Read data to file where fname 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
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, octal, or decimal integer or a mask bit mnemonic
ibwrt string	Write data
ibwrta string	Write data asynchronously
ibwrtf fname	Write data from a file where fname is pathname of file to write

ibic Syntax for NI-488.2 Routines

Table 5-3 summarizes the syntax of NI-488.2 routines in ibic. *v* represents a number that you input and *string* represents a string. *address* represents an address, and *addrlist* represents a list of addresses separated by commas. For more information about the routine parameters, use the ibic help feature or refer to the *NI-488.2M Function Reference Manual for Windows NT*.

Table 5-3. Syntax for NI-488.2 Routines in ibic

Routine 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 addrlist <i>v</i>	Find all Listeners
FindRQS addrlist	Find device asserting SRQ
PassControl address	Pass control to a device
PPoll	Parallel poll devices
PPollConfig address <i>v</i> <i>v</i>	Configure device for parallel poll
PPollUnconfig address	Unconfigure device for parallel poll
RcvRespMsg address string <i>v</i>	Receive response message
ReadStatusByte address	Serial poll a device
Receive address string <i>v</i>	Receive data from a device
ReceiveSetup address	Receive setup
ResetSys addrlist	Reset multiple devices
Send address string <i>v</i>	Send data to a device
SendCmds string	Send command bytes
SendDataBytes addrlist string <i>v</i>	Send data bytes
SendIFC	Send interface clear
SendList addrlist string <i>v</i>	Send data to multiple devices
SendLLO	Put devices in local lockout

(continues)

Table 5-3. Syntax for NI-488.2 Routines in ibic (Continued)

Routine Syntax	Description
SendSetup addrlist	Send setup
SetRWLS addrlist	Put devices in remote with lockout state
TestSys addrlist	Cause multiple devices to perform self-tests
TestSRQ	Test for service request
Trigger address	Trigger a device
TriggerList addrlist	Trigger multiple devices
WaitSRQ	Wait for service request

Status Word

In `ibic`, all NI-488 functions (except `ibfind` and `ibdev`) and NI-488.2 routines 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. It shows that the device function write operation completed successfully:

```
ud0: ibwrt "f2t3x"
[0100] (cmp1)
count: 5
```

```
ud0:
```

For more information about the status word, refer to Chapter 3, *Developing Your Application*.

Error Information

If an NI-488 function or NI-488.2 routine completes with an error, `ibic` displays the relevant error mnemonic. In the following example, an error condition `EBUS` has occurred during a data transfer.

```
ud0: ibwrt "f2t3x"
[8100] (err cmp1)
error: EBUS
count: 1
```

```
ud0:
```

In this example, the addressing command bytes could not be transmitted to the device. This indicates that either `dev1` 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

When an I/O function completes, `ibic` 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 of an NI-488.2 routine is invalid, then the error is EARG and `ibic` displays the index of the invalid address as the count.

The count has a different meaning depending on which NI-488 function or NI-488.2 routine is called. Refer to the function descriptions in the *NI-488.2M Function Reference Manual for Windows NT* for the correct interpretation of the count return.

Common NI-488 Functions

ibfind

Use the `ibfind` function to open a board. The following example opens `gpib0`.

```
:ibfind gpib0
id = 32000

gpib0:
```

`id` is the unit descriptor of the board. The prompt `gpib0` indicates that the board is open.

Any name you use with the `ibfind` function must be a valid symbolic name in the driver. `gpib0` is the default name found in the driver. For more information about valid names, refer to Chapter 7, *ibconf-Interface Bus Configuration Utility*.

ibdev

The `ibdev` command initializes a device descriptor with the input information.

With `ibdev`, you specify the following values:

- Access Board for the Device
- Primary Address
- Secondary Address

- Timeout Setting
- EOT mode
- EOS mode

The following example shows `ibdev` opening an available device and assigning it to access `gpib0` (board = 0) with a primary address of 6 (`pad = 6`), a secondary address of hex 67 (`sad = 0x67`), a timeout of 10 s. (`tmo=13`), the END message enabled (`eot =1`), and the EOS mode disabled (`eos=0`).

```
:ibdev 0 6 0x67 13 1 0
id = 32256

ud0:
```

If you use `ibdev` without specifying parameters, `ibic` prompts you for the input parameters as shown in the following example:

```
:ibdev
  enter board index: 0
  enter primary address: 6
  enter secondary address: 0x67
  enter timeout: 13
  enter 'EOI on last byte' flag: 1
  enter end-of-string mode/byte: 0
id = 32256

ud0:
```

Three distinct errors can occur with the `ibdev` call:

- EDVR-No device is available, the board index entered refers to a nonexistent board (that is, not 0, 1, 2, or 3), or the board has no driver installed. The following example illustrates an EDVR error.

```
:ibdev 4 6 0x67 7 1 0
id = -1
[8000] (err)
error: EDVR (2)

:
```

- ENEB-The board index entered refers to a known board (such as 0), but the driver cannot find the board. In this case, run `ibconf` to verify that the base address of the board is set correctly and that the Use This GPIB Interface field is set to yes.

- EARG—One of the last five parameters is an invalid value. The `ibdev` call returns with a new prompt and the EARG error (invalid function argument). If the `ibdev` call returns with an EARG error, you must identify which parameter is incorrect and use the appropriate command to correct it. In the following example, the pad has an invalid value. You can correct it with an `ibpad` call as shown:

```
:ibdev 0 66 0x67 7 1 0
id = 32256
[8100] (err cmpl)
error: EARG

ud0: ibpad 6
previous value: 16
```

ibwrt

The `ibwrt` command sends data from one GPIB device to another. For example, to send the six character data string F3R5T1 from the computer to a device called `dev1` you enter the following string at the `dev1` prompt as shown in the following example:

```
ud0: ibwrt "F3R5T1"
[0100] (cmpl)
count: 6
```

The returned status word contains the `cmpl` bit, which indicates a successful I/O completion. The byte count 6 indicates that all six characters were sent from the computer and received by the device.

ibrd

The `ibrd` command causes a GPIB device to receive data from another GPIB device. The following example acquires data from the device and displays it on the screen in hex format and in its ASCII equivalent, along with the status word and byte count.

```
ud0: ibrd 20
[2100] (end cmpl)
count: 18
4e 44 43 56 28 30 30 30      N D C V 9 0 0 0
2e 30 30 34 37 45 2b 30      . 0 0 4 7 E + 0
0d 0a                          . .
```

Common NI-488.2 Routines in ibic

Set 488.2

You must use the `set` command before you can use NI-488.2 routines in `ibic`. The syntax for this form of the `set` command is as follows:

```
set 488.2 n
```

where `n` represents a board number (for example, `n=0` for `gpib0`).

Send and SendList

The `Send` routine sends data to a single GPIB device. You can use the `SendList` command to send data to multiple GPIB devices. For example, suppose you want to send the five character string `*IDN?` followed by the new line character with EOI. You want to send the message from the computer to the devices at primary address 2 and 17. To do this, enter the `SendList` command at the `488.2 (0)` prompt as shown in the following example:

```
488.2 (0): SendList 2, 17 "*IDN?" NLend
[0128] (cmpl cic tacs)
count: 6
```

The returned status word contains the `cmpl` bit, which indicates a successful I/O completion. The byte count 6 indicates that all six characters, including the added new line, were sent from the computer and received by both devices.

Receive

The `Receive` routine causes the GPIB board to receive data from another GPIB device. The following example acquires 10 data bytes from the device at primary address 5. It stops receiving data when 10 characters have been received or when the END message is received. The acquired data is then displayed in hex format along with its ASCII equivalent. The `ibic` program also displays the status word and the count of transferred bytes.

```
488.2 (0): Receive 5 10 STOPend
[2124] (end cmpl cic lacs)
count: 5
48 65 6c 6c 6f      Hello
```

Auxiliary Functions

Table 5-4 summarizes the auxiliary functions that you can use in `ibic`.

Table 5-4. Auxiliary Functions in `ibic`

Function	Description
<code>set udname</code>	Select active device or board where <code>udname</code> is the symbolic name of the new device or board (for example, <code>dev1</code> or <code>gpib0</code>). Call <code>ibfind</code> or <code>ibdev</code> initially to open each device or board.
<code>Set 488.2 v</code>	Enter 488.2 mode for board v
<code>help [option]</code>	Display help information where <code>option</code> is any NI-488 or NI-488.2 call. If you do not enter an <code>option</code> , a menu of options appears.
<code>!</code>	Repeat previous function.
<code>-</code>	Turn OFF display.
<code>+</code>	Turn ON display.
<code>n* function</code>	Execute function <code>n</code> times where <code>function</code> represents the correct <code>ibic</code> function syntax.
<code>n* !</code>	Execute previous function <code>n</code> times.
<code>\$ filename</code>	Execute indirect file where <code>filename</code> is the pathname of a file that contains <code>ibic</code> functions to be executed.
<code>print string</code>	Display string on screen where <code>string</code> is an ASCII character sequence, octal bytes, hex bytes, or special symbols.
<code>e</code>	Exit or quit.
<code>q</code>	Exit or quit.

Set (udname or 488.2)

You can use the `set` command to select 488.2 mode or to communicate with a different device or board.

The following example shows how to enter 488.2 mode. The `488.2 (0)` prompt indicates that you are in NI-488.2 mode on board 0.

```
: set 488.2 0
```

```
488.2 (0):
```

The next example switches communication from using NI-488.2 routines for `gpib0` to using a unit descriptor (`ud0`) previously acquired by an `ibdev` call.

```
488.2 (0): set ud0
```

```
ud0:
```

Help (Display Help Information)

The help feature displays a menu of topics to choose from. Each topic lists relevant functions and other information. You can access help for a specific NI-488 function or NI-488.2 routine by typing `help` followed by the call name (for example, `help ibwrt`). Help describes the function syntax for all NI-488 functions and NI-488.2 routines.

! (Repeat Previous Function)

The `!` function repeats the most recent function executed. The following example issues an `ibsic` command and then repeats that same command:

```
gpib0: ibsic
[0130] (cmpl cic attn)

gpib0: !
[0130] (cmpl cic attn)
```

- (Turn Display Off) and + (Turn Display On)

The `-` function turns off all screen output except for the prompt. This function is useful when you want to repeat any I/O function quickly without waiting for screen output to be displayed.

The `+` function turns the screen output on.

In the following example 24 consecutive letters of the alphabet are read from a device using three `ibrd` calls.

```
ud0: ibrd 8
[2100] (end cmpl)
count: 8
61 62 63 64 65 66 67 68      a b c d e f g h

ud0: -
ud0: ibrd 8
```

```
ud0: +
ud0: ibrd 8
[2100] (end cmp1)
count: 8
71 72 73 74 75 76 77 78      q r s t u v w x
```

n* (Repeat Function n Times)

The `n*` function repeats the execution of the specified function `n` times, where `n` is an integer. In the following example, the message `Hello` is sent five times to the device described by `ud0`.

```
ud0: 5*ibwrt "Hello"
```

In the following example, the word `Hello` is sent 5 times, 20 times, and then 10 more times.

```
ud0: 5*ibwrt "Hello"
ud0: 20* !
ud0: 10* !
```

Notice that the multiplier (`*`) does not become part of the function name; that is, `ibwrt "Hello"` is repeated 20 times, not `5* ibwrt "Hello"`.

\$ (Execute Indirect File)

The `$` function reads a specified file and executes the `ibic` functions listed in that file, in sequence, as if they were entered in that order from the keyboard. The following example executes the `ibic` functions listed in the file `userfile`.

```
gpib0: $ userfile
```

The following example repeats the operation three times.

```
gpib0: 3*$ userfile
```

The display mode that is in effect before this function was executed can be changed by functions in the indirect file.

Print (Display the ASCII String)

You can use the `print` function to echo a string to the screen. The following example shows how you can use ASCII or hex with the `print` command.

```
dev1: print "hello"
hello

dev1: print "and\r\n\x67\x6f\x6f\x64\x62\x79\x65"
and
goodbye
```

You can also use `print` to display comments from indirect files. The print string appears even if the display is suppressed with the `-` function.

Chapter 6

GPIB Programming Techniques

This chapter describes techniques for using some NI-488 functions and NI-488.2 routines in your application program.

For more detailed information about each function or routine, refer to the *NI-488.2 Function Reference Manual for Windows NT*.

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, the NI-488.2M driver asserts EOI 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 NI-488.2M driver asserts the GPIB EOI line 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 NI-488.2M driver automatically asserts the GPIB EOI line 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, the NI-488.2M driver terminates `ibrd`, `ibrda`, and `ibrdf` calls when the EOS byte is detected on the GPIB or 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 inform you whether or not 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, the NI-488.2M driver reports END 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. To determine whether your GPIB interface board has the TNT4882C hardware, use the `GPIBInfo` utility. If you attempt to enable HS488 on a GPIB board that does not have the TNT4882C hardware, the error ECAP is returned.

Enabling HS488

To enable HS488 for your GPIB board, 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 board 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-488.2M software automatically sends the HS488 configuration message to devices. If you enabled the HS488 protocol in `wibconf`, the NI-488.2M 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-488.2M software sends out the HS488 message again the next time you call a device-level function.

If you are using board-level functions or NI-488.2 routines 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 meters, only CFGn values of 1 through 15 (hex 61 through 6F) are valid. If the cable length was configured properly in `wibconf`, you can determine how many meters of cable are in your system by calling `ibask` (option `IbaHSCableLength`) in your application program. For CFE and CFGn messages, refer to Appendix A, *Multiline Interface Messages*, in the *NI-488.2M Function Reference Manual for Windows NT*.

System Configuration Effects on HS488

Maximum data transfer rates can be limited by your host computer and GPIB system setup. For example, even though the theoretical maximum transfer rate with HS488 is 8 Mbytes/s, the maximum transfer rate obtainable on PC -compatible computers with an ISA bus is 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 three HS488 devices connected by four meters 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, then pass a wait mask to the function. The wait mask should always include the TIM0 event; otherwise, your application is suspended indefinitely until one of the wait mask events occurs.

Device-Level Calls and Bus Management

The NI-488 device-level calls are designed to perform all of the GPIB management for your application program. However, the NI-488.2M driver can handle bus management only when the GPIB interface board 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 board the CIC:

- If your GPIB board 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 board 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 `ibconf` configuration utility to activate the CIC protocol. If the interface board is not CIC,

and you make a device-level call with the CIC Protocol enabled, the following sequence occurs:

1. The GPIB interface board asserts the SRQ line.
2. The current CIC serial polls the board.
3. The interface board returns a response byte of hex 42.
4. The current CIC passes control to the GPIB board.

If the current CIC does not pass control, the NI-488.2M 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 board. 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-488.2M software in most non-Controller situations. These situations are known as Talker/Listener applications because the interface board is not the GPIB Controller. A typical Talker/Listener application waits for events from the Controller and responds as appropriate. The following paragraphs describe some programming techniques for Talker/Listener applications.

Waiting for Messages from the Controller

A Talker/Listener application typically uses `ibwait` with a mask of 0 to monitor the status of the interface board. 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 board. 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.

Using the Event Queue

Some applications need to know the order in which certain messages are sent by the Controller. To monitor the ordering of these messages, your application program must enable the EVENT bit, using `ibconfig` (option `IbcEventQueue`). When the

EVENT bit is enabled, the DCAS and DTAS bits are no longer activated. Instead, all DCAS and DTAS messages are stored in a queue, in the order that they are received. The event queue also stores interface clear (IFC) messages. When the queue contains some information, the NI-488.2 software sets the EVENT bit in `ibsta`. When the application program detects EVENT, it can call the function `ibevent` to retrieve the first event that occurred. Retrieving events from the queue ensures that the application can respond to device clear, device trigger, and interface clear messages in the correct order.

Requesting Service

Another type of event that might be important in a Talker/Listener application is the serial poll. A Talker/Listener application can call `ibrsv` with a serial poll response byte when it needs to request service from the Controller. If the application needs to know when the Controller has read the serial poll response byte, it can enable the SPOLL bit in `ibsta` using `ibconfig`, option `IbcSPollBit`. The NI-488.2 software sets the SPOLL bit when the Controller serial polls the board.

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 you can 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 any time the SRQ line is asserted. The autopolling procedure occurs as follows:

1. To enable autopolling, use the configuration utility, `ibconf`, or the configuration function, `ibconfig` with option `IbcAUTOPOLL`. (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 whatever response is received. You should 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, you should continue to call `ibrsp` until RQS is cleared.

Stuck SRQ State

If autopolling is enabled and the GPIB interface board detects an SRQ, the driver serial polls all open devices connected to that board. 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-488.2M software can perform autopolling after any device-level NI-488 call as long as 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-488.2M software. Autopolling can also occur when a device-level `ibwait` for RQS is in progress. Autopolling is not allowed whenever an application calls a board-level NI-488 function or any NI-488.2 routine, or the *stuck SRQ* (ESRQ) condition occurs.

Note: *The NI-488.2M software for Windows NT does not function properly if interrupts are disabled.*

SRQ and Serial Polling with NI-488 Device Functions

You can use the device-level NI-488 function `ibrsp` to conduct a serial poll. `ibrsp` conducts a single serial poll and returns the serial poll response byte to the application program. If automatic serial polling is enabled, the application program 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 illustrates the use of the `ibwait` and `ibrsp` functions in a typical SRQ servicing situation when automatic serial polling is enabled.

```
#include "decl.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 NI-488.2 Routines

The NI-488.2M software includes a set of NI-488.2 routines that you can use to conduct SRQ servicing and serial polling. Routines pertinent to SRQ servicing and serial polling are `AllSpoll`, `FindRQS`, `ReadStatusByte`, `TestSRQ`, and `WaitSRQ`.

`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 analogous to the device-level NI-488 `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 routine returns the index and status byte value of the device requesting service.

`TestSRQ` determines whether the SRQ line is asserted or unasserted, and returns to the program immediately.

`WaitSRQ` is similar to `TestSRQ`, except that `WaitSRQ` suspends the application program until either SRQ is asserted or the timeout period is exceeded.

The following examples use NI-488.2 routines 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.

Note: *Automatic serial polling is not used in these examples because you cannot use it with NI-488.2 routines.*

Example 1: Using FindRQS

This example illustrates the use of 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 illustrates the use of 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 NI-488 functions or NI-488.2 routines. If you use NI-488.2 routines to execute parallel polls, you do not need extensive knowledge of the parallel polling messages. However, you should use the NI-488 functions for parallel polling when the GPIB board is not the Controller and must configure itself for a parallel poll and set its own individual status bit (`ist`).

Parallel Polling with NI-488 Functions

Follow these steps to implement parallel polling using NI-488 functions. 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 or not the function configures or unconfigures 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` = 1, and 0 if the device is to assert the assigned data line when `ist` = 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 NI-488 functions. The device asserts DIO7 if its `ist` = 0.

In this example, the `ibdev` command is used to open 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.h"
char ppr;

dev = ibdev(0,3,0,T3s,1,0);

ibppc(dev, 0x66);
```

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

In the following example, the GPIB board is to configure itself to participate in a parallel poll. It asserts DIO5 when `ist` = 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 NI-488.2 Routines

Follow these steps to implement parallel polling using NI-488.2 routines. Each step contains example code.

1. Configure the device for parallel polling using the `PPollConfig` routine, 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.h"
char response;
Addr4882_t AddressList[2];

/* The following command clears the GPIB. */
SendIFC(0);

/* The value of sense is compared with the 1st 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* = 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 1st bit of the
device at that time is equal to 1. If it does not appear,
the 1st bit is equal to 0. Check the bit in the following
statement. */

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

3. Unconfigure the device for parallel polling using the PPollUnconfig routine 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);
```

Chapter 7

ibconf—Interface Bus Configuration Utility

This chapter contains a description of `ibconf`, the NI-488.2M software configuration utility you can use to configure your software.

Overview

The `ibconf` utility is a Windows Control Panel application program you can use to view or modify the configuration of your GPIB interface boards. You can use it to view or modify the GPIB device templates, which provide compatibility with older applications.

In most cases, you should use `ibconf` only to change the hardware configuration of your GPIB interface boards. To change the GPIB characteristics of your boards and the configuration of the device templates, use the `ibconfig` function in your application program. If your application program uses `ibconfig` whenever it needs to modify a configuration option, it is able to run on any computer with the appropriate NI-488.2M software, regardless of the configuration of that computer.

Because you can use `ibconf` to modify the configuration of the NI-488.2M kernel drivers, you must be logged on to Windows NT as the Administrator to make any changes with `ibconf`. If you start `ibconf` without Administrator privileges, it runs in read-only mode; you can view the settings, but you cannot make changes.

Starting and Exiting ibconf

When you install the NI-488.2M software for Windows NT, the installation program places `ibconf` into your Control Panel. To start `ibconf` simply open your



Windows NT Control Panel and select the icon. The main **GPIB Configuration** dialog box appears containing a list of the GPIB boards and device templates as shown in Figure 7-1.

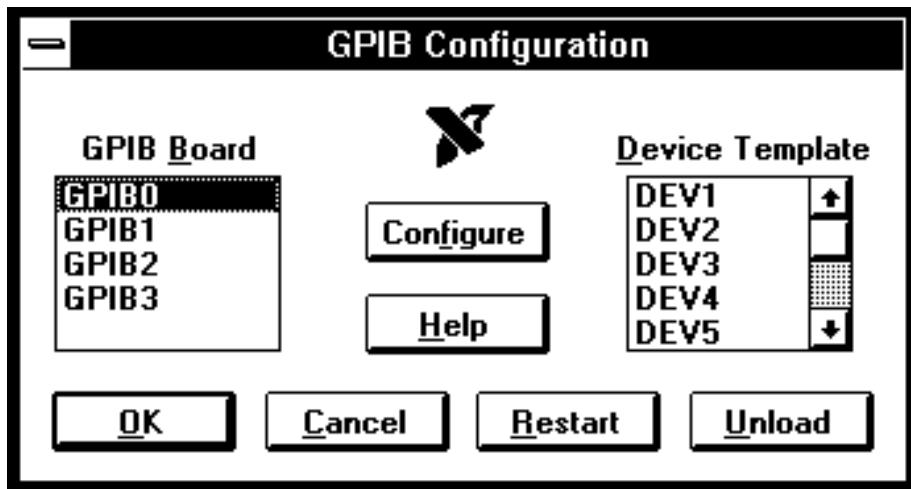


Figure 7-1. Main Dialog Box in ibconf

If at any point you need more help, click on the **Help** button or press the <F1> key. Either of these actions brings up the help screen, which gives you more information about the current dialog box.

After you have finished configuring your GPIB boards and device templates, click on the **OK** button to save the changes and exit. Click the **Cancel** button to exit without saving any of the changes you made. To save your changes and force the new settings to take effect immediately, click on the **Restart** button. *ibconf* attempts to unload and reload the NI-488.2M software so that the software uses your new settings. If *ibconf* cannot unload the software because it is being used by another application, it instructs you either to exit all GPIB-related applications and click **Restart** again, or to shut down and restart your computer.

If you need to unload the NI-488.2M software and prevent it from reloading when you restart your computer, click the **Unload** button. If *ibconf* cannot unload the NI-488.2M software, it instructs you either to exit all GPIB-related applications, or to shut down and restart your computer. If you want to use the software again after unloading it, click on the **Restart** button.

Board Configuration

Your modifications will usually be to the GPIB board configurations. To view or modify the configuration of one of your GPIB boards, select the board name in the main **GPIB Configuration** dialog box and click on the **Configure** button. You could also double-click on the board name. The board configuration dialog box appears.

The board configuration dialog box contains hardware specific information for your particular GPIB interface board. Boards like the AT-GPIB require several pieces of information to be entered into `ibconf`, while other boards such as the MC-GPIB do not. With the MC-GPIB, you must use the Micro Channel configuration program that came with your computer to modify many of the hardware settings for your board. Figure 7-2 shows the board configuration dialog box for the AT-GPIB board.

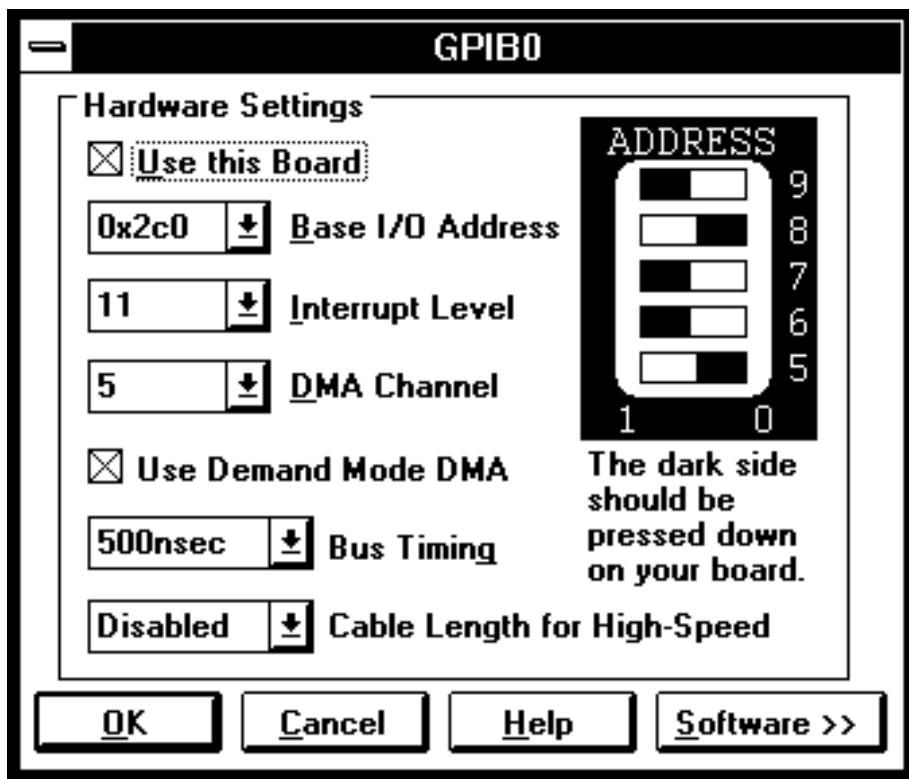


Figure 7-2. Board Configuration for an AT-GPIB Interface Board

The following configuration items appear on the board configuration dialog box for all interface boards.

Use this Board Use this item to disable an interface board. If this item is not selected, the NI-488.2M software ignores the board. By default, `gpib0` is enabled and `gpib1`, `gpib2`, and `gpib3` are disabled.

Bus Timing	Use this item to specify the source handshake T1 delay of the board. This delay determines the minimum amount of time, after the data is placed on the bus, that the board asserts the GPIB DAV line during a write or command operation. Refer to the ANSI/IEEE Standard 488.1-1987, Section 5.2 for more information about the factors that might affect the choice of the T1 delay. For example, if the total length of the GPIB cable in the system is less than 15 meters, then the value 350 ns is appropriate. The default for this item, 500 ns, should work in all systems.
Cable Length for High Speed	This field specifies the number of meters of GPIB cable you have in your system. If you use the HS488 high-speed protocol to communicate with HS488-compliant devices, you must specify the total number of meters of GPIB cable in your system. The System Controller, when it initializes the GPIB, must send this information to all HS488 devices so high-speed transfers occur without errors.
OK	Use this button to keep the configuration as shown and return to the main dialog box.
Cancel	Use this button to discard any configuration changes made to the board and return to the main dialog box.
Help	Use this button or the <F1> key to bring up help for this dialog box.
Software	Use this button to expand the board configuration dialog box. You can then view or modify the GPIB characteristics of the board which you would normally configure in your application program using the <code>ibconfig</code> function.

The following configuration items appear only for certain GPIB interface boards such as the AT-GPIB. Other boards such as the MC-GPIB are configured automatically.

Base I/O Address	Use this item to select the I/O address of the interface board. It must be set to the same value as the base I/O address selected with the switches on the board. For more information about setting the base I/O address of your board, refer to the getting started manual that came with your GPIB interface board.
	To assist you in configuring the interface board properly, <code>ibconf</code> shows a picture of the base I/O address switch of the board. You should confirm that the switch settings on your interface board match the picture in <code>ibconf</code> . The switch picture in <code>ibconf</code> is also an interactive control. You can use your mouse to change the position of the switches in the picture. When you change the position of the switches, <code>ibconf</code> updates the number displayed in the Base I/O Address field. Set the switch in <code>ibconf</code> to look like the switch on your board.

Interrupt Level	Use this item to select the hardware interrupt level used by your interface board. It must be set to the same value as interrupt level selected with the jumpers on the board. For more information about setting the interrupt level of your board, refer to the getting started manual that came with your GPIB interface board.
DMA Channel	Use this item to select the hardware DMA channel used by your interface board. It must be set to the same value as DMA channel selected with the jumpers on the board. For more information about setting the DMA channel of your board, refer to the getting started manual that came with your GPIB interface board.
Use Demand Mode DMA	Use this item to select the DMA transfer mode that the NI-488.2M software uses. When this item is selected, the NI-488.2M software uses demand mode for DMA transfers. When this item is unselected, the NI-488.2M software uses single cycle DMA. Almost all PC-compatible computers can use demand mode, which is the fastest DMA mode. But some newer computers cannot use demand mode. Before changing this item, you should use the <code>ibdiag</code> utility which tests the DMA controller in your computer and alerts you if demand mode cannot be used.

Expanded Board Configuration

If you need to modify the GPIB characteristics of an interface board, click on the **Software** button of the board configuration dialog box. The expanded dialog box appears, containing all of the GPIB characteristics of the board as shown in Figure 7-3.

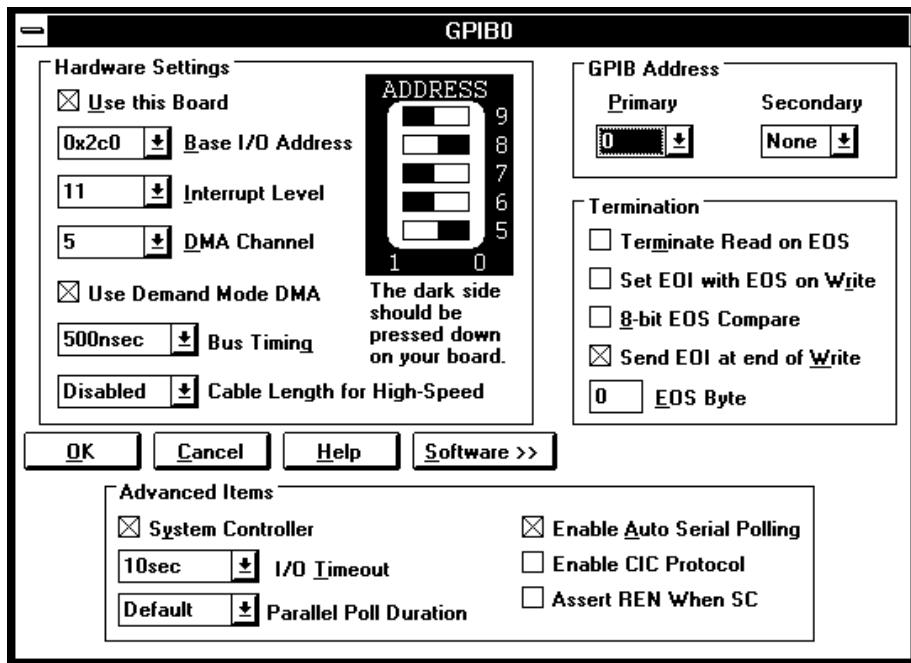


Figure 7-3. Expanded Board Configuration for an AT-GPIB board

If possible, you should change these characteristics within your application program using the `ibconfig` function. But if you are using an older application that requires changes to the GPIB characteristics before it can run, you might need to make the changes in `ibconf`. The following configuration items appear in the expanded dialog box.

GPIB Primary Address All GPIB boards must be assigned a unique primary address. This address, a number in the range 0 to 30 decimal, is used by the NI-488.2M software to compute the talk and listen addresses of the board. The default primary address of all interface boards is zero.

GPIB Secondary Address If extended addressing is needed, the GPIB board should be assigned a unique secondary address. This number must be in the range 96 to 126 decimal. If extended addressing is not required, select **None**.

Terminate Read On EOS Some devices send an end-of-string byte to signal the end of a GPIB data transfer. When this field is selected, the NI-488.2M software terminates a read operation when it receives the EOS byte. By default this option is not selected.

Set EOI with EOS on Write	Some devices expect the GPIB EOI line to be asserted when the EOS byte is transferred. When this field is selected, the NI-488.2M software asserts the GPIB EOI line whenever it sends the EOS byte. By default this option is not selected.
8-bit EOS Compare	When the GPIB board is configured to use the EOS byte, it can test either seven or eight bits of the EOS byte for a match. When this item is selected, the NI-488.2M software uses all eight bits of the EOS byte when checking for a match. By default this option is not selected.
Send EOI at end of Write	Many GPIB devices require the GPIB EOI line to be asserted at the end of a data transfer. This signals the device that the transfer has ended. When this item is selected, the NI-488.2M software will assert the EOI line at the end of each data transfer. By default this option is selected.
EOS Byte	If one or more of the EOS modes are enabled, this value defines the EOS byte. Use a decimal number in the range 0 to 255. The value is used by the NI-488.2M software for all selected EOS operations.
System Controller	The System Controller in a GPIB system is the device that maintains ultimate control over the bus. When the NI-488.2M software is being used to control a GPIB system, the GPIB interface board should normally be the System Controller. Some situations, such as a network of computers, require that the interface board <i>not</i> be the System Controller. By default this option is selected.
I/O Timeout	Use this option to select the timeout value for all GPIB I/O operations. The timeout value is the approximate length of time that GPIB functions wait for data to be transferred or commands to be sent. It is also the length of time that the <code>ibwait</code> function waits for an event before returning. The default timeout period is 10 s.
Parallel Poll Duration	Use this option to select the length of time the NI-488.2M software waits when conducting a parallel poll. For a normal bus configuration (the Controller and devices on the same bus) use the default duration of 2 μ s. If you are using a GPIB bus extender in transparent parallel poll mode, you should increase the poll duration to 10 μ s or more so the bus extender can operate transparently to your applications.
Enable Auto Serial Polling	Use this option to enable or disable the automatic serial polling of devices when the GPIB Service Request (SRQ) line is asserted. Positive poll responses are stored by the NI-488.2M software and can be retrieved with the <code>ibrss</code> function. This feature usually does not conflict with any device that conforms to the IEEE 488.1 standard. If a conflict exists with a device, do not select this option. By default this option is selected.

Enable CIC Protocol If a device-level NI-488 call is made after control has been passed to another device, this protocol causes the interface board to assert SRQ with a serial poll response byte of hex 42 to regain control. If the current Controller recognizes this request and passes control back to the board, the device-level call is executed as usual. If control is not passed back within the timeout period, the ECIC error is returned. If your board needs to regain control, but this protocol is disabled, ECIC is returned immediately. By default this option is not selected.

Assert REN When SC When this option is selected and the interface board is the System Controller, the GPIB Remote Enable (REN) line is automatically asserted any time a device-level call is made. By default this option is not selected.

Device Template Configuration

To view or modify the configuration of a GPIB device, select the device name in the main GPIB Configuration dialog box and click on the **Configure** button. You can also double-click on the device name. The device template dialog box appears as shown in Figure 7-4.

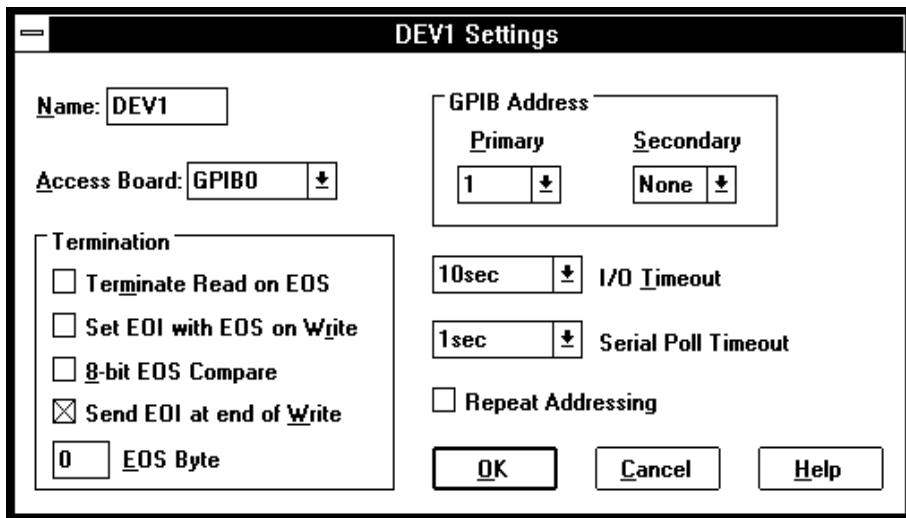


Figure 7-4. Device Template Configuration

Use the device templates if you have an older application that uses the `ibfind` function to find a given device by name (for example, `ibfind ("dev1")`) instead of using the preferred function `ibdev`. In some cases, you might need to change the actual name of the device template.

The device template options are similar to those of the expanded board configuration. If possible, use the `ibconfig` function to change the device characteristics in your application program.

The following is a list of the device template configuration options.

Name	This field contains the symbolic name of the device to which this template refers. This is the name that should be used in the <code>ibfind</code> call of the application. This name must be eight characters or less and cannot contain any of the following characters: . " / \ [] : < > + = ; ,
	You cannot name a device to the same name as an interface board (<code>gpib0</code> , <code>gpib1</code> , and so on).
Access Board	Use this option to select which interface board is used to communicate with that particular device. This option contains a list of interface boards to choose from.
GPIB Primary Address	All GPIB devices must be assigned a unique primary address. This address, a number in the range 0 to 30 decimal, is used by the NI-488.2M software to compute the talk and listen addresses of the device.
GPIB Secondary Address	If extended addressing is needed, the device should be assigned a unique secondary address. This number must be in the range 96 to 126 decimal. If extended addressing is not required, select None .
Terminate Read On EOS	Some devices send an end-of-string byte to signal the end of a GPIB data transfer. When this field is selected, the NI-488.2M software terminates a read operation when it receives the EOS byte. By default this option is not selected.
Set EOI with EOS on Write	Some devices expect the GPIB EOI line to be asserted when the EOS byte is transferred. When this field is selected, the NI-488.2M software asserts the GPIB EOI line whenever it sends the EOS byte. By default this option is not selected.
8-bit EOS Compare	When the NI-488.2M software is configured to use the EOS byte, it can test either seven or eight bits of the EOS byte for a match. When this item is selected, the NI-488.2M software uses all eight bits of the EOS byte when checking for a match. By default this option is not selected.
Send EOI at end of Write	Many GPIB devices require the GPIB EOI line to be asserted at the end of a data transfer. This signals the device that the transfer has ended. When this item is selected, the NI-488.2M software asserts the EOI line at the end of each data transfer. By default this option is selected.

EOS Byte	If one or more of the EOS modes are enabled, this value defines the EOS byte. Use a decimal number in the range 0 to 255. The value is used by the NI-488.2M software for all selected EOS operations.
I/O Timeout	Use this option to select the timeout value for all GPIB I/O operations. The timeout value is the approximate length of time that GPIB functions wait for data to be transferred or commands to be sent. It is also the length of time that the <code>ibwait</code> function waits for an event before returning. The default timeout period is 10 s.
Serial Poll Timeout	Use this option to select the length of time the NI-488.2M software waits for a serial poll response from the device. The IEEE 488 standard does not specify the length of time a Controller should wait for the response byte. The default value of 1 s works for most devices. If you have problems with serial polls, try using a longer timeout value.
Repeat Addressing	If this option is selected, the NI-488.2M software addresses the device before every read or write operation. Devices are usually not addressed each time a read or write operation is performed, but some older IEEE 488.1 devices require their address to be sent before each operation. By default this option is not selected.

Appendix A

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 Chapter 3, *Developing Your Application*.

If a function call returns an ENEB or EDVR error, all status word bits except the ERR bit are cleared, indicating that it is not possible to obtain the status of the GPIB board.

Each bit in `ibsta` can be set for device calls (dev), board calls (brd), or both (dev, brd).

The following table shows the status word layout.

Table A-1. Status Word Bits

Mnemonic	Bit Pos.	Hex Value	Type	Description
ERR	15	8000	dev, brd	GPIB 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
SPOLL	10	400	brd	Board has been serial polled by the Controller
EVENT	9	200	brd	A DCAC, DTAS, or IFC event has occurred
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 B, *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 been exceeded. TIMO is set in the status word following an `ibwait` call if the TIMO bit of the `ibwait` mask parameter is set and the time limit expires. TIMO is also set following any synchronous I/O functions (for example, `ibcmd`, `ibrd`, `ibwrt`, `Receive`, `Send`, and `SendCmds`) if a timeout occurs during one of these calls. 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 board 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 board is CIC, the GPIB SRQ line is asserted, and the automatic serial poll capability is disabled. SRQI is cleared either when the GPIB board 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 bit 6 is asserted in the serial poll status byte of the device. The serial poll that obtains the status byte can be the result of a call to `ibrsp`, or the poll might be automatic if automatic serial polling is enabled. Do not issue an `ibwait` on RQS for a device that does not respond to serial polls. RQS is cleared when an `ibrsp` reads the serial poll status byte that caused the RQS.

SPOLL (brd)

Use SPOLL in Talker/Listener applications to determine when the Controller has serial polled the GPIB board. The SPOLL bit is disabled by default. Use the `ibconfig` function (option `IbcSPoll1Bit`) to enable it. When this bit is enabled, it is set after the board has been serial polled. SPOLL is cleared on any call immediately after an `ibwait` call, if the SPOLL bit was set in the wait mask, or immediately following a call to `ibrsv`.

EVENT (brd)

Use EVENT in Talker/Listener applications (applications in which the GPIB interface is not the Controller) to monitor the order of GPIB device clear, group execute trigger, and send interface clear commands. The usual DCAS and DTAS bits of `ibsta` might be insufficient.

The EVENT bit is disabled by default. If you want to use this bit, you must use the `ibconfig` function (option `IbcEventQueue`) to enable it. When you enable this bit, the DCAS and DTAS bits are disabled. When an event occurs, this bit is set and any I/O in progress is aborted. The application can then call the `ibevevt` function to determine which event occurred.

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

REM (brd)

REM indicates whether or not the board is in the remote state. REM is set whenever the Remote Enable (REN) GPIB line is asserted and the GPIB board detects that its listen address has been sent either by the GPIB board or by another Controller. REM is cleared in the following situations:

- When REN becomes unasserted
- When the GPIB board as a Listener detects that the Go to Local (GTL) command has been sent either by the GPIB board 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 board is the Controller-In-Charge. CIC is set when the `SendIFC` routine or `ibsic` function is executed either while the GPIB board is System Controller or when another Controller passes control to the GPIB board. CIC is cleared either when the GPIB board detects Interface Clear (IFC) from the System Controller or when the GPIB board 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 board is addressed as a Talker. TACS is set whenever the GPIB board detects that its talk address (and secondary address, if enabled) has been sent either by the GPIB board itself or by another Controller. TACS is cleared whenever the GPIB board 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 board is addressed as a Listener. LACS is set whenever the GPIB board detects that its listen address (and secondary address, if enabled) has been sent either by the GPIB board itself or by another Controller. LACS is also set whenever the GPIB board shadow handshakes as a result of the `ibgts` function. LACS is cleared whenever the GPIB board 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 board has detected a device trigger command. DTAS is set whenever the GPIB board, 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 board has detected a device clear command. DCAS is set whenever the GPIB board detects that the Device Clear (DCL) command has been sent by another Controller, or whenever the GPIB board as a Listener detects that the Selected Device Clear (SDC) command has been sent by another Controller. DCAS is cleared on any call immediately following an `ibwait` call, if the DCAS bit was set in the `ibwait` mask parameter. It also clears on any call immediately following a read or write.

Appendix B

Error Codes and Solutions

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

The following table lists the GPIB error codes.

Table B-1. GPIB Error Codes

Error Mnemonic	iberr Value	Meaning
EDVR	0	System error
ECIC	1	Function requires GPIB board to be CIC
ENOL	2	No Listeners on the GPIB
EADR	3	GPIB board not addressed correctly
EARG	4	Invalid argument to function call
ESAC	5	GPIB board not System Controller as required
EABO	6	I/O operation aborted (timeout)
ENEB	7	Nonexistent GPIB board
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 board or device name passed to `ibfind`, or the board index passed to `ibdev`, cannot be accessed. The global variable `ibcntl` contains the system error code 2, *File Not Found*. This error occurs when you try to access a board or device that is not installed or configured properly.

EDVR is also returned if an invalid unit descriptor is passed to any NI-488 function call.

Solutions

- Use `ibdev` to open a device without specifying its symbolic name.
- Use only device or board names that are configured in the utility program `ibconf` as parameters to the `ibfind` function.
- Using `ibconf`, ensure that each board you want to access is configured properly, that base address, DMA channel, and interrupt level are correct, and that the `Use This Board` field is selected.
- If the NI-488.2M driver is installed and configured, but you continue to receive the error EDVR, use the Windows NT Event Viewer to find a solution. The driver maintains a log of errors in this utility and posts possible corrections to any problems that occur while loading. Refer to Chapter 4, *Debugging Your Application*, for more information.
- Use the unit descriptor returned from `ibdev` or `ibfind` as the first parameter in subsequent NI-488 functions. Examine the variable before the failing function to make sure the function has not been corrupted.

ECIC (1)

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

- Any device-level NI-488 functions that affect the GPIB
- Any board-level NI-488 functions that issue GPIB command bytes: `ibcmd`, `ibcmda`, `ibln`, and `ibrpp`
- `ibcac` and `ibgts`
- Any of the NI-488.2 routines that issue GPIB command bytes: `SendCmds`, `PPoll`, `Send`, and `Receive`

Solutions

- Use `ibsic` or `SendIFC` to make the GPIB board become CIC on the GPIB.
- Use `ibrsc1` to make sure your GPIB board 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 board.

ENOL (2)

ENOL usually occurs when a write operation is attempted with no Listeners addressed. For a device write, this error 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 in which the GPIB board is not the CIC and the Controller asserts ATN before the write call in progress has ended.

Solutions

- 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.
- Reduce the write byte count to that which is expected by the Controller.

EADR (3)

EADR occurs when the GPIB board 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

- Make sure that the GPIB board 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 NI-488 call made with a valid device descriptor, or a device-level NI-488 call made with a board descriptor.
- An NI-488.2 routine called with an invalid address.
- `PPollConfig` called with an invalid data line or sense bit.

Solutions

- Make sure that the parameters passed to the NI-488 function or NI-488.2 routine 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 board does not have System Controller capability.

Solutions

Give the GPIB board System Controller capability by calling `ibrsc1` or by using `ibconf` 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

- 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 `ibtm0`.
- Make sure that you have configured your device to send data before you request data.

ENEB (7)

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

Solutions

Make sure there is a GPIB board in your computer that is properly configured both in hardware and software using a valid base I/O address.

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`, `ibwait`, and `ibonl` or perform other non-GPIB operations. If any other call is attempted, EOIP is returned.

Once the asynchronous I/O has begun, further GPIB calls other than `ibstop`, `ibwait`, or `ibonl` are strictly limited. If a call might interfere with the I/O operation in progress, the driver returns EOIP.

Solutions

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

- **ibwait** If the returned `ibsta` contains CMPL then 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 board 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 board 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 Windows NT error code for this condition is contained in `ibcnt`.

Solutions

- 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 `ibtm0` function. EBUS results if a timeout occurred while sending these command bytes.

Solutions

- 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

- Call `ibrsp` more frequently to empty the queue.
- Disable autopolling with the `ibconfig` function or the `ibconf` utility.

ESRQ (16)

ESRQ occurs only during the `ibwait` function or the `WaitSRQ` routine. 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 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`, `FindRQS`, and `ibeevent` 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.
- In the case of `ibeevent`, ETAB means the event queue overflowed and event information was lost.

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. In the case of ETAB returned from `ibeevent`, call `ibeevent` more often to empty the queue.

Appendix C

Customer Communication

For your convenience, this appendix contains forms to help you gather the information necessary to help us solve technical problems you might have as well as a form you can use to comment on the product documentation. Filling out a copy of the *Technical Support Form* before contacting National Instruments helps us help you better and faster.

National Instruments provides comprehensive technical assistance around the world. In the U.S. and Canada, applications engineers are available Monday through Friday from 8:00 a.m. to 6:00 p.m. (central time). In other countries, contact the nearest branch office. You may fax questions to us at any time.

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Glossary

Prefix	Meaning	Value
n-	nano-	10^{-9}
μ -	micro-	10^{-6}
m-	milli-	10^{-3}
k-	kilo-	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 <i>source handshake</i> and <i>handshake</i> .
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.
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 (autopolling)	A feature of the NI-488.2M software in which serial polls are executed automatically by the driver whenever a device asserts the GPIB SRQ line.

B

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

Glossary

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 that 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 <i>handshake</i> .
DCL (Device Clear)	The GPIB command used to reset the device or internal functions of all devices. See <i>SDC</i> .
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 <i>programmed I/O</i> .
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 is used to signal 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 is part of the IEEE 488.2-defined status byte which is received from a device responding to a serial poll.

G

GET (Group Execute Trigger)	Group Execute Trigger is 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 488.2-1987.
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 interface boards.
GTL (Go To Local)	Go To Local is 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. The three GPIB lines DAV, NRFD, and NDAC 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.
-----------	--

Glossary

hex Hexadecimal; a number represented in base 16. For example, decimal 16 = hex 10.

high-level function See *device-level function*.

Hz Hertz.

I

ibcnt After each NI-488 I/O function, this global variable contains the actual number of bytes transmitted.

ibconf The NI-488.2M driver configuration program.

iberr A global variable that contains the specific error code associated with a function call that failed.

ibic The Interface Bus Interactive Control program is used to communicate with GPIB devices, troubleshoot problems, and develop your application.

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 the context of this manual, the transmission of commands or messages between the computer 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.

ist An Individual Status bit of the status byte used in the Parallel Poll Configure function.

K

KB Kilobytes.

L

LAD (listen address)	See <i>MLA</i> .
language interface	Code that enables an application program that uses NI-488 functions or NI-488.2 routines 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.
MB	Megabytes of memory.
memory-resident	Resident in RAM.
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.

Glossary

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*.

PIO See *programmed I/O*.

PPC
(Parallel Poll Configure) Parallel Poll Configure is the GPIB command used to configure an addressed Listener to participate in polls.

PPD
(Parallel Poll Disable) Parallel Poll Disable is the GPIB command used to disable a configured device from participating in polls. There are 16 PPD commands.

PPE
(Parallel Poll Enable) Parallel Poll Enable is 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) Parallel Poll Unconfigure is the GPIB command used to disable any device from participating in polls.

programmed I/O Low-speed data transfer between the GPIB board and memory in which the CPU moves each data byte according to program instructions. See *DMA*.

R

RAM Random-access memory.

resynchronize The NI-488.2M 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 <i>DCL</i> .
serial poll	The process of polling and reading the status byte of one device at a time. See <i>parallel poll</i> .
service request	See <i>SRQ</i> .
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 <i>acceptor handshake</i> and <i>handshake</i> .
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 <i>SPD</i> .
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 <i>ibsta</i> .
synchronous	Refers to the relationship between the NI-488.2M 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.

Glossary

T

TAD (Talk Address)	See <i>MTA</i> .
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 NI-488.2M 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 board 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.

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