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GPIB-PCII

Getting Started with Your GPIB-PCII/IA and the NI-488.2™ Software for Windows

November 1994 Edition

Part Number 370906A-01

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This equipment generates and uses radio frequency energy and, if not installed and used in strict accordance with the instructions in this manual, may cause interference to radio and television reception. This equipment has been tested and found to comply with the following two regulatory agencies:

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This device complies with Part 15 of the Federal Communications Commission (FCC) Rules for a Class A digital device. Operation is subject to the following two conditions:

1. This device may not cause harmful interference in commercial environments.
2. This device must accept any interference received, including interference that may cause undesired operation.

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Le présent appareil numérique n'émet pas de bruits radioélectriques dépassant les limites applicables aux appareils numériques de classe A prescrites dans le règlement sur le brouillage radioélectrique édicté par le ministère des communications du Canada.

Instructions to Users

These regulations are designed to provide reasonable protection against harmful interference from the equipment to radio reception in commercial areas. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense.

There is no guarantee that interference will not occur in a particular installation. However, the chances of interference are much less if the equipment is installed and used according to this instruction manual.

If the equipment does cause interference to radio or television reception, which can be determined by turning the equipment on and off, one or more of the following suggestions may reduce or eliminate the problem.

- Operate the equipment and the receiver on different branches of your AC electrical system.

- Move the equipment away from the receiver with which it is interfering.
- Reorient or relocate the receiver's antenna.
- Be sure that the equipment is plugged into a grounded outlet and that the grounding has not been defeated with a cheater plug.

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

If necessary, consult National Instruments or an experienced radio/television technician for additional suggestions. The following booklet prepared by the FCC may also be helpful: *How to Identify and Resolve Radio-TV Interference Problems*. This booklet is available from the U.S. Government Printing Office, Washington, DC 20402, Stock Number 004-000-00345-4.

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Contents

About This Manual	xi
How to Use the Manual Set	xi
Organization of This Manual	xii
Conventions Used in This Manual.....	xii
Related Documentation	xiii
Customer Communication	xiv

Chapter 1

Introduction	1-1
How to Use This Manual	1-1
What You Need to Get Started	1-2
Hardware Description	1-2
Software Description	1-2
Optional Programming Environments	1-3

Chapter 2

Hardware Configuration and Installation	2-1
Default Hardware Configuration	2-1
Install the Hardware	2-2
Configure the Hardware (Optional).....	2-3
GPIB-PC Mode Selection	2-5
Switch and Jumper Settings.....	2-7
7210/9914 Mode Selection	2-8
Selecting the Base I/O Address	2-9
GPIB-PCII Mode	2-9
GPIB-PCIIA Mode	2-11
Possible Conflicts	2-14
Selecting the Interrupt Request Line	2-14
GPIB-PCII Mode	2-14
GPIB-PCIIA Mode	2-15
Possible Conflicts	2-19
Selecting the DMA Channel	2-19
Using Programmed I/O for GPIB Transfers	2-20
Setting the Shield Ground Configuration	2-21

Chapter 3

Software Installation and Configuration	3-1
NI-488.2 Software Components	3-1
Install the Software	3-1
Configure the Software (Optional)	3-2

Chapter 4	
Installation Verification and Troubleshooting	4-1
Run the Hardware Diagnostic Test	4-1
Troubleshooting Hardware Diagnostic Test Error Messages	4-1
Run the Software Diagnostic Test	4-3
Troubleshooting Software Diagnostic Test Error Messages	4-3
Presence Test of Driver	4-3
Presence Test of Board	4-4
GPIB Cables Connected	4-4
Common Questions	4-5
Chapter 5	
Using Your NI-488.2 Software	5-1
Introduction to the Win16 Interactive Control Utility	5-1
General Programming Considerations	5-1
Appendix A	
Hardware Specifications	A-1
Appendix B	
Possible Conflicts	B-1
Possible Base I/O Conflicts	B-1
Possible Interrupt Conflicts	B-3
Appendix C	
Customer Communication	C-1
Glossary	G-1

Figures

Figure 2-1.	Installing the GPIB-PCII/IIA	2-2
Figure 2-2.	GPIB-PCII/IIA Parts Locator Diagram.....	2-4
Figure 2-3.	GPIB-PC Mode Selection Settings	2-6
Figure 2-4.	7210/9914 Mode Selection Settings	2-8
Figure 2-5.	Base I/O Address Switch Settings for GPIB-PCII Mode	2-10
Figure 2-6.	Base I/O Address Switch Settings for GPIB-PCIIA Mode.....	2-12
Figure 2-7.	Interrupt Jumper Setting for IRQ7	2-15
Figure 2-8.	Default Interrupt Jumper Setting for GPIB-PCIIA Mode.....	2-16
Figure 2-9.	Interrupt Jumper Settings for GPIB-PCIIA Mode	2-17
Figure 2-10.	DMA Channel Jumper Setting for DMA Channel 1.....	2-20
Figure 2-11.	Ground Configuration Jumper Settings	2-21
Figure 3-1.	Software Installation Screen	3-2

Tables

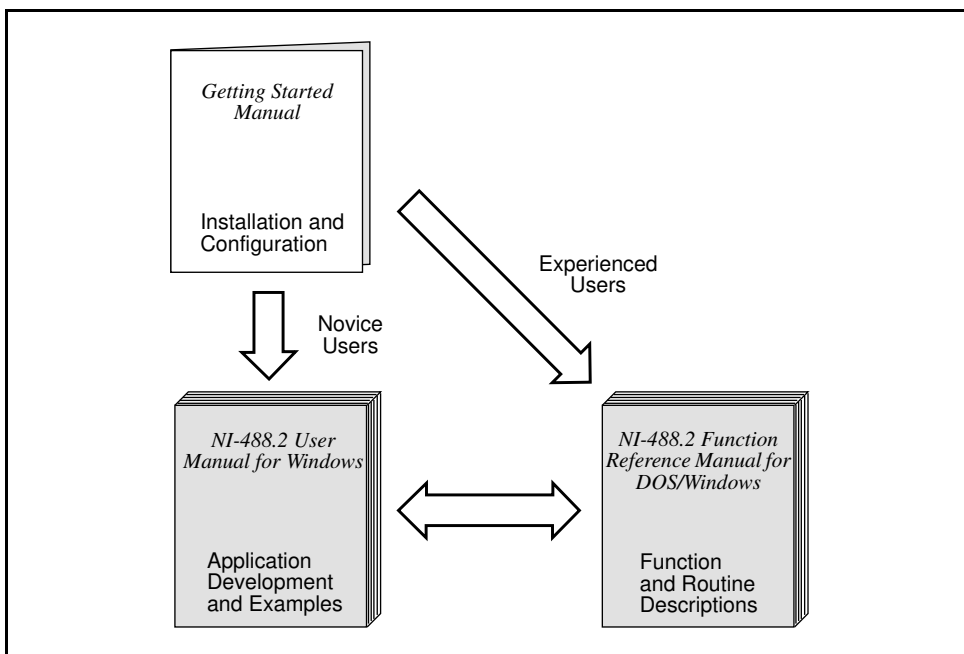
Table 2-1.	Hardware Default Settings	2-1
Table 2-2.	Factory Default Settings and Available Configurations for GPIB-PCII Mode.....	2-7
Table 2-3.	Factory Default Settings and Available Configurations for GPIB-PCIIA Mode	2-7
Table 2-4.	DMA Channels	2-20
Table A-1.	Electrical Characteristics.....	A-1
Table A-2.	Environmental Characteristics	A-1
Table A-3.	Physical Characteristics	A-1
Table B-1.	I/O Addresses Used by Other Devices	B-2
Table B-2.	Interrupt Lines Used by Other Devices.....	B-4

About This Manual

This manual contains instructions for installing and configuring the National Instruments GPIB-PCII/IIA interface board and the NI-488.2 software for Windows. The NI-488.2 software is intended for use with Windows version 3.1 or higher.

This manual assumes that you are already familiar with the Windows operating system.

How to Use the Manual Set



Use this getting started manual to install and configure your GPIB board and the NI-488.2 software for Windows.

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

Use the *NI-488.2 Function Reference Manual for DOS/Windows* 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*, explains how to use this manual, lists what you need to get started, and includes a brief description of the GPIB-PCII/IIA board and the NI-488.2 software.
- Chapter 2, *Hardware Configuration and Installation*, contains instructions for configuring and installing your GPIB-PCII/IIA board.
- Chapter 3, *Software Installation and Configuration*, contains instructions for installing and configuring your NI-488.2 software.
- Chapter 4, *Installation Verification and Troubleshooting*, describes how to verify the hardware and software installation and how to troubleshoot problems.
- Chapter 5, *Using Your NI-488.2 Software*, describes the Win16 Interactive Control utility and lists some programming considerations.
- Appendix A, *Hardware Specifications*, describes the electrical, environmental, and physical characteristics of the GPIB-PCII/IIA board and the recommended operating conditions.
- Appendix B, *Possible Conflicts*, contains tables to help you determine possible address and interrupt conflicts.
- 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 a description of terms used in this manual, including abbreviations, acronyms, metric prefixes, mnemonics, and symbols.

Conventions Used in This Manual

The following conventions are used in this manual.

bold	Bold text denotes menus, menu items, dialog buttons, options, or icon names.
<i>italic</i>	Italic text denotes emphasis, a cross reference, or an introduction to a key concept.
<i>bold italic</i>	Bold italic text denotes a note, caution, or warning.

monospace	Text in this font denotes text or characters that are to be literally input from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, directories, programs, subprograms, subroutines, device names, functions, variables, field names and filenames.
bold monospace	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-Alt-Delete>.
<Enter>	Key names are capitalized.
IEEE 488 and IEEE 488.2	IEEE 488 and IEEE 488.2 refer to the ANSI/IEEE Standard 488.1-1987 and the ANSI/IEEE Standard 488.2-1987, 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 488.2-1987, *IEEE Standard Codes, Formats, Protocols, and Common Commands*
- *IBM Personal Computer Technical Reference Manual*
- *Microsoft Windows User's Guide*, Microsoft Corporation

Customer Communication

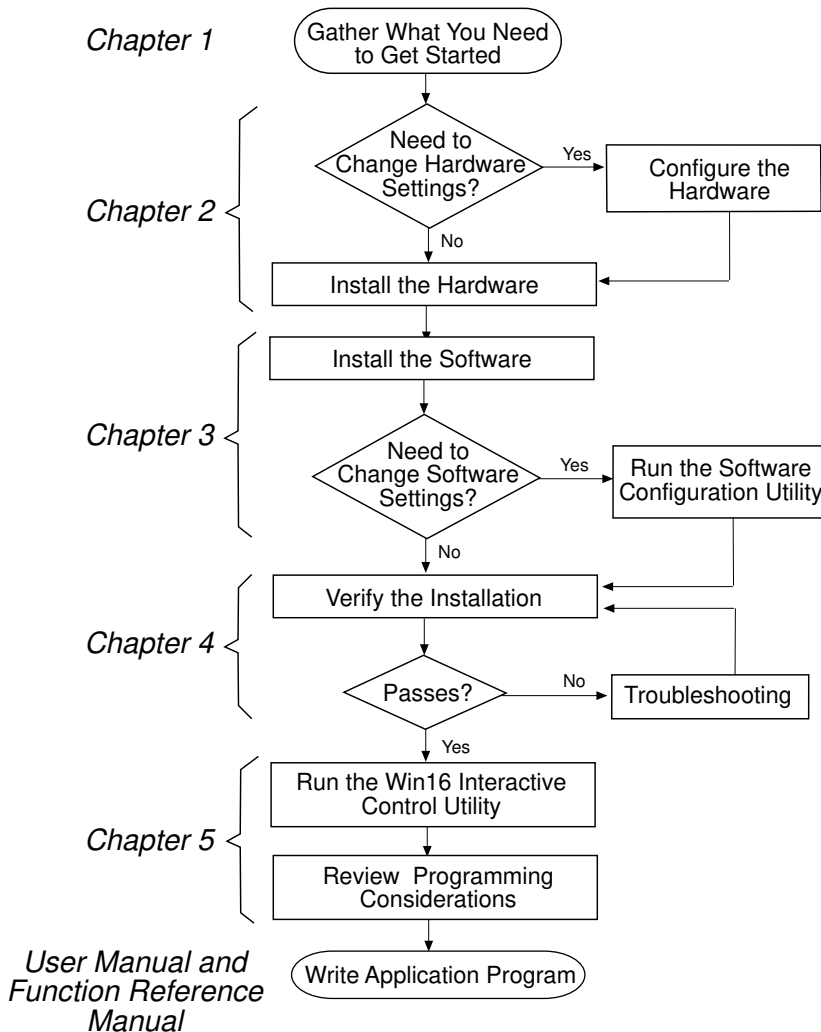
National Instruments wants to receive your comments on our products and manuals. We are interested in the applications you develop with our products, and we want to help if you have problems with them. To make it easy for you to contact us, this manual contains comment and configuration forms for you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

Chapter 1

Introduction

This chapter explains how to use this manual, lists what you need to get started, and includes a brief description of the GPIB-PCII/IIA board and the NI-488.2 software.

How to Use This Manual



What You Need to Get Started

- ❑ GPIB-PCII/IIA board configured for one of the following modes:
GPIB-PCIIA
or
GPIB-PCII
- ❑ *NI-488.2 Software for Windows. Distribution Disk for the GPIB-PCII/IIA*
3.5 in. low density (720 KB), Diskettes 1 and 2
- ❑ Microsoft Windows version 3.1 or higher installed on your computer

Hardware Description

The GPIB-PCII/IIA interface board combines the functionality of the National Instruments GPIB-PCII and GPIB-PCIIA interface boards. It can be configured to function in either GPIB-PCII mode or GPIB-PCIIA mode, depending on the setting of the configuration switches.

GPIB-PCII mode and GPIB-PCIIA mode use different regions of I/O space, and GPIB-PCIIA mode supports shared interrupts. If you already have a board in your computer that uses GPIB-PCII mode or GPIB-PCIIA mode, you should use the GPIB-PCII/IIA in that mode to ensure compatibility between the boards.

The GPIB-PCII/IIA board, equipped with the NAT4882 ASIC, transforms any IBM PC, PC/XT, PC AT, or compatible computer into a full-functioning IEEE 488.2 Talker/Listener/Controller. The NAT4882 controller chip is fully compatible with the IEEE 488.2 standard.

You can use standard GPIB cables to connect the GPIB-PCII/IIA with up to 14 instruments. If you want to use more instruments, you can order a bus extender or expander from National Instruments. Refer to Appendix A, *Hardware Specifications*, for more information about the GPIB-PCII/IIA hardware specifications and recommended operating conditions.

Software Description

The NI-488.2 software for Windows includes a Windows dynamic link library, language interface libraries, and debugging and development utilities. The NI-488.2 software and GPIB hardware transform a general-purpose PC into a GPIB Talker/Listener/Controller that has complete communications and bus management capability.

Optional Programming Environments

Your kit includes the NI-488.2 software for Windows. In addition, you can order the LabWindows[®]/CVI or LabVIEW software from National Instruments. LabWindows/CVI and LabVIEW include instrument driver libraries that make it easier to communicate with your GPIB instruments.

LabWindows/CVI is an interactive ANSI C development environment for building test and measurement and instrument control systems. It includes interactive code-generation tools and a graphical editor for building custom user interfaces. It also includes built-in libraries for IEEE 488.2, VXI, RS-232 control, and plug-in data acquisition. When you order LabWindows/CVI, you also get more than 300 complete instrument drivers, which are modular, source-code programs that handle the communication with your instrument so that you do not have to learn the programming details.

LabVIEW is a complete programming environment that departs from the sequential nature of traditional programming languages and features a graphical programming environment. It includes all the tools needed for instrument control, data acquisition, analysis, and presentation. LabVIEW also includes an extensive instrument driver library.

For more information about LabWindows/CVI and LabVIEW, contact National Instruments.

Chapter 2

Hardware Configuration and Installation

This chapter contains instructions for configuring and installing your GPIB-PCII/IIA board.

Warning: *Several components on your GPIB-PCII/IIA board can be damaged by electrostatic discharge. To avoid such damage in handling the board, touch the antistatic plastic package to a metal part of your computer chassis before removing the board from the package.*

Default Hardware Configuration

The GPIB-PCII/IIA default settings are suitable for most PC AT compatible computer systems. However, if the default settings conflict with another device in your system or if you need to install more than one GPIB-PCII/IIA board, you must reconfigure the hardware. If you already have GPIB-PCII/IIA boards installed in your computer, you can run the GPIB Information utility to determine how the boards are configured. For more information about the GPIB Information utility, refer to Chapter 4, *Debugging Your Application*, in the *NI-488.2 User Manual for Windows*.

Table 2-1 shows the default settings for the switches and jumpers on the GPIB-PCII/IIA.

Table 2-1. Hardware Default Settings

GPIB Board Setting	GPIB-PCIIA	GPIB-PCII
Base I/O Address (hex)	2E1	2B8
DMA Channel	1	1
Interrupt Line (IRQ)	7	7

To modify the default settings of the GPIB-PCII/IIA board, refer to the *Configure the Hardware* section of this chapter. If you do not need to reconfigure the board, refer to the *Install the Hardware* section.

Install the Hardware

Perform the following steps to install the GPIB-PCII/IIA:

1. Turn off your computer and all external devices, such as monitors or tape drives.
2. Unplug the power cord from the wall outlet.
3. Remove the top cover or access port of the I/O channel.
4. Remove the expansion slot cover on the back panel of the computer.
5. Insert the GPIB-PCII/IIA into any unused slot with the GPIB connector sticking out of the opening on the back panel, as shown in Figure 2-1. It might be a tight fit, but do not force the board into place.

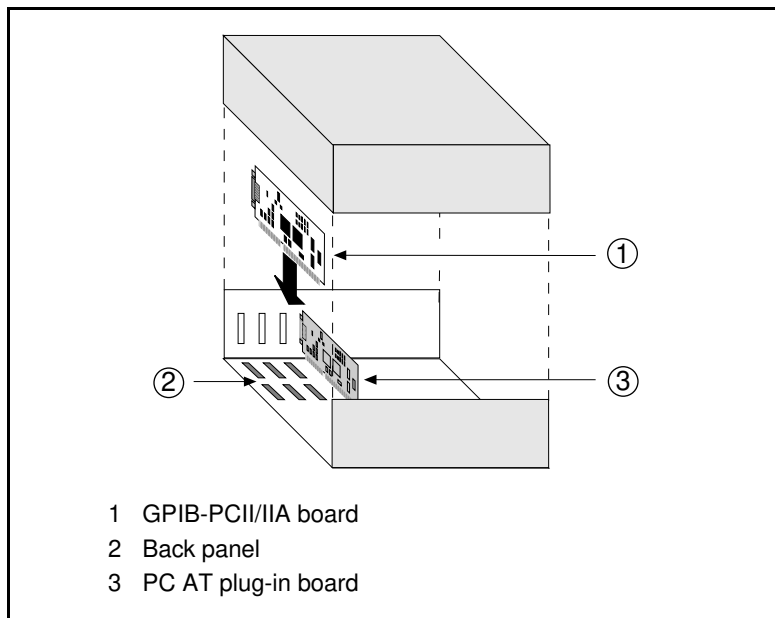


Figure 2-1. Installing the GPIB-PCII/IIA

6. Screw the mounting bracket of the GPIB-PCII/IIA to the back panel rail of the computer.
7. Verify that the GPIB-PCII/IIA is securely installed.
8. Replace the retaining screw of the expansion slot cover if there is one.

9. Replace the cover on the computer.
10. Plug the power cord into the wall outlet.
11. Turn on your computer and external devices.

After you have installed your board, you are ready to install the NI-488.2 software. Refer to Chapter 3, *Software Installation and Configuration*.

Configure the Hardware (Optional)

Follow the instructions in this section to change the hardware default settings of the GPIB-PCII/IIA. The GPIB-PCII/IIA default settings are suitable for most PC AT compatible computer systems. However, if the default settings conflict with another device in your system or if you need to install more than one GPIB-PCII/IIA, you must reconfigure the hardware.

The default settings for the switches and jumpers on the GPIB-PCII/IIA are:

- Base I/O Address (hex): 2E1 (GPIB-PCIIA) or 2B8 (GPIB-PCII)
- DMA Channel: 1
- Interrupt Line (IRQ): 7

The following sections describe the configuration options in more detail.

Figure 2-2 shows the location of the configuration jumpers and switches on the GPIB-PCII/IIA.

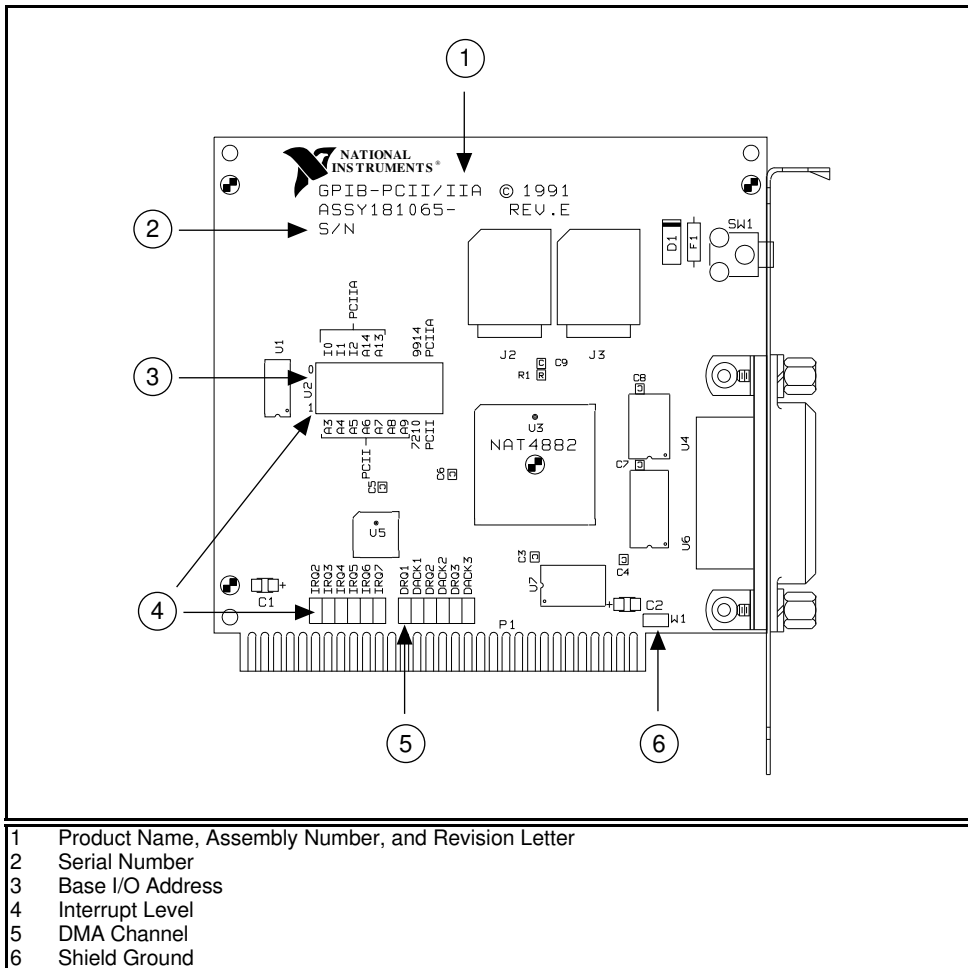


Figure 2-2. GPIB-PCII/IIA Parts Locator Diagram

GPIB-PC Mode Selection

The GPIB-PCII/IIA interface board is set at the factory to function as either a GPIB-PCII or a GPIB-PCIIA board. Using the board in its default configuration ensures that the software configuration is consistent with the hardware.

There are three cases in which you might need to change the GPIB-PC mode of the board:

- If another board in your computer uses GPIB-PCII mode or GPIB-PCII/IIA mode, you should use the GPIB-PCII/IIA in that mode to ensure compatibility between the boards.
- GPIB-PCII mode and GPIB-PCIIA mode use different regions of I/O space. If you cannot obtain a non-conflicting I/O address in one of the modes, you should switch to the other mode.
- GPIB-PCIIA mode supports shared interrupts, while GPIB-PCII mode does not. If you want two GPIB boards to share the same interrupt level, you should use GPIB-PCIIA mode.

To change the GPIB-PC mode of the board, use switch 9 in switch block U2. To select GPIB-PCII mode, push the switch down on the side labeled PCII. To select GPIB-PCIIA mode, push the switch down on the side labeled PCIIA.

Figure 2-3 shows the GPIB-PC mode selection switch set for GPIB-PCII mode and for GPIB-PCIIA mode.

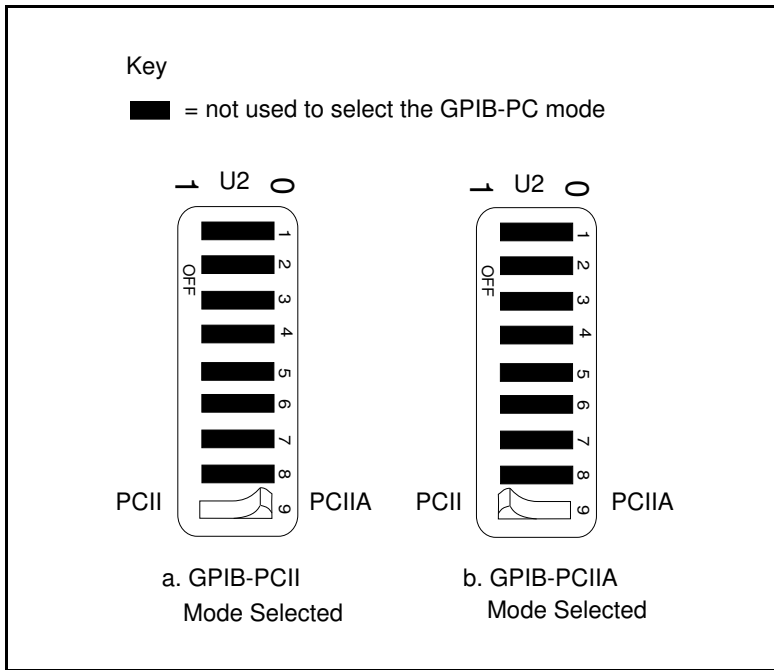


Figure 2-3. GPIB-PC Mode Selection Settings

If you change the GPIB-PC mode of your board, remember that after you install the NI-488.2 software, you must use the GPIB software configuration utility to configure your software settings to match your new hardware settings. Refer to the *Configure the Software* section of Chapter 3, *Software Installation and Configuration*, for more information.

Switch and Jumper Settings

Table 2-2 shows the factory settings and available configurations for the switches and jumpers on the GPIB-PCII/IIA in GPIB-PCII mode. Table 2-3 shows the factory settings and available configurations for the switches and jumpers in GPIB-PCIIA mode.

Table 2-2. Factory Default Settings and Available Configurations for GPIB-PCII Mode

GPIB-PCII	Default	Available
Base I/O Address (hex)	2B8	100 to 3F8 in increments of 8
DMA Channel	1	1, 2, 3, or Not Used
Interrupt Line (IRQ)	7	2, 3, 4, 5, 6, 7, or Not Used
7210/9914 Mode	7210	7210 or 9914
Shield Ground	Connected	Connected or disconnected

Table 2-3. Factory Default Settings and Available Configurations for GPIB-PCIIA Mode

GPIB-PCIIA	Default	Available
Base I/O Address (hex)	2E1	2E1, 22E1, 42E1, or 62E1
DMA Channel	1	1, 2, 3, or Not Used
Interrupt Line (IRQ)	7	2, 3, 4, 5, 6, 7, or Not Used
7210/9914 Mode	7210	7210 or 9914
Shield Ground	Connected	Connected or disconnected

If you make any changes to these settings, record the new settings on the *GPIB-PCII/IIA Hardware and Software Configuration Form* in Appendix C, *Customer Communication*.

7210/9914 Mode Selection

The GPIB-PCII/IIA can emulate IEEE 488 interface boards that use the TI 9914A GPIB Controller chip or the 7210 chip. Use switch 8 in switch block U2 to select either TI 9914A mode or NEC 7210 mode. Figure 2-4 shows the 7210/9914 mode selection switch settings for 7210 mode and 9914 mode.

Note: *9914 mode should be used only for compatibility with boards that use the TI9914A GPIB Controller chip. For normal operation with National Instruments software, leave this switch in the 7210 position.*

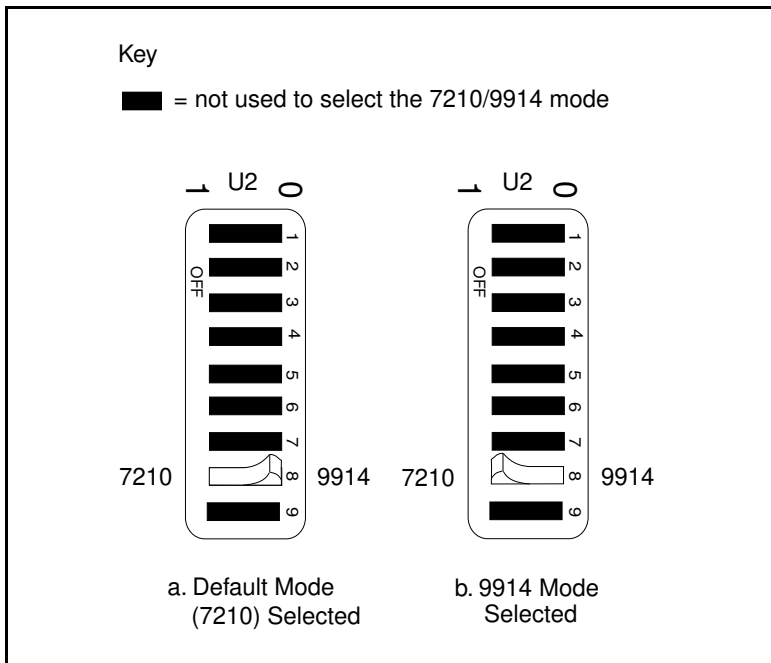


Figure 2-4. 7210/9914 Mode Selection Settings

Notice that if you change the 7210/9914 mode of your board, you cannot use the NI-488.2 software with the board. The NI-488.2 software works properly only if you use the board in 7210 mode.

Selecting the Base I/O Address

GPIB-PCII Mode

The GPIB-PCII base I/O address is set using the switches at position U2. The switch block is used to set the address for address lines A3 through A9. The addresses are in a consecutive block of eight beginning on any multiple of 8 between 100 and 3F8 hex.

By default, the GPIB board is configured to use base I/O address 2B8 hex. With this setting, the board uses the I/O address space 2B8 hex through 2BF hex. If this address range is already in use by another device or if you are installing more than one board, follow these steps to reconfigure the base I/O address setting.

1. Choose a new base I/O address setting.

You can configure the base I/O addresses to any setting between 0x100 and 0x3F8 that is a multiple of 0x08. If you are installing more than one GPIB board, each board must use a unique base I/O address. You should not configure a base I/O address of less than 0x100 for the board, because this portion of the address space is reserved for your computer's system board.

2. Locate the base I/O address switch at U2 on your GPIB-PCII/IIA board. Refer to Figure 2-2.
3. Change the switch settings to configure the GPIB-PCII/IIA board to the new base I/O address.

Press down on the side marked 1 to select a binary value of 1 for the corresponding address bit. Press down on the 0 side of the switch to select a binary value of 0. Refer to Figure 2-5 for two examples of the switch settings and corresponding base I/O addresses.

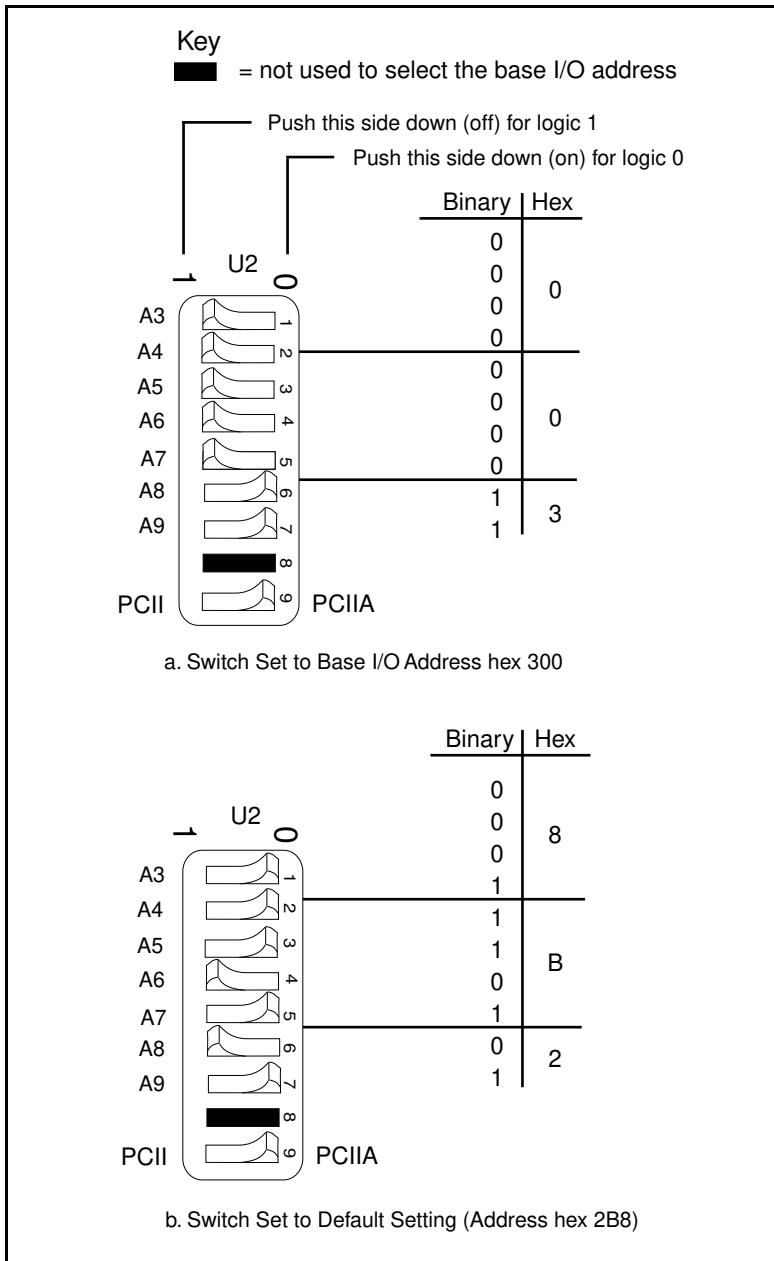


Figure 2-5. Base I/O Address Switch Settings for GPIB-PCII Mode

4. Record your new setting on the *GPIB-PCII/IIA Hardware and Software Configuration Form* in Appendix C, *Customer Communication*.
5. Remember that after you install the NI-488.2 software, you must use the GPIB software configuration utility to configure your software settings to match your new hardware settings. Refer to the *Configure the Software* section of Chapter 3, *Software Installation and Configuration*, for more information.

GPIB-PCIIA Mode

Complete the following steps to set the GPIB-PCIIA base I/O address.

1. Choose a new base I/O address setting.

The GPIB-PCIIA base I/O address is set using switches 4 and 5 of the switch block at U2. The four possible base I/O addresses are 2E1, 22E1, 42E1, and 62E1 hex. If you are installing more than one GPIB board, each board must use a unique base I/O address.

2. Locate the base I/O address switch at U2 on your GPIB-PCII/IIA board. Refer to Figure 2-2.
3. Change the switch settings to configure the GPIB-PCII/IIA board to the new base I/O address.

Press down on the side marked 1 to select a binary value of 1 for the corresponding address bit. Press down on the 0 side of the switch to select a binary value of 0. Figure 2-6 shows the switch settings for the four possible base I/O addresses and the address space used for each setting. Figure 2-6a shows how the base I/O address was calculated from the switch positions.

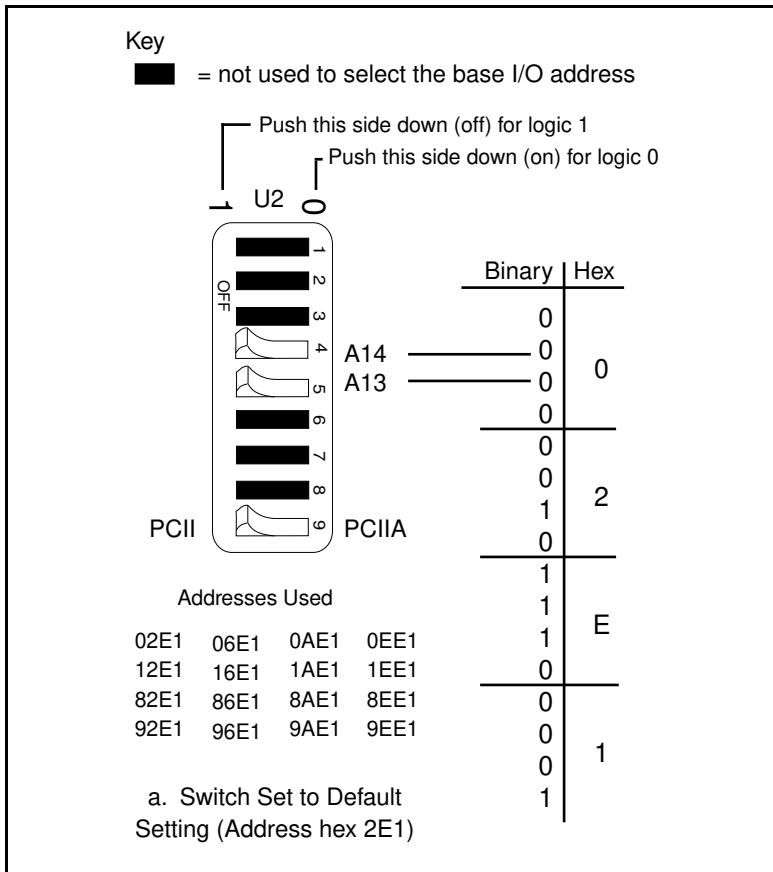


Figure 2-6. Base I/O Address Switch Settings for GPIB-PCIIA Mode (Continues)

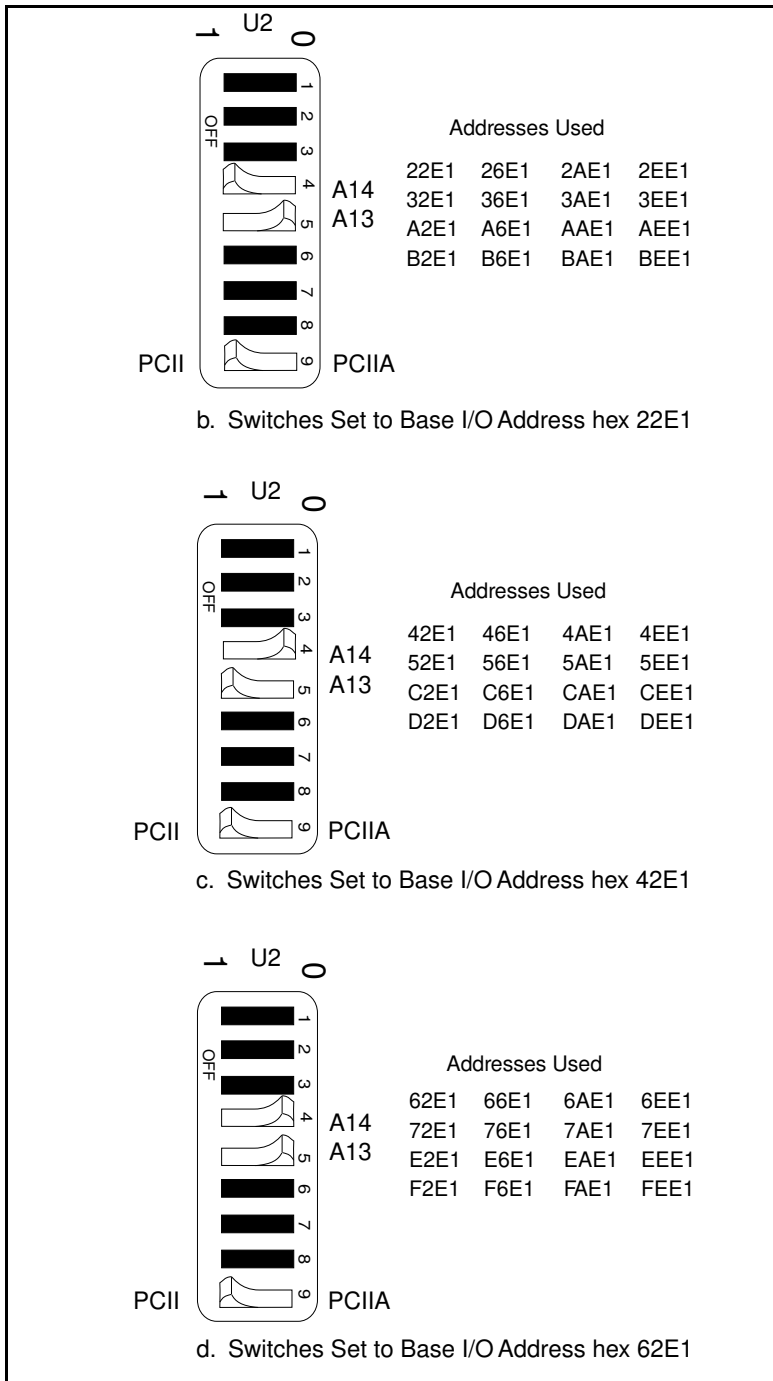


Figure 2-6. Base I/O Address Switch Settings for GPIB-PCIIA Mode (Continued)

4. Record your new setting on the *GPIB-PCII/IIA Hardware and Software Configuration Form* in Appendix C, *Customer Communication*.
5. Remember that after you install the NI-488.2 software, you must use the GPIB software configuration utility to configure your software settings to match your new hardware settings. Refer to the *Configure the Software* section of Chapter 3, *Software Installation and Configuration*, for more information.

Possible Conflicts

National Instruments has made every effort to select a default base I/O address that will work. However, because of the numerous different interface boards available for use in the PC, it is not possible to select a base I/O address that is guaranteed to work in all systems. Refer to the *Possible Base I/O Address Conflicts* section of Appendix B, *Possible Conflicts*, for a list of some of the I/O addresses used by other PC plug-in interface boards and adapters. This list may help you determine possible address conflicts.

Note: *In GPIB-PCII mode, eight consecutive addresses are used. In GPIB-PCIIA mode, 16 addresses spread throughout the upper address space are used.*

Selecting the Interrupt Request Line

PC-compatible computers have a series of interrupt lines available to devices. Devices use interrupts to get immediate service from the CPU for asynchronous events. Your GPIB hardware and the NI-488.2 software use interrupts to get service from the CPU when necessary.

The GPIB-PCII/IIA can use any of six interrupt lines available on the PC, or no interrupts at all. Multiple GPIB-PCII/IIA boards can share the same interrupt line if they are all configured for GPIB-PCIIA mode.

GPIB-PCII mode

By default, the GPIB-PCII/IIA is configured to use interrupt request line 7. If this is not an acceptable setting or if you are installing more than one board, perform the following steps to reconfigure the interrupt request line:

1. Choose a new interrupt request line (IRQ) setting.

If you are installing more than one GPIB-PCII/IIA, each board must either use a unique IRQ level or not use interrupts at all, unless all the boards are configured for GPIB-PCIIA mode. If your board is configured for GPIB-PCIIA mode, see the next section, *GPIB-PCIIA Mode*, for instructions on configuring the interrupt request line.

2. Find the jumpers that set the interrupt request line. The jumpers are located on the lower edge of your GPIB-PCII/IIA. Refer to Figure 2-2.
3. Change the jumper settings to configure the GPIB-PCII/IIA to the new interrupt request line. Figure 2-7 shows the selection of interrupt line 7.

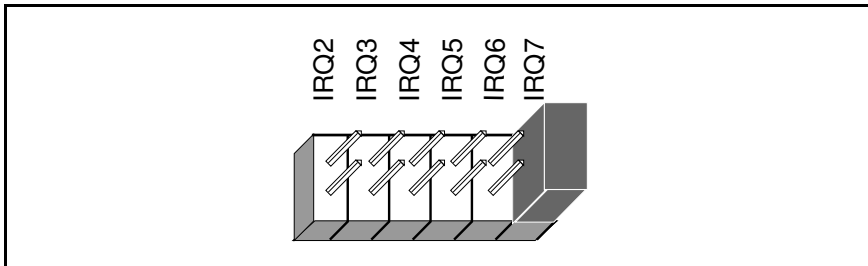


Figure 2-7. Interrupt Jumper Setting for IRQ7

4. Record your new setting on the *GPIB-PCII/IIA Hardware and Software Configuration Form* in Appendix C, *Customer Communication*.
5. Remember that after you install the NI-488.2 software, you must use the GPIB software configuration utility to configure your software settings to match your new hardware settings. Refer to the *Configure the Software* section of Chapter 3, *Software Installation and Configuration*, for more information.

If you do not want to use interrupts, you must disconnect the GPIB-PCII/IIA from the IRQ lines by selecting **None** for the interrupt line when you run the GPIB software configuration utility. The board can remain in the back panel and no jumpers have to be moved or changed.

GPIB-PCIIA Mode

If you use the GPIB-PCII/IIA in GPIB-PCIIA mode and you want to change the interrupt line, you must set switches I0, I1, and I2 in switch set U2 to the new interrupt level setting in addition to setting the interrupt jumpers.

By default, the GPIB-PCII/IIA is configured to use interrupt request line 7. If this is not an acceptable setting, perform the following steps to reconfigure the interrupt request line:

1. Choose a new interrupt request line (IRQ) setting. Multiple GPIB-PCII/IIA boards can share the same interrupt level if they are all configured for GPIB-PCIIA mode.
2. Find switch set U2 and the jumpers that set the interrupt request line. The jumpers are located on the lower edge of your GPIB-PCII/IIA. Refer to Figure 2-2.

3. Change the jumper and switch settings to configure the GPIB-PCII/IIA to the new interrupt request line.

Figure 2-8 shows the switch and jumper settings for the default interrupt setting, IRQ7, and shows how the interrupt setting was calculated from the switch positions. The switches shown in black are not used in determining the interrupt line.

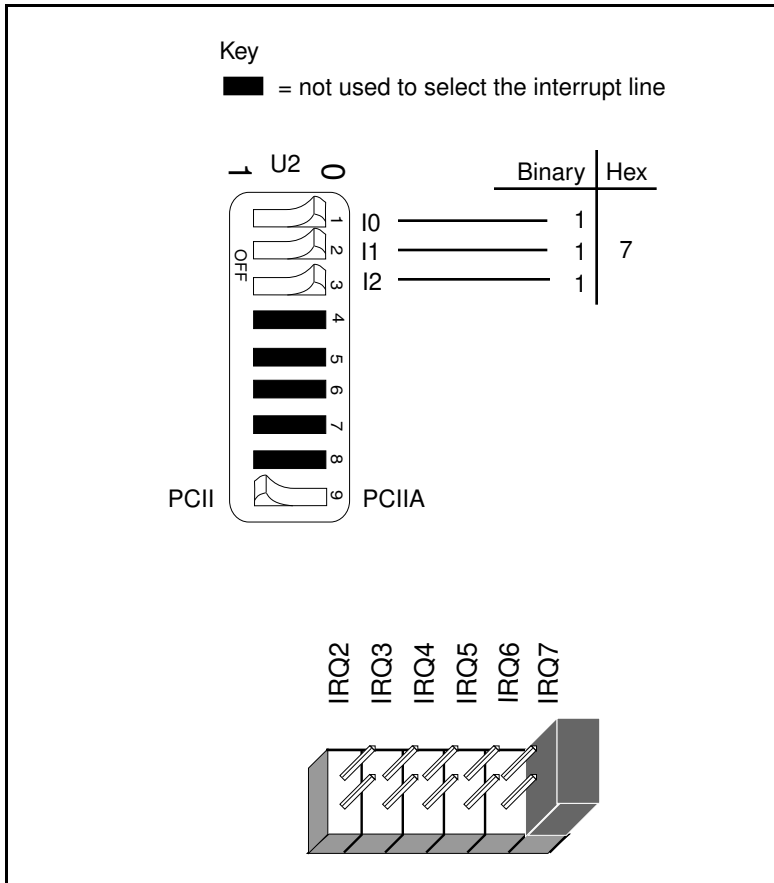


Figure 2-8. Default Interrupt Jumper Setting for GPIB-PCIIA Mode

Figure 2-9 shows the switch and jumper settings for the five interrupt lines other than the default, IRQ7. The switches shown in black are not used in determining the interrupt line.

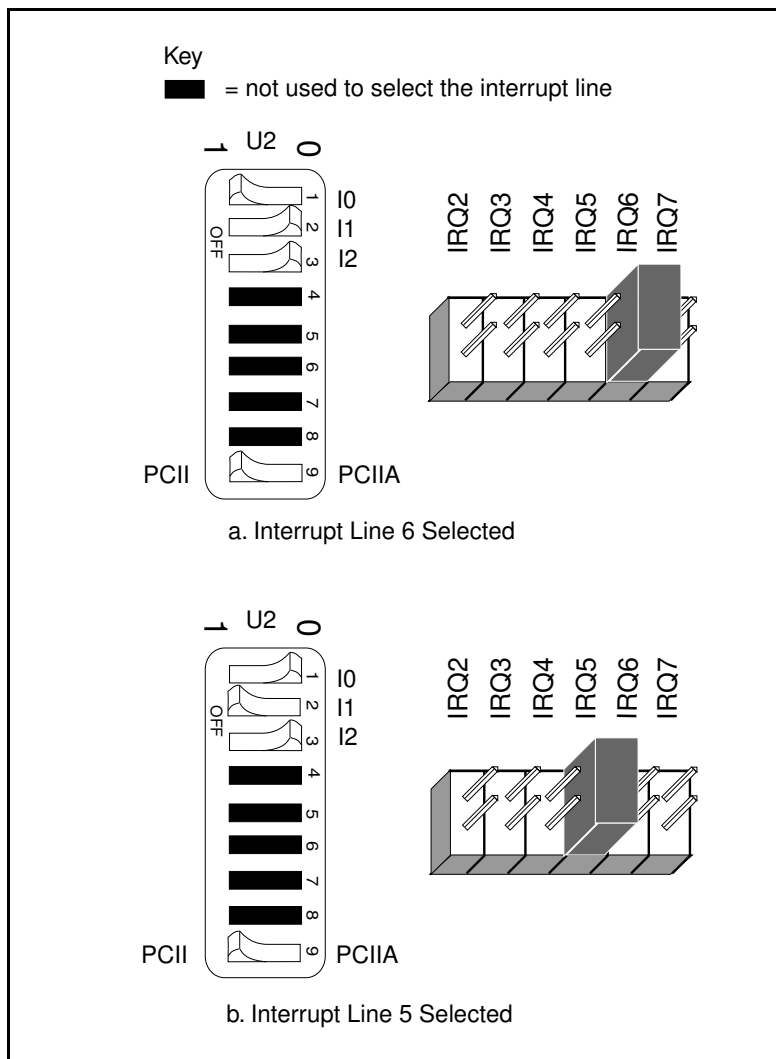


Figure 2-9. Interrupt Jumper Settings for GPIB-PCIIA Mode (Continues)

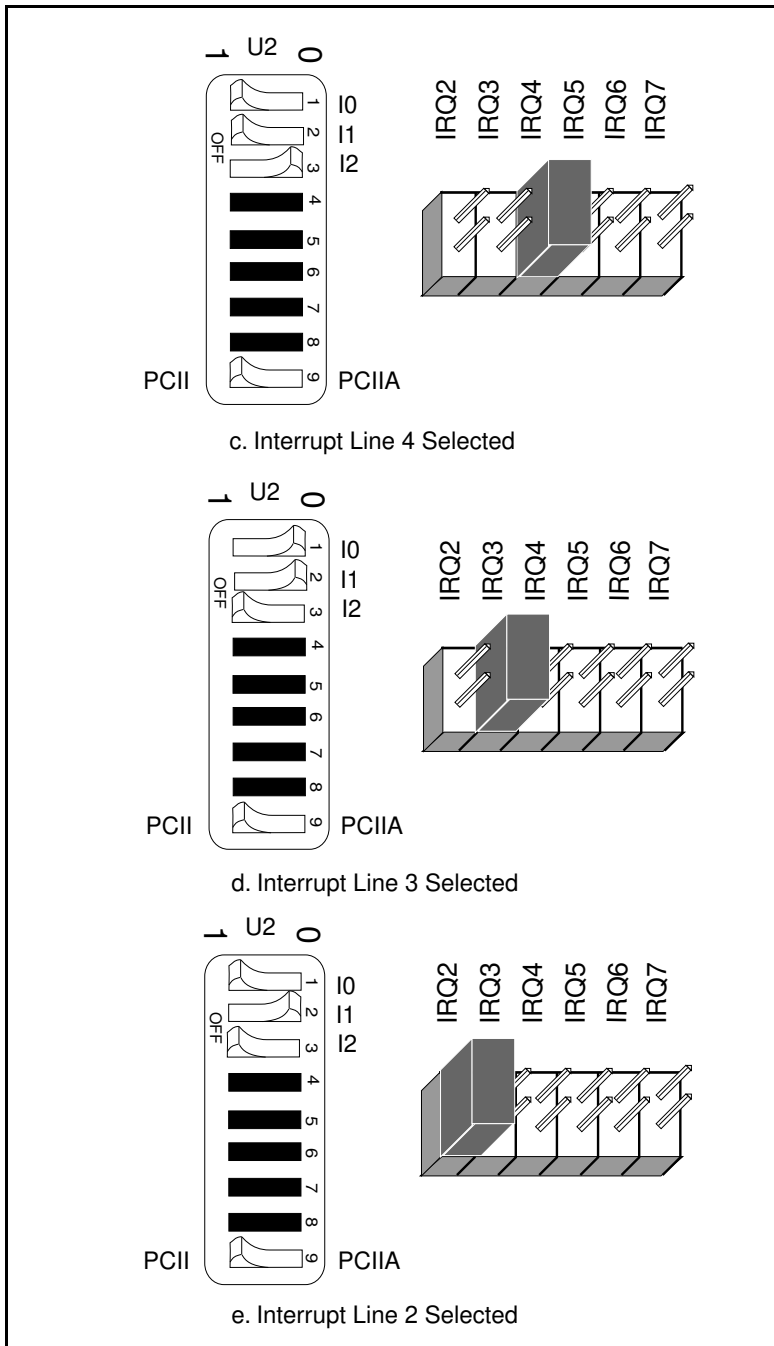


Figure 2-9. Interrupt Jumper Settings for GPIB-PCIIA Mode (Continued)

4. Record your new setting on the *GPIB-PCII/IIA Hardware and Software Configuration Form* in Appendix C, *Customer Communication*.
5. Remember that after you install the NI-488.2 software, you must use the GPIB software configuration utility to configure your software settings to match your new hardware settings. Refer to the *Configure the Software* section of Chapter 3, *Software Installation and Configuration*, for more information.

If you do not want to use interrupts, you must disconnect the GPIB-PCII/IIA from the IRQ lines by selecting **None** for the interrupt line when you run the GPIB software configuration utility. The board can remain in the back panel and no jumpers have to be moved or changed.

Possible Conflicts

National Instruments has made every effort to select a default interrupt line that will work. However, because of the numerous different interface boards available for use in the PC, it is not possible to select an interrupt line that is guaranteed to work in all systems. Refer to the *Possible Interrupt Conflicts* section of Appendix B, *Possible Conflicts*, for a list of some of the interrupt lines used by other PC plug-in interface boards and adapters. This list may help you determine possible interrupt conflicts.

Selecting the DMA Channel

Direct memory access (DMA) refers to data transfers directly to or from devices such as the GPIB-PCII/IIA and computer memory. Your GPIB hardware and the NI-488.2 software are designed to perform DMA. In most cases, data transfers using DMA are significantly faster than programmed I/O transfers, which use more CPU time.

By default, the GPIB-PCII/IIA is configured to use DMA channel 1. If this is not an acceptable setting or if you are installing more than one board, follow these steps to reconfigure the DMA channel.

1. Choose a new DMA channel setting.

You can set the DMA channel setting to 1, 2, 3, or no DMA. If you are installing more than one GPIB-PCII/IIA, each board must either use a unique DMA channel or not use DMA at all. If no DMA channel is available, configure the software to run without DMA by using the GPIB software configuration utility. Refer to the *Configure the Software* section of Chapter 3, *Software Installation and Configuration*, for more information.

2. Locate the jumpers that select the DMA channel. Refer to Figure 2-2.
3. Change the jumper settings to configure the GPIB-PCII/IIA to the new DMA channel. To select a new DMA channel, you must set both the DMA Acknowledge and DMA Request lines, as shown in Table 2-4.

Table 2-4. DMA Channels

DMA Channel	Signal Lines	
	DMA Acknowledge	DMA Request
1	DACK1	DRQ1
2	DACK2	DRQ2
3	DACK3	DRQ3

Figure 2-10 shows the jumper position for selecting DMA channel 1.

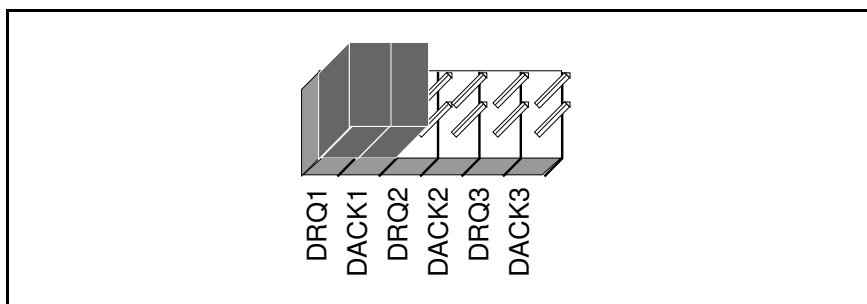


Figure 2-10. DMA Channel Jumper Setting for DMA Channel 1

4. Record your new setting on the *GPIB-PCII/IIA Hardware and Software Configuration Form* in Appendix C, *Customer Communication*.
5. Remember that after you install the NI-488.2 software, you must use the GPIB software configuration utility to configure your software settings to match your new hardware settings. Refer to the *Configure the Software* section of Chapter 3, *Software Installation and Configuration*, for more information.

Using Programmed I/O for GPIB Transfers

As an alternative to DMA transfers, you can use programmed I/O. To use programmed I/O, you should disable DMA for the GPIB-PCII/IIA by selecting **None** for the **DMA Channel** option when you run the GPIB software configuration utility. The board can remain in the back panel and no jumpers have to be moved or changed. Refer to the *Configure the Software* section of Chapter 3, *Software Installation and Configuration*, for more information.

If you change the DMA jumper setting from the default setting, record the new setting on the *GPIB-PCII/IIA Hardware and Software Configuration Form* in Appendix C, *Customer Communication*.

Setting the Shield Ground Configuration

The GPIB-PCII/IIA is set at the factory with the jumper in place to connect the logic ground of the board to its shield ground. This configuration minimizes EMI emissions.

Caution: *The GPIB-PCII/IIA was tested for compliance with FCC standards with the shield ground connected to logic ground. Removing the jumper might cause EMI emissions to exceed any or all of the applicable standards.*

If your application requires that logic ground be disconnected from shield ground, follow these steps:

1. Refer to Figure 2-2 to locate the shield ground jumper W1 on the GPIB-PCII/IIA.
2. Remove the jumper and place it across only one of the jumper pins, as shown in Figure 2-11.

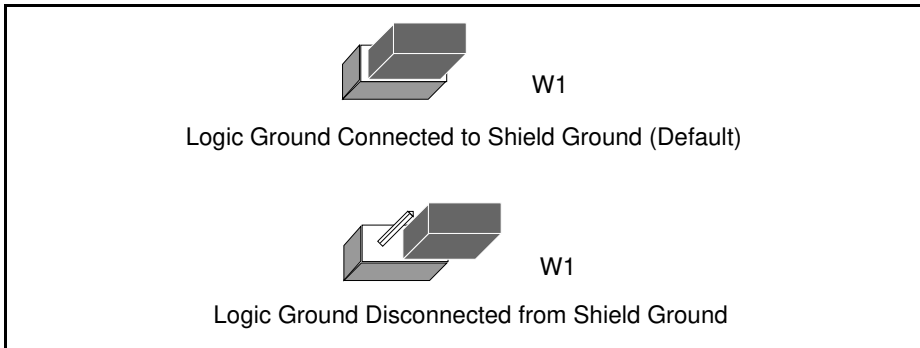


Figure 2-11. Ground Configuration Jumper Settings

3. Record the jumper setting on the *GPIB-PCII/IIA Hardware and Software Configuration Form* in Appendix C, *Customer Communication*.

Now that you have properly configured the hardware, return to the *Install the Hardware* section at the beginning of this chapter for the installation instructions.

Chapter 3

Software Installation and Configuration

This chapter contains instructions for installing and configuring your NI-488.2 software.

NI-488.2 Software Components

The NI-488.2 software includes the following components:

- Device driver
- Hardware and software diagnostic tests
- Configuration utility
- Interactive control program
- Utilities for software development and debugging
- Language interface libraries for the following languages:
 - Microsoft C
 - Microsoft Visual Basic for Windows
- Sample programs that use NI-488 functions and NI-488.2 routines

For a detailed list of files, refer to the *NI-488.2 User Manual for Windows*.

Install the Software

After you have installed and configured the hardware, you are ready to install the NI-488.2 software. Complete the following steps to run the software installation program.

1. Insert the NI-488.2 software for Windows distribution disk into an unused drive.
2. Choose **Run...** from the **File** menu in the **Program Manager** window and type the following command into the dialog box:

```
x:\setup
```

where *x* is the letter of the drive containing the distribution disk (usually a or b).

The software installation begins with the screen shown in Figure 3-1.

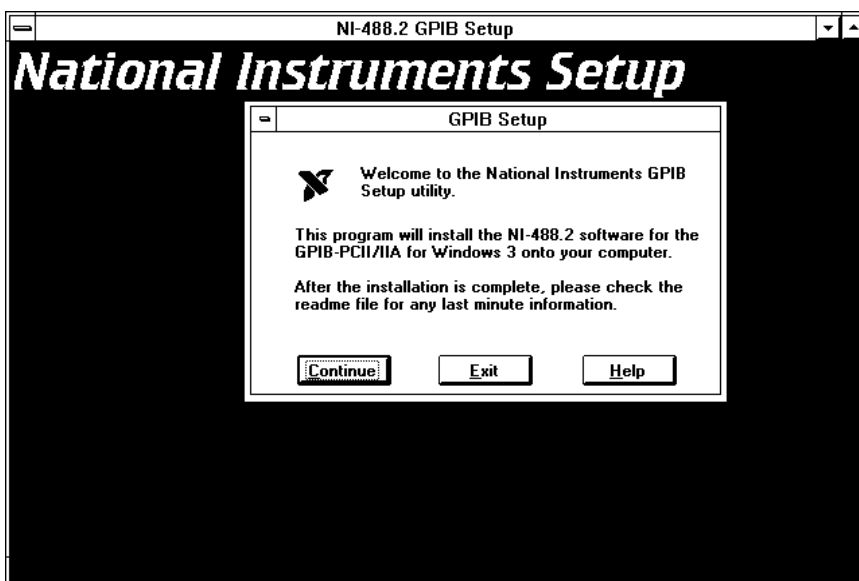


Figure 3-1. Software Installation Screen

The interactive Windows setup program takes you through the necessary steps to install the NI-488.2 software. For help during the installation, press the **Help** button. You can exit the setup at any time by pressing the **Exit** button.

3. After the installation is complete, restart Windows.

After you have installed your software, you might want to view or modify the driver configuration. If you modified the hardware configuration or if you installed more than one GPIB board, you must reconfigure the software. Refer to the next section for instructions on running the GPIB software configuration utility. If you do not need to configure the software, refer to Chapter 4, *Installation Verification and Troubleshooting*, for instructions on verifying the hardware and software installation.

Configure the Software (Optional)

The GPIB software configuration utility is an interactive utility that you can use to examine or modify the configuration of the driver. You can also use it to enable or disable DMA or interrupts.

Note: *You must run the GPIB software configuration utility if you changed any of the hardware default settings or if you installed more than one GPIB board.*

To run the GPIB software configuration utility, double-click on the **GPIB** icon in the **Control Panel**, which is located in the **Main** group of the **Program Manager**.

The GPIB software configuration utility displays a list of all the GPIB boards and device names. Double-click on any name to examine or edit it. You can use the online help if you have any questions. For more information about the GPIB software configuration utility, refer to the *NI-488.2 User Manual for Windows*.

After the software is installed and configured, you should verify the installation. Refer to Chapter 4, *Installation Verification and Troubleshooting*.

Chapter 4

Installation Verification and Troubleshooting

This chapter describes how to verify the hardware and software installation and how to troubleshoot problems.

Run the Hardware Diagnostic Test

To verify and test the hardware installation, run the Hardware Diagnostic Test that came with your NI-488.2 software. The Hardware Diagnostic Test verifies that your hardware is functioning properly and that the configuration of your board does not conflict with anything else in your system.

Follow these steps to run the Hardware Diagnostic Test:

1. Disconnect any GPIB cables.
2. Double-click on the **Hardware Diagnostic Test** icon in the **NI-488.2 GPIB Software** group in the **Program Manager**.

If the Hardware Diagnostic Test completes with no errors, your hardware is functioning properly. If it returns an error message, refer to the next section for troubleshooting instructions.

Troubleshooting Hardware Diagnostic Test Error Messages

First verify that all GPIB cables are disconnected and make sure that the switch and jumper settings on the hardware match the values you entered for `ibdiag`. Then perform the following steps to troubleshoot `ibdiag` error messages.

1. Make sure you are using a valid base I/O address.

Run the Hardware Diagnostic Test again. When it prompts you for values, enter your base I/O address, but enter `<N>` for both the interrupt request line and the DMA channel. If the test fails again, one of the following situations is occurring:

- The base address that you entered when prompted does not match the switch settings of the board. Check the switch settings again.
- A GPIB cable is connected to the board. Remove all GPIB cables before running the Hardware Diagnostic Test again.

- Another board or built-in device in your computer is using the same address space. Change the base I/O address of your GPIB board and repeat this step using the new setting.
- The board is defective or is not compatible with your computer. Complete the forms in Appendix C, *Customer Communication*, and contact National Instruments.

2. Make sure you are using a valid interrupt request line.

Run the Hardware Diagnostic Test again. When it prompts you for values, enter the valid base I/O address as determined in Step 1, the interrupt request line, and <N> for the DMA channel. If the test fails, one of the following situations is occurring:

- The interrupt request line that you entered when prompted does not match the jumper setting of the board. Check the jumper setting again.
- Another board or built-in device in your computer is using the same interrupt request line. Change the interrupt request line of the GPIB board and repeat this step using the new setting.
- The board is defective or is not compatible with your computer. Complete the forms in Appendix C, *Customer Communication*, and contact National Instruments.

3. Make sure you are using a valid DMA channel.

Run the Hardware Diagnostic Test again. When it prompts you for values, enter the valid base I/O address and interrupt request line as determined in Steps 1 and 2, and enter the current DMA channel. If the test fails this time, one of the following situations is occurring:

- The DMA channel that you entered when prompted does not match the jumper setting of the board. Check the jumper setting again.
- Another board or built-in device in your computer is using the same DMA channel. Change the DMA channel of the GPIB board and repeat this step using the new setting.
- The board is defective or is not compatible with your computer. Complete the forms in Appendix C, *Customer Communication*, and contact National Instruments.

Run the Software Diagnostic Test

To verify and test the hardware and software installation, run the Software Diagnostic Test that came with your NI-488.2 software. The Software Diagnostic Test is a Windows application that requires no user interaction.

Follow these steps to run the Software Diagnostic Test:

1. Disconnect any GPIB cables.
2. Double-click on the **Software Diagnostic Test** icon in the **NI-488.2 GPIB Software** group in the **Program Manager**.

If the Software Diagnostic Test completes with no errors, you have installed the NI-488.2 software correctly. If it returns an error message, refer to the next section for troubleshooting instructions.

Troubleshooting Software Diagnostic Test Error Messages

The following sections explain common error messages generated by the Software Diagnostic Test.

The Software Diagnostic Test may lock up your computer if the GPIB board under test is configured to use an incorrect interrupt level. You can either reconfigure the hardware to use a different interrupt level or use the GPIB software configuration utility to disable the use of interrupts. For detailed instructions, refer to the sections *Configure the Hardware* in Chapter 2 and *Configure the Software* in Chapter 3.

Note: *In the following paragraphs, `gplib x` refers to board `gplib0`, `gplib1`, `gplib2`, or `gplib3` as appropriate.*

Presence Test of Driver

The Software Diagnostic Test checks for the presence of the NI-488.2 driver `gplib.dll` and the NI-488.2 configuration information file `gplib.ini`. If `gplib.dll` is not in the Windows System directory, a warning box pops up with the following text:

File Error: Cannot find GPIB.DLL

Press the **Close** button. The Software Diagnostic Test displays the following error message when it fails:

<<< No handler present for GPIBx. >>>

To correct the problem, make sure that `gplib.dll` is located in the Windows System directory (usually `c:\windows\system`).

If `gpib.ini` is not in the Windows directory, the Software Diagnostic Test displays the same error message when it fails:

```
<<< No handler present for GPIBx. >>>
```

To correct this problem, make sure that `gpib.ini` is located in the Windows directory (usually `c:\windows`).

If you are unable to locate `gpib.dll` or `gpib.ini`, you should reinstall the software.

Presence Test of Board

The following error message appears if the board `gpibx` is not installed or if the software is not configured properly:

```
<<< No board present for GPIBx. >>>
```

If this message appears, you could have one of the following situations:

- The `Use this Board` field in the GPIB software configuration utility might be unchecked for board `gpibx`. If you want to use the board, you must check this field.
- The board might not be properly installed and configured. Refer to the *Configure the Hardware* section in Chapter 2, *Hardware Configuration and Installation*, for detailed instructions.
- The software and hardware settings do not match. You can run the GPIB software configuration utility to check the current configuration of the software.

GPIB Cables Connected

The following error message appears if a GPIB cable is connected to the board when you run the Software Diagnostic Test:

```
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.

Common Questions

Which NI-488.2 software (DOS or Windows) do I need to install?

If you want to run a GPIB application under DOS, install the NI-488.2 software for DOS. If you want to run a GPIB application in Windows, you must install the NI-488.2 software for Windows.

Can I have the NI-488.2 for DOS and Windows drivers installed at the same time?

Yes, there is nothing wrong with installing both. However, it is better not to use them at the same time.

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

Run the GPIB Information utility. If you run the GPIB Information utility without specifying any parameters, it returns information about the GPIB boards currently configured for use in your system. For more information about the GPIB Information utility, refer to the *NI-488.2 User Manual for Windows*.

How can I determine if my board is configured and used as a GPIB-PCII or GPIB-PCIIA board?

If switch 9 on switch block U2 is pushed down on the side labeled PCII, the board is in PCII mode. If switch 9 is pushed down on the side labeled PCIIA, the board is in PCIIA mode. When the board settings in the GPIB software configuration utility match the actual board settings, you can read this and other configuration information on the GPIB software configuration utility screen.

What is the difference between GPIB-PCII and GPIB-PCIIA mode?

The GPIB-PCIIA and GPIB-PCII use different regions of I/O space. Additionally, the GPIB-PCIIA supports shared interrupts, while the GPIB-PCII does not. If you cannot obtain a non-conflicting I/O address in one of the modes, you should switch to the other mode. If you want two GPIB boards to share the same interrupt level, you should use GPIB-PCIIA mode.

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

Run the GPIB Information utility. If you run the utility without specifying any parameters, it returns information about the version of the NI-488.2 software currently installed. For more information about the GPIB Information utility, refer to the *NI-488.2 User Manual for Windows*.

What should I do if one of the diagnostic tests fails with an error?

Refer to the troubleshooting sections of this chapter for specific information about what might cause these tests to fail.

When should I use the Win16 Interactive Control utility?

You can use the Win16 Interactive Control utility to test and verify instrument communication, troubleshoot problems, and develop your application program. For more information, refer to Chapter 5, *Interactive Control Program*, in the *NI-488.2 User Manual for Windows*.

How do I use an NI-488.2 language interface?

For information about using NI-488.2 language interfaces, refer to Chapter 3, *Developing Your Application*, in the *NI-488.2 User Manual for Windows*.

What information should I have before I call National Instruments?

When you call National Instruments, you should have the results of the diagnostic tests and the output from the GPIB Information utility. Also, make sure you have filled out the configuration form in Appendix C, *Customer Communication*.

Chapter 5

Using Your NI-488.2 Software

This chapter describes the Win16 Interactive Control utility and lists some programming considerations.

Introduction to the Win16 Interactive Control Utility

You can use the interactive control utility to enter NI-488 functions and NI-488.2 routines interactively and see the values returned by the function calls. Without writing an application, you can use the utility to do the following:

- Verify GPIB communication with your device quickly and easily.
- Learn the NI-488 functions and NI-488.2 routines before you write your application.
- Become familiar with the commands of your device.
- Receive data from your GPIB device.
- Troubleshoot problems with your application.

For more information about the Win16 Interactive Control utility, refer to the *NI-488.2 User Manual for Windows*.

General Programming Considerations

As you begin developing your NI-488.2 application, remember the following points:

- You must link the language interface library with your compiled source code.
- You must include the header file in your source code.

For information about choosing a programming method, developing your application, or compiling and linking, refer to the *NI-488.2 User Manual for Windows*. For detailed information about each NI-488 function and NI-488.2 routine, refer to the *NI-488.2 Function Reference Manual for DOS/Windows*.

Appendix A

Hardware Specifications

This appendix describes the electrical, environmental, and physical characteristics of the GPIB-PCII/IIA board and the recommended operating conditions.

Table A-1. Electrical Characteristics

Characteristic	Specification
Maximum GPIB Transfer Rates GPIB Reads GPIB Writes	400 kbytes/s* 400 kbytes/s*
Power Requirement (from PC/XT/AT I/O channel)	+5 VDC 250 mA Typical 490 mA Maximum
* Actual rates are dependent on instrument capabilities and system configuration.	

Table A-2. Environmental Characteristics

Characteristic	Specification
Operating Environment Component Temperature Relative Humidity	0° to 40° C 10% to 90%, noncondensing
Storage Environment Temperature Relative Humidity	-20° to 70° C 5% to 90%, noncondensing
EMI	FCC Class B Certified

Table A-3. Physical Characteristics

Characteristic	Specification
Dimensions	10.668 cm by 11.05 cm (4.2 in. by 4.35 in.)
I/O Connector	IEEE 488 Standard 24-pin

Appendix B

Possible Conflicts

This appendix contains tables to help you determine possible address and interrupt conflicts.

Possible Base I/O Address Conflicts

Table B-1 lists some of the I/O addresses used by other PC plug-in interface boards and adapters. This is not a complete list, but it may help you determine possible address conflicts. Symptoms of I/O address conflicts vary widely. At one extreme, conflicts can prevent the computer from booting. At the other extreme, conflicts can cause problems that do not surface until a considerable amount of time has elapsed. When they do surface, the problems can exhibit themselves simply as strange behavior.

National Instruments has made every effort to select a default base I/O address that will work. However, because of the numerous different interface boards available for use in the PC, it is not possible to select a base I/O address that is guaranteed to work in all systems.

Note: *In GPIB-PCII mode, eight consecutive addresses are used. In GPIB-PCIIA mode, 16 addresses spread throughout the upper address space are used.*

Table B-1. I/O Addresses Used by Other Devices

I/O Address Range (Hex)	Device
100 to 1EF 1F0 to 1F8	IBM PC Fixed Disk
200 to 20F 208 210 to 217 210 to 213	PC and PC AT Game Controller, reserved LIM Expanded Memory Card PC Expansion Unit AT-DIO-24
218 219 to 21E 21F 220 to 23F 240 to 25F 248 258 260 to 27F 259 to 267 268 269 to 277 278 to 27F 280 to 29F 2A0 to 2A7 2A8 2A9 to 2AF 2B0 to 2DF 2B8 2B9 to 2BF 2C0 to 2DF 2E0 to 2FF 2E1 2E2 to 2E3 2E4 to 2E7 2E8 2E9 to 2F7 2F8 to 2FF	LIM Expanded Memory Card Reserved AT-MIO-16 AT-DIO-32F LIM Expanded Memory Card LIM Expanded Memory Card LabPC (default) LIM Expanded Memory Card AT Parallel Printer Port 2 WD EtherCard + (default) LIM Expanded Memory Card PC, AT EGA (alternate) LIM Expanded Memory Card, GPIB-PCII (base) AT-GPIB board 0 (default) AT-GPIB board 1 (default) IBM GPIB Adapter 0, GPIB-PCIIA (base) IBM Data Acquisition Adapter 0 LIM Expanded Memory Card PC, AT Serial Port 2 (COM2)

(continues)

Table B-1. I/O Addresses Used by Other Devices (Continued)

I/O Address Range (Hex)	Device
300 to 31F	PC, AT Prototype card
300 to 30F	3Com EtherLink (default)
320 to 32F	IBM PC/XT Fixed Disk Controller
330 to 347	
348 to 357	DCA 3278
358 to 35F	
360 to 363	PC Network (low address)
364 to 367	Reserved
368 to 36B	PC Network (high address)
36C to 36F	Reserved
370 to 377	
378 to 37F	PC, AT Parallel Printer Port 1
380 to 38C	SDLC Communications
380 to 389	Bisynchronous (BSC) Communications (alternate)
390 to 393	Cluster Adapter 0
394 to 39F	
3A0 to 3A9	Bisynchronous (BSC) Communications (primary)
3AA to 3AF	
3B0 to 3BF	Monochrome Display/Parallel Printer Adapter 0
3C0 to 3CF	Enhanced Graphics Adapter, VGA
3D0 to 3DF	Color/Graphics Monitor Adapter, VGA
3E0 to 3EF	
3F0 to 3F7	Diskette Controller
3F8 to 3FF	Serial Port 1 (COM1)

Possible Interrupt Conflicts

Table B-2 lists some of the interrupt lines used by other PC plug-in interface boards and adapters. This is not a complete list, but it may help you determine possible interrupt conflicts. Symptoms of interrupt conflicts vary widely. Interrupt conflicts can prevent the computer from booting. They may also cause repeated timeouts on GPIB function calls. When they do surface, the problems can exhibit themselves simply as strange behavior.

National Instruments has made every effort to select a default interrupt line that will work. However, because of the numerous different interface boards available for use in the PC, it is not possible to select an interrupt line that is guaranteed to work in all systems. Therefore, be certain of your system's interrupt assignments before proceeding with installation.

Table B-2. Interrupt Lines Used by Other Devices

IRQ	Device
7	Parallel Port 1 Data Acquisition and Control (default) GPIB-PCII/IIA
6	Diskette Controller Fixed Disk and Diskette Drive
5	Parallel Port 2 PC-DIO-24 (default) LabPC (default)
4	Serial Port 1 BSC BSC Alt. SDLC
3	Serial Port 2 BSC BSC Alt. Cluster (Primary) PC Network (default) PC Network Alt. (default) SDLC WD EtherCard + (default) 3Com EtherLink (default)
2	IRQ Chain for PC AT
1	Keyboard Controller Output Buffer Full
0	Timer Channel 0 Output

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.

Corporate Headquarters

(512) 795-8248

Technical support fax: (800) 328-2203
(512) 794-5678

Branch Offices	Phone Number	Fax Number
Australia	(03) 879 9422	(03) 879 9179
Austria	(0662) 435986	(0662) 437010-19
Belgium	02/757.00.20	02/757.03.11
Denmark	45 76 26 00	45 76 71 11
Finland	(90) 527 2321	(90) 502 2930
France	(1) 48 14 24 00	(1) 48 14 24 14
Germany	089/741 31 30	089/714 60 35
Italy	02/48301892	02/48301915
Japan	(03) 3788-1921	(03) 3788-1923
Mexico	95 800 010 0793	95 800 010 0793
Netherlands	03480-33466	03480-30673
Norway	32-848400	32-848600
Singapore	2265886	2265887
Spain	(91) 640 0085	(91) 640 0533
Sweden	08-730 49 70	08-730 43 70
Switzerland	056/20 51 51	056/20 51 55
Taiwan	02 377 1200	02 737 4644
U.K.	0635 523545	0635 523154

Technical Support Form

Photocopy this form and update it each time you make changes to your software or hardware, and use the completed copy of this form as a reference for your current configuration. Completing this form accurately before contacting National Instruments for technical support helps our applications engineers answer your questions more efficiently.

If you are using any National Instruments hardware or software products related to this problem, include the configuration forms from their user manuals. Include additional pages if necessary.

Name _____

Company _____

Address _____

Fax (____) _____ Phone (____) _____

Computer brand _____

Model _____ Processor _____

Operating system _____

Speed _____MHz RAM _____MB

Display adapter _____

Mouse _____yes _____no

Other adapters installed _____

Hard disk capacity _____MB Brand _____

Instruments used _____

National Instruments hardware product model _____

Revision _____

Configuration _____

National Instruments software product _____

Version _____

Configuration _____

(continues)

The problem is _____

List any error messages _____

The following steps will reproduce the problem _____

GPIB-PCII/IIA Hardware and Software Configuration Form

Record the settings and revisions of your hardware and software on the line to the right of each item. Update this form each time you revise your software or hardware configuration, and use this form as a reference for your current configuration.

National Instruments Products

- GPIB-PCII/IIA Hardware Revision _____
- GPIB-PC Mode of GPIB-PCII/IIA _____
- 7210/9914 Mode of GPIB-PCII/IIA _____
- NI-488.2 Software Version Number on Disk _____
- Programming Language Interface Revision _____
- Shield Ground Connected to Logic Ground (yes or no) _____
- Board Settings

	Base I/O Address	Interrupt Level	DMA Channel
gpib0	_____	_____	_____
gpib1	_____	_____	_____
gpib2	_____	_____	_____
gpib3	_____	_____	_____

Other Products

- Computer Make and Model _____
- Microprocessor _____
- Clock Frequency _____
- Type of Monitor Card Installed _____
- Windows Version _____
- Application Programming Language (BASIC, C, Pascal, and so on) _____

- Other Boards in System _____
- Base I/O Address of Other Boards _____
- Interrupt Level of Other Boards _____
- DMA Channels of Other Boards _____

Documentation Comment Form

National Instruments encourages you to comment on the documentation supplied with our products. This information helps us provide quality products to meet your needs.

Title: **Getting Started with Your GPIB-PCII/IIA and the NI-488.2TM Software for Windows**

Edition Date: **November 1994**

Part Number: **370906A-01**

Please comment on the completeness, clarity, and organization of the manual.

(continues)

If you find errors in the manual, please record the page numbers and describe the errors.

Thank you for your help.

Name _____

Title _____

Company _____

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Glossary

Prefix	Meaning	Value
m-	milli-	10^{-3}
c-	centi-	10^{-2}
k-	kilo-	10^3
M-	mega-	10^6

°	degrees
%	percent
A	amperes
AC	alternating current
ANSI	American National Standards Institute
ASIC	application-specific integrated circuit
C	Celsius
CPU	central processing unit
DIP	dual inline package
DMA	direct memory access
EMI	electromagnetic interference
FCC	Federal Communications Commission
GPIO	General Purpose Interface Bus
hex	hexadecimal
Hz	hertz
IEEE	Institute of Electrical and Electronic Engineers
in.	inches
I/O	input/output
IRQ	interrupt request
KB	kilobytes of memory
m	meters
MB	megabytes of memory
PC	personal computer
RAM	random-access memory
s	seconds
VDC	volts direct current