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PC-104-GPIB

GPIB

Getting Started with Your PC/104-GPIB and the NI-488.2M™ Software for Windows NT

May 1997 Edition
Part Number 321375A-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. Classification requirements are the same for the Federal Communications Commission (FCC) and the Canadian Department of Communications (DOC). This equipment has been tested and found to comply with the following two regulatory agencies:

Federal Communications Commission

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

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

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

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

Canadian Department of Communications

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

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



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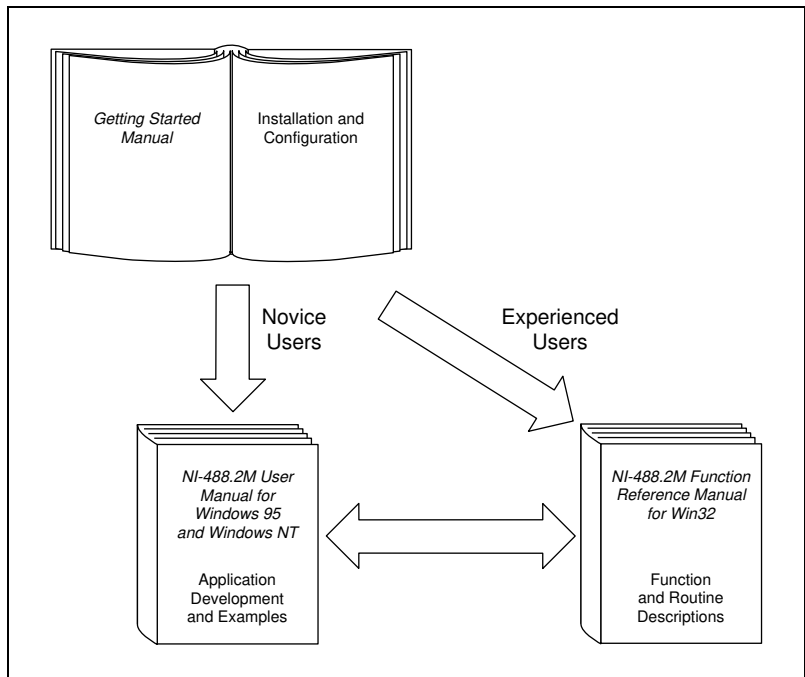
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About This Manual

This manual contains instructions to help you install and configure the National Instruments PC/104-GPIB interface module and the NI-488.2M software for Windows NT. The interface module is intended for use in a PC/104-based system.

This manual assumes that you are already familiar with Windows NT.

How to Use the Manual Set



Use this getting started manual to install and configure your PC/104-GPIB and the NI-488.2M software for Windows NT.

Use the *NI-488.2M User Manual for Windows 95 and 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 Win32* 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 briefly describes the PC/104-GPIB and the NI-488.2M software for Windows NT.
- Chapter 2, *Hardware Configuration and Installation*, contains instructions to help you configure and install your PC/104-GPIB.
- Chapter 3, *Software Installation and Configuration*, contains instructions to help you install and configure your NI-488.2M software for Windows NT.
- Chapter 4, *Installation Verification*, describes how to verify the hardware and software installation.
- Chapter 5, *Using the GPIB Software*, helps you get started with the NI-488.2M software for Windows NT.
- Appendix A, *Troubleshooting and Common Questions*, contains troubleshooting information and the answers to common questions.
- Appendix B, *Specifications*, describes the physical characteristics of the PC/104-GPIB and the transfer rates of the NI-488.2M software, along with the recommended operating conditions.
- 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 appear in this manual.

»	The » symbol leads you through nested menu items and dialog box options to a final action. The sequence File»Page Setup»Options»Substitute Fonts directs you to pull down the File menu, select the Page Setup item, select Options , and finally select the Substitute Fonts options from the last dialog box.
bold	Bold text denotes the names of menus, menu items, parameters, dialog boxes, dialog box buttons or options, icons, windows, or LEDs.
<i>bold italic</i>	Bold italic text denotes a note, caution, or warning.
bold monospace	Bold text in this font denotes the messages and responses that the system automatically prints to the screen. This font also emphasizes lines of code that are unique.
IEEE 488 and IEEE 488.2	IEEE 488 and IEEE 488.2 refer to the ANSI/IEEE Standard 488.1-1987 and the ANSI/IEEE Standard 488.2-1992, respectively, which define the GPIB.
<i>italic</i>	Italic text denotes emphasis, a cross reference, or an introduction to a key concept. This font also denotes text for which you supply the appropriate word or value.
<i>italic monospace</i>	Italic text in this font denotes that you must supply the appropriate words or values in place of these items.
monospace	Text in this font denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font can also denote the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames and extensions, and for statements and comments taken from programs.

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 User's Guide*, Microsoft Corporation
- *PC/104 Specification, Version 2.3*

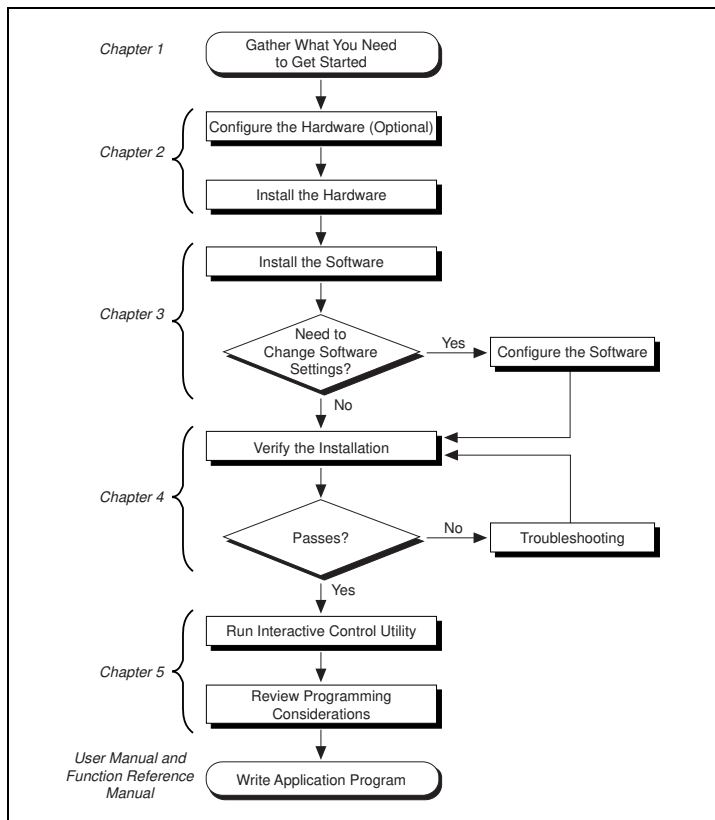
Customer Communication

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.

Introduction

This chapter explains how to use this manual, lists what you need to get started, and briefly describes the PC/104-GPIB and the NI-488.2M software for Windows NT.

How to Use This Manual



What You Need to Get Started

Make sure you have all of the items listed before you attempt to install the hardware and software.

- ☐ Windows NT version 3.51 or higher installed on your system
- ☐ One of the following modules, which your kit contains:
 - 16-bit PC/104-GPIB
 - 8-bit PC/104-GPIB
- ☐ PC/104 installation kit, which your kit contains:
 - Four standoffs
 - Four screws
 - Four hex nuts
 - 20 in. GPIB connection ribbon cable
- ☐ The following 3.5 in., high density (1.44 MB) disks, which your kit contains:
 - GPIB Software for Windows NT (Setup Disk)*
 - GPIB Software for Windows NT (NI-488.2M Software)*
- ☐ GPIB cables—single-shielded or double-shielded, Type X1, X2, or X5, which you can order from National Instruments

Optional Equipment

Call National Instruments for more information about the following optional equipment.

- Serial or parallel bus extender and cables
- Bus expander/isolator
- GPIB mechanical switch

GPIB Hardware Overview

The *PC/104 Specification, Version 2.3* defines a compact version of the PC AT bus that is optimized for embedded systems applications. Unlike ISA boards that are installed in a fixed computer backplane, PC/104

modules are stacked, one on top of the other. Modules are available in 8-bit and 16-bit versions, which correspond to the PC and PC AT bus implementations, respectively.

The PC/104-GPIB, equipped with a TNT4882C ASIC, transforms any PC/104 system into a fully-functioning GPIB Talker/Listener/Controller. The TNT4882C chip combines the circuitry of the NAT4882 ASIC, the Turbo488 performance-enhancing ASIC, and GPIB transceivers to create a single-chip IEEE 488.2 Talker/Listener/Controller interface. The TNT4882C also implements the HS488 high-speed protocol, which increases the maximum data transfer rate of the PC/104-GPIB up to 1.5 Mbytes/s. For more information about HS488, refer to Chapter 7, *GPIB Programming Techniques*, in the *NI-488.2M User Manual for Windows 95 and Windows NT*.

The PC/104-GPIB is functionally identical to the AT-GPIB/TNT and can run any NI-488.2 driver software for the AT-GPIB/TNT. The PC/104-GPIB is available in an 8-bit version and a 16-bit version. You can plug the 16-bit version into an 8-bit stack if you disable DMA transfers. The PC/104-GPIB is equipped with a 20 in. ribbon cable terminated with a panel-mount GPIB connector. You can use standard GPIB cables to connect the PC/104-GPIB with up to 14 instruments. If you want to use more than the maximum number of instruments, you can order a bus extender or expander from National Instruments. Refer to Appendix B, *Specifications*, for more information about the GPIB hardware specifications and recommended operating conditions.

NI-488.2M Software Overview

The NI-488.2M software, along with the PC/104-GPIB, transforms a PC/104 system into a GPIB Talker/Listener/Controller with complete communications and bus management capability. The NI-488.2M software includes the following components:

- Device driver
- Diagnostic test utility
- Configuration utility
- Interactive control program
- Utilities for software development

- Language interface libraries for Microsoft Visual C/C++ 2.0 or higher, Borland C/C++ 4.0 or higher, and Microsoft Visual Basic 4.0 or higher
- Example programs that use NI-488 functions and NI-488.2 routines

Refer to Appendix B, *Specifications*, for information about the NI-488.2M software transfer rates.

Optional Programming Environments

Your kit includes the NI-488.2M 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 hundreds of 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.

Hardware Configuration and Installation

Chapter

2

This chapter contains instructions to help you configure and install your PC/104-GPIB.

Using the Hardware Default Settings

The PC/104-GPIB default settings are suitable for most PC/104 systems. However, if the default settings conflict with another device in your system, if you are installing the PC/104-GPIB in an 8-bit stack, or if you need to install more than one PC/104-GPIB, you must reconfigure the hardware.

Table 2-1 shows the default settings for the switches and jumpers on the PC/104-GPIB.

Table 2-1. Hardware Default Settings

PC/104-GPIB Setting	Default
Base I/O Address (hex)	2C0
DMA Channel	5
Interrupt Line (IRQ)	11

To modify the default settings of the PC/104-GPIB, skip to the *Configure the Hardware (Optional)* section of this chapter. If you do not need to reconfigure the module, continue to the next section, *Install the Hardware*.

Install the Hardware



Warning: *Electrostatic discharge can damage several components on your PC/104-GPIB. To avoid electrostatic damage when you handle the module, touch the antistatic plastic package to a metal part of your system chassis before you remove the module from the package.*

The PC/104-GPIB is available in two versions: stackthrough 16-bit and stackthrough 8-bit. 16-bit modules have two PC/104 connectors and 8-bit modules have one PC/104 connector. Verify that you have the correct version for your system.

Perform the following steps to install the PC/104-GPIB. In this section, the term *parent module* generically refers to either the parent system or the adjacent PC/104 module you stack the PC/104-GPIB onto.

1. Power off your PC/104 system. Keep the system plugged in so that it remains grounded while you install the PC/104-GPIB.
2. Mount the provided standoffs to the parent module before installing the PC/104-GPIB. You might need to install the provided hex nuts on the bottom side of the parent module to secure the standoffs in place. Notice that the parent module might have only two mounting holes for the standoffs instead of four; in this case, you need only two standoffs.
3. Plug the PC/104-GPIB into the parent module. The PC/104 header is keyed so that it fits in only one direction. Do not force the PC/104 connector into place.

After you plug in the PC/104-GPIB, ensure proper contact by gently pressing down at the PC/104 connector region of the PC/104-GPIB until the module is level with respect to the parent module.

4. Fasten the PC/104-GPIB to the standoffs with the provided 4-40 screws. Refer to Figure 2-1.

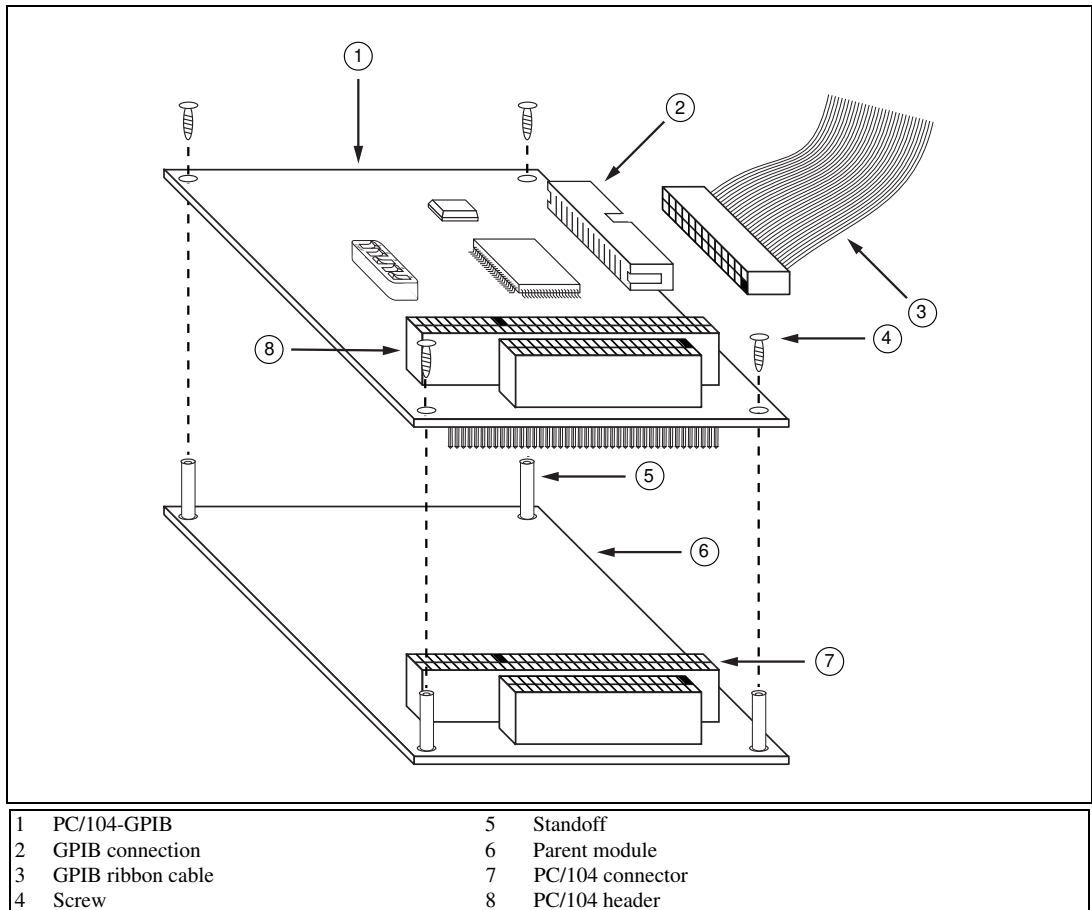


Figure 2-1. Installing the PC/104-GPIB

- Plug the GPIB ribbon cable into the GPIB connection on the PC/104-GPIB. The header is keyed so that it fits in only one direction. Do not force the GPIB ribbon cable connector into place. The GPIB ribbon cable is 20 in. long and terminated with a panel-mount GPIB connector that can be mounted for easy access in your system.

**Note:**

If you plan to perform HS488 high-speed protocol transfers, you must configure the NI-488.2M software for the amount of GPIB cable length in your system. You must add the 20 in. GPIB ribbon cable to your total GPIB cable length.

6. Check the installation.
7. Power on your system and start Windows NT.

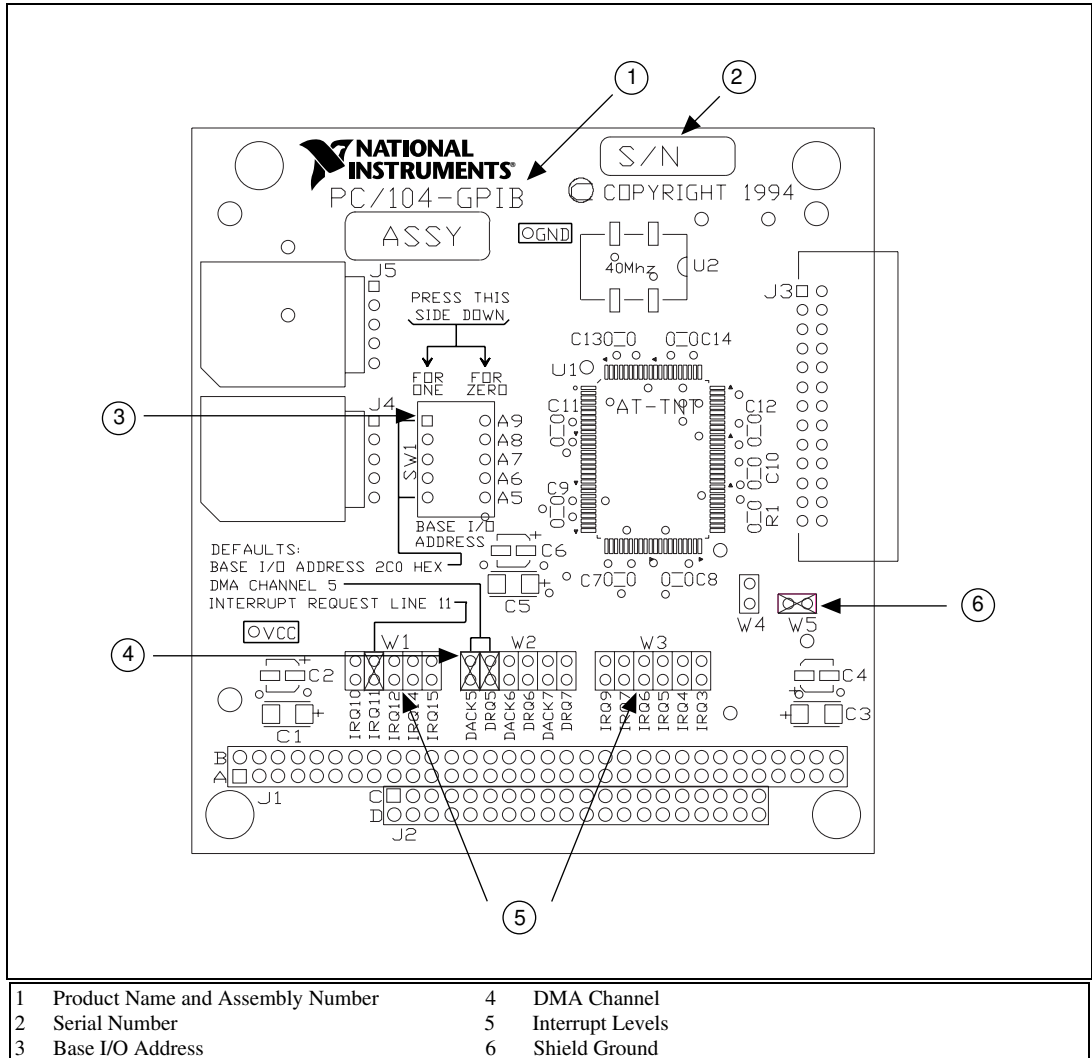
The PC/104-GPIB hardware installation is now complete. Proceed to Chapter 3, *Software Installation and Configuration*.

Configure the Hardware (Optional)

Follow the instructions in this section to change the hardware default settings of the PC/104-GPIB before you install it.

The default settings are suitable for most PC/104 systems. However, if the default settings conflict with another device in your system, if you are installing the PC/104-GPIB in an 8-bit stack, or if you need to install more than one PC/104-GPIB, you must reconfigure the hardware. If you are installing the PC/104-GPIB in an 8-bit stack, you must configure the PC/104-GPIB to use interrupt request level 3, 4, 5, 6 or 7 and disable DMA.

Figure 2-2 shows the location of the configuration jumpers and switches on the PC/104-GPIB.



Selecting the Base I/O Address

PC/104-compatible systems have a segment of address space reserved for input and output. This segment is called the I/O address space. The base I/O address of a PC/104 module such as the PC/104-GPIB is the first position in the I/O address space occupied by the PC/104 module.

By default, the PC/104-GPIB is configured to use base I/O address 2C0 hex. With this setting, the module uses the I/O address space 2C0 hex through 2DF hex. If another device is already using this address range or if you are installing more than one PC/104-GPIB, 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 0x3E0 that is a multiple of 0x20 hex. If you are installing more than one PC/104-GPIB, each module must use a unique base I/O address.

Table 2-2 lists the possible switch settings, the corresponding base I/O addresses, and the I/O address space used for each setting. The default settings are in ***bold italics***.

Table 2-2. Possible Base I/O Address Switch Settings

Switch Setting					Base I/O Address (hex)	I/O Address Space Used (hex)
A9	A8	A7	A6	A5		
0	1	0	0	0	100	100 to 11F
0	1	0	0	1	120	120 to 13F
0	1	0	1	0	140	140 to 15F
0	1	0	1	1	160	160 to 17F
0	1	1	0	0	180	180 to 19F
0	1	1	0	1	1A0	1A0 to 1BF
0	1	1	1	0	1C0	1C0 to 1DF
0	1	1	1	1	1E0	1E0 to 1FF
1	0	0	0	0	200	200 to 21F
1	0	0	0	1	220	220 to 23F

Table 2-2. Possible Base I/O Address Switch Settings (Continued)

Switch Setting					Base I/O Address (hex)	I/O Address Space Used (hex)
A9	A8	A7	A6	A5		
1	0	0	1	0	240	240 to 25F
1	0	0	1	1	260	260 to 27F
1	0	1	0	0	280	280 to 29F
1	0	1	0	1	2A0	2A0 to 2BF
1	0	1	1	0	2C0	2C0 to 2DF
1	0	1	1	1	2E0	2E0 to 2FF
1	1	0	0	0	300	300 to 31F
1	1	0	0	1	320	320 to 33F
1	1	0	1	0	340	340 to 35F
1	1	0	1	1	360	360 to 37F
1	1	1	0	0	380	380 to 39F
1	1	1	0	1	3A0	3A0 to 3BF
1	1	1	1	0	3C0	3C0 to 3DF
1	1	1	1	1	3E0	3E0 to 3FF

2. Locate the base I/O address switch at SW1 on your PC/104-GPIB. Refer to the parts locator diagram, Figure 2-2.
3. Change the switch settings to configure the PC/104-GPIB 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 2-3 for an example of the switch settings and corresponding base I/O addresses.

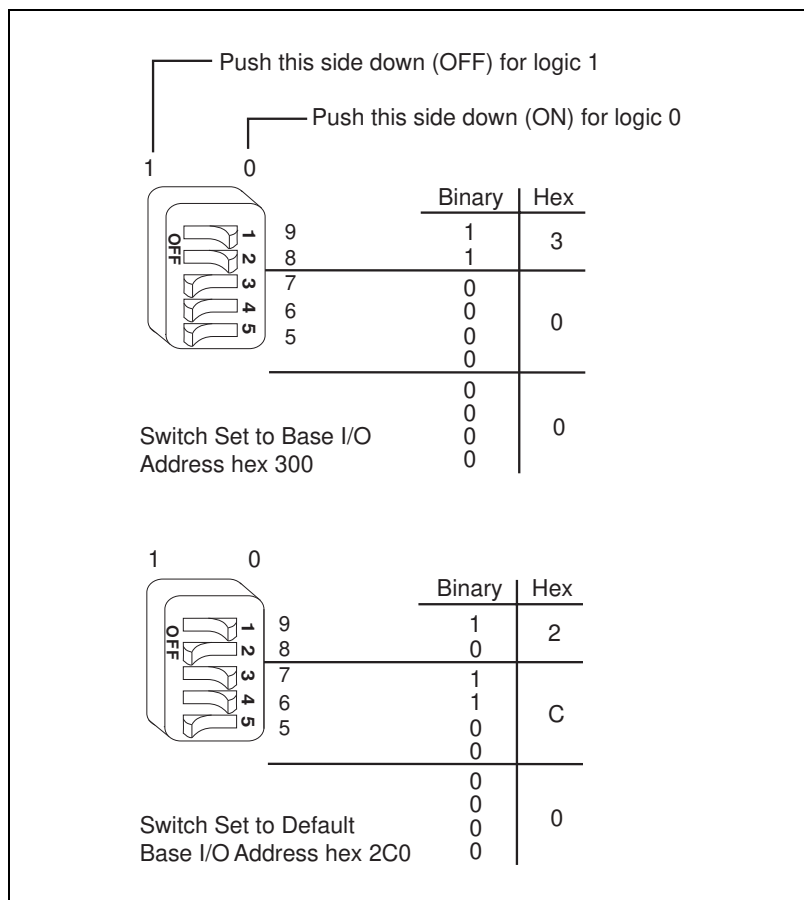


Figure 2-3. Base I/O Address Switch Settings

4. Record your new settings on the *Hardware and Software Configuration Form* in Appendix C, *Customer Communication*.
5. Remember that after you install the NI-488.2M software, you must use the GPIB Configuration utility to configure your software settings to match your new hardware settings. Refer to the *Configure the Software (Optional)* section in Chapter 3, *Software Installation and Configuration*, for information about the GPIB Configuration utility.

Selecting the Interrupt Request Line

PC/104-compatible systems have a series of interrupt request lines available to devices. Devices use interrupts to get immediate service from the CPU for asynchronous events. Your GPIB hardware and the NI-488.2M software use interrupts to get service from the CPU when necessary.



Note:

The GPIB software for Windows NT requires that the PC/104-GPIB be configured to use an interrupt request line.

By default, the PC/104-GPIB is configured to use interrupt request line 11. If this setting conflicts with another device in your system, if you are installing the PC/104-GPIB in an 8-bit stack, or if you need to install more than one PC/104-GPIB, follow these steps to reconfigure the interrupt request line:

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

If you are installing the PC/104-GPIB in a 16-bit stack, you can configure it to use any of the following interrupt lines: IRQ3, 4, 5, 6, 7, 9, 10, 11, 12, 14, or 15. You might not want to select interrupt lines 6 or 14 because the diskette drive controller typically uses interrupt line 6 and the hard disk drive controller uses interrupt line 14 on most systems.

If you are installing the PC/104-GPIB in an 8-bit stack, the only interrupt lines available to you are 3, 4, 5, 6, and 7.

If you are installing more than one PC/104-GPIB, each module must use a unique IRQ level.

2. Find the jumpers at W1 and W3 that set the interrupt request line. The jumpers are located on the lower edge of your PC/104-GPIB. Refer to the parts locator diagram, Figure 2-2.
3. Change the jumper settings to configure the PC/104-GPIB to the new interrupt request line.

To use lines 10, 11, 12, 14, or 15, use the jumper block shown in Figure 2-4. To use interrupt lines 3, 4, 5, 6, 7, or 9, use the jumper block shown in Figure 2-5.

Figure 2-4 shows the setting for IRQ11.

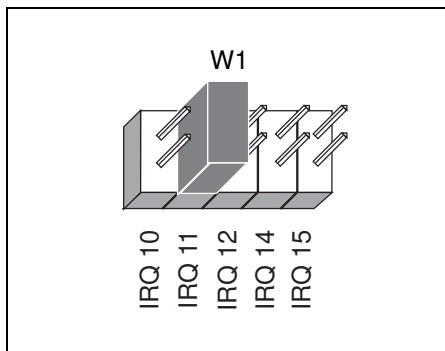


Figure 2-4. Interrupt Jumper Setting for IRQ11 (Default Setting)

Figure 2-5 shows the setting for IRQ5.

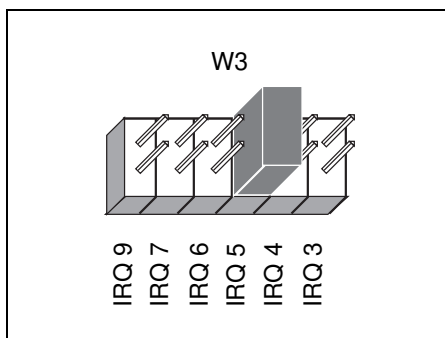


Figure 2-5. Interrupt Jumper Setting for IRQ5

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

Selecting the DMA Channel

Direct memory access (DMA) refers to data transfers directly to or directly from devices such as the PC/104-GPIB and system memory. Your GPIB hardware and the NI-488.2M 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 PC/104-GPIB is configured to use DMA channel 5. If this is not an acceptable setting, if you are installing the PC/104-GPIB in an 8-bit stack, or if you are installing more than one PC/104-GPIB, follow these steps to reconfigure the DMA channel.



Note:

If you are installing the PC/104-GPIB in an 8-bit stack, you must disable DMA, because DMA channels 5, 6, and 7 are 16-bit DMA channels. Refer to Figure 2-8, which shows how to set the DMA jumpers for no DMA.

1. Choose a new DMA channel setting.
You can use channel 5, 6, or 7. If you are installing more than one PC/104-GPIB, each module must either use a unique DMA channel or must not use DMA at all.
2. Locate the jumpers at W2 that select the DMA channel. Refer to the parts locator diagram, Figure 2-2.
3. Change the jumper settings to configure the PC/104-GPIB 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 2-3.

Table 2-3. DMA Channels

DMA Channel	Signal Lines	
	DMA Acknowledge	DMA Request
5	DACK5	DRQ5
6	DACK6	DRQ6
7	DACK7	DRQ7

Figure 2-6 shows the jumper position for selecting DMA channel 7.

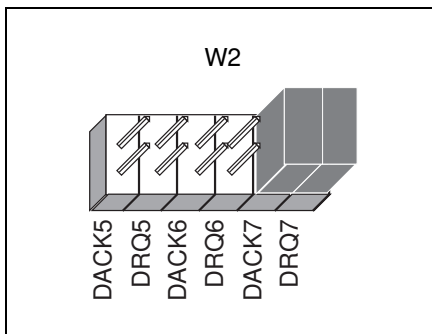


Figure 2-6. DMA Channel Jumper Setting for DMA Channel 7

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

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 PC/104-GPIB by moving the jumpers as shown in Figure 2-7.

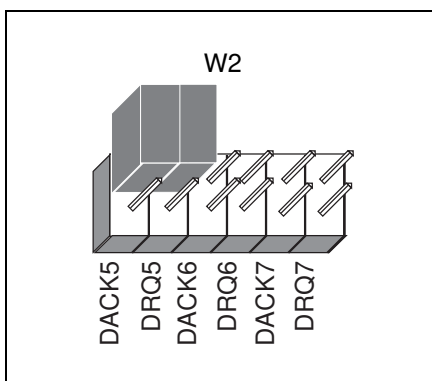


Figure 2-7. DMA Jumper Setting for No DMA Channel

Setting the Shield Ground Configuration

The PC/104-GPIB is set at the factory with the jumper in place to connect the logic ground of the PC/104-GPIB to its shield ground. This configuration minimizes EMI emissions.



Caution:

The PC/104-GPIB 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 W5 on the PC/104-GPIB module.
2. Remove the jumper and place it across only one of the jumper pins, as shown in Figure 2-8.

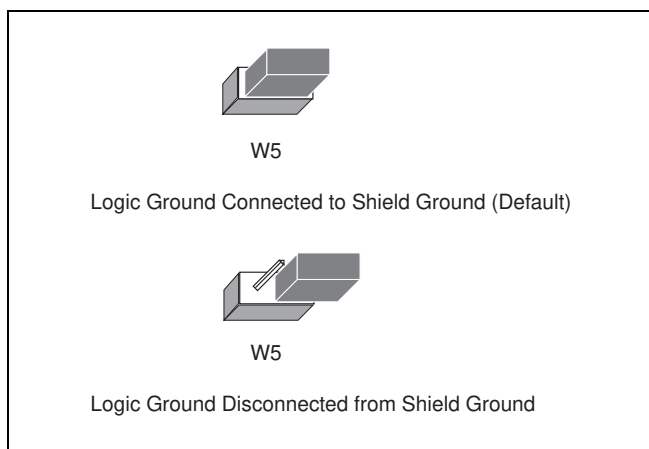


Figure 2-8. Ground Configuration Jumper Settings

3. Record the jumper setting on the *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.

Software Installation and Configuration

Chapter

3

This chapter contains instructions to help you install and configure your NI-488.2M software for Windows NT.

Install the Software

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



Note:

The PC/104-GPIB is functionally identical to the AT-GPIB/TNT. Therefore, the NI-488.2M software for Windows NT refers to the PC/104-GPIB as an AT-GPIB/TNT.

1. Log onto your Windows NT system using the Administrator account. The NI-488.2M installation program must have Administrator privileges because the program modifies the configuration registry of your system.
2. Insert the NI-488.2M software for Windows NT distribution disk into an unused drive.
3. Windows NT 3.51: Select **Run...** from the **File** menu in the **Program Manager**.

Windows NT 4.0 or higher: Select **Run...** from the **Start** menu.

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.

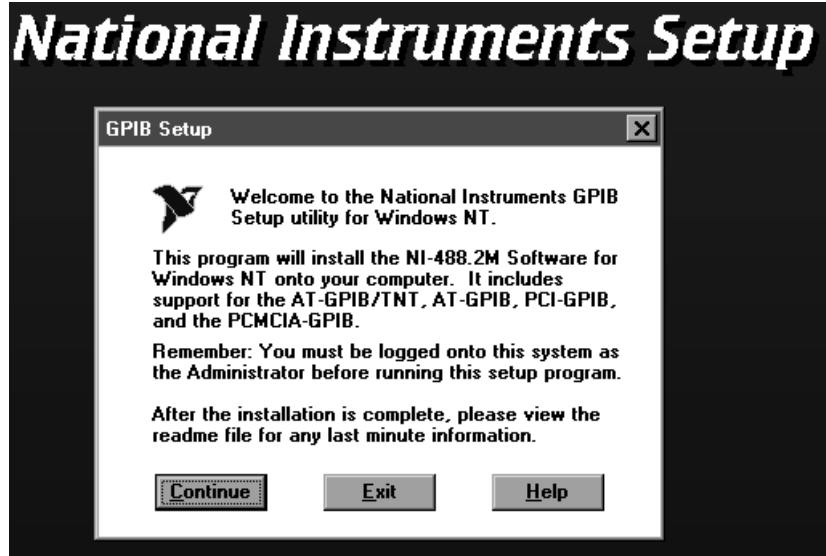


Figure 3-1. NI-488.2M Software for Windows NT Installation Screen

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

When the setup program has finished copying the software onto your system, it attempts to start the NI-488.2M driver. If the setup program cannot start the driver, it instructs you to restart Windows NT, which forces the driver to load.

If you modified the hardware configuration or installed more than one PC/104-GPIB, you must reconfigure the software. Refer to the next section, *Configure the Software (Optional)*, for instructions on running the GPIB Configuration utility. If you do not need to run the GPIB Configuration utility because you are using the default hardware settings, refer to Chapter 4, *Installation Verification*, for instructions on verifying the hardware and software installation.

Configure the Software (Optional)

The GPIB Configuration utility is an interactive utility you can use to examine or modify the configuration of the driver. You must run the GPIB Configuration utility if you changed any of the hardware default settings or if you installed more than one PC/104-GPIB. Follow these steps to run the utility:

1. Double-click on the **GPIB** icon in the **Control Panel**.

Windows NT 3.51: Open the **Control Panel** in the **Main** group of the **Program Manager**.

Windows NT 4.0 or higher: Select **Start»Settings»Control Panel**.

The GPIB Configuration utility displays a list of all the GPIB boards and device names.

2. Use the **Board Type** button to specify the type of GPIB interface. For the PC/104-GPIB, select the **AT-GPIB/TNT Board Type**.
3. Double-click on any name to examine or edit it. For more information about GPIB Configuration utility options, refer to the *NI-488.2M User Manual for Windows 95 and Windows NT* or use the online help.
4. Click on the **OK** button to save your changes.

After you have installed and configured the software, you should verify the installation. Continue to the next chapter, Chapter 4, *Installation Verification*.

Installation Verification

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

You can use the Diagnostic utility, installed with your GPIB software, to test the hardware and software installation. The Diagnostic utility verifies that your hardware and software are functioning properly and that the configuration of your GPIB interfaces does not conflict with anything else in your system.

Follow these instructions to run the Diagnostic utility:

Windows NT 3.51: Double-click on the **Diagnostic** icon in the **NI-488.2M Software for Windows NT** group of the **Program Manager**.

Windows NT 4.0 or higher: Select the **Diagnostic** item under **Start»Programs»NI-488.2M Software for Windows NT**.

When you have started the Diagnostic utility, test your GPIB interfaces by clicking on the **Test All** button. If the Diagnostic utility test is successful, it puts a check mark next to the interface and changes its status from **untested** to **passed**. If the Diagnostic utility test fails, it puts an X next to the interface, and changes its status from **untested** to **failed**. Figure 4-1 shows the Diagnostic utility dialog box after it has tested some GPIB interfaces.

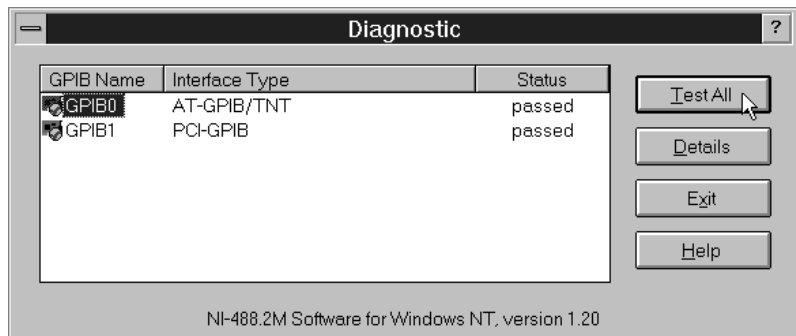


Figure 4-1. Diagnostic Utility after Testing

PC/104-GPIB boards show up as an AT-GPIB/TNT interface type. You can get details on any of the tested GPIB interfaces by selecting the interface and clicking on the **Details** button. For each failed GPIB interface, select it and click on the **Details** button to get a description of the failure encountered. Use that information and the information in Appendix A, *Troubleshooting and Common Questions*, to troubleshoot the problem. There is also extensive troubleshooting information in the Diagnostic online help.

Using the GPIB Software

This chapter helps you get started with the NI-488.2M software for Windows NT.

Introduction to the Win32 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 the function calls return. You can use this 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.

Follow these instructions to run the Win32 Interactive Control Utility:

Windows NT 3.51: Double-click on the **Win32 Interactive Control** icon in the **NI-488.2M Software for Windows NT** group of the **Program Manager**.

Windows NT 4.0 or higher: Select the **Win32 Interactive Control** item under **Start»Programs»NI-488.2M Software for Windows NT**.

This utility includes extensive online help, which you can access by entering `help` at the `:` prompt. For more information about the Win32 Interactive Control utility, refer to the *NI-488.2M User Manual for Windows 95 and Windows NT*.

Introduction to the GPIB Spy Utility

Included with the NI-488.2M software is GPIB Spy, a Win32 utility that you can use to monitor NI-488.2M calls made by Win32, Win16, and DOS GPIB applications. You can use GPIB Spy to do the following:

- Capture information about NI-488 functions and NI-488.2M routines as your GPIB applications invoke them.
- Display captured information, including, but not limited to, input and output parameter values, I/O buffer contents, and return values.
- Save, restore, and print captured information.

Follow these instructions to run GPIB Spy:

Windows NT 3.51: Double-click on the **GPIB Spy** icon in the **NI-488.2M Software for Windows NT** group of the **Program Manager**.

Windows NT 4.0 or higher: Select the **GPIB Spy** item under **Start»Programs»NI-488.2M Software for Windows NT**.

For more information about the GPIB Spy utility, refer to Chapter 5, *GPIB Spy Utility*, in the *NI-488.2M User Manual for Windows 95 and Windows NT*, or use the GPIB Spy context-sensitive online help.

General Programming Considerations

As you begin developing your Win32 NI-488.2M application, remember the following points:

- For your C/C++ application, you must include the NI-488.2M header file in your source code.
- You can access the NI-488.2M software through the 32-bit DLL, `gpiib-32.dll`, either by linking with one of the language interfaces provided with the NI-488.2M software, or by using direct DLL entry from any programming environment.
- Several sample GPIB applications are included with the NI-488.2M software. Use these as a guide for your own application development.

For information about choosing a programming method, developing your application, or compiling and linking, refer to the *NI-488.2M User Manual for Windows 95 and Windows NT*. For detailed information about each NI-488 function and NI-488.2 routine, refer to the *NI-488.2M Function Reference Manual for Win32*.

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 your NI-488.2M software includes.

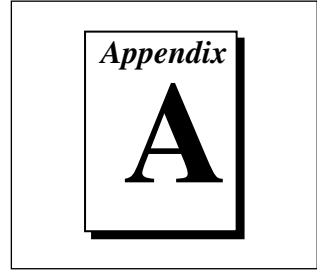
To run DOS GPIB applications, load the special GPIB device driver `gpib-nt.com` instead of `gpib.com`, which you normally use with DOS. When you install the NI-488.2M software, the installation program copies `gpib-nt.com` into a new subdirectory called `doswin16`. To use `gpib-nt.com`, you must modify your `config.nt` file to load `gpib-nt.com` whenever a DOS application runs. 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, the installation program copies `gpib.dll` into the `winnt\system32` directory, where `winnt` is your Windows NT directory, for example `c:\windows`. As long as `gpib.dll` is in your Windows NT directory, your system automatically accesses `gpib.dll` whenever you launch a 16-bit Windows GPIB application.

Troubleshooting and Common Questions



This appendix contains troubleshooting information and the answers to common questions.

Troubleshooting Diagnostic Utility Failures

The following sections explain common error messages the Diagnostic utility generates.

Missing Software Components

This error occurs if the software components that are necessary for the GPIB software for Windows NT to function correctly are not present in the system. If you encounter this problem, reinstall the GPIB software for Windows NT and run the Diagnostic utility again.

No GPIB Interfaces Present

This error occurs if there is no PC/104-GPIB physically present in the system or there is a resource conflict with the interfaces that are installed. If you encounter this problem, use the GPIB Configuration utility to examine any installed GPIB interfaces and the resources assigned to each. Then, run the Diagnostic utility again.

To access this information in the GPIB Configuration utility, complete the following steps:

1. Double-click on the **GPIB** icon in the **Control Panel**.

Windows NT 3.51: Open the **Control Panel** in the **Main** group of the **Program Manager**.

Windows NT 4.0 or higher: Select **Start»Settings»Control Panel**.

2. Click on the **Board Type** button and verify that the type of GPIB interface listed for each logical board name is correct. Click on the **OK** button to return to the main dialog box.
3. Double-click on each board name and verify that the hardware settings displayed in the dialog box match your actual hardware settings.

GPIB Cables Need to Be Disconnected

This error occurs if you have any GPIB cables connected to the PC/104-GPIB. Disconnect all GPIB cables and run the Diagnostic utility again.

Address Resource Conflict

This error occurs if the address resources assigned to a PC/104-GPIB conflict with the address resources that other devices in the system are using. To resolve an address resource conflict, refer to the *Resolving Resource Conflicts* section later in this appendix. After you have resolved the conflict, run the Diagnostic utility again.

Interrupt Resource Conflict

This error occurs if the interrupt resources assigned to a PC/104-GPIB conflict with the interrupt resources that other devices in the system are using. To resolve an interrupt resource conflict, refer to the *Resolving Resource Conflicts* section later in this appendix. After you have resolved the conflict, run the Diagnostic utility again.

DMA Resource Conflict

This error occurs if the DMA resources assigned to a PC/104-GPIB conflict with the DMA resources that other devices in the system are using. To resolve a DMA resource conflict, refer to the *Resolving Resource Conflicts* section later in this appendix. After you have resolved the conflict, run the Diagnostic utility again.

Single-Cycle DMA Required

This error occurs if the Diagnostic utility detects that it is unable to perform demand-mode DMA for the PC/104-GPIB and that you have not configured the GPIB software to use single-cycle DMA. If you encounter

this error, you should use the GPIB Configuration utility to configure the NI-488.2M software to use single-cycle DMA for all DMA transfers, and then run the Diagnostic utility again.

To configure the NI-488.2M software to use single-cycle DMA for the PC/104-GPIB, complete the following steps.

1. Double-click on the **GPIB** icon in the **Control Panel**.
 Windows NT 3.51: Open the **Control Panel** in the **Main** group of the **Program Manager**.
 Windows NT 4.0 or higher: Select **Start»Settings»Control Panel**.
2. Double-click on **AT-GPIB/TNT**.
3. Make sure that the **Use Demand Mode DMA** item is unchecked.

GPIB Software Problem Encountered

This error occurs if the Diagnostic utility detects that it is unable to communicate correctly with the GPIB hardware using the installed GPIB software. If you encounter this error, shut down your system, restart it, and run the Diagnostic utility again. If the problem persists, try reinstalling the GPIB software for Windows NT.

Unknown Problem Encountered

This error occurs if an unknown problem is encountered when you try to execute the Diagnostic utility. If this error occurs, shut down your system, restart it, and run the Diagnostic utility again. If the problem persists, try reinstalling the GPIB software for Windows NT.

Resolving Resource Conflicts

Resource conflicts occur when your system contains hardware that is configured to use the same resources as your PC/104-GPIB. The NI-488.2M driver detects some resource conflicts when it loads. When the driver detects conflicts as it loads, it records an error message describing the conflict. You can use the **Event Viewer**, as described in the following section, *Using Windows NT Diagnostic Tools*, to see which resource is in conflict.

Once you have identified the resource that caused the conflict, use the GPIB Configuration utility to reconfigure your PC/104-GPIB so that it

uses conflict-free resources. To help in the selection of conflict-free resources, Microsoft has provided a utility called **Windows NT Diagnostics**. This utility displays a list of the I/O port addresses, interrupt levels, and DMA channels that are currently being used in your system. Use system resources that this utility does *not* list when you assign resources to your PC/104-GPIB.

Follow these instructions to run the **Windows NT Diagnostics** utility:

Windows NT 3.51: Double-click on the **Windows NT Diagnostics** icon in the **Administrative Tools** group of the **Program Manager**.

Windows NT 4.0 or higher: Select **Start»Programs»Administrative Tools»Windows NT Diagnostics**.



Note: *For 8-bit operation, you must disable DMA and use only interrupt request line 3, 4, 5, 6, or 7.*

Using Windows NT Diagnostic Tools

There are many reasons why the NI-488.2M driver might not load. 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**, and the **Event Viewer**. The following sections describe the information available through each utility.

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**, as shown in the following paragraphs.

Windows NT 3.51: Open the **Control Panel** in the **Main** group of the **Program Manager**.

Windows NT 4.0 or later: Select **Start»Settings»Control Panel**.

This utility lists all of the devices Windows NT detects. 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 (PCI-GPIB)	****	System

The **GPIB Board Class Driver**, the **GPIB Device Class Driver**, and 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. Refer to Chapter 3, *Software Installation and Configuration*.

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, as shown in the following paragraphs.

Windows NT 3.51: Double-click on the **Event Viewer** icon in the **Administrative Tools** group of the **Program Manager**.

Windows NT 4.0 or higher: Select **Start»Programs»Administrative Tools»Event Viewer**. Events that might appear in the system log include the following:

- The system cannot 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 the NI-488.2M software. Refer to Chapter 2, *Hardware Configuration and Installation*, and Chapter 3, *Software Installation and Configuration*, for configuration information.

Common Questions

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

Run the GPIB Configuration utility. To run the utility, open your Windows NT Control Panel and select the National Instruments eagle icon.



Note:

The PC/104-GPIB is functionally identical to the AT-GPIB/TNT. Therefore, the NI-488.2M software for Windows NT refers to the PC/104-GPIB as an AT-GPIB/TNT.

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

Run the Diagnostic utility, as follows:

Windows NT version 3.51: Start the Diagnostic utility by double-clicking on the **Diagnostic** icon in the **NI-488.2M Software for Windows NT** group of the **Program Manager**.

Windows NT version 4.0 or later: Start the Diagnostic utility by choosing the **Diagnostic** item under **Start»Programs»NI-488.2M Software for Windows NT**.

How many GPIB interfaces can I configure for use with my NI-488.2M Software for Windows NT?

You can configure the NI-488.2M Software for Windows NT to communicate with up to 4 GPIB interfaces.

How many devices can I configure for use with my NI-488.2M Software for Windows NT?

The NI-488.2M Software for Windows NT provides a total of 100 logical devices for applications to use. The default number of devices is 32.

Are interrupts and DMA required with the NI-488.2M Software for Windows NT?

Interrupts are required, but DMA is not.

How can I determine if my GPIB hardware and software are correctly installed?

Run the Diagnostic utility, as follows:

Windows NT version 3.51: Start the Diagnostic utility by double-clicking on the **Diagnostic** icon in the **NI-488.2M Software for Windows NT** group of the **Program Manager**.

Windows NT version 4.0 or later: Start the Diagnostic utility by choosing the **Diagnostic** item under **Start»Programs»NI-488.2M Software for Windows NT**.

When should I use the Win32 Interactive Control utility?

You can use the Win32 Interactive Control utility to test and verify instrument communication, troubleshoot problems, and develop your application. For more information, refer to Chapter 6, *Win32 Interactive Control Utility*, in the *NI-488.2M User Manual for Windows 95 and Windows NT*.

How do I use an NI-488.2M language interface?

For information about using NI-488.2M language interfaces, refer to Chapter 3, *Developing Your Application*, in the *NI-488.2M User Manual for Windows 95 and Windows NT*.

What do I do if the Diagnostic utility fails with an error?

Use the Diagnostic online help, or refer to the getting started manual, to troubleshoot specific problems. If you have already completed the troubleshooting steps, fill out the support forms in Appendix C, *Customer Communication*, and contact National Instruments.

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*, in the *NI-488.2M User Manual for Windows 95 and Windows NT*, 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.

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 `iberr`. For more information about global status variables, refer to Chapter 3, *Developing Your Application*, in the *NI-488.2M User Manual for Windows 95 and Windows NT*.

What information should I have before I call National Instruments?

When you call National Instruments, you should have the results of the Diagnostic test. Also, make sure you have filled out the technical support form in Appendix C, *Customer Communication*.

Specifications

This appendix describes the physical characteristics of the PC/104-GPIB and the transfer rates of the NI-488.2M software, along with the recommended operating conditions.

Hardware Characteristics

Table B-1. PC/104-GPIB Hardware Characteristics

Characteristic	Specification
Dimensions	9.017 cm by 9.589 cm (3.55 in. by 3.775 in.)
Power Requirement (from PC AT I/O Channel)	+5 VDC 50 mA Typical 120 mA Maximum
I/O Connector	20 in. Ribbon Cable Terminated with Panel-Mount IEEE 488 Standard 24-Pin
Operating Environment Ambient Temperature Relative Humidity	-40° to 85° C 10% to 90%, Noncondensing
Storage Environment Temperature Relative Humidity	-40° to 85° C 5% to 90%, Noncondensing
EMI	FCC Class A Verified

Software Transfer Rates

Table B-2. NI-488.2M Software Transfer Rates for the PC/104-GPIB

Transfer Method	Maximum GPIB Transfer Rate
3-Wire (IEEE 488)	1.5 Mbytes/s*
High Speed (HS488)	1.8 Mbytes/s*
* Actual speed may vary considerably from speed shown because of system and instrumentation capabilities.	

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.

Electronic Services



Bulletin Board Support

National Instruments has BBS and FTP sites dedicated for 24-hour support with a collection of files and documents to answer most common customer questions. From these sites, you can also download the latest instrument drivers, updates, and example programs. For recorded instructions on how to use the bulletin board and FTP services and for BBS automated information, call (512) 795-6990. You can access these services at:

United States: (512) 794-5422

Up to 14,400 baud, 8 data bits, 1 stop bit, no parity

United Kingdom: 01635 551422

Up to 9,600 baud, 8 data bits, 1 stop bit, no parity

France: 01 48 65 15 59

Up to 9,600 baud, 8 data bits, 1 stop bit, no parity



FTP Support

To access our FTP site, log on to our Internet host, `ftp.natinst.com`, as anonymous and use your Internet address, such as `joesmith@anywhere.com`, as your password. The support files and documents are located in the `/support` directories.



Fax-on-Demand Support

Fax-on-Demand is a 24-hour information retrieval system containing a library of documents on a wide range of technical information. You can access Fax-on-Demand from a touch-tone telephone at (512) 418-1111.





E-Mail Support (currently U.S. only)

You can submit technical support questions to the applications engineering team through e-mail at the Internet address listed below. Remember to include your name, address, and phone number so we can contact you with solutions and suggestions.

support@natinst.com

Telephone and Fax Support

National Instruments has branch offices all over the world. Use the list below to find the technical support number for your country. If there is no National Instruments office in your country, contact the source from which you purchased your software to obtain support.

	 Telephone	 Fax
Australia	03 9879 5166	03 9879 6277
Austria	0662 45 79 90 0	0662 45 79 90 19
Belgium	02 757 00 20	02 757 03 11
Canada (Ontario)	905 785 0085	905 785 0086
Canada (Quebec)	514 694 8521	514 694 4399
Denmark	45 76 26 00	45 76 26 02
Finland	09 725 725 11	09 725 725 55
France	01 48 14 24 24	01 48 14 24 14
Germany	089 741 31 30	089 714 60 35
Hong Kong	2645 3186	2686 8505
Israel	03 5734815	03 5734816
Italy	02 413091	02 41309215
Japan	03 5472 2970	03 5472 2977
Korea	02 596 7456	02 596 7455
Mexico	5 520 2635	5 520 3282
Netherlands	0348 433466	0348 430673
Norway	32 84 84 00	32 84 86 00
Singapore	2265886	2265887
Spain	91 640 0085	91 640 0533
Sweden	08 730 49 70	08 730 43 70
Switzerland	056 200 51 51	056 200 51 55
Taiwan	02 377 1200	02 737 4644
U.K.	01635 523545	01635 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 _____

Title _____

Company _____

Address _____

Fax (____) _____ Phone (____) _____

System brand _____ Model _____ Processor _____

Operating system (include version number) _____

Clock 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 _____

The problem is _____

List any error messages _____

The following steps will reproduce the problem _____

Hardware and Software Configuration Form

Record the settings and revisions of your hardware and software on the line to the right of each item. Complete a new copy of this form each time you revise your software or hardware configuration, and use 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.

National Instruments Products

GPIO Interface Type and Revision _____

GPIO Software for Windows NT Version Number on Disk _____

Programming Language Interface Version _____

Diagnostic Utility Results _____

Other Products

Resource Summary Report from the Device Manager

To create this report, first display the **System Properties** dialog box for the system by double-clicking on the **System** icon under **Start»Settings»Control Panel**. Then click on the **Device Manager** tab and highlight the **Computer** icon. Click on the **Print** button, and check the **Print to file** checkbox in the **Print** dialog box before clicking on **OK**.

Programming Environment Information

Programming Language _____

Compiler Vendor _____ Compiler Version _____

Application Information

DOS Application _____ Win16 Application _____ Win32 Application _____

If Win16 or Win32, method of accessing DLL (link with language interface or direct entry?)

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 PC/104-GPIB Hardware and the NI-488.2M™ Software for Windows NT*

Edition Date: May 1997

Part Number: 321375A-01

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

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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)

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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
ANSI	American National Standards Institute
ASIC	application-specific integrated circuit
C	Celsius
CE	Conformite Europeene
CPU	central processing unit
DMA	direct memory access
FCC	Federal Communications Commission
GPIB	General Purpose Interface Bus

hex	hexadecimal
Hz	hertz
I/O	input/output
IEEE	Institute of Electrical and Electronic Engineers
in.	inches
IRQ	interrupt request
m	meters
MB	megabytes of memory
PC	personal computer
RAM	random-access memory
s	seconds
VDC	volts direct current