Serial

Getting Started with Your PCI Serial Hardware and Software for Windows NT

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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.

Canadian Department of Communications

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Federal Communications Commission

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

• Reorient or relocate the receiving antenna.

• Increase the separation between the equipment and receiver.

• Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.

• Consult the dealer or an experienced radio/TV technician for help.

Canadian Department of Communications

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

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

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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.

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About This Manual

This manual contains instructions to help you install and configure the National Instruments serial hardware and the NI Serial software for Windows NT. The serial hardware covered by this manual includes the PCI-232/2, PCI-232/4, PCI-485/2, PCI-485/4, and PCI-232/8. This manual assumes that you are already familiar with Windows NT.

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, provides an overview of the serial hardware and the NI Serial software, and describes optional equipment you can order.

- Chapter 2, *Installation and Verification,* contains instructions to help you install the NI Serial software, serial hardware, and cables, and to verify the installation.

- Chapter 3, *Configuration*, contains instructions to help you view or change the communication port settings.

- Chapter 4, *Using Your Serial Hardware,* describes how to set the hardware transceiver control mode for your RS-485 interfaces and lists some general programming requirements.

- Appendix A, *Specifications*, describes the characteristics of the serial hardware, the NI Serial software, and the recommended operating conditions.

- Appendix B, *Serial Port Information,* discusses the RS-232, RS-422, and RS-485 standards and explains some of the issues involved with these types of serial communication.

- Appendix C, *Uninstalling the Serial Hardware and Software*, explains how to uninstall your serial hardware and NI Serial software.

- Appendix D, *Troubleshooting and Common Questions,* describes how to troubleshoot problems and answers some common questions.

- Appendix E, *Customer Communication,* contains forms you can use to request help from National Instruments or to comment on our products and manuals.

•   The *Glossary* contains an alphabetical list and description of terms used in this manual, including abbreviations, acronyms, metric prefixes, mnemonics, and symbols.

Conventions Used in This Manual

This manual uses the following conventions:

»	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 open the **File** menu, select the **Page Setup** item, select **Options**, and finally select the **Substitute Fonts** option from the last dialog box.
☞	This icon to the left of bold italicized text denotes a note, which alerts you to important information.
⚠	This icon to the left of bold italicized text denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash.
bold	Bold text denotes the names of icons, menus, menu items, parameters, dialog boxes, or dialog box buttons or options.
bold italic	Bold italic text denotes a note or caution.
italic	Italic text denotes disk names, emphasis, a cross reference, or an introduction to a key concept. This font also denotes text from which you supply the appropriate word or value, as in Windows 3.*x*.
monospace	Text in this font denotes text or characters that you should literally enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames and extensions, and for statements and comments taken from programs.
monospace bold	Bold text in this font denotes the messages and responses that the computer automatically prints to the screen.

Related Documentation

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

- ANSI/EIA-232-D Standard, *Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange*

- EIA/RS-422-A Standard, *Electrical Characteristics of Balanced Voltage Digital Interface Circuits*

- EIA-485 Standard, *Standard for Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems*

- *Microsoft Win32 Software Developer Kit*, Online Documentation for *Win32 Overviews*, *Win32 Reference*, and *Microsoft Windows NT System Guide*, Microsoft Corporation

- *NS16550AF Universal Asynchronous Receiver/Transmitter with FIFOs*, National Semiconductor

- *ST16C654 Asynchronous Receiver/Transmitter with FIFOs*, EXAR Corp.

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 E, *Customer Communication*, at the end of this manual.

1

Introduction

This chapter explains how to use this manual, lists what you need to get started, provides an overview of the serial hardware and the NI Serial software, and describes optional equipment you can order.

How to Use This Manual

Chapter 1	Gather What You Need to Get Started
Chapter 2	Install the NI Serial Software → Install the Serial Hardware → Verify the Installation → Passes? → No → Troubleshooting → Yes → Connect the Cables
Chapter 3	Configure the Serial Port
Chapter 4	Learn About Transceiver Control Modes → Review Programming Requirements
	Write Application Program
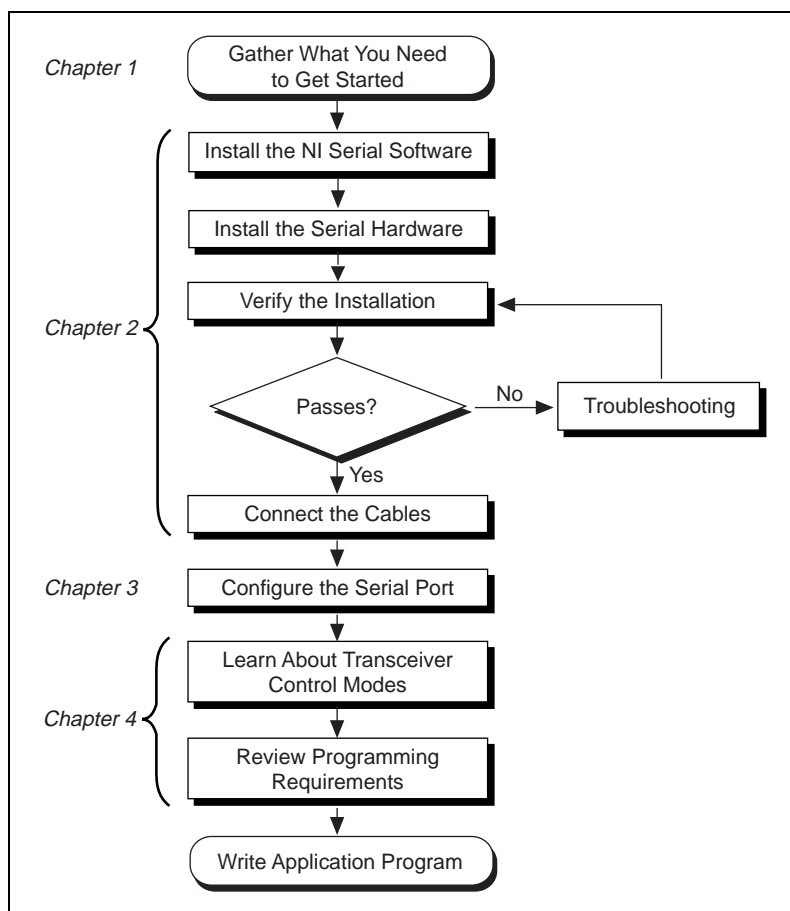
What You Need to Get Started

Make sure you have all of the following items before you attempt to install the serial hardware and software:

❑   Windows NT version 4.0 or later installed on your computer

❑   One of the following serial boards, which is included in your kit:

> PCI-232 (two, four, or eight port)
> PCI-485 (two or four port)

❑   3.5 in., high-density disk (1.44 MB), *NI Serial Software for Windows 95/98 and Windows NT*, which is included in your kit

Optional Equipment

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

•   DB-9 RS-485 termination connector (PCI-485 only)

•   10-position modular jack to DB-9 cable (four-port boards only)

•   10-position modular jack to DB-25 cable (four-port boards only)

•   RS-232 9-pin to 9-pin null modem cable

•   RS-232 9-pin to 25-pin null modem cable

Serial Hardware Overview

The serial hardware gives you a variety of solutions for serial communications. The PCI-232 boards work with the RS-232 protocols, and the PCI-485 boards work with the RS-422 and RS-485 protocols. You can use the PCI-232 boards for serial communication up to distances of 50 ft. You can connect the PCI-485 boards with up to 31 devices using serial cable lengths up to 4,000 ft.

Additionally, the PCI serial boards are available in a two-port version (PCI-232/2 and PCI-485/2), a four-port version (PCI-232/4 and PCI-485/4), and an eight-port version (PCI-232/8). The two-port versions use DB-9 connectors. The four-port versions use 10-position modular jacks to provide all four connections on a single back panel. Optional cable accessories convert the 10-position modular jacks to either DB-9 or DB-25 connectors with standard pinouts. The eight-port version uses an adapter

cable to convert the 68-pin connector on the board to eight DB-9 connectors. Throughout this manual, references to PCI serial boards generally refer to all port versions of the boards.

The PCI-485 boards support four hardware transceiver control modes for reliable communication with two-wire and four-wire devices. Refer to Chapter 4, *Using Your Serial Hardware*, for more information about transceiver control modes.

All of the serial hardware uses standard 16550-compatible UARTs (Universal Asynchronous Receiver/Transmitters) for 100 percent compatibility with standard PC COM ports. The serial hardware contains FIFOs (First-In-First-Out buffers) for reduced susceptibility to interrupt latency and faster transmission rates. Full Plug and Play compatibility gives you the convenience of switchless configuration and installation. Refer to Appendix A, *Specifications*, for more information about the serial hardware specifications and operating conditions.

NI Serial Software Overview

The NI Serial software for Windows NT includes a native Windows NT kernel driver that can provide full interrupt-driven, buffered I/O for multiple COM ports. Using this driver, you can obtain a maximum baud rate of 460.8 KBaud for the PCI-485 and 115.2 KBaud for the PCI-232. The NI Serial software also provides a configuration utility, which is integrated with the Windows NT Control Panel. Refer to Appendix A, *Specifications*, for more information about software specifications and recommended operating conditions.

The NI Serial software includes the following components:

- Device driver
- Diagnostic test
- Configuration utility

The NI Serial software supports all National Instruments serial hardware, including all AT, PCI, PXI, CompactPCI, and PCMCIA versions.

Optional Programming Tools

Your kit includes the NI Serial software for Windows 98/95 and Windows NT. 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 serial 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.

Using the Serial Hardware with Other National Instruments Products

You can use standard serial I/O functions in LabVIEW and LabWindows/CVI with any National Instruments serial interface, once you have installed the hardware and software. If you already have LabVIEW or LabWindows and want to use it with your serial hardware, refer to your LabVIEW or LabWindows documentation for information about serial I/O functions.

2

Installation and Verification

This chapter contains instructions to help you install the NI Serial software, serial hardware, and cables, and to verify the installation.

Install the NI Serial Software

Install the NI Serial software for Windows NT before you install the hardware.

1. Log on as `Administrator` or as a user who has `Administrator` privileges.

2. Select **Start»Settings»Control Panel**.

3. Double-click on the **Add/Remove Programs** icon in the Control Panel to launch the Add/Remove Programs applet. A dialog box similar to the one in Figure 2-1 appears.

Figure 2-1. Add/Remove Programs Properties Dialog Box

4. Click on the **Install** button.

5. When prompted, insert the *NI Serial Software for Windows 95/98 and Windows NT (Setup Disk),* and click on the **Next** button to proceed. The software installation wizard begins with the screen shown in Figure 2-2.

Figure 2-2. NI Serial Setup Screen

The setup wizard guides you through the necessary steps to install the NI Serial software. You can go back and change values where appropriate by clicking on the **Back** button. You can exit the setup where appropriate by clicking on the **Cancel** button.

☞ **Note**   *This installation backs up the Microsoft Windows NT serial driver* serial.sys *to* serial.bak *and then overwrites* serial.sys*. You can find* serial.sys *in the Windows NT* .....\system32\drivers *directory.*

6. If you have already installed your hardware, restart Windows NT then proceed to the section *Verify the Installation*.

The software installation is complete. Proceed to the next section, *Install the PCI Serial Hardware*.

Install the PCI Serial Hardware

This section describes how to install your PCI serial board.

☞ **Note**   *If you are installing a PCI-485, you might need to adjust the value of the bias resistors, depending on your application. For more information, refer to Appendix B,* Serial Port Information*.*

⚠ **Caution**   *Electrostatic discharge can damage several components on your board. 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.*

Complete the following steps to install your PCI serial board:

1. Turn off your computer. Keep the computer plugged in so that it remains grounded while you install the PCI serial board.

2. Remove the top or side cover of the computer.

3. Remove the expansion slot cover on the back of the computer.

4. Insert the PCI serial board into an unused slot with the serial connectors sticking out of the opening on the back panel. Make sure that you insert the board all the way into the slot. The board might seem to click firmly into place, even though it is only part of the way in. Figure 2-3 shows the installation of a PCI serial board.
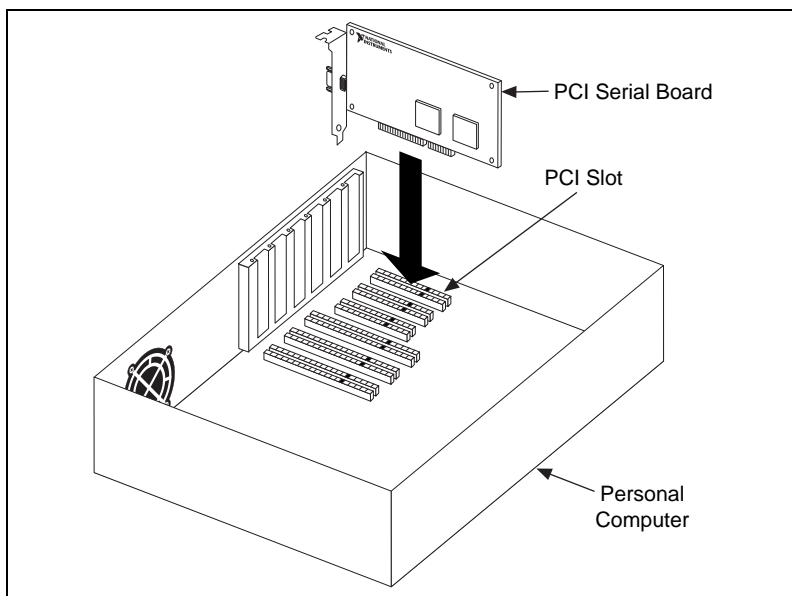
Figure 2-3. PCI Serial Board Installation

5. Screw the mounting bracket of the PCI serial board to the back panel rail of the computer.

6. Replace the cover, and turn on your computer.

The serial hardware installation is now complete.

Verify the Installation

Determine Which Physical Port Is Associated with COMx

Select **Start»Settings»Control Panel**, and double-click on **niports**. A list showing installed National Instruments ports with their logical COM*x* names appears. If your interface is not on the list, refer to Appendix D, *Troubleshooting and Common Questions*.

Select the COM port you want and click on the **Settings** button to display the **General Port Settings** dialog box for that port. This dialog box displays the serial number of the serial hardware and the physical port number starting at 1. On all serial hardware, PORT1 refers to the top port, PORT2 refers to the next port down, and so on.

When you have finished verifying the driver installation and physical port, proceed to the next section, *Run the Diagnostic Test*.

Run the Diagnostic Test

To verify and test the installation, run the diagnostic program that came with your NI Serial software. The diagnostic program verifies that your serial driver is installed properly, that the configuration of your hardware does not conflict with anything else in your system, and that the serial driver can communicate with your hardware correctly.

To run the test, select the **diagnostics** item under **Start»Programs» National Instruments Serial**.

If the diagnostic test completes with no failures, your serial hardware and software are installed properly. If it fails, refer to Appendix D, *Troubleshooting and Common Questions*, for troubleshooting instructions.

Connect the Cables

For the two-port PCI serial boards, you can use the standard DB-9 connector found on most serial cables. To use the DB-9 connector with the four-port PCI serial boards, you need the 10-position modular jack to DB-9 cable (available from National Instruments). You can also use a DB-25 connector with the four-port PCI serial boards by ordering the 10-position modular jack to DB-25 cable from National Instruments. The eight-port PCI serial ships with a pig tail cable adapter, providing eight standard DB-9 connectors.

DB-9 Connector

Figure 2-4 and Table 2-1 give the pin locations and descriptions of the DB-9 connector, which is found on the two-port PCI serial board, the 10-position modular jack to DB-9 cable, and the cable adapter for the eight-port board.
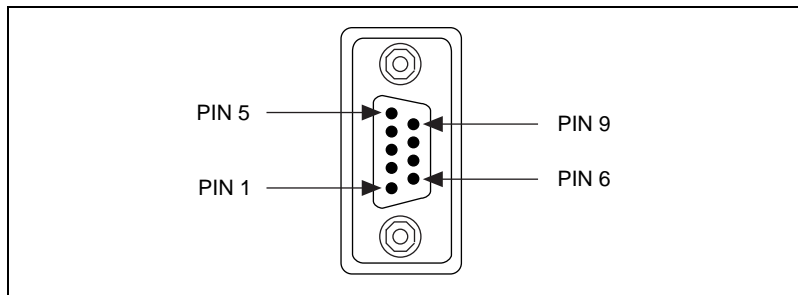
Figure 2-4. DB-9 Connector Pin Locations

Table 2-1. DB-9 Pin Descriptions

DB-9 Pin	232 Signal	485 Signal
Pin 1	DCD	GND
Pin 2	RXD	CTS+ (HSI+)
Pin 3	TXD	RTS+ (HSO+)
Pin 4	DTR	RXD+
Pin 5	GND	RXD–
Pin 6	DSR	CTS- (HSI-)
Pin 7	RTS	RTS– (HSO–)

Table 2-1. DB-9 Pin Descriptions (Continued)

DB-9 Pin	232 Signal	485 Signal
Pin 8	CTS	TXD+
Pin 9	RI	TXD–

Modular Jack Connector

Figure 2-5 and Table 2-2 give the pin locations and descriptions of the 10-position modular jack, which is found on the four-port PCI serial board.
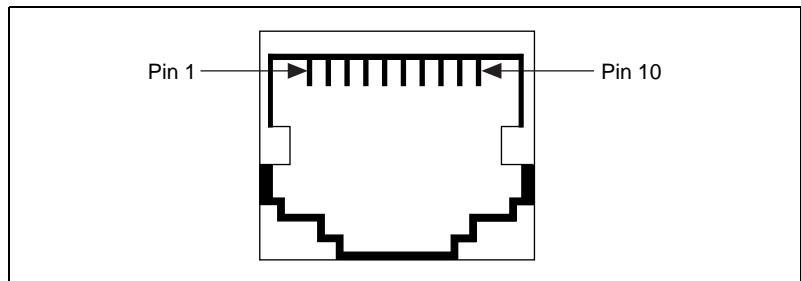
Figure 2-5. 10-Position Modular Jack Pin Locations

Table 2-2. 10-Position Modular Jack Pin Descriptions

10-Position Modular Jack	232 Signal	485 Signal
Pin 10	DCD	GND
Pin 9	RXD	CTS+ (HSI+)
Pin 8	TXD	RTS+ (HSO+)
Pin 7	DTR	RXD+
Pin 6	GND	RXD–
Pin 5	DSR	CTS– (HSI–)
Pin 4	RTS	RTS– (HSO–)
Pin 3	CTS	TXD+
Pin 2	RI	TXD–
Pin 1	No Connect	No Connect

DB-25 Connector

Figure 2-6 and Table 2-3 give the pin locations and descriptions of the DB-25 connector, which is on the optional 10-position modular jack to DB-25 cable.
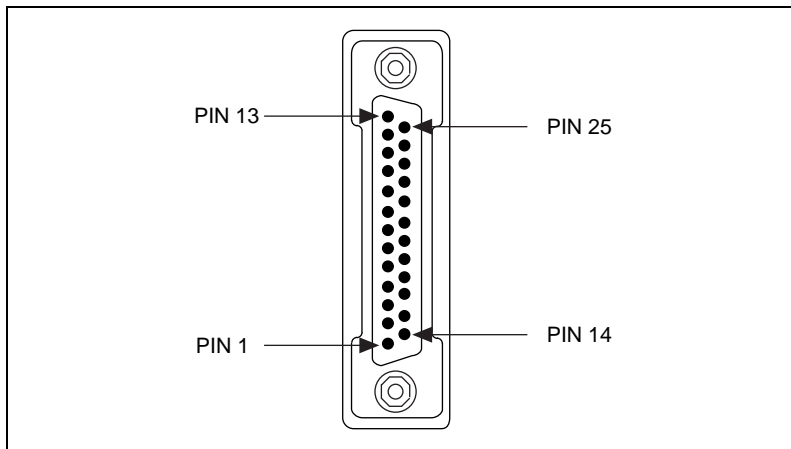
Figure 2-6. DB-25 Connector Pin Locations

Table 2-3. DB-25 Pin Descriptions

DB-25 Pin	232 Signal	485 Signal
Pin 2	TXD	RTS+ (HSO+)
Pin 3	RXD	CTS+ (HSI+)
Pin 4	RTS	RTS- (HSO-)
Pin 5	CTS	TXD+
Pin 6	DSR	CTS– (HSI–)
Pin 7	GND	RXD–
Pin 8	DCD	GND
Pin 20	DTR	RXD+
Pin 22	RI	TXD–
Pins not listed in this table are No Connect.		

Figure 2-7 shows how to connect the cables when you install a four-port version of the PCI serial board.

Figure 2-7. Connecting the Cables to Your Four-Port PCI Serial Board

68-Pin Connector

Figure 2-8 and Table 2-4 give the pin locations and descriptions of the 68-pin connector, which is found on the eight-port PCI serial board.

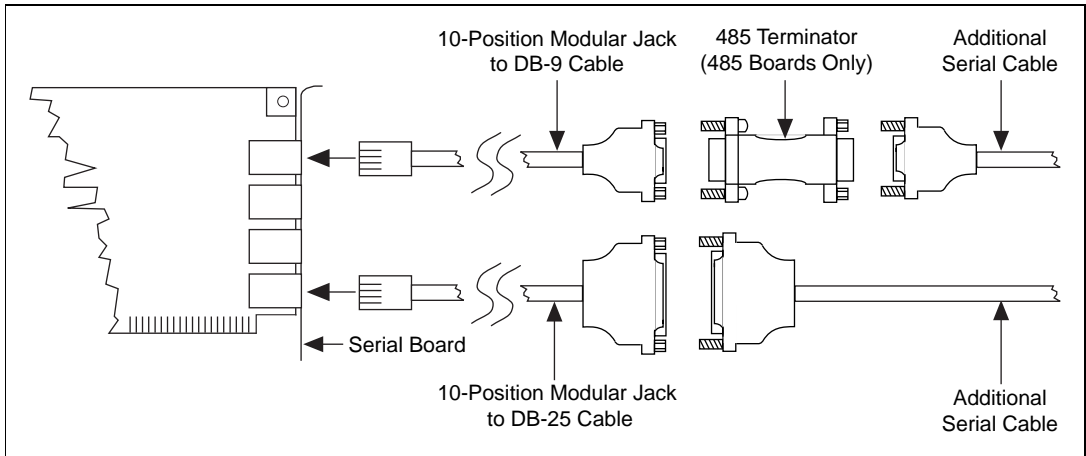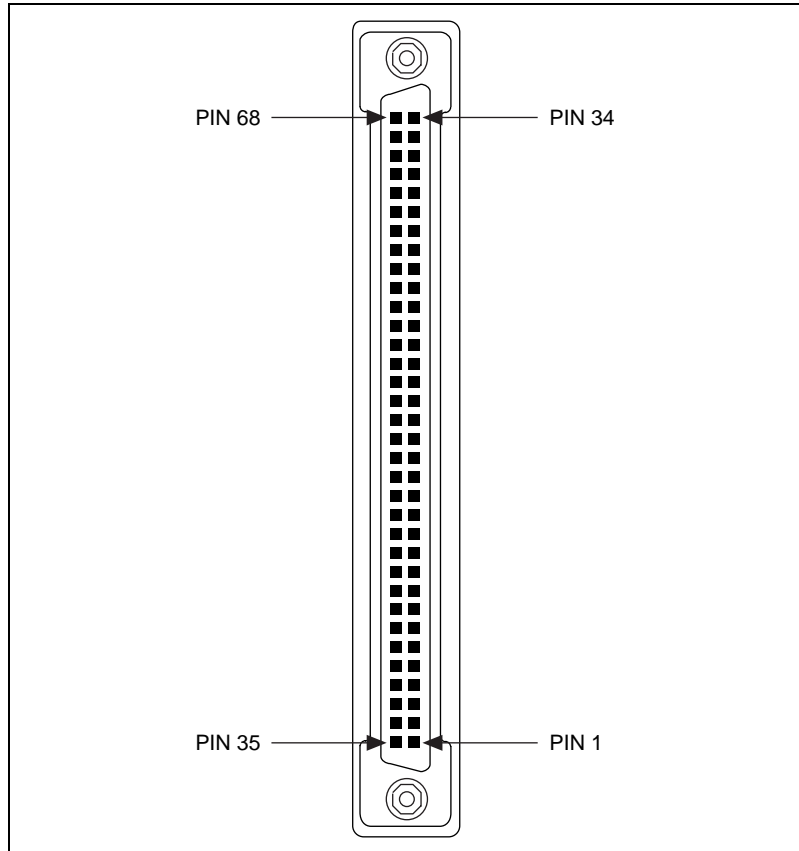**Figure 2-8.** 68-Pin Connector Pin Locations

Table 2-4. 68-Pin Connector Pin Descriptions

68-Pin Connector								Signal	D-Sub 9 Connector
Port 1	Port 2	Port 3	Port 4	Port 5	Port 6	Port 7	Port 8		
61	52	44	35	27	18	10	1	CTS	8
62	53	45	36	28	19	11	2	RTS	7
63	54	46	37	29	20	12	3	DSR	6
64	55	47	38	30	21	13	4	DTR	4
65	56	48	39	31	22	14	5	TXD	3
66	57	49	40	32	23	15	6	CD	1
67	58	50	41	33	24	16	7	RI	9
68	59	51	42	34	25	17	8	RXD	2
60	60	43	43	26	26	9	9	GND	5

Connecting Two-Wire Devices

The PCI-485 boards are designed to work with either two- or four-wire devices. If you are using a two-wire device, refer to the device documentation for specific wiring instructions.

In general, half-duplex networks use a single twisted pair of wires for communication in both directions, so you must connect both the transmitter and the receiver at each end of the same pair of wires. For example, to connect an RS-485 data acquisition device to a port on your PCI-485 using half-duplex communication, you need a single twisted pair of wires. At the PCI-485, connect the TXD+ and RXD+ signals (pins 8 and 4 on a DB-9 connector, pins 5 and 20 on a DB-25 connector) together and to one wire. Connect the other end of this wire to both the TXD+ and RXD+ signals on the data acquisition device. You use the same method to connect the TXD– and RXD– signals (pins 9 and 5 on a DB-9 connector, pins 22 and 7 on a DB-25 connector) to the second wire.

Refer to Chapter 4, *Using Your Serial Hardware*, for information on setting the transceiver mode for two-wire communication. Refer to Appendix B, *Serial Port Information*, for more information on duplex architectures.

3

Configuration

This chapter contains instructions to help you view or change the communication port settings.

Change/View Communication Port Settings

The serial configuration utility is fully integrated with the Windows NT Control Panel. You can use it to examine or modify the configuration of the serial port.

Follow these steps to configure the serial port.

1. Select **Start»Settings»Control Panel** and double-click on the **niports** icon. A list of National Instruments ports appears, as shown in Figure 3-1.
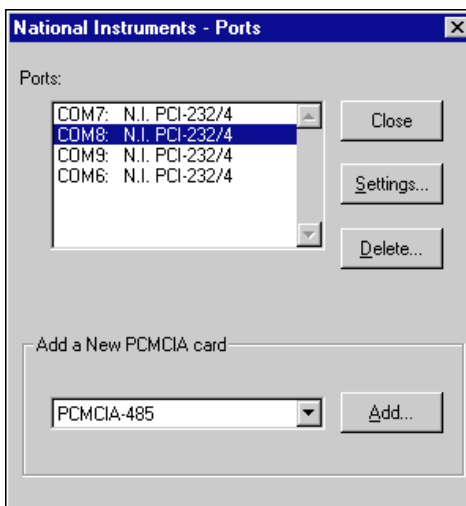
Figure 3-1. niports Configuration Utility

2. Select the port you are interested in.

3. Click on the **Settings** button to view or configure the port settings. Refer to the next section, *General Port Settings*, for more information.

4. Click on the **Resources** button in the **General Port Settings** dialog box to view the resources for the port.

5. Click on **Delete** to remove hardware information about the port from Windows NT. You should do this before you remove your hardware.

General Port Settings

This section describes the options you can set in the **General Port Settings** dialog box, shown in Figure 3-2.
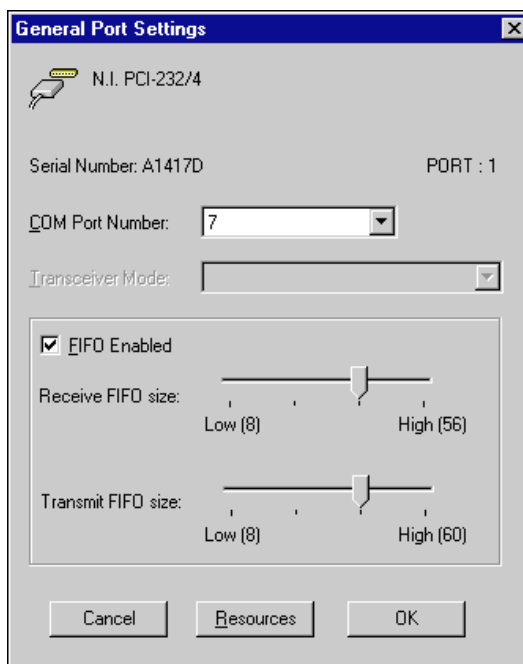
Figure 3-2. General Port Settings Dialog Box

COM Port Number

You can use the **COM Port Number** control to change the COM*x* name of the port selected.

Transceiver Mode

The transceiver mode selection shows the transceiver mode in use, and applies only to PCI-485 boards. Refer to Chapter 4, *Using Your Serial Hardware*, for more information about transceiver modes.

FIFO Enabled

You can use the **FIFO Enabled** control to enable or disable the FIFO buffers on the serial port. FIFO buffers are present on the 16550-compatible UARTs—one for the transmitter and one for the receiver.

FIFO Buffer Size

FIFO buffers are present on the 16550-compatible UARTs—one for the transmitter and one for the receiver. The receive FIFO trigger denotes the number of characters received in the FIFO before the PC is interrupted to read the data. The transmit FIFO trigger denotes the maximum number of bytes written to the FIFO in a block when the PC is interrupted to write the data. Consider the following points when selecting FIFO settings:

- You can select larger FIFO settings to reduce the number of interrupts and therefore minimize system overhead.

- If transfer rates are high, you can lower receive FIFO settings to reduce the number of interrupts and therefore prevent overrun errors.

- If data sizes are small, selecting receive FIFO settings just above data sizes can reduce efficiency, so select lower settings.

Resources

Click on the **Resources** button to display the resource configuration dialog box for the port. You cannot change these resources; they are automatically assigned.

4

Using Your Serial Hardware

This chapter describes how to set the hardware transceiver control mode for your RS-485 interfaces and lists some general programming requirements.

Advanced Transceiver Control for the PCI-485

The PCI-485 boards support four modes of hardware transceiver control. (Transceiver modes apply only to these interfaces.) You can use hardware flow control to enable and disable your transmitters and receivers to work on different bus topologies. Table 4-1 lists the status of the transmitters and receivers under each of the transceiver control modes.

Table 4-1. Transceiver Control Modes

Mode	Transmitter	Receiver
Four-wire mode	Always enabled	Always enabled
Two-wire mode: $\overline{\text{DTR}}$ with echo	Enabled with $\overline{\text{DTR}}$ unasserted	Always enabled
Two-wire mode: $\overline{\text{DTR}}$ controlled	Enabled with $\overline{\text{DTR}}$ unasserted	Enabled with $\overline{\text{DTR}}$ asserted
Two-wire mode: $\overline{\text{TXRDY}}$ auto control	Enabled with $\overline{\text{TXRDY}}$ asserted	Enabled with $\overline{\text{TXRDY}}$ unasserted

☞ **Note**   *Signal names with an overscore, such as $\overline{\text{DTR}}$, indicate that the signal is active low.*

Four-Wire Mode

Use the four-wire mode for most full-duplex systems. In this mode, the transmitter and receiver are always enabled. This mode is the default.

Two-Wire Mode: $\overline{\text{DTR}}$ with Echo

Use this mode in half-duplex systems where the $\overline{\text{DTR}}$ (Data Terminal Ready) line must control the transmitter. In the $\overline{\text{DTR}}$-with-echo mode, the transmitter is tri-stated when the $\overline{\text{DTR}}$ signal of the UART (Universal Asynchronous Receiver/Transmitter) is asserted. To transmit, your application must first clear the $\overline{\text{DTR}}$ bit to enable the transmitter. After the data is fully transmitted, your application once again sets the $\overline{\text{DTR}}$ bit to disable the transmitter. Because the receiver is always enabled in this mode, you not only receive packets from other devices, you also receive the packets sent from your transmitter.

Two-Wire Mode: $\overline{\text{DTR}}$ Controlled

This mode is similar to the two-wire, $\overline{\text{DTR}}$-with-echo mode. Use this mode in half-duplex systems where the $\overline{\text{DTR}}$ line must control the transmitter. Although this mode uses the same method as the $\overline{\text{DTR}}$-with-echo mode to control the transmitter, the hardware automatically disables the receiver whenever the transmitter is enabled. Thus, you do not receive packets that you have transmitted.

Two-Wire Mode: $\overline{\text{TXRDY}}$ Auto Control

In this mode, the hardware transparently enables the transmitter and receiver in a two-wire system. This mode removes the burden of flow control from the user software. By connecting the transmitter to the $\overline{\text{TXRDY}}$ (Transmit Ready) line, the hardware enables the transmitter for each byte to be transmitted. Also, the hardware disables the receiver whenever the transmitter is enabled, so you do not receive packets that you have transmitted.

☞ **Note**   *It is recommended that you use the two-wire $\overline{\text{TXRDY}}$ auto control mode when you are communicating with a two-wire device. Because this mode handles the transmitter/receiver enabling for a two-wire connection in your hardware, it reduces the software overhead required to perform this operation in your application program. For more information about serial communication in two- or four-wire modes, refer to the section* Serial Communication Issues *in Appendix B,* Serial Port Information*.*

Setting the Transceiver Control Mode

The recommended method for setting the transceiver control mode is with the serial configuration utility located in the Windows NT Control Panel. For more information, refer to the *General Port Settings* section in Chapter 3, *Configuration*. The mode you select in the Control Panel is automatically configured when you open a port on a serial interface.

Setting the Transceiver Mode with DeviceIoControl

The NI Serial software extends the Windows function `DeviceIoControl` for programming the transceiver control mode. To program the transceiver control mode using `DeviceIoControl`, complete the following steps.

1. Add the following lines to your source code.

   ```
   #include <winioctl.h>

   #define IOCTL_SERIAL_SET_TRANSCEIVER_MODE
   CTL_CODE(FILE_DEVICE_SERIAL_PORT,37,
   METHOD_BUFFERED,FILE_ANY_ACCESS)
   ```

2. Use the Win32 function `DeviceIoControl`. Use the defined control code value listed in Step 1 to set the transceiver mode, and the input buffer values (unsigned long) listed in Table 4-2 for programming different transceiver modes.

Table 4-2. DeviceIoControl Function Input Values

Transceiver Mode	DeviceIoControl Function Input Value
Four-wire mode	128
Two-wire mode: $\overline{\text{DTR}}$ with echo	129
Two-wire mode: $\overline{\text{DTR}}$ controlled	130
Two-wire mode: $\overline{\text{TXRDY}}$ auto control	131

For example, to set two-wire $\overline{\text{TXRDY}}$ auto control mode, use the following call:

```
ULONG TranceiverMode = 131;
DeviceIoControl(hDevice,
IOCTL_SERIAL_SET_TRANSCEIVER_MODE,(PVOID)
&TransceiverMode,sizeof(ULONG),lpOutBuffer,
nOutBufferSize,lpBytesReturned,lpOverlapped);
```

General Programming Requirements

Once installed, the NI Serial software is integrated into the standard Windows NT communications software. NI serial ports are used like any other Windows NT communications (COM) port. Windows NT has standard communication functions for use within either 16-bit (Win16) applications or 32-bit (Win32) applications.

As you begin developing your application, remember that you must use the standard Microsoft Windows serial communication functions. For information about Microsoft Windows serial communication functions, refer to the *Win32 Software Development Kit*, online help for *Win32 Overviews,* and *Win32 Reference*.

If you have LabVIEW or LabWindows and want to use it with your serial hardware, refer to your LabVIEW or LabWindows documentation for information about serial I/O functions.

A

Specifications

This appendix describes the characteristics of the serial hardware, the NI Serial software, and the recommended operating conditions.

Hardware Specifications

Table A-1. Physical Characteristics of the Two-Port PCI Serial Boards

Characteristic	Specification	
Dimensions	10.67 by 14.20 cm (4.2 by 5.6 in.)	
I/O Connector	DB-9	
Power Requirement (from PCI channel)		
PCI-485/2	+5 VDC	350 mA Typical 750 mA Maximum
PCI-232/2	+5 VDC	50 mA Typical 100 mA Maximum
	±12 VDC	20 mA Typical 200 mA Maximum

Table A-2. Physical Characteristics of the Four-Port PCI Serial Boards

Characteristic	Specification		
Dimensions	10.67 by 17.45 cm (4.2 by 6.8 in.)		
I/O Connector*	10-position modular jack		
Power Requirement (from PCI channel)			
PCI-485/4	+5 VDC	700 mA 1300 mA	Typical Maximum
PCI-232/4	+5 VDC	70 mA 150 mA	Typical Maximum
	±12 VDC	40 mA 400 mA	Typical Maximum
* The four-port PCI serial board requires cables to convert the 10-position modular jack to either DB-9 or DB-25 connectors.			

Table A-3. Physical Characteristics of the Eight-Port PCI Serial Boards

Characteristic	Specification		
Dimensions	10.67 by 14.45 cm (4.2 by 5.7 in.)		
I/O Connector*	68-position SCSI type connector		
Power Requirement (from PCI channel)	+5 VDC	100 mA 180 mA	Typical Maximum
	±12 VDC	80 mA 800 mA	Typical Maximum
* The eight-port PCI serial board requires a cable, which is included in your kit, to convert the 68-position connector to eight DB-9 connectors.			

Table A-4. Environmental Characteristics of the Serial Hardware

Characteristic	Specification
Operating Environment	
Component Temperature	0° to 70° C
Relative Humidity	10% to 90%, noncondensing
Storage Environment	
Temperature	–40° to 120° C
Relative Humidity	5% to 90%, noncondensing
EMI	
PCI Serial	FCC Class A Certified

Software Specifications

Table A-5. Software Characteristics

Characteristic	Specification
Maximum Serial Transfer Rate	
RS-485	460,800 bps*
RS-232	115,200 bps*
Space Required for NI Serial Software	1 MB
* Actual speed may vary considerably from speed shown due to system and instrumentation capabilities.	

B

Serial Port Information

This appendix discusses the RS-232, RS-422, and RS-485 standards and explains some of the issues involved with these types of serial communication.

RS-232

RS-232, as specified in the ANSI/EIA-232-D Standard, *Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange*, standardizes serial communication between computers and between computer terminals and modems. Most applications use the RS-232 standard for interfacing peripherals to personal computers. RS-232 uses transmission lines in which the state of each signal is represented by referencing the voltage level of a single line to ground. RS-232 was designed for serial communication up to distances of 50 ft. and with data rates up to 20 kb/s. However, because of improvements in line drivers and cabling, you can often increase the actual performance of the bus past the limitations on speed and distance recommended in the specification.

RS-422

RS-422, as specified in the EIA RS-422-A Standard, *Electrical Characteristics of Balanced Voltage Digital Interface Circuits*, defines a serial interface much like RS-232. However, RS-422 uses balanced (or differential) transmission lines. Balanced transmission lines use two transmission lines for each signal. The state of each signal is represented, not by a voltage level on one line referenced to ground as in RS-232, but rather by the relative voltage of the two lines to each other. For example, the TX signal is carried on two wires, wire A and wire B. A logical 1 is represented by the voltage on line A being greater than the voltage on line B. A logical 0 is represented by the voltage on line A being less than the voltage on line B. Differential voltage transmission creates a signal that is much more immune to noise as well as voltage loss due to transmission line effects. Thus, you can use RS-422 for much longer distances (up to 4,000 ft.) and much greater transmission speeds (up to 10 Mb/s) than RS-232.

RS-485

RS-485, as specified in the EIA-485 Standard, *Standard for Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems*, expands on the RS-422 standard by increasing the number of devices you can use from 10 to 32 and by working with half-duplex bus architectures. Unlike the RS-422 standard, RS-485 addresses the issue of using multiple transmitters on the same line. RS-485 defines the electrical characteristics necessary to ensure adequate signal voltages under maximum load, short-circuit protection, and the ability to withstand multiple drivers driving conflicting signals at the same time.

Table B-1 lists the features of the RS-232, RS-422, and RS-485 standards.

Table B-1. RS-232, RS-422, and RS-485 Features

Feature	RS-232	RS-422	RS-485
Type of transmission lines	Unbalanced	Differential	Differential
Maximum number of drivers	1	1	32
Maximum number of receivers	1	10	32
Maximum cable length	50 ft.	4,000 ft.	4,000 ft.
Maximum data rate	20 kb/s	10 Mb/s	10 Mb/s
Maximum CMV	± 25 V	±7 V	+12 to –7 V
Driver output	5 to 25 V	2 to 6 V	1.5 to 6 V
Driver load	>3 kΩ	100 Ω	60 Ω

Serial Communication Issues

This section explains some serial communication issues, such as duplex architectures, termination methods, bias resistors, and types of connecting equipment.

Duplex Architectures

Duplex refers to the means of bandwidth usage in a serial system. The two common means of bi-directional serial communication are full duplex and half duplex. Half-duplex communication involves a transmitter and a receiver connected to each end of the same wire or pair of wires. Because the same transmission line is used for both sending and receiving data, devices cannot send data in both directions at the same time. First, one device transmits over the wire(s) to the receiver of the second device. When the first device finishes transmitting, both devices switch the connections from their transmitter to their receiver or vice versa. The device that was receiving data can then transmit over the line.

In full-duplex communication, the devices use a separate wire (or pair of wires) for simultaneous transmission in each direction. Thus, there is no need to switch between transmitting and receiving.

In a differential serial bus (for example, RS-422 or RS-485), a half-duplex system can transmit and receive over the same twisted pair of wires. Thus, half-duplex communication is often referred to as *two-wire* communications. Likewise, full-duplex communication is often referred to as *four-wire* communications, because the full-duplex system uses a separate pair of wires for communication in each direction.

Full Duplex

A typical full-duplex multidrop bus architecture involves a master-slave protocol. Only one device, the master, can control access to the bus. All other devices are slaves. Slave devices must wait for the master to give them access to the bus. In a typical full-duplex system, one transmission line connects the bus master's transmitter to all of the slave receivers. A second transmission line connects all of the slave transmitters to the bus master's receiver. Because in a differential system each transmission line is composed of two separate wires, a full-duplex system is often referred to as a four-wire system. Figure B-1 shows a typical full-duplex system.

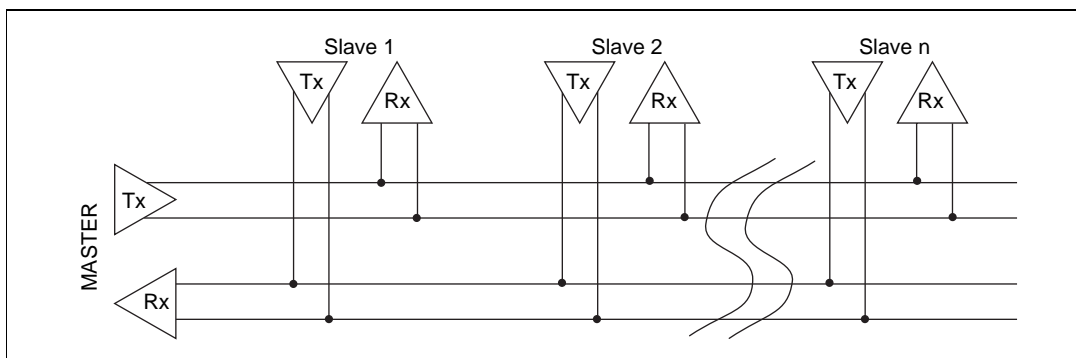**Figure B-1.** Typical Full-Duplex System

Half Duplex

A typical half-duplex multidrop bus architecture also involves a master-slave protocol. In a half-duplex system, all transmitters and receivers are connected to the same transmission line. A half-duplex system is often referred to as a two-wire system. Figure B-2 shows a typical half-duplex system.
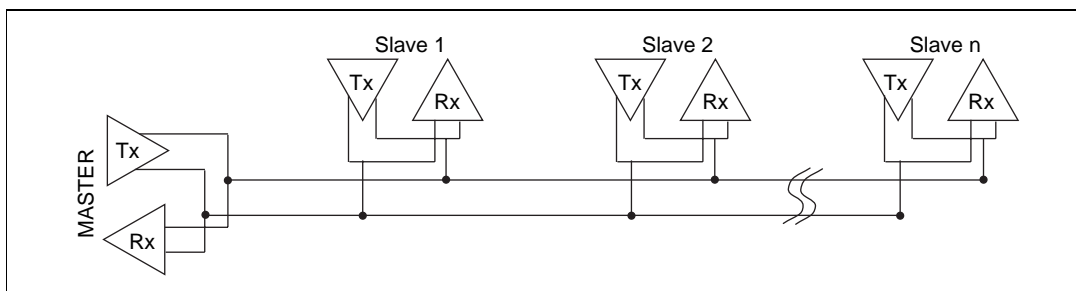

Figure B-2. Typical Half-Duplex System

Termination

Because each differential pair of wires is a transmission line, you must properly terminate the line to prevent reflections. A common method of terminating a two-wire multidrop RS-485 network is to install terminating resistors at each end of the multidrop network. If you daisy-chained multiple instruments together, you need a terminating resistor at only the first and last instruments. The terminating resistor should match the characteristic impedance of the transmission line (typically 100–120 Ω). National Instruments offers an optional DB-9 RS-485 termination connector that contains embedded terminating resistors for easy termination.

Figure B-3 shows a multidrop network using terminating resistors.
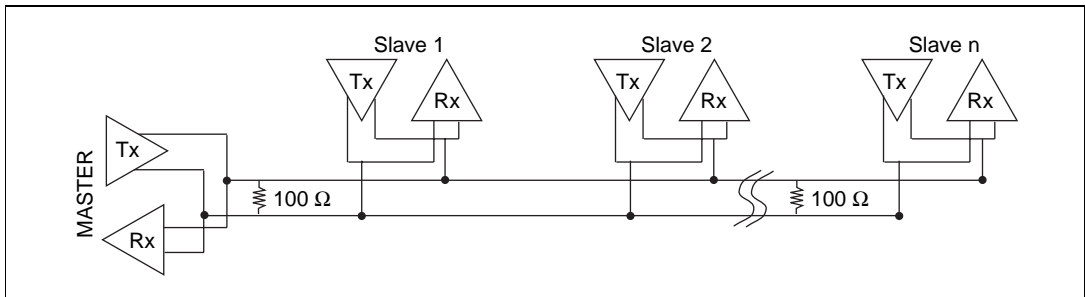
Figure B-3. Multidrop Network Using Terminating Resistors

Bias Resistors

A transmission line enters an indeterminate state if no nodes are transmitting on it. This indeterminate state can cause the receivers to receive invalid data bits from noise picked up on the cable. To prevent these data bits, you should force the transmission line into a known state. By installing two 620 Ω bias resistors at one node on the transmission line, you can create a voltage divider that forces the voltage between the differential pair to be less than 200 mV, the threshold voltage for the receiver. You should install these resistors on only one node.

Figure B-4 shows a transmission line using bias resistors.

Figure B-4. Transmission Line Using Bias Resistors

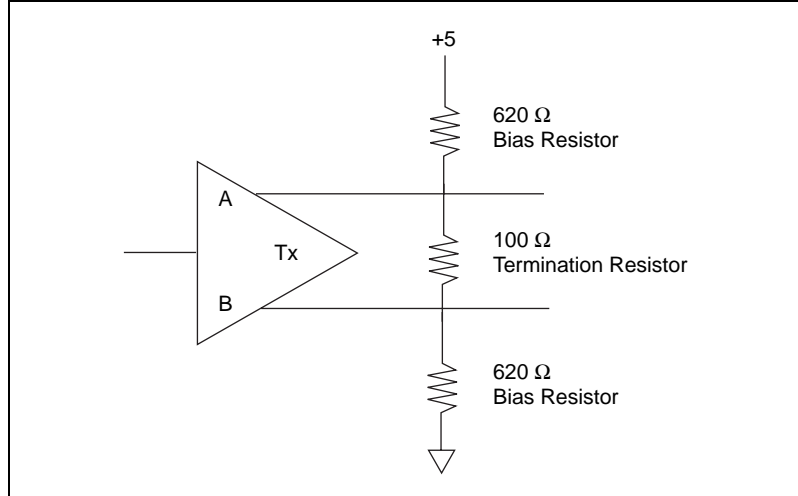Rather than using two 620 Ω resistors at one node, you can also increase the value of the resistors and put them at every node. For instance, if there are eight nodes in a system, you can use 4.7 kΩ resistors at each node to effectively achieve the same result.

DTE vs. DCE

Data Terminal Equipment (DTE) and Data Communications Equipment (DCE) were the terms used in the RS-232 specification for the types of equipment on either end of a serial connection. (A DCE is called Data Circuit-Terminating Equipment in Revision D of the RS-232 specification.) In general, DTE and DCE refer to computer equipment and modems, respectively. Because the RS-232 specification mainly involves connecting a DTE directly to a DCE and vice versa, the pinouts are defined so that cabling is simple. That is, a cable connected a computer to a modem by wiring pin 1 to pin 1, pin 2 to pin 2, and so on. This method is commonly known as *straight-through* cabling.

Figure B-5 shows straight-through cabling in a DTE-to-DCE interface.
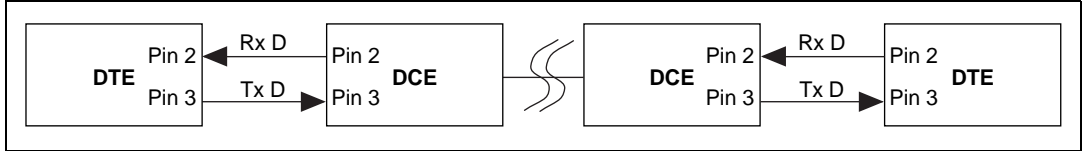
Figure B-5. Straight-Through Cabling in a DTE-to-DCE Interface

Straight-through cabling is still the standard method to connect a modem to your PC. However, because many applications use serial communication to connect two or more DTEs without modems, the cabling becomes more complicated. If two DTEs are wired together using a straight-through cable, one transmitter is connected to the other transmitter, and one receiver is connected to the other receiver. In this setup, no transmissions can occur. Thus, these applications must use a cabling scheme that connects the transmitter on one device to the receiver on the other device and vice versa. This method is known as *null-modem* cabling, because it replaces the two modems that traditional RS-232 applications would require between the two DTEs. You should use a null-modem cable to communicate from one serial port to another.

Figure B-6 shows null-modem cabling in a DTE-to-DTE interface.
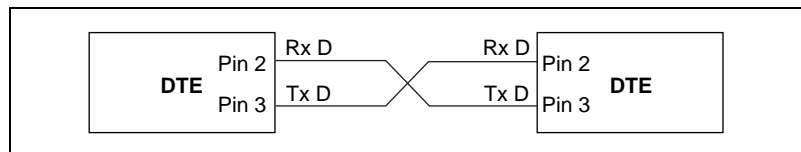
Figure B-6. Null-Modem Cabling in a DTE-to-DTE Interface

C

Uninstalling the Serial Hardware and Software

This appendix explains how to uninstall your serial hardware and NI Serial software.

Removing the Hardware Information

Before physically removing the serial hardware, you must remove the hardware information from the Windows NT Control Panel.

Follow these steps to uninstall the hardware:

1. Double-click on the **niports** icon under **Start»Settings»Control Panel**.

2. Select the port to remove from the list of ports as shown in Figure C-1.
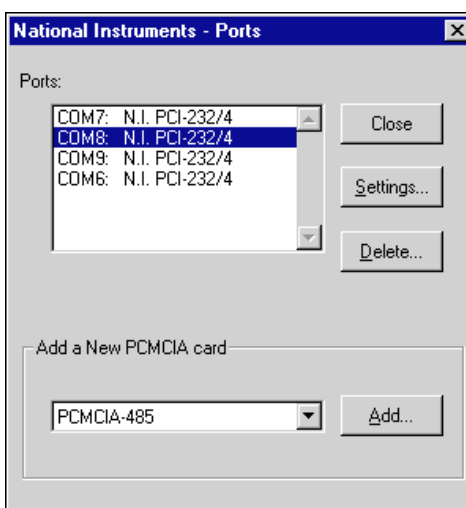
Figure C-1. Selecting an Interface to Uninstall

3. Click on the **Delete** button.

Uninstalling the NI Serial Software

Before uninstalling the software, remove all serial port information from the Windows NT Control Panel, as described in the previous section. You do not need to shut down Windows NT before uninstalling the software.

Complete the following steps to remove the NI Serial software:

1. Select **Start»Settings»Control Panel**.

2. Double-click on the **Add/Remove Programs** icon in the Control Panel to launch the Add/Remove Programs applet. A dialog box similar to the one in Figure C-2 appears. This dialog box lists the software available for removal.
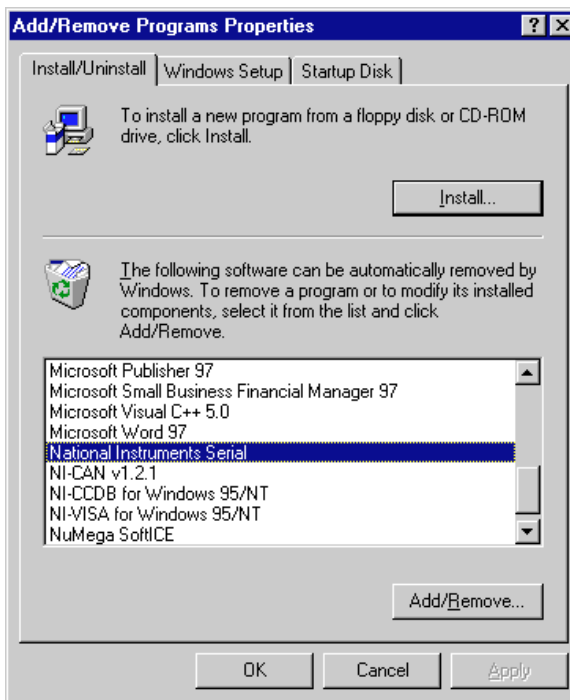
Figure C-2. Add/Remove Programs Properties Dialog Box

3. Select the serial software you want to remove, and click on the **Add/Remove** button. The uninstall program runs and removes all folders, utilities, and registry entries associated with the NI Serial software. Figure C-3 shows the results of a successful uninstallation.
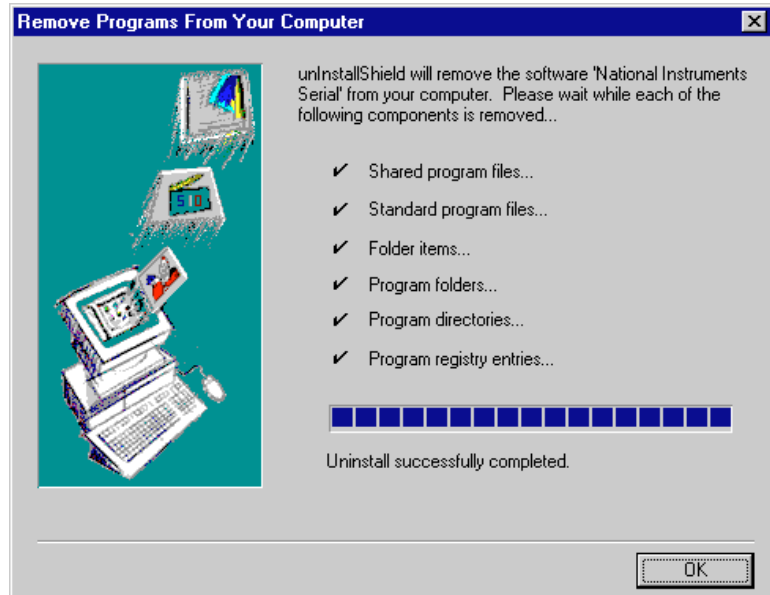
Figure C-3. Uninstallation Results

4. Shut down Windows NT, power off your computer, and remove your serial interfaces.

If you want to reinstall the hardware and software, refer to Chapter 2, *Installation and Verification*.

D

Troubleshooting and Common Questions

This appendix describes how to troubleshoot problems and answers some common questions.

Missing Serial Port in the niports List

The serial configuration utility **niports** contains configuration information for serial hardware it is aware of that is installed in your system.

To start the configuration utility, select **Start»Settings»Control Panel**, and double-click on the **niports** icon.

If your PCI serial hardware is missing from this list, make sure the board is properly installed. Verify that the National Instruments serial driver `serial.sys` is installed.

Resolving Resource Conflicts

Resource conflicts occur when your system contains hardware that is configured to use the same resources as your serial interface. The serial 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 to see which resource is in conflict. To run the Event Viewer, select **Start»Programs»Administrative Tools»Event Viewer**.

After you have identified the resource that caused the conflict, change the resources of the device that caused the conflict.

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, IRQ levels, and DMA channels that are currently being used in your system.

To run the Windows NT Diagnostics, select **Start»Programs» Administrative Tools»Windows NT Diagnostics**.

Troubleshooting Diagnostic Messages

This section lists possible diagnostic error messages, along with solutions.

- If the **No National Instruments serial port found** error message appears, refer to Chapter 2, *Installation and Verification*, to follow these troubleshooting steps:

    1. Verify the hardware resources. To verify the hardware resources, click on the **Resources** button on the **General Port Settings** page. For more information about resource conflicts, refer to Chapter 3, *Configuration*.

    2. Verify that the National Instruments serial driver is installed. Use the Windows Explorer to display the **Properties** of serial.sys.

    3. If either the serial hardware or serial.sys file is missing, reinstall the hardware and software. You should find serial.sys in the \WinNT\system32\drivers directory.

- If the utility reports fewer ports installed than it should, refer to Chapter 2, *Installation and Verification*, and follow these troubleshooting steps:

    1. Verify the hardware resources.

    2. Verify that the National Instruments serial driver is installed. Use the Windows Explorer to display the **Properties** of serial.sys.

    3. Check the hardware installation to make sure the correct number of boards/ports are installed.

- If the **I/O address test failed, Interrupt test cannot be performed** error message appears, you probably have an I/O address conflict with legacy boards in your system. Change the base I/O addresses assigned to your legacy boards.

- If the **Interrupt test failed** error message appears, you probably have an IRQ conflict with legacy boards in your system. Change the IRQ level assigned to your legacy board.

Common Questions

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

Double-click on the **niports** icon under **Start»Settings»Control Panel** to display a list of installed ports.

What do I do if the diagnostic test fails with an error?

Refer to the troubleshooting sections of this manual for specific information about what might cause the test to fail.

How can I determine which port is associated with COM*x*?

Refer to the section *Determine Which Physical Port Is Associated with COMx*, in Chapter 2, *Installation and Verification*.

How can I name National Instruments serial ports COM1, COM2, COM3, or COM4?

Refer to the *General Port Settings* section in Chapter 3, *Configuration*.

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

The Read Me file gives the version of the software. To read the file, select **Read Me** under **Start»Programs»National Instruments Serial**.

What is the maximum baud rate supported and how can I set it?

The maximum baud rate supported is 460.8 Kbaud for RS-485 and 115.2 Kbaud for RS-232. You can use the Win32 function **SetCommState** and pass the actual value of the baud rate in the **BaudRate** field of the **DCB** structure.

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 hardware and software configuration form in Appendix E, *Customer Communication*.

E

Customer Communication

For your convenience, this appendix contains forms to help you gather the information necessary to help us solve your technical problems and a form you can use to comment on the product documentation. When you contact us, we need the information on the Technical Support Form and the configuration form, if your manual contains one, about your system configuration to answer your questions as quickly as possible.

National Instruments has technical assistance through electronic, fax, and telephone systems to quickly provide the information you need. Our electronic services include a bulletin board service, an FTP site, a fax-on-demand system, and e-mail support. If you have a hardware or software problem, first try the electronic support systems. If the information available on these systems does not answer your questions, we offer fax and telephone support through our technical support centers, which are staffed by applications engineers.

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 USA 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.

Country	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
Brazil	011 288 3336	011 288 8528
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 6120092	03 6120095
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
United Kingdom	01635 523545	01635 523154
United States	512 795 8248	512 794 5678

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 (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 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

Serial hardware and revision _____

    PCI-232 board revision _____

      Two port_____ Four port_____Eight port _____

    PCI-485 board revision _____

      Two port _____   Four port _____

NI serial software revision number on distribution disk_____

Hardware settings:

	Base I/O Address	Interrupt Level
COM1	_____	_____
COM2	_____	_____
COM3	_____	_____
COM4	_____	_____
COM5	_____	_____
COM6	_____	_____
COM7	_____	_____
COM8	_____	_____
COM9	_____	_____

Other Products

Computer make and model _____

Microprocessor _____

Clock frequency or speed _____

Type of monitor card installed _____

Windows version _____

Application programming language (Microsoft C, Visual Basic for Windows) _____

_____

Number of serial ports in system:

    Built in _____   Adapter cards _____

Other boards in system _____

Base I/O address of other boards _____

Interrupt level 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 PCI Serial Hardware and Software for Windows NT*

Edition Date: August 1998

Part Number: 321825B-01

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

_____

_____

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_____

_____

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

_____

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Thank you for your help.

Name _____

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Glossary

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

°	degrees
%	percent
Ω	ohms
A	amperes
ANSI	American National Standards Institute
b	bits
B	bytes
baud	bits per second
bps	bits per second
C	Celsius
COM	Computer Output Microform
CTS	Clear To Send
DB-*xx*	subminiature D connector (where *xx* is the number of pins)
DCD	Data Carrier Detect
DCE	Data Communications Equipment or Data Circuit-Terminating Equipment
DMA	direct memory access
DSR	Data Set Ready

DTE	Data Terminal Equipment
$\overline{\text{DTR}}$	Data Terminal Ready (where the overscore denotes that the signal is active low)
EIA	Electronic Industries Association
EMI	electromagnetic interference
FCC	Federal Communications Commission
FIFO	first-in-first-out
ft.	feet
GND	Ground
HSI	Handshake Input
HSO	Handshake Output
Hz	hertz
IEEE	Institute of Electrical and electronic Engineers
in.	inches
I/O	input/output
IRQ	interrupt request
ISA	Industry Standard Architecture
Kbaud	kilobits per second
m	meters
MB	megabytes of memory
PC	personal computer
PCI	Peripheral Components Interconnect
PCMCIA	Personal Computer Memory Card International Association
RAM	random-access memory

RI	Ring Indicator
RX	Receive
RXD	Receive Data
RTS	Request to Send
s	seconds
SCSI	Small Computer Systems Interface
TX	Transmit
TXD	Transmit Data
$\overline{\text{TXRDY}}$	Transmit Ready (where the overscore denotes that the signal is active low)
UART	universal asynchronous receiver/transmitter
V	volts
VDC	volts direct current
VXI	VME eXtensions for Instrumentation