

CAN

Getting Started with Your CAN Hardware and the NI-CAN™ Software for Windows NT

Worldwide Technical Support and Product Information

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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.

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.*

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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.

Contents

About This Manual

How To Use the Manual Set.....	ix
Conventions	x
Related Documentation.....	x

Chapter 1

Introduction

What You Need to Get Started	1-1
CAN Hardware Overview	1-2
NI-CAN Software Overview	1-3
Optional Programming Tools	1-3

Chapter 2

Installation and Configuration

Install the NI-CAN Software	2-1
Installing for Windows NT 3.51.....	2-1
Installing for Windows NT 4.0.....	2-1
Install the CAN Hardware	2-3
Check the Configuration of Your PCI-CAN Series Board	2-3
Install Your PCI-CAN Series Board	2-3
Install Your PCMCIA-CAN Series Card	2-5
Connect the Cables.....	2-6
Configure the NI-CAN Software.....	2-6

Chapter 3

Verify the Installation

Chapter 4

Begin to Use the NI-CAN Software

Using the NI-CAN Software.....	4-1
General Programming Considerations.....	4-2

Appendix A

Uninstalling the Hardware and Software

Uninstalling the CAN Hardware from Windows NT	A-1
Uninstalling the NI-CAN Software from Windows NT	A-1

Appendix B

Cabling Requirements for High-Speed CAN

Connector Pinouts	B-1
Power Supply Information for the High-Speed CAN Ports	B-3
Bus Power Supply Requirements	B-4
Cable Specifications	B-5
Cable Lengths	B-5
Number of Devices.....	B-6
Cable Termination	B-6
Cabling Example	B-7

Appendix C

Cabling Requirements for Low-Speed CAN

Connector Pinouts	C-1
Power Supply Information for the Low-Speed CAN Ports.....	C-2
Bus Power Supply Requirements	C-3
Cable Specifications	C-4
Number of Devices.....	C-4
Low-Speed Termination.....	C-5
Determining the Necessary Termination Resistance for Your Board.....	C-5
Replacing the Termination Resistors	C-6
Cabling Example	C-8

Appendix D

Troubleshooting and Common Questions

Missing CAN Interface in the NI-CAN Configuration Utility.....	D-1
Diagnostic Utility Failures	D-1
Resource Errors.....	D-1
NI-CAN Software Problem Encountered	D-2
Missing CAN Interface in Diagnostic Utility	D-2
CAN Hardware Problem Encountered.....	D-2
Common Questions	D-2

Appendix E

Specifications

Appendix F

Technical Support Resources

Glossary

Figures

Figure 2-1.	Add/Remove Programs Properties Dialog Box.....	2-2
Figure 2-2.	Installing the PCI-CAN	2-4
Figure 2-3.	Inserting the PCMCIA-CAN.....	2-5
Figure 2-4.	CAN Interface That Is Working Properly	2-7
Figure 2-5.	Resources Dialog Box for the PCMCIA-CAN	2-7
Figure 2-6.	NI-CAN Hardware Settings Dialog Box.....	2-8
Figure 3-1.	NI-CAN Diagnostic Utility after Testing	3-1
Figure A-1.	Add/Remove Programs Properties Dialog Box.....	A-2
Figure B-1.	Pinout for 9-Pin D-Sub Connector	B-1
Figure B-2.	Pinout for 5-Pin Combicon-Style Pluggable Screw Terminal	B-2
Figure B-3.	PCMCIA-CAN Cable.....	B-2
Figure B-4.	PCI-CAN/2 Parts Locator Diagram	B-3
Figure B-5.	Power Source Jumpers	B-4
Figure B-6.	Termination Resistor Placement	B-6
Figure B-7.	Cabling Example	B-7
Figure C-1.	Pinout for 9-Pin D-Sub Connector	C-1
Figure C-2.	PCI-CAN/LS2 Parts Locator Diagram.....	C-2
Figure C-3.	Power Source Jumpers	C-3
Figure C-4.	Termination Resistor Placement for Low-Speed CAN.....	C-5
Figure C-5.	Location of Termination Resistors on PCI-CAN/LS2 Board	C-7
Figure C-6.	Preparing Lead Wires of Replacement Resistors	C-7
Figure C-7.	Cabling Example	C-8

Tables

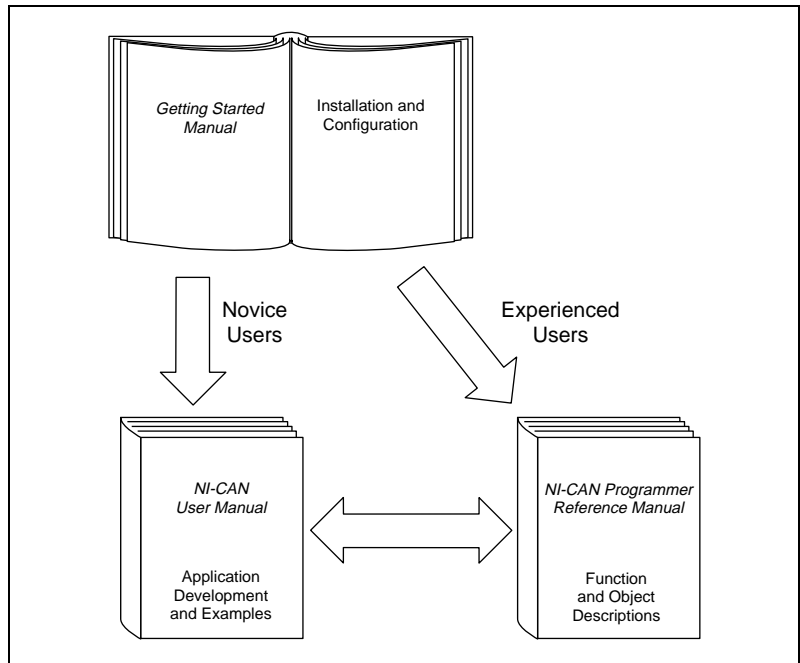
Table B-1.	Power Requirements for the CAN Physical Layer for Bus-Powered Versions	B-4
Table B-2.	ISO 11898 Specifications for Characteristics of a CAN_H and CAN_L Pair of Wires	B-5
Table B-3.	DeviceNet Cable Length Specifications.....	B-5
Table C-1.	Power Requirements for the Low-Speed CAN Physical Layer for Bus-Powered Versions.....	C-3
Table C-2.	ISO 11519-2 Specifications for Characteristics of a CAN_H and CAN_L Pair of Wires	C-4

About This Manual

This manual contains instructions to help you install and configure the National Instruments CAN hardware and the NI-CAN software for Windows NT. The National Instruments CAN hardware supported under Windows NT includes the PCI-CAN, PCI-CAN/LS, PCI-CAN/2, PCI-CAN/LS2, PCMCIA-CAN, and PCMCIA-CAN/2.

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 CAN hardware and the NI-CAN software for Windows NT.

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

Use the *NI-CAN Programmer Reference Manual* for specific information about each NI-CAN function and object, such as format, parameters, and possible errors.

Conventions

The following conventions appear in this manual:

» The » symbol leads you through nested menu items and dialog box options to a final action. The sequence **File»Page Setup»Options** directs you to pull down the **File** menu, select the **Page Setup** item, and select **Options** from the last dialog box.



This icon denotes a note, which alerts you to important information.



This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash.

bold Bold text denotes items that you must select or click on in the software, such as menu items and dialog box options. Bold text also denotes parameter names.

CAN hardware *CAN hardware* refers to the PCI-CAN, PCI-CAN/LS, PCI-CAN/2, PCI-CAN/LS2, PCMCIA-CAN, and PCMCIA-CAN/2 in cases where the material applies to all the interfaces.

italic Italic text denotes variables, emphasis, a cross reference, or an introduction to a key concept. This font also denotes text that is a placeholder for a word or value that you must supply.

monospace Text in this font denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames and extensions, and code excerpts.

Related Documentation

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

- ANSI/ISO Standard 11898-1993, *Road Vehicles—Interchange of Digital Information—Controller Area Network (CAN) for High-Speed Communication*

- ANSI/ISO Standard 11519-2-1994, *Road Vehicles—Low-Speed Serial Data Communication—Part 2: Low-Speed Controller Area Network (CAN)*
- *CAN Specification Version 2.0*, 1991, Robert Bosch GmbH, Postfach 500, D-7000 Stuttgart 1
- CiA Draft Standard 102, Version 2.0, *CAN Physical Layer for Industrial Applications*
- *DeviceNet Specification, Volume 1, Version 2.0*, Open DeviceNet Vendor Association
- *Microsoft Windows NT user's guide*, Microsoft Corporation

Introduction

This chapter lists what you need to get started, provides an overview of the CAN hardware and the NI-CAN software for Windows NT, and describes optional equipment you can order.

What You Need to Get Started

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

- Windows NT 3.51 or later installed on your computer
- One of the following CAN interfaces, which is included in your kit:
 - PCI-CAN
 - PCI-CAN/LS
 - PCI-CAN/2
 - PCI-CAN/LS2
 - PCMCIA-CAN
 - PCMCIA-CAN/2
- 3.5 in., high-density (1.44 MB) disks, which are included in your kit:
 - *NI-CAN Software for Windows 95/98/NT
Version 1.3
(Disk x of 3)*
- PCMCIA-CAN cable, which is included in your kit, if you have a PCMCIA-CAN series card
- CAN interface cables that meet the requirements in Appendix B, *Cabling Requirements for High-Speed CAN* or Appendix C, *Cabling Requirements for Low-Speed CAN*.

CAN Hardware Overview

The National Instruments CAN hardware covered in this manual includes the PCI-CAN, PCI-CAN/LS, PCI-CAN/2, PCI-CAN/LS2, PCMCIA-CAN, and PCMCIA-CAN/2.

The PCI-CAN and PCI-CAN/LS series boards are completely software configurable and compliant with the PCI Local Bus Specification. With a PCI-CAN or PCI-CAN/LS series board, you can make your PC-compatible computer with PCI Local Bus slots communicate with and control CAN devices.

The PCMCIA-CAN series cards are Type II PC Cards that are completely software configurable and compliant with the PCMCIA standards for 16-bit PC Cards. With a PCMCIA-CAN series card, you can make your PC-compatible notebook with PCMCIA sockets communicate with and control CAN devices.

CAN interfacing is accomplished using the Intel 82527 CAN controller chip. The high-speed CAN physical layer fully conforms to the ISO 11898 physical layer specification for CAN and is optically isolated to 500 V. The low-speed CAN physical layer conforms to the ISO 11519-2 physical layer specification for CAN and is also optically isolated to 500 V.

PCI-CAN series boards are available with two physical connector types: DB-9 D-Sub and Combicon-style pluggable screw terminals. Low-speed PCI-CAN/LS boards are available with DB-9 D-Sub connectors. PCMCIA-CAN cables include both a DB-9 D-Sub and a Combicon-style pluggable screw terminal.

The CAN physical layer on PCI-CAN series cards can be powered either internally (from the card) or externally (from the bus cable power). The power source for the CAN physical layer for each port is configured with a jumper. There are two cables available for the PCMCIA-CAN cards. In one cable the CAN physical layer is powered internally (from the card). In the other cable the CAN physical layer is powered externally (from the bus cable power). The CAN hardware supports a wide variety of transfer rates up to 1 Mb/s.

All of the CAN hardware uses the Intel 386EX embedded processor to implement time-critical features provided by the NI-CAN software. The CAN hardware communicates with the NI-CAN driver through on-board shared memory and an interrupt.

NI-CAN Software Overview

The NI-CAN software includes a native, 32-bit multitasking Windows NT kernel driver.

The NI-CAN software for Windows NT supports the concurrent use of multiple types of CAN hardware. For example, you can communicate with CAN devices through both a PCI-CAN and PCI-CAN/2 in the same system at the same time. The NI-CAN software is fully integrated into the Windows NT operating system. It is configurable through the Windows NT Control Panel and uninstalleable through the Add/Remove Programs applet of the Control Panel.

The NI-CAN software, along with the CAN hardware, transforms your computer into a CAN interface with complete communications and bus management capability. The NI-CAN software includes the following components:

- Firmware (runs on embedded Intel 386EX)
- Device driver
- Diagnostic test utility
- Configuration utility
- Language interface libraries for Microsoft Visual C/C++ 2.0 or later, LabWindows/CVI 4.0 or later, and LabVIEW 4.0 or later
- Example programs that use NI-CAN functions

Optional Programming Tools

Your kit includes the NI-CAN software for Windows NT. In addition, you can order the LabWindows/CVI or LabVIEW software from National 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.

Installation and Configuration

This chapter describes how to install and configure the CAN hardware and the NI-CAN software for Windows NT.

Install the NI-CAN Software

Before installing the CAN hardware, complete the following steps to install the NI-CAN software for Windows NT.

Installing for Windows NT 3.51

1. Log in as `Administrator` or as a user that has `Administrator` privileges. The NI-CAN setup program must have `Administrator` privileges because the program modifies the configuration registry of your system.
2. Insert the *NI-CAN Software for Windows 95/98/NT (Disk 1 of 3)* into an unused drive.
3. In the **Run** dialog box, type the following:
`x:\setup`
where `x` is the letter of the drive containing the disk (usually `a` or `b`).
4. Shut down Windows NT and turn off your computer when the setup is complete.
5. Proceed to the section *Install the CAN Hardware*.

Installing for Windows NT 4.0

1. Log in as `Administrator` or as a user that has `Administrator` privileges. The NI-CAN setup program must have `Administrator` privileges because the program modifies the configuration registry of your system.
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

You can use this same applet to uninstall the NI-CAN software at a later time. Refer to Appendix A, [Uninstalling the Hardware and Software](#), for more information.

4. Click on the **Install** button.
5. Insert the *NI-CAN Software for Windows 95/98/NT (Disk 1 of 3)*, and click on the **Next** button to proceed.
6. The setup wizard guides you through the necessary steps to install the NI-CAN software. You may 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.
7. Shut down Windows NT and turn off your computer when the setup is complete.

Install the CAN Hardware

This section describes how to install your CAN hardware.

Check the Configuration of Your PCI-CAN Series Board

If you plan to use your CAN board in a system where bus power is available, you may want to configure the power supply jumpers on your board. See Appendix B, *Cabling Requirements for High-Speed CAN*, for more information.

If you are installing a low-speed CAN board, you may need to change the power supply jumpers or termination resistors. See Appendix C, *Cabling Requirements for Low-Speed CAN*, for more information.

Install Your PCI-CAN Series Board



Caution Electrostatic discharge can damage several components on these CAN interfaces. To avoid such damage in handling your interface, touch the antistatic plastic package to a metal part of your computer chassis before removing the interface from the package.

1. Make sure that your computer is turned off. Keep the computer plugged in so that it remains grounded while you install the CAN interface.
2. Remove the top cover (or other access panels) to give yourself access to the computer expansion slots.
3. Find an unused expansion slot of the appropriate type in your computer.
4. Remove the corresponding slot cover on the back panel of the computer.

5. Insert the CAN interface into the slot with the CAN connector(s) sticking out of the opening on the back panel. It might be a tight fit, but do not force the interface into place. Figure 2-2 shows how to install the PCI-CAN into a PCI expansion slot.

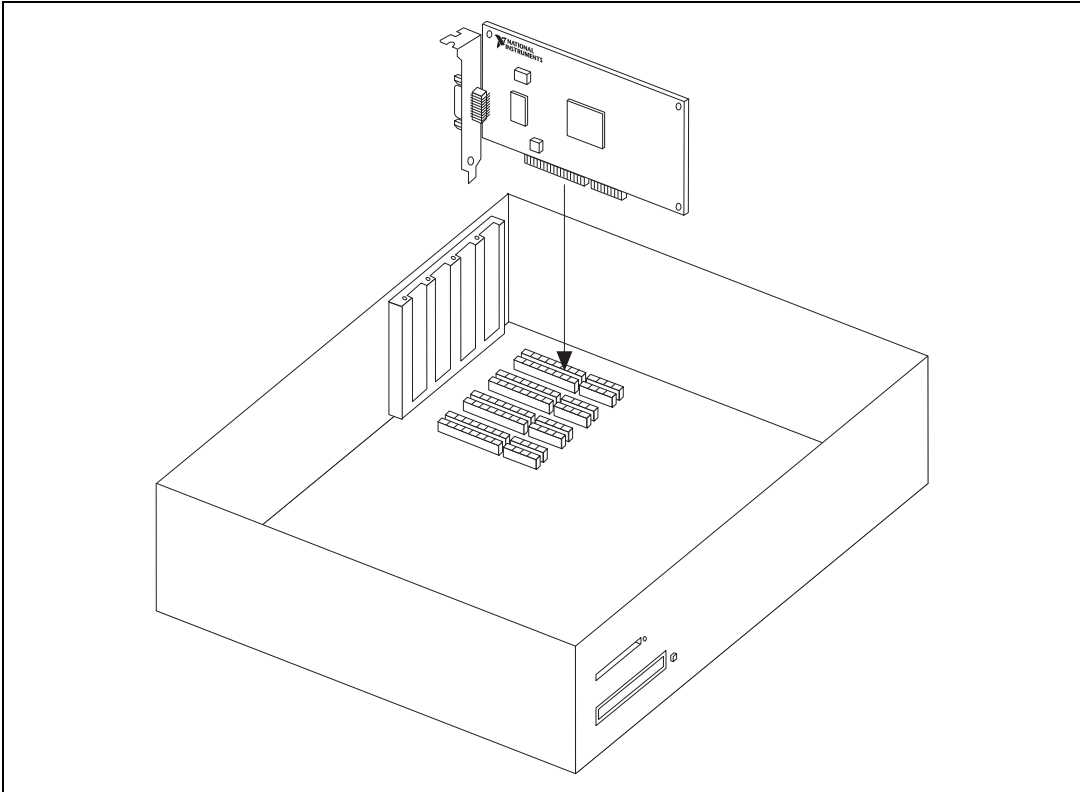


Figure 2-2. Installing the PCI-CAN

6. Screw the mounting bracket of the CAN interface to the back panel rail of the computer.
7. Replace the top cover (or the access panel to the expansion slot).
8. Turn on your computer and start Windows NT.

When you have finished installing the hardware, proceed to the [Connect the Cables](#) section, later in this chapter.

Install Your PCMCIA-CAN Series Card



Caution Electrostatic discharge can damage several components on these CAN interfaces. To avoid such damage in handling your interface, touch the antistatic plastic package to a metal part of your computer chassis before removing the interface from the package.



Note Because of restrictions imposed by Windows NT, only one PCMCIA-CAN or PCMCIA-CAN/2 can be used in a Windows NT system. For example, if you have a PCMCIA-CAN card in your system, you cannot use a PCMCIA-CAN/2 card at the same time.

1. Shut down your operating system and power off your system.
2. Insert the card into a free PC Card (PCMCIA) socket. The card has no jumpers or switches to set. Figure 2-3 shows how to insert the card and how to connect the PCMCIA-CAN cable and connector to the card.

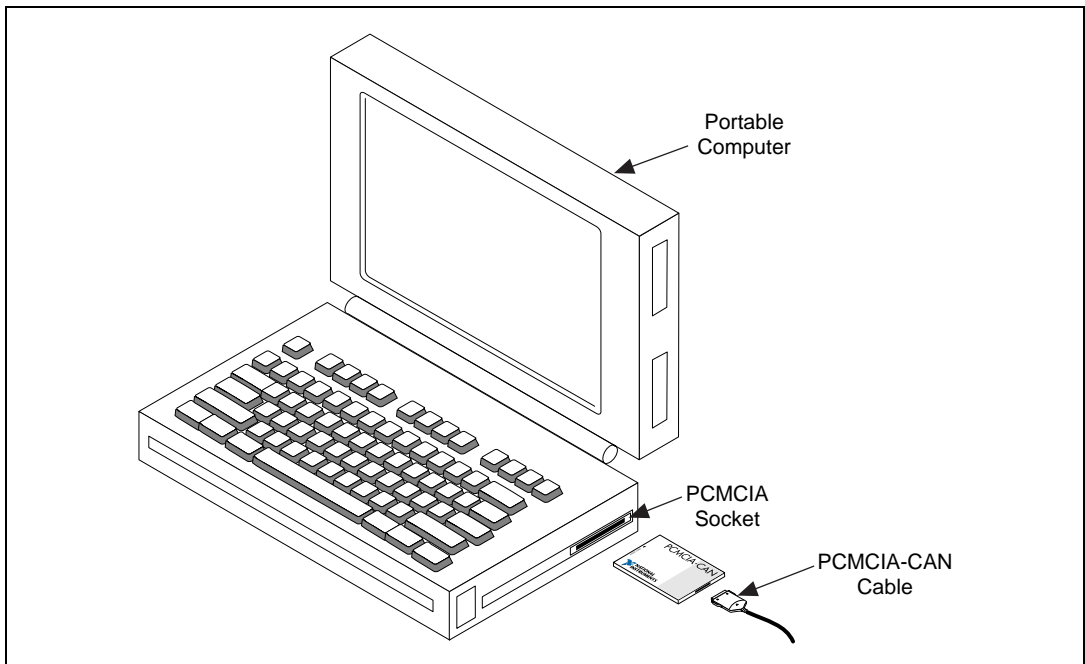


Figure 2-3. Inserting the PCMCIA-CAN

3. Connect the PCMCIA-CAN cable to the card.
4. Power on your computer.

When you have finished installing the hardware, proceed to the next section, [Connect the Cables](#).

Connect the Cables

After you have installed the CAN interface, connect your CAN cables to the interface. Because exact cabling requirements will vary for each application, National Instruments does not provide cables, other than the PCMCIA-CAN cable. Refer to Appendix B, [Cabling Requirements for High-Speed CAN](#), or Appendix C, [Cabling Requirements for Low-Speed CAN](#), for information about the cabling requirements of the CAN hardware for information about the cabling requirements of the CAN hardware.

Configure the NI-CAN Software

The NI-CAN Configuration utility is located in the Windows NT Control Panel. You can use it to examine or modify the configuration of the NI-CAN software. The context-sensitive online help, available by right-clicking on any of the controls on the configuration utility buttons, includes all the information that you need to configure the NI-CAN software.

To use the NI-CAN Configuration utility, you must first log in as Administrator or as a user that has Administrator privileges. To configure the NI-CAN software, double-click on the **NI-CAN Configuration** 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 later: Select **Start»Settings»Control Panel**.

Figure 2-4 shows a CAN interface that is working properly. If no interfaces are listed under **NI-CAN Configuration**, refer to the [Missing CAN Interface in the NI-CAN Configuration Utility](#) section in Appendix D, [Troubleshooting and Common Questions](#), to resolve the problem.

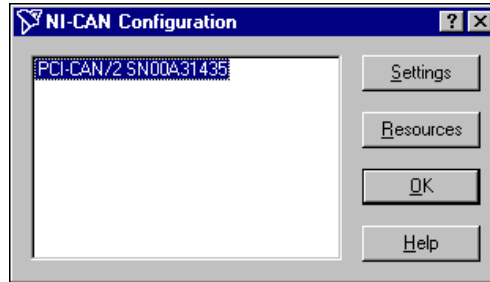


Figure 2-4. CAN Interface That Is Working Properly

To select a particular interface, click on that interface in the list.

When you install a PCI-CAN interface, your computer automatically assigns valid resources to it. Because this resource assignment is automatic, you do not need to use the **Resources** dialog box for the PCI-CAN, and you do not need to restart Windows NT.

When you install a PCMCIA-CAN interface, your computer assigns default resources to it. Because the default resources may conflict with other devices in your system, you must use the **Resources** dialog box to select valid resources for the PCMCIA-CAN. Figure 2-5 shows the **Resources** dialog box for the PCMCIA-CAN.

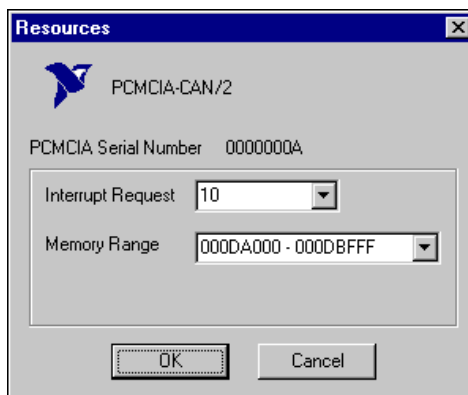


Figure 2-5. Resources Dialog Box for the PCMCIA-CAN

Click on the **Settings** button to view information about the NI-CAN software configuration for the CAN interface. Figure 2-6 shows the **Settings** dialog box.

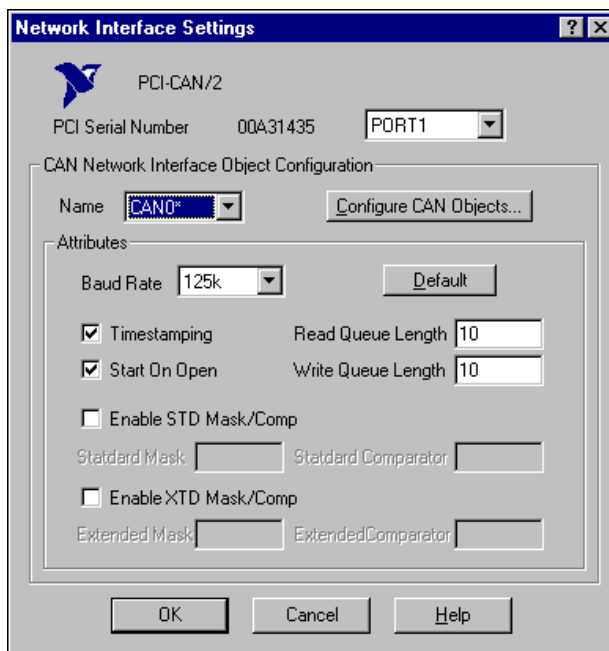


Figure 2-6. NI-CAN Hardware Settings Dialog Box

Each port of the CAN hardware interface is configured from this tab. Use the drop-down box nearest the top of the tab to select the physical port number to configure. For each port, use the **Name** drop-down box to select the name for the CAN Network Interface Object (CAN0, CAN1, and so on). You use this name to refer to the physical port from within your NI-CAN application.

To access online help for the NI-CAN Configuration utility, click on the **Help** button. Alternately, you can right-click on a specific control and select **What's This?** from the pop-up menu to see context-sensitive help for the item you have clicked on.

When you have finished configuring the NI-CAN software, proceed to Chapter 3, *Verify the Installation*.



Note If you changed the resources for any PCMCIA-CAN or PCMCIA-CAN/2 interface, you must restart Windows NT for the changes to take effect.

Verify the Installation

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

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

To run the utility, select the **NI-CAN Diagnostic** item:

- Windows NT 3.51—Double-click on the **NI-CAN Diagnostic** icon in the **NI-CAN Software for Windows NT** group of the **Program Manager**.
- Windows NT 4.0 or later—Select **Start»Programs»National Instruments CAN»NI-CAN Diagnostic**.

When you have started the NI-CAN Diagnostic utility, test your CAN interfaces by clicking on the **Test All** button. You can also test one CAN interface by highlighting it and clicking on the **Test One** button. If the NI-CAN Diagnostic is successful, it puts a checkmark next to the interface and changes its status from **Untested** to **Passed**. If the NI-CAN Diagnostic fails, it puts an X next to the interface, and changes its status from **Untested** to **Failed**. Figure 3-1 shows the NI-CAN Diagnostic utility after it has tested some CAN interfaces.

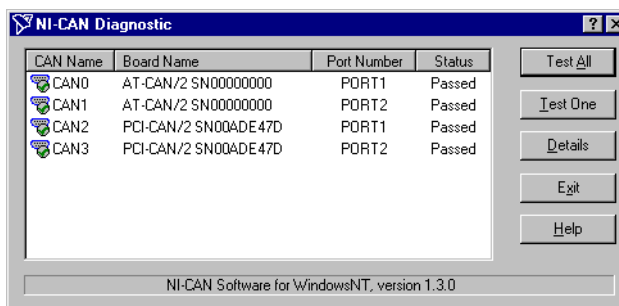


Figure 3-1. NI-CAN Diagnostic Utility after Testing

You can get details about any tested CAN interface by selecting the interface and clicking on the **Details** button. For each failed CAN interface, select it and click on the **Details** button to get a description of the failure. Use that information and the information in Appendix D, *Troubleshooting and Common Questions*, to troubleshoot the problem. Troubleshooting information is also available in the online help for the NI-CAN Diagnostic utility, which you can access by clicking on the **Help** button.

Begin to Use the NI-CAN Software

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

Using the NI-CAN Software

The functions provided by the NI-CAN software are similar to those provided by many other device drivers. For example, NI-CAN has open, close, read, and write functions. NI-CAN provides two different levels of access to a CAN network: the CAN Network Interface Object and CAN Objects. Both forms of access support timestamping of incoming data, as well as various forms of queuing.

The CAN Network Interface Object provides low-level access to a CAN network. Each CAN Network Interface Object maps to a specific CAN port, with no limitation on the maximum number of ports or cards you can use (for example, two PCI-CAN/2 interfaces would provide CAN0 through CAN3). You can use this object to transmit and receive entire CAN frames. For example, to transmit a CAN frame, you would specify the outgoing arbitration ID, frame type (data or remote), data length, and data.

The CAN Objects provide higher level access to a CAN network. Each CAN Object maps to a specific data item (arbitration ID), and you can use multiple CAN Objects for a given port. When configuring a CAN Object for use, you specify the arbitration ID, direction of data transfer, data length, and how you want the data to be accessed (such as periodically). For example, you could configure a CAN Object to transmit an outgoing data frame for a specific arbitration ID every 100 ms. After opening this CAN Object, you use the write function to provide data to transmit, and the NI-CAN embedded firmware handles all periodic timing.

For detailed information about the NI-CAN software and functions, refer to the *NI-CAN User Manual* and the *NI-CAN Programmer Reference Manual*.

General Programming Considerations

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

- For your LabVIEW application, you must use the NI-CAN LabVIEW functions in `nican.llb`.
- For your C/C++ application, you must include the NI-CAN header file, `nican.h`, in your source code.
- The NI-CAN software is accessed through the 32-bit DLL, `nican.dll`, either by linking with one of the language interfaces provided with the NI-CAN software, or by using direct DLL entry from other programming environments.
- Several sample CAN applications are included with the NI-CAN software. Use these as a guide for your own application development.

For information about developing your application, refer to the *NI-CAN User Manual*. For detailed information about NI-CAN functions and objects, refer to the *NI-CAN Programmer Reference Manual*.

Uninstalling the Hardware and Software

This appendix describes how to uninstall the CAN hardware and the NI-CAN software from Windows NT.

Uninstalling the CAN Hardware from Windows NT

Because Windows NT 3.51 and 4.0 do not maintain hardware information for the CAN interfaces, you just need to physically remove the CAN interfaces from your computer. To do so, shut down Windows NT, power off your computer, and physically remove the CAN interfaces.

Uninstalling the NI-CAN Software from Windows NT



Note The following instructions apply to Windows NT 4.0 only. If you are using Windows NT 3.51, refer to the `readme.txt` file in your NI-CAN directory for information on how to uninstall the NI-CAN software.

Before uninstalling the NI-CAN software, you should remove all CAN interface hardware from your computer, as explained in the previous section.

Complete the following steps to remove the NI-CAN software from Windows NT 4.0:

1. Select the **Add/Remove Programs** icon under **Start»Settings»Control Panel**. A dialog box similar to the one in Figure A-1 appears. This dialog box lists the software available for removal.

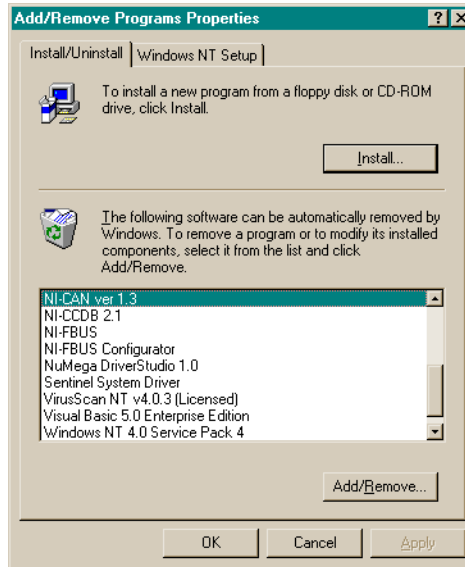


Figure A-1. Add/Remove Programs Properties Dialog Box

2. Select the NI-CAN software you want to remove, and click on the **Add/Remove** button. The uninstall program runs and removes all folders, utilities, device drivers, DLLs, and registry entries associated with the NI-CAN software.

The uninstall program removes only items that the installation program installed. If you add anything to a directory that was created by the installation program, the uninstall program does not delete that directory, because the directory is not empty after the uninstallation. You need to remove any remaining components yourself.

If you want to reinstall the hardware and software, refer to Chapter 2, [Installation and Configuration](#).

Cabling Requirements for High-Speed CAN

This appendix describes the cabling requirements for CAN interfaces.

Cables should be constructed to meet these requirements, as well as the requirements of the other CAN or DeviceNet devices in the network.

Connector Pinouts

Depending on the type of CAN interface you are installing, the CAN hardware either has DB-9 D-Sub connectors(s), or Combicon-style pluggable screw terminal connector(s).

The 9-pin D-Sub follows the pinout recommended by CiA DS 102. Figure B-1 shows the pinout for this connector.

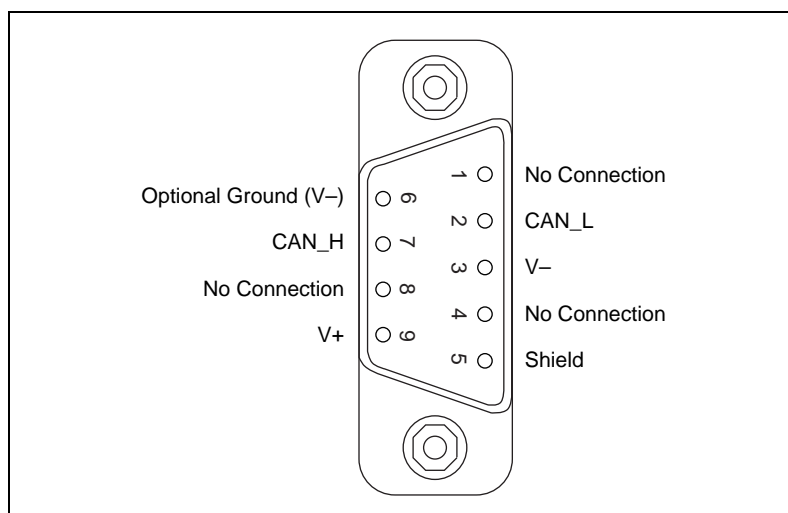


Figure B-1. Pinout for 9-Pin D-Sub Connector

The 5-pin Combicon-style pluggable screw terminal follows the pinout required by the DeviceNet specification. Figure B-2 shows the pinout for this connector.

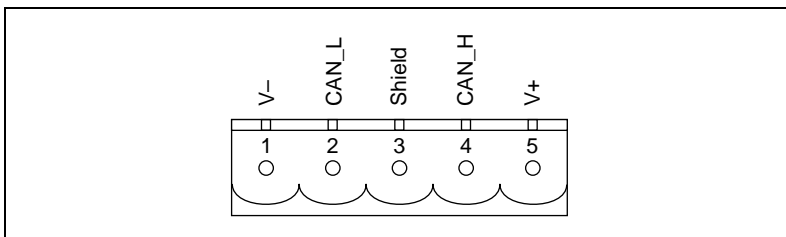


Figure B-2. Pinout for 5-Pin Combicon-Style Pluggable Screw Terminal

CAN_H and CAN_L are signal lines that carry the data on the CAN network. These signals should be connected using twisted-pair cable.

The V+ and V- pins are used to supply bus power to the CAN physical layer if external power is required for the CAN physical layer. If internal power for the CAN physical layer is used, the V- pin serves as the reference ground for CAN_H and CAN_L. See the next section, [Power Supply Information for the High-Speed CAN Ports](#), for more information.

Figure B-3 shows the end of a PCMCIA-CAN cable. The arrow points to pin 1 of the 5-pin screw terminal block. All of the signals on the 5-pin Combicon-style pluggable screw terminal are connected directly to the corresponding pins on the 9-pin D-Sub.

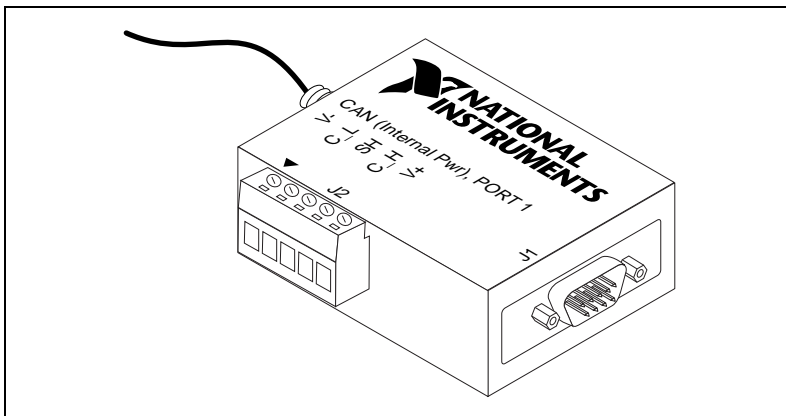


Figure B-3. PCMCIA-CAN Cable

Power Supply Information for the High-Speed CAN Ports

For the PCI-CAN series boards, the power source for the CAN physical layer is configured with a jumper. For the PCI-CAN and port one of the PCI-CAN/2, power is configured with jumper J6. For port two of the PCI-CAN/2, power is configured with jumper J5. The location of these jumpers is shown in Figure B-4.

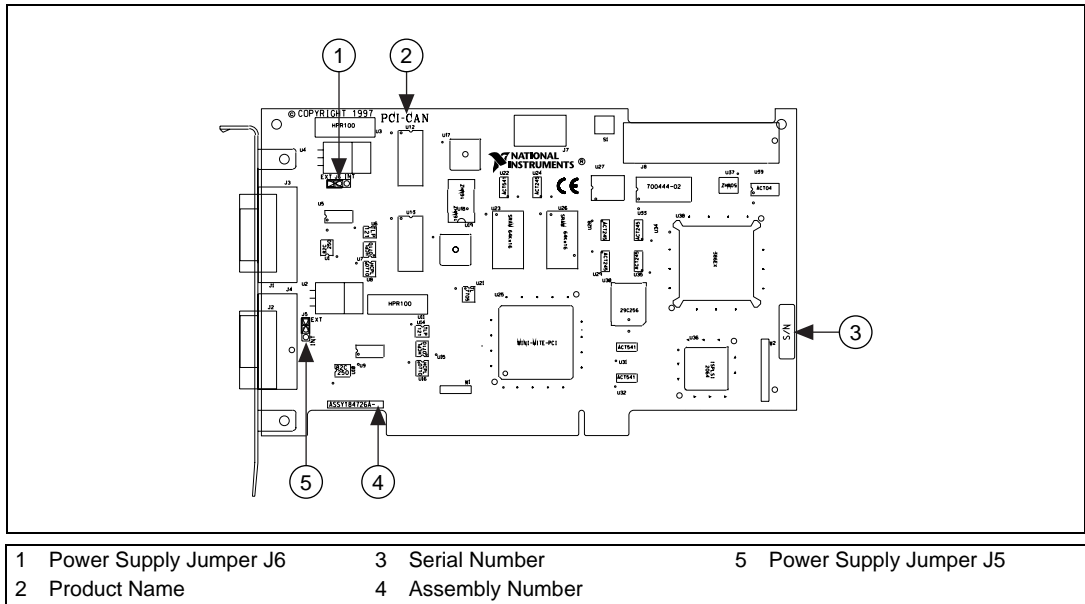


Figure B-4. PCI-CAN/2 Parts Locator Diagram

Connecting pins 1 and 2 of a jumper configures the CAN physical layer to be powered externally (from the bus cable power). In this configuration, the power must be supplied on the V+ and V- pins on the port connector.

Connecting pins 2 and 3 of a jumper configures the CAN physical layer to be powered internally (from the card). In this configuration, the V- signal serves as the reference ground for the isolated signals.

Figure B-5 shows how to configure your jumpers for internal or external power supplies.

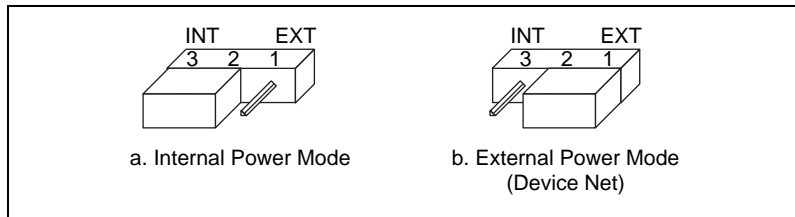


Figure B-5. Power Source Jumpers

The CAN physical layer is still isolated regardless of the power source chosen.

The PCMCIA-CAN series cards are available with two types of cable. The DeviceNet (bus powered) cable requires that the CAN physical layer be powered from the bus cable power.

The internal-powered cable supplies power to the CAN physical layer from the host computer. The V+ pin is not connected to any internal signals, but the corresponding pins on the 9-pin D-Sub and the 5 pin Combicon-style connectors are still connected. The V- pins serves as the reference ground for the isolated signals.

The CAN physical layer is isolated from the computer in both types of cable.

Bus Power Supply Requirements

If the CAN physical layer is powered from a bus power supply, the power supply should be a DC power supply with an output of 10 V to 30 V. The power requirements for the CAN ports for Bus-Powered configurations are shown in Table B-1. You should take these requirements into account when determining requirements of the bus power supply for the system.

Table B-1. Power Requirements for the CAN Physical Layer for Bus-Powered Versions

Characteristic	Specification
Voltage Requirement	V+ 10–30 VDC
Current Requirement	40 mA typical 100 mA maximum

Cable Specifications

Cables should meet the physical medium requirements specified in ISO 11898, shown in Table B-2.

Belden cable (3084A) meets all of those requirements, and should be suitable for most applications.

Table B-2. ISO 11898 Specifications for Characteristics of a CAN_H and CAN_L Pair of Wires

Characteristic	Value
Impedance	108 Ω minimum, 120 Ω nominal, 132 Ω maximum
Length-related resistance	70 m Ω /m nominal
Specific line delay	5 ns/m nominal

Cable Lengths

The allowable cable length is affected by the characteristics of the cabling and the desired bit transmission rates. Detailed cable length requirements can be found in the ISO 11898, CiA DS 102, and DeviceNet specifications.

ISO 11898 specifies 40 m total cable length with a maximum stub length of 0.3 m for a bit rate of 1 Mb/s. The ISO 11898 specification says that significantly longer cable lengths may be allowed at lower bit rates, but each node should be analyzed for signal integrity problems.

Table B-3 lists the DeviceNet cable length specifications.

Table B-3. DeviceNet Cable Length Specifications

Bit Rate	Thick Cable	Thin Cable
500 kb/s	100 m	100 m
250 kb/s	200 m	100 m
100 kb/s	500 m	100 m

Number of Devices

The maximum number of devices depends on the electrical characteristics of the devices on the network. If all of the devices meet the requirements of ISO 11898, at least 30 devices may be connected to the bus. Higher numbers of devices may be connected if the electrical characteristics of the devices do not degrade signal quality below ISO 11898 signal level specifications. If all of the devices on the network meet the DeviceNet specifications, 64 devices may be connected to the network.

Cable Termination

The pair of signal wires (CAN_H and CAN_L) constitutes a transmission line. If the transmission line is not terminated, each signal change on the line causes reflections that may cause communication failures.

Because communication flows both ways on the CAN bus, CAN requires that both ends of the cable be terminated. However, this requirement does not mean that every device should have a termination resistor. If multiple devices are placed along the cable, only the devices on the ends of the cable should have termination resistors. See Figure B-6 for an example of where termination resistors should be placed in a system with more than two devices.

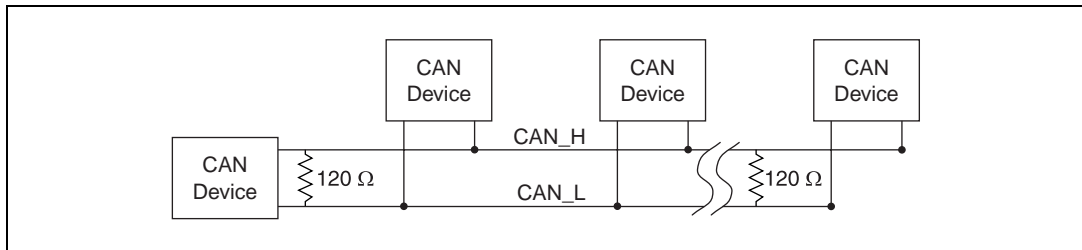


Figure B-6. Termination Resistor Placement

The termination resistors on a cable should match the nominal impedance of the cable. ISO 11898 requires a cable with a nominal impedance of 120 Ω; therefore, a 120 Ω resistor should be used at each end of the cable. Each termination resistor should be capable of dissipating 0.25 W of power.

Cabling Example

Figure B-7 shows an example of a cable to connect two CAN devices. For the internal power configuration, no V+ connection is required.

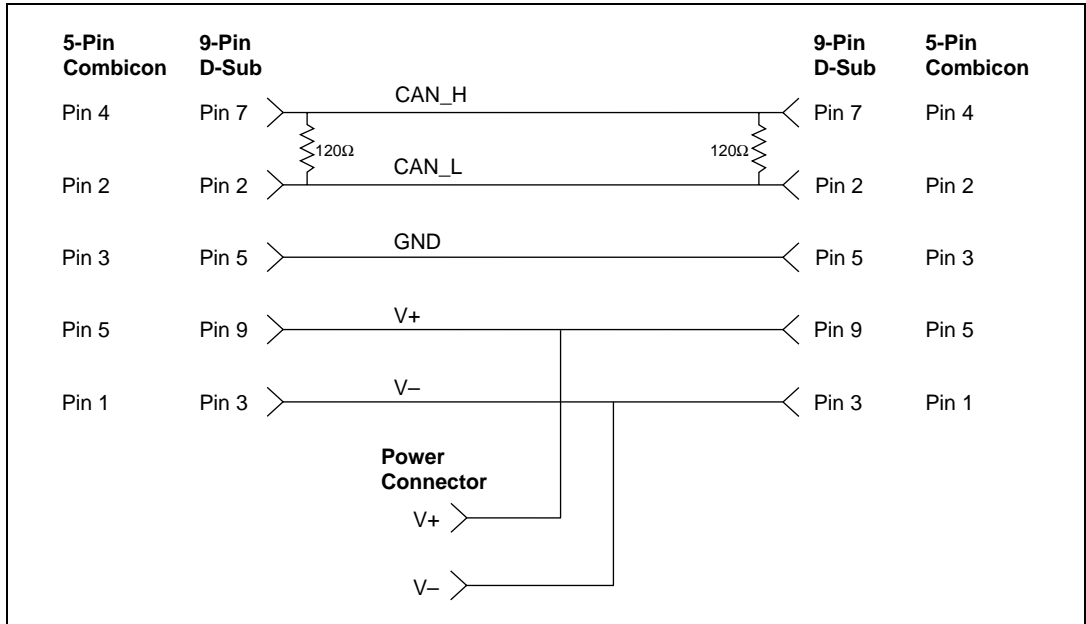


Figure B-7. Cabling Example



Cabling Requirements for Low-Speed CAN

This appendix describes the cabling requirements for the low-speed CAN hardware.

Cables should be constructed to meet these requirements, as well as the requirements of the other CAN devices in the network.

Connector Pinouts

The low-speed CAN hardware has DB-9 D-Sub connector(s). The 9-pin D-Sub follows the pinout recommended by CiA DS 102. Figure C-1 shows the pinout for this connector.

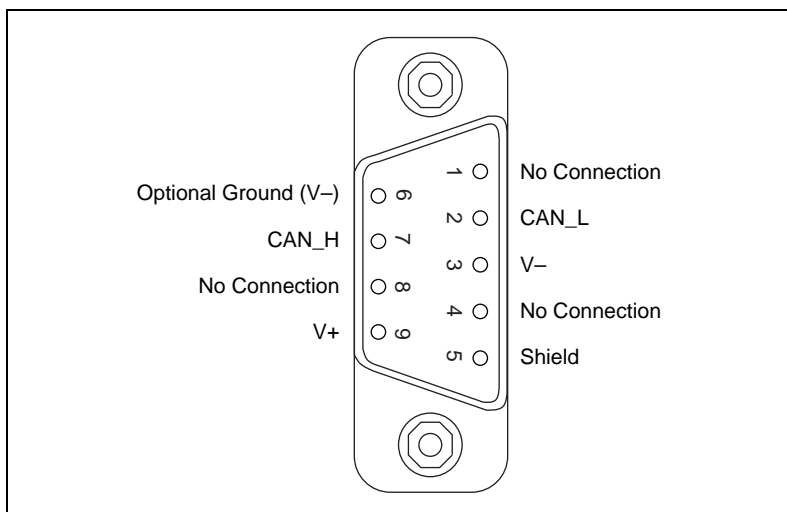


Figure C-1. Pinout for 9-Pin D-Sub Connector

CAN_H and CAN_L are signal lines that carry the data on the CAN network. These signals should be connected using twisted-pair cable.

The V+ and V- pins are used to supply bus power to the CAN physical layer if external power is required for the CAN physical layer. If internal power for the CAN physical layer is used, the V- pin serves as the reference ground for CAN_H and CAN_L. See the next section, *Power Supply Information for the Low-Speed CAN Ports*, for more information.

Power Supply Information for the Low-Speed CAN Ports

For the PCI-CAN/LS and port one of the PCI-CAN/LS2, power is configured with jumper J6. For port two of the PCI-CAN/LS2, power is configured with jumper J5. These jumpers are shown in Figure C-2.

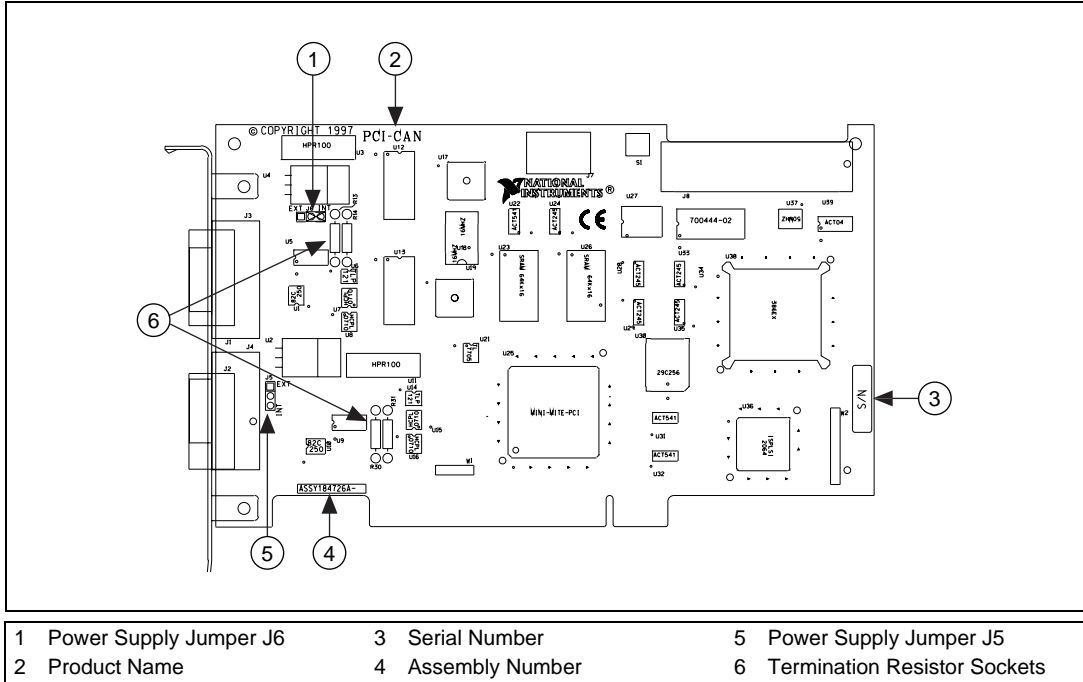


Figure C-2. PCI-CAN/LS2 Parts Locator Diagram

Connecting pins 1 and 2 of a jumper configures the CAN physical layer to be powered externally (from the bus cable power). In this configuration, the power must be supplied on the V+ and V- pins on the port connector.

Connecting pins 2 and 3 of a jumper configures the CAN physical layer to be powered internally (from the card). In this configuration, the V₋ signal serves as the reference ground for the isolated signals. Even if the CAN physical layer is powered internally, the fault-tolerant CAN transceiver still requires bus power to be supplied in order for it to monitor the power supply (battery) voltage.

Figure C-3 shows how to configure your jumpers for internal or external power supplies.

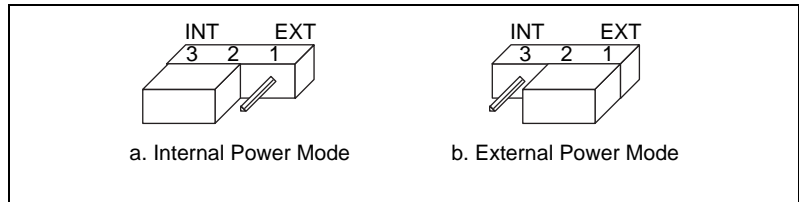


Figure C-3. Power Source Jumpers

The CAN physical layer is still isolated regardless of the power source chosen.

Bus Power Supply Requirements

If the CAN physical layer is powered from a bus power supply, the power supply should be a DC power supply with an output of 8 V to 27V. The power requirements for the CAN ports for Bus-Powered configurations are shown in Table C-1. You should take these requirements into account when determining requirements of the bus power supply for the system.

Table C-1. Power Requirements for the Low-Speed CAN Physical Layer for Bus-Powered Versions

Characteristic	Specification
Voltage requirement	V ₊ 8-27 VDC
Current requirement	40 mA typical 100 mA maximum

Cable Specifications

Cables should meet the physical medium requirements specified in ISO 11519-2, shown in Table C-2.

Belden cable (3084A) meets all of those requirements, and should be suitable for most applications.

Table C-2. ISO 11519-2 Specifications for Characteristics of a CAN_H and CAN_L Pair of Wires

Characteristic	Value
Length-related resistance	90 m Ω /m nominal
Length-related capacitance: CAN_L and ground, CAN_H and ground, CAN_L and CAN_H	30 pF/m nominal

Number of Devices

The maximum number of devices depends on the electrical characteristics of the devices on the network. If all of the devices meet the requirements of ISO 11519-2, at least 20 devices may be connected to the bus. Higher numbers of devices may be connected if the electrical characteristics of the devices do not degrade signal quality below ISO 11519-2 signal level specifications.

Low-Speed Termination

Every device on the low-speed CAN network requires a termination resistor for each CAN data line: R_{RTH} for CAN_H and R_{RTL} for CAN_L. Figure C-4 shows termination resistor placement in a low-speed CAN network.

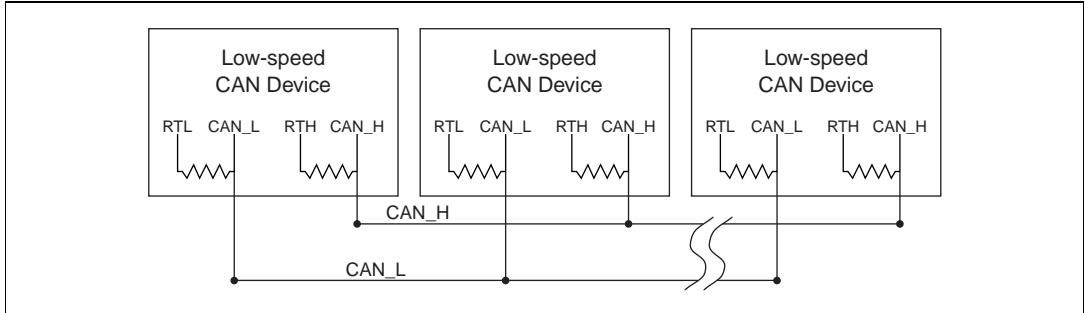


Figure C-4. Termination Resistor Placement for Low-Speed CAN

The following sections explain how to determine the correct resistor values for your low-speed CAN board, and how to replace those resistors, if necessary.

Determining the Necessary Termination Resistance for Your Board

Unlike high-speed CAN, low-speed CAN requires termination at the low-speed CAN transceiver instead of on the cable. The termination requires one resistor for each CAN line. This configuration allows the Philips fault-tolerant CAN transceiver to detect any of seven network faults. You can use your PCI-CAN/LS to connect to a low-speed CAN network having from two to 32 nodes as specified by Philips (including the port on the PCI-CAN/LS as a node). You can also use the PCI-CAN/LS to communicate with individual low-speed CAN devices. It is important to determine the overall termination of your existing network, or the termination of your individual device, before connecting it to a PCI-CAN/LS port. Philips recommends an overall RTH and RTL termination of 100 to 500 Ω (each) for a properly terminated low-speed network. The overall network termination may be determined as follows:

$$\frac{1}{R_{RTH \text{ overall}}^\dagger} = \frac{1}{R_{RTH \text{ node 1}}} + \frac{1}{R_{RTH \text{ node 2}}} + \frac{1}{R_{RTH \text{ node 3}}} + \frac{1}{R_{RTH \text{ or node n...}}}$$

Philips also recommends an individual device RTH and RTL termination of 500 Ω to 16 k Ω . The PCI-CAN/LS board ships with mounted RTH and RTL values of 510 $\Omega \pm 5\%$ per port. The PCI-CAN/LS kit also includes a pair of 15 k $\Omega \pm 5\%$ resistors for each port. After determining the termination of your existing network or device, you can use the following formula to indicate which value should be placed on your PCI-CAN/LS board in order to produce the proper overall RTH and RTL termination of 100 to 500 Ω upon connection of the board:

$$R_{\text{RTH overall}^{\dagger}} = \frac{1}{\left(\frac{1}{R_{\text{RTH of low-speed CAN interface}^{**}}} + \frac{1}{R_{\text{RTH of existing network or device}}} \right)}$$

* $R_{\text{RTH overall}}$ should be between 100 and 500 Ω

** $R_{\text{RTH of low-speed CAN interface}} = 510 \Omega \pm 5\%$ (mounted) or 15 k $\Omega \pm 5\%$ (in kit)

$\dagger R_{\text{RTH}} = R_{\text{RTL}}$

As the formula indicates, the 510 $\Omega \pm 5\%$ shipped on your board will work with properly terminated networks having a total RTH and RTL termination of 125 to 500 Ω , or individual devices having an RTH and RTL termination of 500 Ω to 16 k Ω . For communication with a network having an overall RTH and RTL termination of 100 to 125 Ω , you will need to replace the 510 Ω resistors with the 15 k Ω resistors in the kit. Please refer to the next section, *Replacing the Termination Resistors*.

Replacing the Termination Resistors

Follow these steps to replace the termination resistors, after you have determined the correct value in the previous section, *Determining the Necessary Termination Resistance for Your Board*.

1. Remove the termination resistors on your low-speed CAN board. Figure C-5 shows the location of the termination resistor sockets on a PCI-CAN/LS2 board.

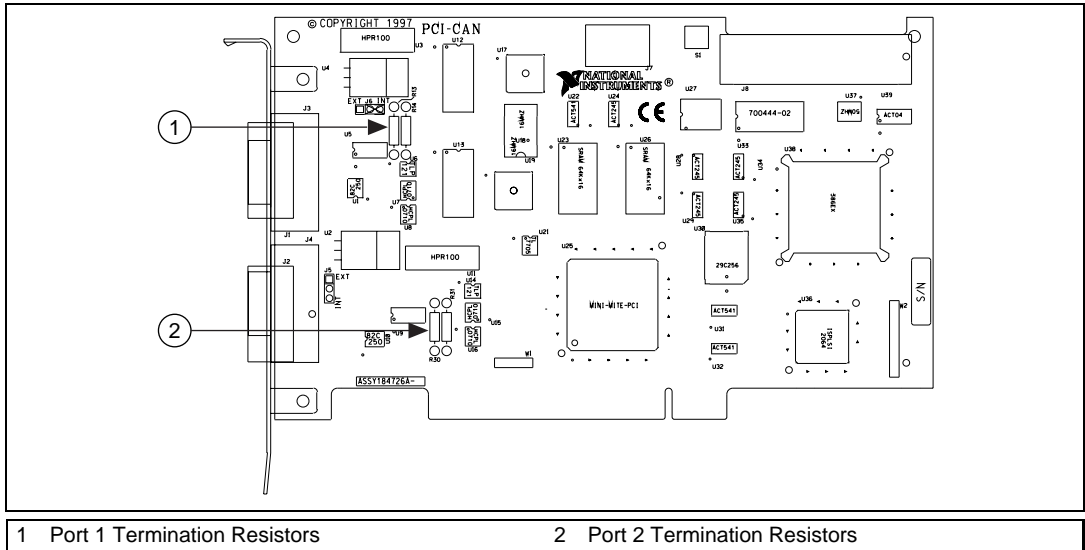


Figure C-5. Location of Termination Resistors on PCI-CAN/LS2 Board

2. Cut and bend the lead wires of the resistors you want to install. Refer to Figure C-6.

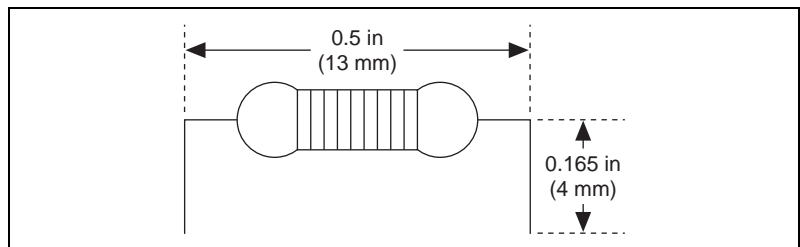


Figure C-6. Preparing Lead Wires of Replacement Resistors

3. Insert the replacement resistors into the empty sockets.
4. Refer to *Install the CAN Hardware*, in Chapter 2, *Installation and Configuration*, to complete the hardware installation.

Cabling Example

Figure C-7 shows an example of a cable to connect two low-speed CAN devices. For the internal power configuration, the V+ connection is required for the low-speed transceiver to operate as specified in the Philips data sheet.

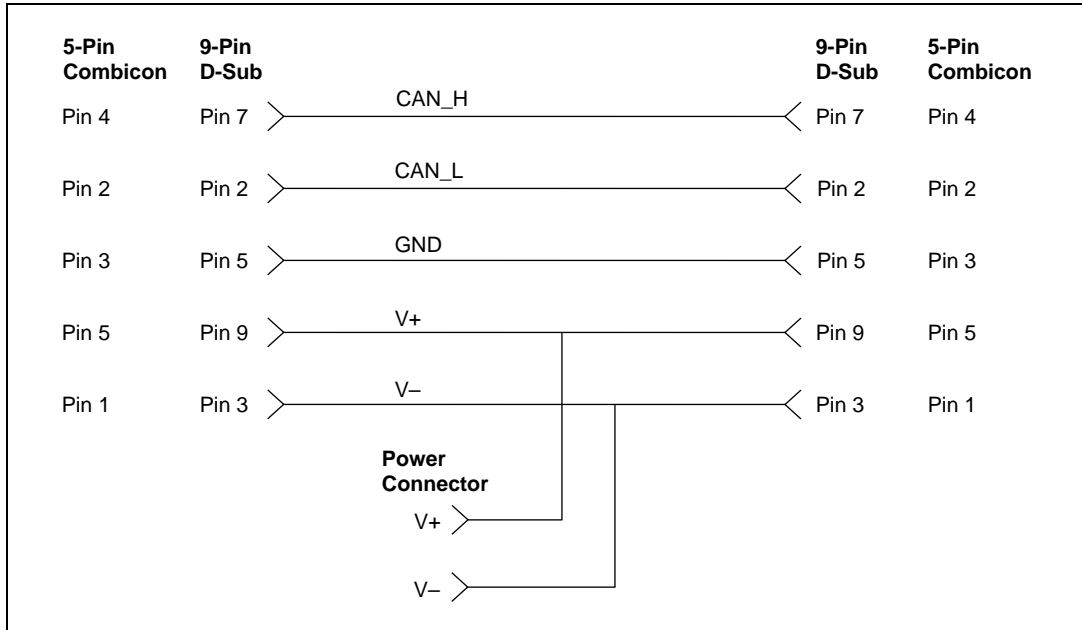


Figure C-7. Cabling Example

Troubleshooting and Common Questions

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

Missing CAN Interface in the NI-CAN Configuration Utility

The NI-CAN Configuration utility contains configuration information for all of the CAN hardware it is aware of that is installed in your system. To start the NI-CAN Configuration utility, double-click on the **NI-CAN Configuration** 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 later—Select **Start»Settings»Control Panel**.

If the CAN interface you are looking for is not listed under **NI-CAN Configuration**, the CAN interface is not properly installed. For National Instruments CAN hardware, this means that the interface is not physically present in the system. If the interface is firmly plugged into its slot and the problem persists, contact National Instruments.

Diagnostic Utility Failures

The following sections explain common error messages generated by the NI-CAN Diagnostic utility.

Resource Errors

This error occurs if the memory resource or interrupt resource assigned to a CAN interface conflicts with the resources being used by other devices in the system. If a resource error occurs, click on the **Resources** button in the NI-CAN Configuration utility to view the board resources. For the PCMCIA-CAN, change the conflicting resource shown in **Resources** until

the interface passes the diagnostic test. For the PCI-CAN, if legacy boards in your system are using the resources, change the resource configuration of the legacy board. If the problem persists, contact National Instruments.

NI-CAN Software Problem Encountered

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

Missing CAN Interface in Diagnostic Utility

If a National Instruments CAN interface is physically installed in your system, but is not listed in the NI-CAN Diagnostic utility, check to see if the NI-CAN Configuration utility has detected the hardware. For more information, refer to the [Missing CAN Interface in the NI-CAN Configuration Utility](#) section earlier in this appendix.

CAN Hardware Problem Encountered

This error occurs if the NI-CAN Diagnostic utility detects a defect in the CAN hardware. If you get this error, write down the numeric code shown with the error, and contact National Instruments. Depending on the cause of the hardware failure, you may need to repair or replace your CAN interface.

Common Questions

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

Run the NI-CAN Configuration utility. To run the utility, select **Start»Settings»Control Panel»NI-CAN Configuration**. If any CAN hardware is correctly installed, it is listed under **National Instruments CAN Interfaces**.

How do I connect a CAN cable to my CAN interface?

For information about cabling requirements for National Instruments CAN hardware, refer to Appendix B, [Cabling Requirements for High-Speed CAN](#), or Appendix C, [Cabling Requirements for Low-Speed CAN](#).

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

Run the NI-CAN Diagnostic utility. To run the utility, select the **NI-CAN Diagnostic** item under **Start»Programs»National Instruments CAN**. The NI-CAN Diagnostic utility displays information about the version of the NI-CAN software currently installed.

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

Refer to the [Diagnostic Utility Failures](#) section in this appendix for specific information about what might cause the NI-CAN Diagnostic utility to fail. If you have already completed the troubleshooting steps, contact National Instruments.

How many CAN boards can I configure for use with my NI-CAN software for Windows NT?

The NI-CAN software for Windows NT can be configured to communicate with up to 10 CAN boards.

Are interrupts required for the NI-CAN software for Windows NT?

Yes, one interrupt per board is required.

How do I use an NI-CAN language interface?

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

How do I use NI-CAN from within LabVIEW?

For information about using NI-CAN from within LabVIEW, refer to Chapter 3, *Developing Your Application*, in the *NI-CAN User Manual*.

Why does the uninstall program leave some components installed?

The uninstall program removes only items that the installation program installed. If you add anything to a directory that was created by the installation program, the uninstall program does not delete that directory, because the directory is not empty after the uninstallation. You must remove any remaining components yourself.

Specifications

This appendix describes the physical characteristics of the CAN hardware, along with the recommended operating conditions.

PCI-CAN Series

Dimensions.....	10.67 by 17.46 cm (4.2 by 6.88 in.)
Power requirement	+5 VDC, 775 mA typical
I/O connector.....	9-pin D-Sub for each port (standard) or 5-pin Combicon-style pluggable DeviceNet screw terminal (high-speed CAN only)
Operating environment	
Ambient temperature	0 to 55 °C
Relative humidity.....	10% to 90%, noncondensing
Storage environment	
Temperature.....	-20 to 70 °C
Relative humidity.....	5% to 90%, noncondensing

PCMCIA-CAN Series

Dimensions.....	8.56 by 5.40 by 0.5 cm (3.4 by 2.1 by 0.4 in.)
Power requirement	500 mA typical
I/O connector.....	Cable with 9-pin D-Sub and 5-pin Combicon-style pluggable screw terminal for each port

Operating environment

Component temperature0 to 55 °C

Relative humidity10% to 90%, noncondensing

Storage Environment

Temperature.....-20 to 70 °C

Relative humidity5% to 90%, noncondensing

High-Speed CAN Port Characteristics for Bus-Powered Ports

Power requirement.....10–30 V, 40 mA typical
100 mA maximum

Isolation500 VDC optical

Low-Speed CAN Port Characteristics for Bus-Powered Ports

Power requirement.....8–27 V, 40 mA typical
100 mA maximum

Isolation500 VDC optical

Technical Support Resources

This appendix describes the comprehensive resources available to you in the Technical Support section of the National Instruments Web site and provides technical support telephone numbers for you to use if you have trouble connecting to our Web site or if you do not have internet access.

NI Web Support

To provide you with immediate answers and solutions 24 hours a day, 365 days a year, National Instruments maintains extensive online technical support resources. They are available to you at no cost, are updated daily, and can be found in the Technical Support section of our Web site at www.natinst.com/support.

Online Problem-Solving and Diagnostic Resources

- **KnowledgeBase**—A searchable database containing thousands of frequently asked questions (FAQs) and their corresponding answers or solutions, including special sections devoted to our newest products. The database is updated daily in response to new customer experiences and feedback.
- **Troubleshooting Wizards**—Step-by-step guides lead you through common problems and answer questions about our entire product line. Wizards include screen shots that illustrate the steps being described and provide detailed information ranging from simple getting started instructions to advanced topics.
- **Product Manuals**—A comprehensive, searchable library of the latest editions of National Instruments hardware and software product manuals.
- **Hardware Reference Database**—A searchable database containing brief hardware descriptions, mechanical drawings, and helpful images of jumper settings and connector pinouts.
- **Application Notes**—A library with more than 100 short papers addressing specific topics such as creating and calling DLLs, developing your own instrument driver software, and porting applications between platforms and operating systems.

Software-Related Resources

- **Instrument Driver Network**—A library with hundreds of instrument drivers for control of standalone instruments via GPIB, VXI, or serial interfaces. You also can submit a request for a particular instrument driver if it does not already appear in the library.
- **Example Programs Database**—A database with numerous, non-shipping example programs for National Instruments programming environments. You can use them to complement the example programs that are already included with National Instruments products.
- **Software Library**—A library with updates and patches to application software, links to the latest versions of driver software for National Instruments hardware products, and utility routines.

Worldwide Support

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Glossary

Prefix	Meaning	Value
n-	nano-	10^{-9}
m-	milli-	10^{-3}
c-	centi-	10^{-2}
k-	kilo-	10^3
M-	mega-	10^6

°	degrees
Ω	ohms
%	percent
A	amperes
AC	alternating current
ANSI	American National Standards Institute
AT-compatible	compatible with the 16-bit Industry Standard Architecture
b	bits
B	bytes
C	Celsius
CAN	Controller Area Network
CAN/LS	Low-speed CAN
CiA	CAN in Automation
DLL	dynamic link library
DMA	direct memory access
EMI	electromagnetic interference
FCC	Federal Communications Commission
Hz	hertz

Glossary

IEEE	Institute of Electrical and Electronic Engineers
in.	inches
IRQ	interrupt request
ISA	Industry Standard Architecture
ISO	International Standards Organization
m	meters
PC	personal computer
PCI	peripheral component interconnect
PCMCIA	Personal Computer Memory Card International Association
RAM	random-access memory
resource	hardware settings used by National Instruments CAN hardware, including an interrupt request level (IRQ) and an 8 KB physical memory range (such as D0000 to D1FFF hex)
s	seconds
V	volts
VDC	volts direct current
W	watts