DAQ

DAQCard™ E Series
User Manual

Multifunction I/O Devices for PCMCIA

NATIONAL INSTRUMENTS™

Worldwide Technical Support and Product Information

`ni.com`

National Instruments Corporate Headquarters

11500 North Mopac Expressway   Austin, Texas 78759-3504   USA   Tel: 512 683 0100

Worldwide Offices

Australia 03 9879 5166, Austria 0662 45 79 90 0, Belgium 02 757 00 20, Brazil 011 3262 3599,
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Compliance

FCC/Canada Radio Frequency Interference Compliance*

Determining FCC Class

The Federal Communications Commission (FCC) has rules to protect wireless communications from interference. The FCC places digital electronics into two classes. These classes are known as Class A (for use in industrial-commercial locations only) or Class B (for use in residential or commercial locations). Depending on where it is operated, this product could be subject to restrictions in the FCC rules. (In Canada, the Department of Communications (DOC), of Industry Canada, regulates wireless interference in much the same way.)

Digital electronics emit weak signals during normal operation that can affect radio, television, or other wireless products. By examining the product you purchased, you can determine the FCC Class and therefore which of the two FCC/DOC Warnings apply in the following sections. (Some products may not be labeled at all for FCC; if so, the reader should then assume these are Class A devices.)

FCC Class A products only display a simple warning statement of one paragraph in length regarding interference and undesired operation. Most of our products are FCC Class A. The FCC rules have restrictions regarding the locations where FCC Class A products can be operated.

FCC Class B products display either a FCC ID code, starting with the letters **EXN**, or the FCC Class B compliance mark that appears as shown here on the right.

Consult the FCC Web site at `www.fcc.gov` for more information.

Trade Name	Model Number
FC	Tested to Comply with FCC Standards
FOR HOME OR OFFICE USE	
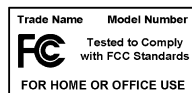
FCC/DOC Warnings

This equipment generates and uses radio frequency energy and, if not installed and used in strict accordance with the instructions in this manual and the CE Mark Declaration of Conformity**, may cause interference to radio and television reception. Classification requirements are the same for the FCC and the Canadian DOC.

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

Class A
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

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.

Class B
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.

Compliance to EU Directives

Readers in the European Union (EU) must refer to the Manufacturer's Declaration of Conformity (DoC) for information** pertaining to the CE Mark compliance scheme. The Manufacturer includes a DoC for most every hardware product except for those bought for OEMs, if also available from an original manufacturer that also markets in the EU, or where compliance is not required as for electrically benign apparatus or cables.

To obtain the DoC for this product, click **Declaration of Conformity** at `ni.com/hardref.nsf/`. This Web site lists the DoCs by product family. Select the appropriate product family, followed by your product, and a link to the DoC appears in Adobe Acrobat format. Click the Acrobat icon to download or read the DoC.

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* Certain exemptions may apply in the USA, see FCC Rules §15.103 **Exempted devices**, and §15.105(c). Also available in sections of CFR 47.

** The CE Mark Declaration of Conformity will contain important supplementary information and instructions for the user or installer.

Contents

Chapter 4
Signal Connections

Chapter 5
Calibration

Appendix A
Specifications

Appendix B
Optional Cable Connector Descriptions

Appendix C
Common Questions

Appendix D
Technical Support and Professional Services

Glossary

Index

About This Manual

This manual describes the electrical and mechanical aspects of data acquisition (DAQ) devices in the DAQCard E Series product line and contains information concerning their operation and programming.

The DAQCard E Series family devices that are described in this manual include the following cards:

- DAQCard-AI-16E-4
- DAQCard-AI-16XE-50

You can download the manuals for other DAQCard E Series devices from `ni.com/manuals`.

The DAQCard E Series cards are high-performance multifunction analog input (AI), digital I/O (DIO), and timing I/O (TIO) devices for computers with PCMCIA slots compliant with PCMCIA revision 2.1 specifications. Supported functions include AI, DIO, and TIO.

Conventions Used in this Manual

The following conventions are used in this manual.

<>	Angle brackets that contain numbers separated by an ellipsis represent a range of values associated with a bit or signal name—for example, DBIO<3..0>. Angle brackets can also denote a variable in a channel name—for example, ACH<*i*> and ACH <*i* + 8>.
»	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.
♦	The ♦ indicates that the text following it applies only to specific DAQCard E Series devices.
	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. When this symbol is marked on the product, refer to the *Safety Information* section of Chapter 1, *Introduction*, for precautions to take.
bold	Bold text denotes items that you must select or click in the software, such as menu items and dialog box options. Bold text also denotes parameter names and hardware labels.
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.
NI-DAQ	NI-DAQ refers to NI-DAQ software unless otherwise noted.
PC Card	PC Card refers to a PCMCIA device.
SCXI	SCXI stands for Signal Conditioning eXtensions for Instrumentation and is an NI product line designed to perform front-end signal conditioning for NI plug-in DAQ devices.

National Instruments Documentation

The *DAQCard E Series User Manual* is one piece of the documentation set for the DAQ system. You could have any of several types of documentation depending on the hardware and software in the system. Use the manuals you have as follows:

- *Getting Started with SCXI*—If you are using SCXI, this is the first manual you should read. It gives an overview of the SCXI system and contains the most commonly needed information for the modules, chassis, and software.

- SCXI hardware user manuals—If you are using SCXI, read these manuals next for detailed information about signal connections and module configuration. They also explain in greater detail how the module works and contain application hints. These manuals also contain maintenance information on the chassis and installation instructions.

- DAQ hardware user manuals—These manuals have detailed information about the DAQ hardware that plugs into or is connected to the computer. Use these manuals for hardware installation and configuration instructions, specification information about the DAQ hardware, and application hints.

- Software documentation—You might have several sets of software documentation, including LabVIEW, Measurement Studio, and NI-DAQ. After you set up the hardware system, use either the application software, such as LabVIEW or Measurement Studio, or the NI-DAQ documentation to help you write your application. If you have a large and complicated system, it is worthwhile to look through the software documentation before you configure the hardware.

- Accessory installation guides or manuals—If you are using accessory products, read the terminal block and cable assembly installation guides. They explain how to physically connect the relevant pieces of the system. Consult these guides when you are making signal connections.

Related Documentation

The following NI documents contain information you may find helpful:

- *DAQCard E Series Register-Level Programmer Manual*, located at `ni.com/manuals`

- *DAQ Quick Start Guide*, located at `ni.com/manuals`

- *DAQ-STC Technical Reference Manual*, located at `ni.com/manuals`

- *NI-DAQ Function Reference Manual for PC Compatibles*, located at `ni.com/manuals`

- *NI-DAQ Function Reference Help*, which you can access by selecting **Start»Programs»National Instruments»NI-DAQ»NI-DAQ Help**

- *NI-DAQ User Manual for PC Compatibles*, located at `ni.com/manuals`

- The NI Developer Zone tutorial, *Field Wiring and Noise Considerations for Analog Signals*, at `ni.com/zone`

- *PCMCIA Specification Revision 2.1*

1

Introduction

This chapter describes the DAQCard E Series devices, lists what you need to get started, describes the optional software and optional equipment, and explains how to unpack the DAQCard E Series device.

About the DAQCard E Series Devices

Thank you for buying a National Instruments DAQCard E Series device. The DAQCard E Series devices are multifunction AI, DIO, and TIO devices for computers equipped with Type II PCMCIA slots. This family of devices features 12-bit and 16-bit A/D converters (ADCs) with eight lines of TTL-compatible DIO, and two 24-bit counter/timers for TIO.

The DAQCard E Series devices use the National Instruments DAQ-STC system timing controller for time-related functions. The DAQ-STC consists of three timing groups that control AI, analog output (AO), and general-purpose counter/timer (GPCTR) functions. These groups include a total of seven 24-bit and three 16-bit counters and a maximum timing resolution of 50 ns. The AO timing group is unused on the DAQCard E Series devices.

The DAQCard E Series devices can interface to an SCXI system so that you can acquire over 3,000 analog signals from thermocouples, resistance temperature detectors (RTDs), strain gauges, voltage sources, and current sources. You can also acquire or generate digital signals for communication and control. SCXI is the instrumentation front end for plug-in DAQ devices.

Detailed specifications for the DAQCard E Series devices are in Appendix A, *Specifications*.

What You Need to Get Started

To set up and use the DAQCard E Series device, you need the following items:

❑   One of the following devices:

–   DAQCard-AI-16E-4

–   DAQCard-AI-16XE-50

❑   *DAQCard E Series User Manual*

❑   NI-DAQ

❑   One of the following software packages and documentation (optional):

–   LabVIEW (Windows/Macintosh)

–   Measurement Studio (Windows)

–   VI Logger (Windows)

❑   A computer

Software Programming Choices

When programming National Instruments DAQ hardware, you can use an NI application development environment (ADE) or other ADEs. In either case, use NI-DAQ.

NI-DAQ

NI-DAQ, which shipped with the DAQCard E Series device, has an extensive library of functions that you can call from the ADE. These functions allow you to use all the features of the DAQCard E Series device.

NI-DAQ carries out many of the complex interactions, such as programming interrupts, between the computer and the DAQ hardware. NI-DAQ maintains a consistent software interface among its different versions so that you can change platforms with minimal modifications to the code. Whether you use LabVIEW, Measurement Studio, VI Logger or other ADEs, your application uses NI-DAQ, as illustrated in Figure 1-1.
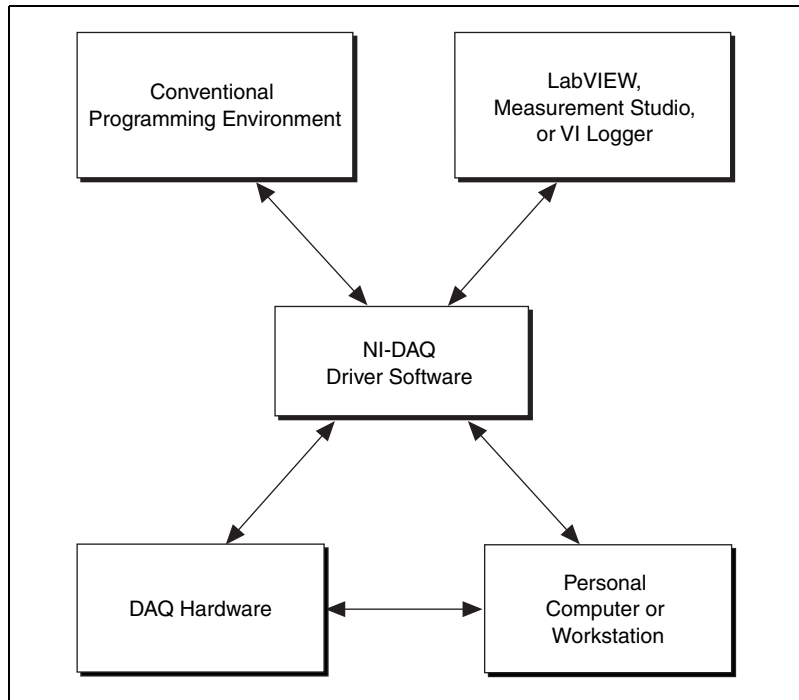
Figure 1-1. The Relationship Among the Programming Environment,
NI-DAQ, and the Hardware

To download a free copy of the most recent version of NI-DAQ, click
Download Software at ni.com.

National Instruments ADE Software

LabVIEW features interactive graphics, a state-of-the-art interface, and a
powerful graphical programming language. The LabVIEW Data
Acquisition VI Library, a series of virtual instruments for using LabVIEW
with National Instruments DAQ hardware, is included with LabVIEW.

Measurement Studio, which includes LabWindows/CVI, tools for Visual
C++, and tools for Visual Basic, is a development suite that allows you to
use ANSI C, Visual C++, and Visual Basic to design the test and
measurement software. For C developers, Measurement Studio includes
LabWindows/CVI, a fully integrated ANSI C application development
environment that features interactive graphics and the LabWindows/CVI
Data Acquisition and Easy I/O libraries. For Visual Basic developers,
Measurement Studio features a set of ActiveX controls for using National
Instruments DAQ hardware. These ActiveX controls provide a high-level

programming interface for building virtual instruments. For Visual C++ developers, Measurement Studio offers a set of Visual C++ classes and tools to integrate those classes into Visual C++ applications. The libraries, ActiveX controls, and classes are available with Measurement Studio and NI-DAQ.

VI Logger is an easy-to-use yet flexible tool specifically designed for data logging applications. Using dialog windows, you can configure data logging tasks to easily acquire, log, view, and share your data. VI Logger does not require any programming; it is a stand-alone, configuration-based software.

Using LabVIEW, Measurement Studio, or VI Logger greatly reduces the development time for your data acquisition and control application.

Register-Level Programming

The final option for programming any National Instruments DAQ hardware is to write register-level software. Writing register-level programming software can be very time consuming and inefficient and is not recommended for most users.

Even if you are an experienced register-level programmer, consider using NI-DAQ, LabVIEW, or Measurement Studio to program the National Instruments DAQ hardware. Using the NI-DAQ, LabVIEW, or Measurement Studio is as easy and as flexible as register-level programming and can save weeks of development time.

The DAQCard E Series *Register-Level Programmer Manual* is available at `ni.com/manuals`.

Optional Equipment

NI offers a variety of products to use with the DAQCard E Series devices, including cables, connector blocks, and other accessories, as follows:

•   Cables and cable assemblies, shielded and ribbon

•   Connector blocks, shielded and unshielded, with 50- and 68-pin screw terminals

•   SCXI modules and accessories for isolating, amplifying, exciting, and multiplexing signals for relays and analog output. With SCXI you can condition and acquire up to 3,072 channels per DAQ device.

- Low channel-count signal conditioning modules, devices, and accessories, including conditioning for strain gauges and RTDs, simultaneous sample-and-hold circuitry, and relays

For more specific information about these products, refer to ni.com/catalog.

Custom Cabling

NI offers cables and accessories for you to prototype your application or to use if you frequently change DAQCard interconnections.

If you want to develop your own cable, however, use the following guidelines:

- For the AI signals, shielded twisted-pair wires for each AI pair yield the best results, assuming that you use differential inputs. Connect the shield for each signal pair to the ground reference at the source. For more information on the types of input configurations and signal sources, refer to Chapter 4, *Signal Connections*.
- Route the analog lines separately from the digital lines.
- When using a cable shield, use separate shields for the analog and digital signals in the cable. Failure to do so results in noise coupling into the analog signals from transient digital signals.

The following list gives recommended NI cable assemblies that connect to the DAQCard I/O connector.

- PSHR68-68M, a shielded 68-position ribbon cable, with male-to-male connectors. This cable connects to an SH6868 or SH6850 shielded cable.
- PR68-68F, an unshielded 68-position ribbon cable.

Unpacking

The DAQCard E Series device is shipped in an antistatic package to prevent electrostatic damage to the device. Electrostatic discharge can damage several components on the device.

⚠ **Caution**   *Never* touch the exposed pins of connectors.

To avoid such damage in handling the device, take the following precautions:

- Ground yourself using a grounding strap or by holding a grounded object.
- Touch the antistatic package to a metal part of the computer chassis before removing the device from the package.

Remove the DAQCard E Series device from the package and inspect the device for loose components or any sign of damage. Notify NI if the device appears damaged in any way. Do *not* install a damaged device into the computer.

Store the device in the antistatic envelope when not in use.

Safety Information

The following section contains important safety information that you *must* follow when installing and using the product.

Do *not* operate the product in a manner not specified in this document. Misuse of the product can result in a hazard. You can compromise the safety protection built into the product if the product is damaged in any way. If the product is damaged, return it to National Instruments for repair.

Do *not* substitute parts or modify the product except as described in this document. Use the product only with the chassis, modules, accessories, and cables specified in the installation instructions. You *must* have all covers and filler panels installed during operation of the product.

Do *not* operate the product in an explosive atmosphere or where there may be flammable gases or fumes. Operate the product only at or below the pollution degree stated in Appendix A, *Specifications*. Pollution is foreign matter in a solid, liquid, or gaseous state that can reduce dielectric strength or surface resistivity. The following is a description of pollution degrees:

- Pollution degree 1 means no pollution or only dry, nonconductive pollution occurs. The pollution has no influence.
- Pollution degree 2 means that only nonconductive pollution occurs in most cases. Occasionally, however, a temporary conductivity caused by condensation must be expected.
- Pollution degree 3 means that conductive pollution occurs, or dry, nonconductive pollution occurs that becomes conductive due to condensation.

Clean the product with a soft nonmetallic brush. Make sure that the product is completely dry and free from contaminants before returning it to service.

You *must* insulate signal connections for the maximum voltage for which the product is rated. Do *not* exceed the maximum ratings for the product. Remove power from signal lines before connecting them to or disconnecting them from the product.

Operate this product only at or below the installation category stated in Appendix A, *Specifications*.

The following is a description of installation categories:

• Installation Category I is for measurements performed on circuits not directly connected to MAINS[1]. This category is a signal level such as voltages on a printed wire board (PWB) on the secondary of an isolation transformer.

 Examples of Installation Category I are measurements on circuits not derived from MAINS and specially protected (internal) MAINS-derived circuits.

• Installation Category II is for measurements performed on circuits directly connected to the low-voltage installation. This category refers to local-level distribution such as that provided by a standard wall outlet.

 Examples of Installation Category II are measurements on household appliances, portable tools, and similar equipment.

• Installation Category III is for measurements performed in the building installation. This category is a distribution level referring to hardwired equipment that does not rely on standard building insulation.
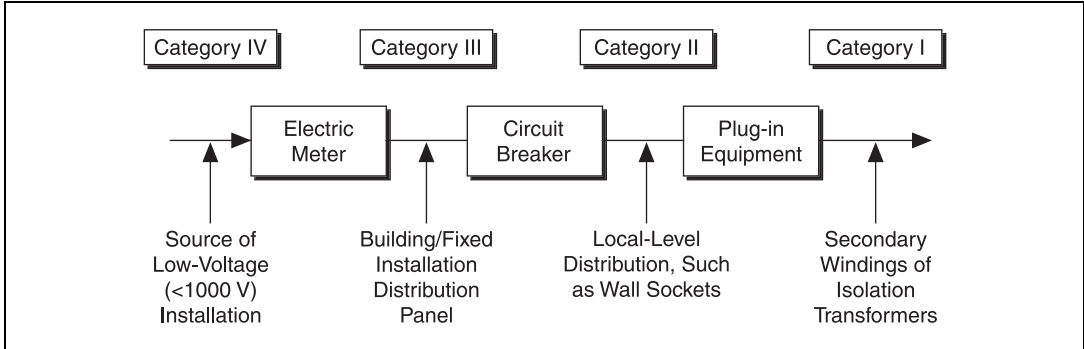
 Examples of Installation Category III include measurements on distribution circuits and circuit breakers. Other examples of Installation Category III are wiring including cables, bus-bars, junction boxes, switches, socket outlets in the building/fixed installation, and equipment for industrial use, such as stationary motors with a permanent connection to the building/fixed installation.

• Installation Category IV is for measurements performed at the source of the low-voltage (<1,000 V) installation.

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[1] MAINS is defined as the electricity supply system to which the equipment concerned is designed to be connected either for powering the equipment or for measurement purposes.

Examples of Installation Category IV are electric meters, and measurements on primary overcurrent protection devices and ripple-control units.

Below is a diagram of a sample installation.

Category IV	Category III	Category II	Category I
Electric Meter	Circuit Breaker	Plug-in Equipment	
Source of Low-Voltage (<1000 V) Installation	Building/Fixed Installation Distribution Panel	Local-Level Distribution, Such as Wall Sockets	Secondary Windings of Isolation Transformers

2

Installing and Configuring the Device

This chapter explains how to install and configure a DAQCard E Series device.

Installing the Software

Complete the following steps to install the software before installing the DAQCard E Series device.

1. Install the ADE, such as LabVIEW or Measurement Studio, according to the instructions on the CD and the release notes.

2. Install NI-DAQ according to the instructions on the CD and the *DAQ Quick Start Guide* included with the device.

✎ **Note** It is important to install NI-DAQ before installing the DAQCard E Series device to ensure that the device is properly detected.

Installing the Hardware

The following are general installation instructions. Consult the computer user manual or technical reference manual for specific instructions and warnings about installing new devices.

Refer to Figure 2-1 when installing the DAQCard E Series device.

1. Power off and unplug the computer.

2. Insert the PCMCIA bus connector of the DAQCard in any available Type II PC Card slot until the connector is firmly seated.

   The DAQCard has two connectors—a 68-pin PCMCIA bus connector on one end and a 68-pin I/O connector on the other end. The DAQCard and the I/O cable are keyed so you can insert it only one way.

3. Visually verify the installation by making sure that the DAQCard is fully inserted into the slot.

4. Attach the I/O cable. You can connect the E Series DAQCard to 68- and 50-pin accessories. You can use either a 68-pin female cable to plug into the PSHR68-68M with the DAQCard, or a 50-pin male cable and the PSHR68-68M and SH6850 with the DAQCard. Refer to Appendix B, *Optional Cable Connector Descriptions*, for more information.

✏️ **Note**   Be careful not to put strain on the I/O cable when inserting it into and removing it from the DAQCard. Always grasp the cable by the connector you are plugging or unplugging. *Never* pull directly on the I/O cable to unplug it from the DAQCard.

5. Plug in and power on the computer.

The DAQCard is now installed. You are ready to make the appropriate connections to the I/O connector cable as described in Chapter 4, *Signal Connections*.

Figure 2-1 shows an example of a typical configuration.

1	Portable Computer	3	E Series DAQCard Device	5	SH6868 Cable
2	Type II PCMCIA Socket	4	PSHR68-68M I/O Cable	6	I/O Signals
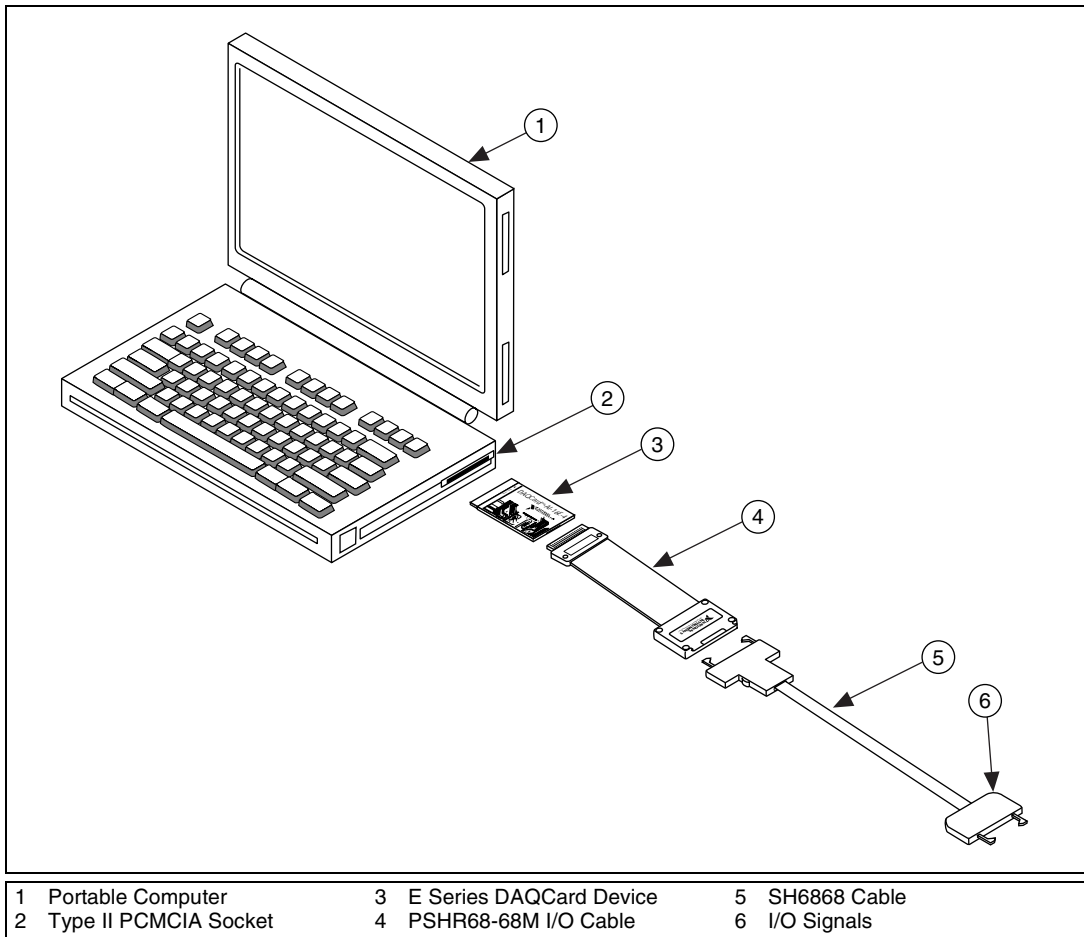
Figure 2-**1.** A Typical Configuration for the DAQCard E Series Device

Configuring the Device

The DAQCard is completely software-configurable. Refer to the Measurement & Automation Explorer (MAX) *Measurement & Automation Explorer Help for DAQ* online help file to configure the device. To access the help file, click **Help»Help Topics»NI-DAQ** from the MAX main screen.

If you are using NI-DAQ, refer to the NI-DAQ release notes to install the driver software. Find the installation section for the operating system and follow the instructions given there.

If you are using LabVIEW, refer to the LabVIEW release notes to install the application software. After you have installed LabVIEW, refer to the NI-DAQ release notes and follow the instructions given there for the operating system and LabVIEW.

Data acquisition-related configuration, which you must perform, includes such settings as AI coupling and range, and others. You can modify these settings using NI-DAQ or application-level software, such as LabVIEW and Measurement Studio.

To configure the device in MAX, refer to either the *DAQ Quick Start Guide* or to the *NI-DAQ User Manual for PC Compatibles.*

Hardware Overview

This chapter presents an overview of the hardware functions on the DAQCard E Series devices.

Figure 3-1 shows the block diagram for the DAQCard-AI-16E-4.
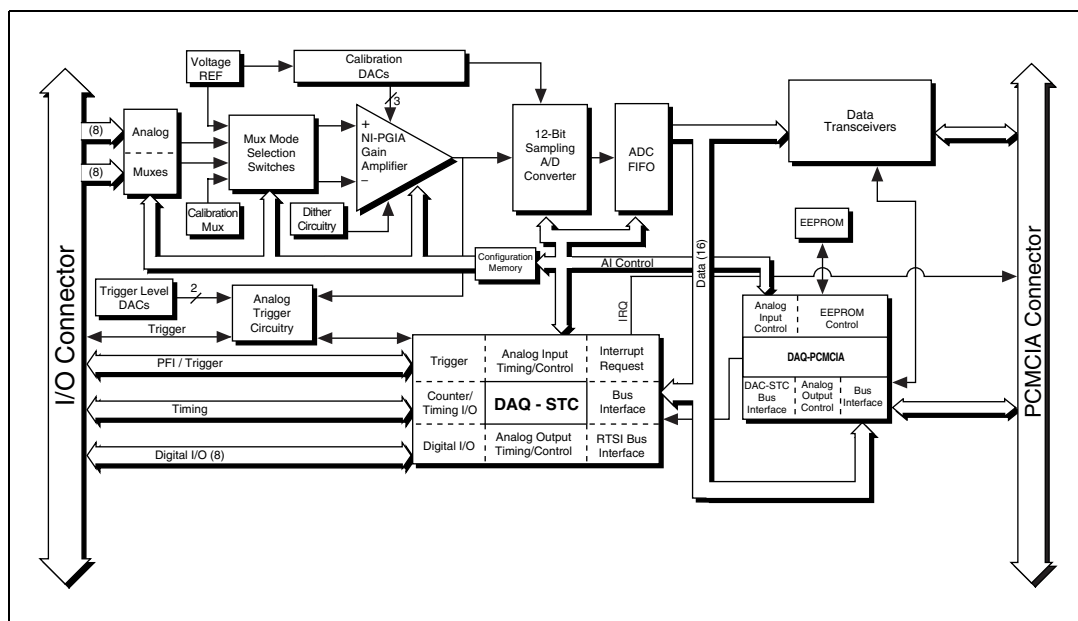
Figure 3-1. DAQCard-AI-16E-4 Block Diagram

Figure 3-2 shows a block diagram for the DAQCard-AI-16XE-50.
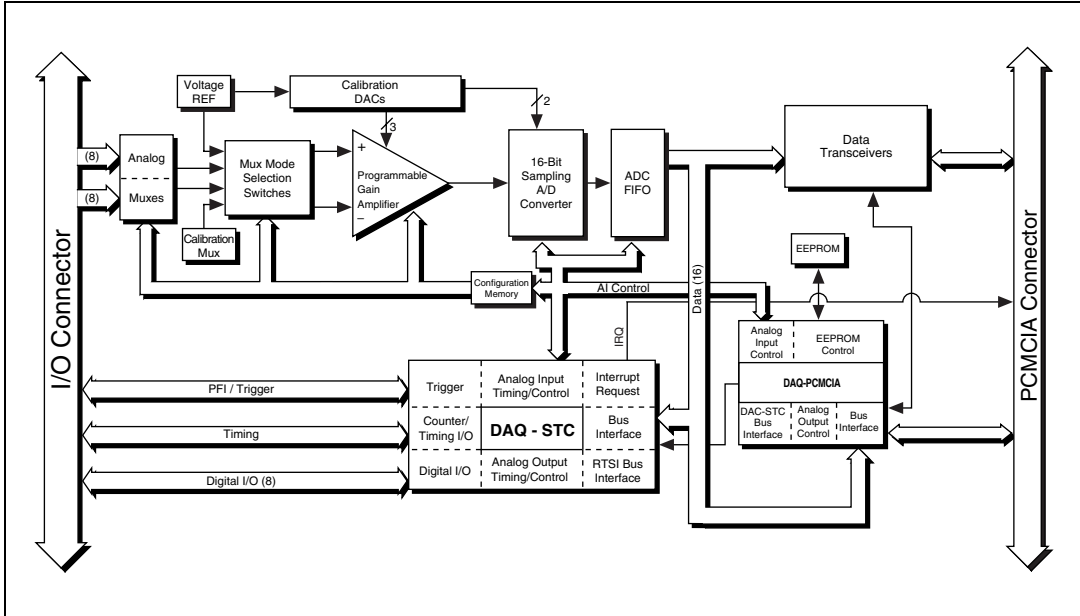
Figure 3-2. DAQCard-AI-16XE-50 Block Diagram

Analog Input

The AI section of each DAQCard is software configurable. You can select different AI configurations through application software designed to control the DAQCards. The following sections describe in detail each AI category.

Input Mode

The DAQCards have three input modes—nonreferenced single-ended (NRSE), referenced single-ended (RSE), and differential (DIFF). The single-ended input configurations use up to 16 channels. The DIFF input configuration uses up to eight channels. Input modes are programmed on a per channel basis for multiple mode scanning. For example, you can configure the circuitry to scan 12 channels—four differentially configured channels and eight single-ended channels. Table 3-1 describes the three input configurations.

Table 3-1. Available Input Configurations for the DAQCard E Series

Configuration	Description
DIFF	A channel configured in DIFF input mode uses two analog channel input lines. One line connects to the positive input of the DAQCard programmable gain instrumentation amplifier (PGIA), and the other connects to the negative input of the PGIA.
RSE	A channel configured in RSE mode uses one analog channel input line, which connects to the positive input of the PGIA. The negative input of the PGIA connects internally to AI ground (AIGND).
NRSE	A channel configured in NRSE mode uses one analog channel input line, which connects to the positive input of the PGIA. The negative input of the PGIA connects to the AI sense (AISENSE) input.

For more information about the three types of input configuration, refer to the *Analog Input Signal Connections* section of Chapter 4, *Signal Connections*, which contains diagrams showing the signal paths for the three configurations.

Input Polarity and Input Range

♦   DAQCard-AI-16E-4

This DAQCard has two input polarities—unipolar and bipolar. Unipolar input means that the input voltage range is between 0 and V_{ref}, where V_{ref} is a positive reference voltage. Bipolar input means that the input voltage range is between $-V_{ref}/2$ and $+V_{ref}/2$. The DAQCard-AI-16E-4 has a unipolar input range of 10 V (0 to 10 V) and a bipolar input range of 10 V (±5 V). You can program polarity and range settings on a per channel basis so that you can configure each input channel uniquely.

The software-programmable gain on these devices increases their overall flexibility by matching the input signal ranges to those that the ADC can accommodate. The DAQCard-AI-16E-4 has gains of 0.5, 1, 2, 5, 10, 20, 50, and 100 and is suited for a wide variety of signals. With the proper gain setting, you can use the full resolution of the ADC to measure the input signal. Table 3-2 shows the overall input range and precision according to the range configuration and gain used.

Table 3-2. Actual Range and Measurement Precision

Range Configuration	Gain	Actual Input Range	Resolution[1]
0 to +10 V	1.0 2.0 5.0 10.0 20.0 50.0 100.0	0 to +10 V 0 to +5 V 0 to +2 V 0 to +1 V 0 to +500 mV 0 to +200 mV 0 to +100 mV	2.44 mV 1.22 mV 488.28 µV 244.14 µV 122.07 µV 48.83 µV 24.41 µV
–5 to +5 V	0.5 1.0 2.0 5.0 10.0 20.0 50.0 100.0	–10 to +10 V –5 to +5 V –2.5 to +2.5 V –1 to +1 V –500 to +500 mV –250 to +250 mV –100 to +100 mV –50 to +50 mV	4.88 mV 2.44 mV 1.22 mV 488.28 µV 244.14 µV 122.07 µV 48.83 µV 24.41 µV

[1] The value of 1 least significant bit (LSB) of the 12-bit ADC; that is, the voltage increment corresponding to a change of one count in the ADC 12-bit count.

Note: Refer to Appendix A, *Specifications*, for absolute maximum ratings.

♦   DAQCard-AI-16XE-50

This DAQCard has two input polarities—unipolar and bipolar. Unipolar input means that the input voltage range is between 0 and V_{ref}, where V_{ref} is a positive reference voltage. Bipolar input means that the input voltage range is between $-V_{ref}$ and $+V_{ref}$. The DAQCard-AI-16XE-50 has a unipolar input range of 10 V (0 to 10 V) and a bipolar input range of 20 V (±10 V). You can program polarity and range settings on a per channel basis so that you can uniquely configure each input channel.

✎   **Note**   You can calibrate the DAQCard-AI-16XE-50 AI circuitry for either unipolar or bipolar polarity. If you mix unipolar and bipolar channels in the scan list and you are using NI-DAQ, NI-DAQ loads the calibration constants appropriate to the polarity for which AI channel 0 is configured.

The software-programmable gain on these devices increases their overall flexibility by matching the input signal ranges to those that the ADC can accommodate. The DAQCard-AI-16XE-50 has gains of 1, 2, 10, and 100 and is suited for a wide variety of signal levels. With the proper gain setting,

you can use the full resolution of the ADC to measure the input signal. Table 3-3 shows the overall input range and precision according to the range configuration and gain used.

Table 3-3. Actual Range and Measurement Precision, DAQCard-AI-16XE-50

Range Configuration	Gain	Actual Input Range	Precision[1]
0 to +10 V	1.0 2.0 10.0 100.0	0 to +10 V 0 to +5 V 0 to +1 V 0 to 100 mV	152.59 μV 76.29 μV 15.26 μV 1.53 μV
−10 to +10 V	1.0 2.0 10.0 100.0	−10 to +10 V −5 to +5 V −1 to +1 V −100 to +100 mV	305.18 μV 152.59 μV 30.52 μV 3.05 μV

[1] The value of 1 LSB of the 16-bit ADC; that is, the voltage increment corresponding to a change of one count in the ADC 16-bit count.

Note: Refer to Appendix A, *Specifications*, for absolute maximum ratings.

Considerations for Selecting Input Ranges

Which input polarity and range you select depends on the expected range of the incoming signal. A large input range can accommodate a large signal variation, but reduces the voltage resolution. Choosing a smaller input range improves the voltage resolution, but may result in the input signal going out of range. For best results, match the input range as closely as possible to the expected range of the input signal. For example, if you are certain the input signal is not negative (below 0 V), unipolar input polarity is best. However, if the signal is negative or equal to zero, inaccurate readings occur if you use unipolar input polarity.

Dither

When you enable dither, you add approximately 0.5 LSB$_{rms}$ of white Gaussian noise to the signal the ADC converts. This addition is useful for applications involving averaging to increase the resolution of the DAQCard, as in calibration or spectral analysis. In such applications, noise modulation is decreased and differential linearity is improved by the addition of dither. When taking DC measurements, such as when checking the DAQCard calibration, you should enable dither and average about 1,000 points to take a single reading. This process removes the effects of quantization and reduces measurement noise, resulting in improved

resolution. For high-speed applications not involving averaging or spectral analysis, you may want to disable the dither to reduce noise. You enable and disable the dither circuitry through software.

Figure 3-3 illustrates the effect of dither on signal acquisition. Figure 3-3a shows a small (±4 LSB) sine wave acquired with dither off. The quantization of the ADC is clearly visible. Figure 3-3b shows what happens when 50 such acquisitions are averaged together; quantization is still plainly visible. In Figure 3-3c, the sine wave is acquired with dither on. There is a considerable amount of noise visible. But averaging about 50 such acquisitions, as shown in Figure 3-3d, eliminates both the added noise and the effects of quantization. Dither has the effect of forcing quantization noise to become a zero-mean random variable rather than a deterministic function of the input signal.
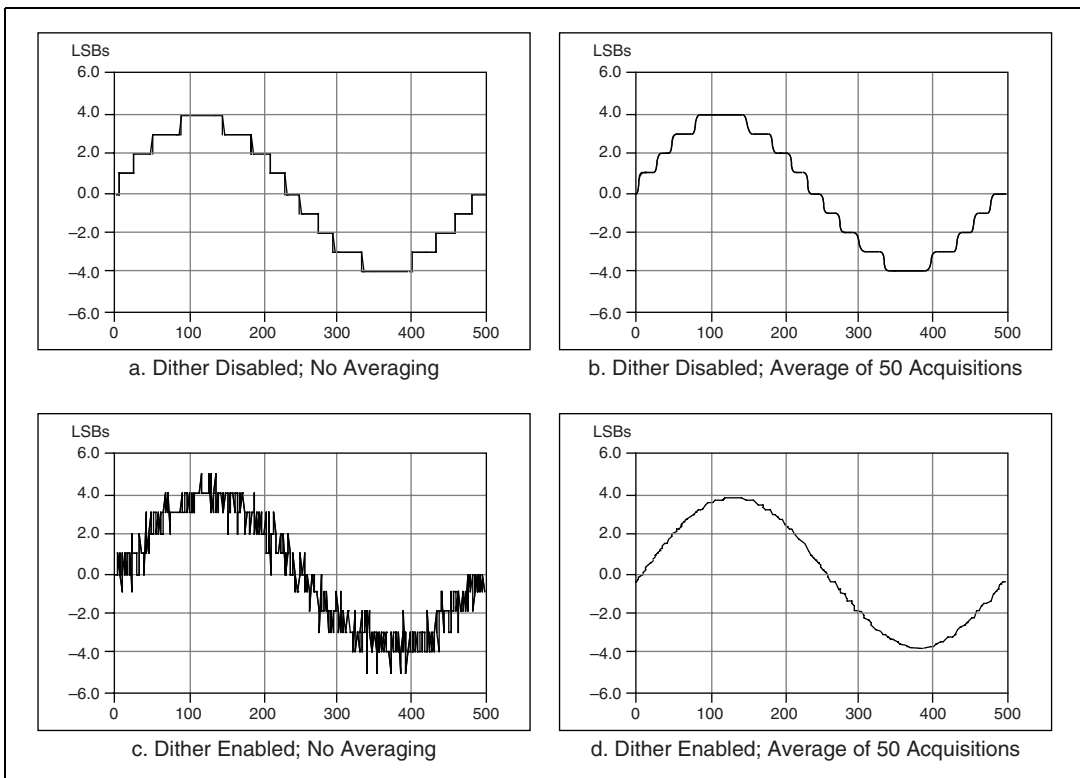
Figure 3-3. Dither

You cannot disable dither on the DAQCard-AI-16XE-50 because the ADC resolution is so fine that the ADC and the PGIA inherently produce more

than 0.5 LSB rms of noise. This is equivalent to having a dither circuit that is always enabled.

Multichannel Scanning Considerations

All of the DAQCard E Series devices can scan multiple channels at the same maximum rate as the single-channel rate; however, pay careful attention to the settling times for each DAQCard. The settling time for most DAQCards is independent of the selected gain, even at the maximum sampling rate. The settling time for the high-channel count and high-speed devices is gain dependent, which can affect the useful sampling rate for a given gain. No extra settling time is necessary between channels as long as the gain is constant and source impedances are low. Refer to Appendix A, *Specifications*, for a complete listing of settling times for each DAQCard.

When scanning among channels at various gains, the settling times can increase. When the PGIA switches to a higher gain, the signal on the previous channel can be well outside the new, smaller range. For example, suppose a 4 V signal is connected to channel 0 and a 1 mV signal is connected to channel 1, and suppose the PGIA is programmed to apply a gain of one to channel 0 and a gain of 100 to channel 1. When the multiplexer switches to channel 1 and the PGIA switches to a gain of 100, the new full-scale range is 100 mV (if the ADC is in unipolar mode).

The approximately 4 V step from 4 V to 1 mV is 4,000% of the new full-scale range. For a 12-bit DAQCard to settle within 0.012% (120 ppm or 1/2 LSB) of the 100 mV full-scale range on channel 1, the input circuitry has to settle to within 0.0003% (3 ppm or 1/80 LSB) of the 4 V step. It can take as long as 100 μs for the circuitry to settle this much. For a 16-bit DAQCard to settle within 0.0015% (15 ppm or 1 LSB) of the 100 mV full-scale range on channel 1, the input circuitry has to settle within 0.00004% (0.4 ppm or 1/400 LSB) of the 4 V step. It can take as long as 200 μs for the circuitry to settle this much. In general, this extra settling time is not needed when the PGIA is switching to a lower gain.

Settling times can also increase when scanning high-impedance signals due to a phenomenon called *charge injection*, where the AI multiplexer injects a small amount of charge into each signal source when that source is selected. If the source impedance is not low enough, the effect of the charge—a voltage error—does not decay by the time the ADC samples the signal. For this reason, you should keep source impedances under 1 kΩ to perform high-speed scanning.

Because of the previously described limitations of settling times resulting from these conditions, multichannel scanning is not recommended unless

sampling rates are low enough or it is necessary to sample several signals as nearly simultaneously as possible. The data is much more accurate and channel-to-channel independent if you acquire data from each channel independently (for example, 100 points from channel 0, then 100 points from channel 1, then 100 points from channel 2, and so on).

Analog Trigger

♦ DAQCard-AI-16E-4

In addition to supporting internal software triggering and external digital triggering to initiate a DAQ sequence, the DAQCard-AI-16E-4 also supports analog triggering. You can configure the analog trigger circuitry to accept either a direct analog input from the PFI0/TRIG1 pin on the I/O connector or a postgain signal from the output of the PGIA, as shown in Figure 3-4. The trigger-level range for the direct analog channel is ±10 V in 78 mV steps. The range for the post-PGIA trigger selection is simply the full-scale range of the selected channel, and the resolution is that range divided by 256.
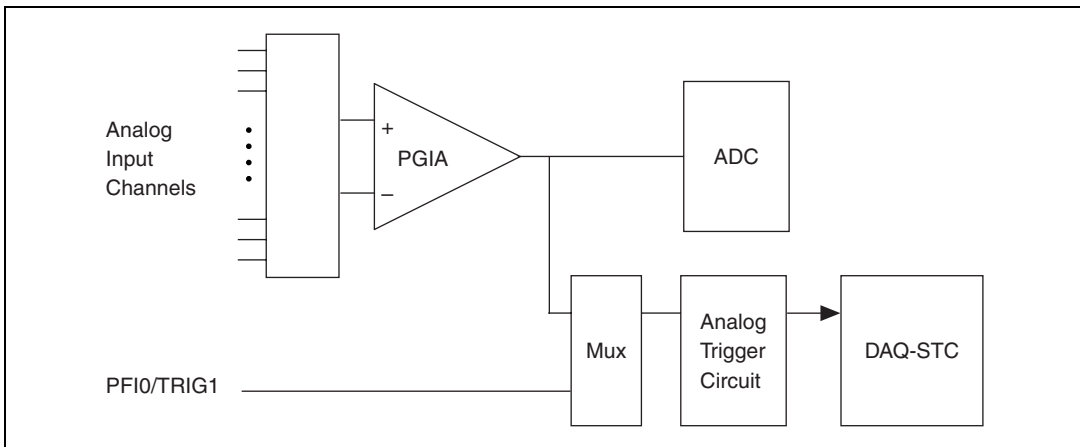
Figure 3-4. Analog Trigger Block Diagram

There are five analog triggering modes available, as shown in Figures 3-5 through 3-9. You can set **lowValue** and **highValue** independently in software.

In below-low-level analog triggering mode, the trigger is generated when the signal value is less than **lowValue**. **HighValue** is unused.
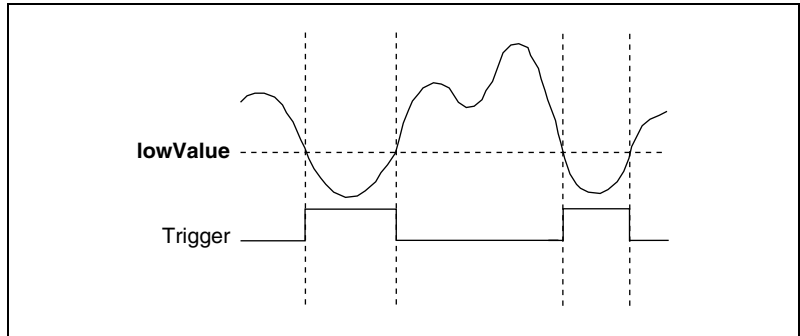
Figure 3-5. Below-Low-Level Analog Triggering Mode

In above-high-level analog triggering mode, the trigger is generated when the signal value is greater than **highValue**. **LowValue** is unused.
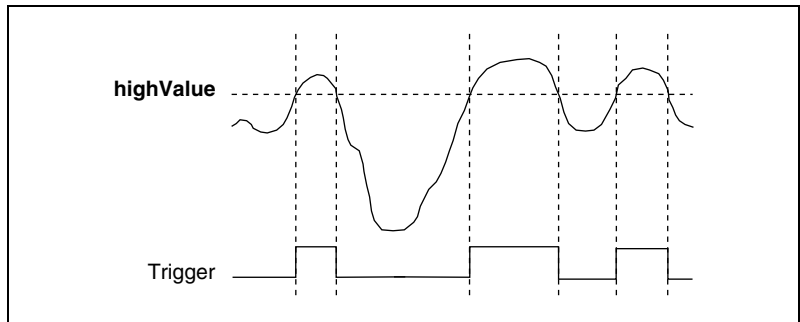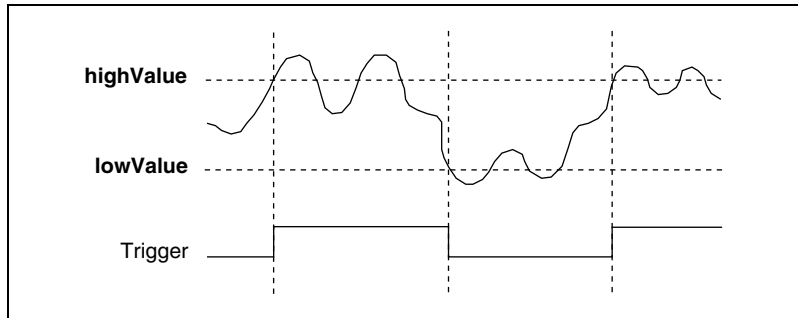

Figure 3-6. Above-High-Level Analog Triggering Mode

In inside-region analog triggering mode, the trigger is generated when the signal value is between **lowValue** and **highValue**.
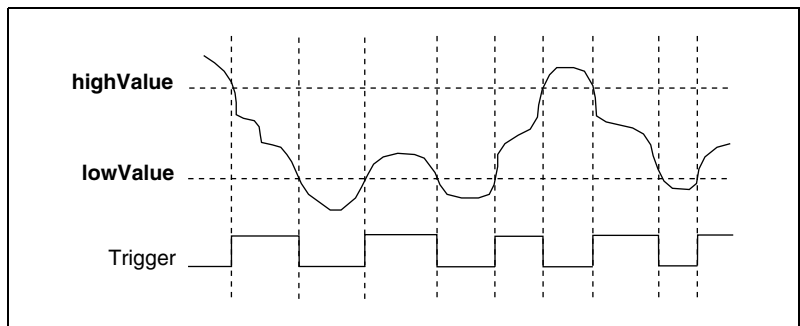
Figure 3-7. Inside-Region Analog Triggering Mode

In high-hysteresis analog triggering mode, the trigger is generated when the signal value is greater than **highValue**, with the hysteresis specified by **lowValue**.

Figure 3-8. High-Hysteresis Analog Triggering Mode

In low-hysteresis analog triggering mode, the trigger is generated when the signal value is less than **lowValue**, with the hysteresis specified by **highValue**.
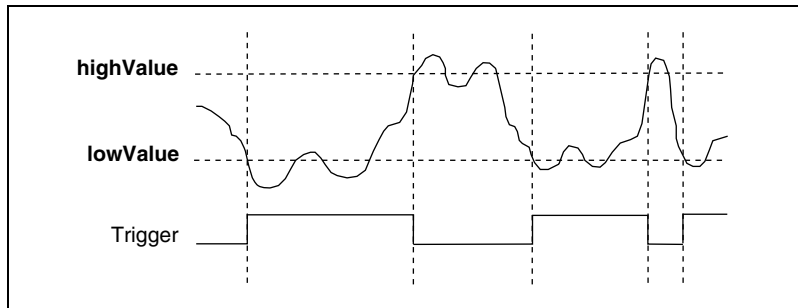
Figure 3-9. Low-Hysteresis Analog Triggering Mode

The analog trigger circuit generates an internal digital trigger based on the AI signal and the user-defined trigger levels. This digital trigger can be used by the AI or GPCTR timing sections of the DAQ-STC. For example, you can configure the AI section to acquire *n* scans after the AI signal crosses a specific threshold.

Digital I/O

The DAQCard E Series devices contain eight lines of DIO for general-purpose use. You can individually configure each line through software for either input or output. At system startup and reset, the DIO ports are all high-impedance.

The hardware up/down control for general-purpose counters 0 and 1 are connected onboard to DIO6 and DIO7, respectively. Thus, you can use DIO6 and DIO7 to control the general-purpose counters. The up/down control signals, GPCTR0_UP_DOWN and GPCTR1_UP_DOWN, are input only and do not affect the operation of the DIO lines.

Timing Signal Routing

The DAQ-STC provides a flexible interface for connecting timing signals to other devices or external circuitry. The DAQCard uses the programmable function input (PFI) pins on the I/O connector to connect to external circuitry. These connections are designed to enable the DAQCard to both control and be controlled by other devices and circuits.

The DAQ-STC has 13 internal timing signals that can be controlled by an external source. These timing signals can also be controlled by signals generated internally to the DAQ-STC, and these selections are fully software configurable. For example, the signal routing multiplexer for controlling the CONVERT* signal is shown in Figure 3-10.
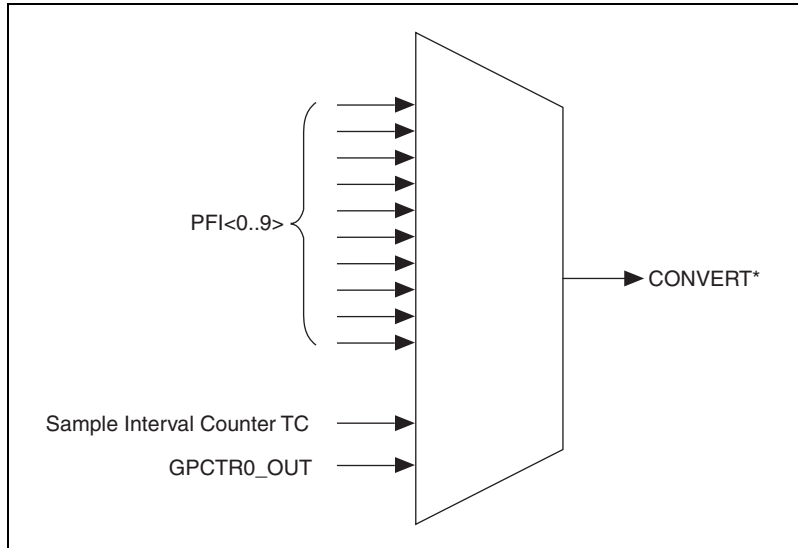
Figure 3-10. CONVERT* Signal Routing

Figure 3-10 shows that CONVERT* can be generated from a number of sources, including the external signals PFI<0..9> and the internal signals sample interval (SI2) counter TC and GPCTR0_OUT.

Programmable Function Inputs

The PFIs are connected to the signal routing multiplexer for each timing signal, and software can select a PFI as the external source for a given timing signal. Any PFI can be used simultaneously as an input by any timing signal and that multiple timing signals can simultaneously use the same PFI. This flexible routing scheme reduces the need to change physical connections to the I/O connector for different applications.

You can also individually enable each PFI pin to output a specific internal timing signal. For example, if you need the CONVERT* signal as an output on the I/O connector, software can turn on the output driver for the PFI2/CONVERT* pin.

DAQCard Clocks

Many functions performed by the DAQCard E Series devices require a frequency timebase to generate the necessary timing signals for controlling A/D conversions or general-purpose signals at the I/O connector.

The DAQCard directly uses its internal 20 MHz timebase as the primary frequency source.

4

Signal Connections

This chapter describes how to make input and output signal connections to the DAQCard device through the DAQCard I/O connector.

Table 4-1. I/O Connector Details

Device with I/O Connector	Number of Pins	Cable for Connecting to 68-pin Accessories	Cable for Connecting to 50-pin Signal Accessories
DAQCard E Series Device	68	PSHR68-68M and SH6868 Shielded Cables, PR68-68F Ribbon Cable	PSHR68-68M and SH6850 Shielded Cables, PR68-50F Ribbon Cable

I/O Connector

Figure 4-1 shows the pin assignments for the 68-pin I/O connector on the DAQCard-AI-16E-4 and DAQCard-AI-16XE-50. A signal description follows the connector pinouts.

⚠ **Caution** Exceeding the differential and common-mode input ranges distorts the input signals. Exceeding the maximum input voltage rating can damage the DAQCard E Series device and the computer. NI is *not* liable for any damage resulting from such signal connections. The maximum input voltage ratings are listed in the *Protection* column of Tables 4-3 and 4-4.

ACH8	34	68	ACH0
ACH1	33	67	AIGND
AIGND	32	66	ACH9
ACH10	31	65	ACH2
ACH3	30	64	AIGND
AIGND	29	63	ACH11
ACH4	28	62	AISENSE
AIGND	27	61	ACH12
ACH13	26	60	ACH5
ACH6	25	59	AIGND
AIGND	24	58	ACH14
ACH15	23	57	ACH7
Reserved	22	56	AIGND
Reserved	21	55	Reserved
Reserved	20	54	Reserved
DIO4	19	53	DGND
DGND	18	52	DIO0
DIO1	17	51	DIO5
DIO6	16	50	DGND
DGND	15	49	DIO2
+5V	14	48	DIO7
DGND	13	47	DIO3
DGND	12	46	SCANCLK
PFI0/TRIG1	11	45	EXTSTROBE*
PFI1/TRIG2	10	44	DGND
DGND	9	43	PFI2/CONVERT*
+5V	8	42	PFI3/GPCTR1_SOURCE
DGND	7	41	PFI4/GPCTR1_GATE
PFI5	6	40	GPCTR1_OUT
PFI6	5	39	DGND
DGND	4	38	PFI7/STARTSCAN
PFI9/GPCTR0_GATE	3	37	PFI8/GPCTR0_SOURCE
GPCTR0_OUT	2	36	DGND
FREQ_OUT	1	35	DGND

Figure 4-1. I/O Connector Pin Assignment for the DAQCard-AI-16E-4 and DAQCard-AI-16XE-50

Table 4-2. I/O Connector Signal Descriptions

Signal Name	Reference	Direction	Description
AIGND	—	—	Analog Input Ground—These pins are the reference point for single-ended measurements and the bias current return point for differential measurements. Both ground references—AIGND and DGND—are connected on the DAQCard E Series device.
ACH<0..15>	AIGND	Input	Analog Input Channels 0 through 15—Each channel pair, ACH<i, i+8> (i = 0..7), can be configured as either one differential input or two single-ended inputs.
AISENSE	AIGND	Input	Analog Input Sense—This pin serves as the reference node for any of channels ACH<0..15> in NRSE input mode.
DGND	—	—	Digital Ground—This pin supplies the reference for the digital signals at the I/O connector as well as the +5 VDC supply. All three ground references—AIGND, AOGND, and DGND—are connected on the DAQCard.
DIO<0..7>	DGND	Input or Output	Digital I/O signals—DIO6 and 7 can control the up/down signal of general-purpose counters 0 and 1, respectively.
+5V	DGND	Output	+5 VDC Source—These pins are fused for up to 250 mA of +5 V supply. The fuse is self-resetting.
SCANCLK	DGND	Output	Scan Clock—This pin pulses once for each A/D conversion in the scanning modes when enabled. The low-to-high edge indicates when the input signal can be removed from the input or switched to another signal.
EXTSTROBE*	DGND	Output	External Strobe—This output can be toggled under software control to latch signals or trigger events on external devices.
PFI0/TRIG1	DGND	Input	PFI0/Trigger 1—As an input, this is a PFI or the source for the hardware analog trigger. PFI signals are explained in the *Timing Connections* section. The hardware analog trigger is explained in the *Analog Trigger* section of Chapter 3, *Hardware Overview*.
		Output	As an output, this is the TRIG1 signal. In posttrigger DAQ sequences, a low-to-high transition indicates the initiation of the DAQ sequence. In pretrigger applications, a low-to-high transition indicates the initiation of the pretrigger conversions.
PFI1/TRIG2	DGND	Input	PFI1/Trigger 2—As an input, this is a PFI.
		Output	As an output, this is the TRIG2 signal. In pretrigger applications, a low-to-high transition indicates the initiation of the posttrigger conversions. TRIG2 is not used in posttrigger applications.

Table 4-2. I/O Connector Signal Descriptions (Continued)

Signal Name	Reference	Direction	Description
PFI2/CONVERT*	DGND	Input	PFI2/Convert—As an input, this is a PFI.
		Output	As an output, this is the CONVERT* signal. A high-to-low edge on CONVERT* indicates that an A/D conversion is occurring.
PFI3/GPCTR1_SOURCE	DGND	Input	PFI3/Counter 1 Source—As an input, this is a PFI.
		Output	As an output, this is the GPCTR1_SOURCE signal. This signal reflects the actual source connected to general-purpose counter 1.
PFI4/GPCTR1_GATE	DGND	Input	PFI4/Counter 1 Gate—As an input, this is a PFI.
		Output	As an output, this is the GPCTR1_GATE signal. This signal reflects the actual gate signal connected to general-purpose counter 1.
GPCTR1_OUT	DGND	Output	Counter 1 Output—This output is from the general-purpose counter 1 output.
PFI5	DGND	Input	PFI5/Update—As an input, this is a PFI.
		Output	PFI5 cannot be an output.
PFI6	DGND	Input	PFI6/Waveform Trigger—As an input, this is a PFI.
		Output	PFI6 cannot be an output.
PFI7/STARTSCAN	DGND	Input	PFI7/Start of Scan—As an input, this is a PFI.
		Output	As an output, this is the STARTSCAN signal. This pin pulses once at the start of each AI scan in the interval scan. A low-to-high transition indicates the start of the scan.
PFI8/GPCTR0_SOURCE	DGND	Input	PFI8/Counter 0 Source—As an input, this is a PFI.
		Output	As an output, this is the GPCTR0_SOURCE signal. This signal reflects the actual source connected to general-purpose counter 0.
PFI9/GPCTR0_GATE	DGND	Input	PFI9/Counter 0 Gate—As an input, this is a PFI.
		Output	As an output, this is the GPCTR0_GATE signal. This signal reflects the actual gate signal connected to general-purpose counter 0.
GPCTR0_OUT	DGND	Output	Counter 0 Output—This output is from the general-purpose counter 0 output.
FREQ_OUT	DGND	Output	Frequency Output—This output is from the frequency generator output.

Table 4-3 shows the I/O signal summary for the DAQCard-AI-16E-4.

Table 4-3. I/O Signal Summary for the DAQCard-AI-16E-4

Signal Name	Drive	Impedance Input/ Output	Protection (Volts) On/Off	Source (mA at V)	Sink (mA at V)	Rise Time (ns)	Bias
ACH<0..15>	AI	100 GΩ in parallel with 100 pF	25/15	—	—	—	±200 pA
AISENSE	AI	100 GΩ in parallel with 100 pF	25/15	—	—	—	±200 pA
AIGND	AI	—	—	—	—	—	—
DGND	DO	—	—	—	—	—	—
VCC	DO	0.45 Ω	Short-circuit to ground	250 at V_{cc}	—	—	—
DIO<0..7>	DIO	—	V_{cc} +0.5	13 at (V_{cc} –0.4)	24 at 0.4	1.1	50 kΩ pu[1]
SCANCLK	DO	—	—	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
EXTSTROBE*	DO	—	—	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
PFI0/TRIG1	ADIO	10 kΩ	V_{cc} +0.5/±35	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu[2]
PFI1/TRIG2	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
PFI2/CONVERT*	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
PFI3/GPCTR1_SOURCE	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
PFI4/GPCTR1_GATE	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
GPCTR1_OUT	DO	—	—	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
PFI5	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
PFI6	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
PFI7/STARTSCAN	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
PFI8/GPCTR0_SOURCE	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
PFI9/GPCTR0_GATE	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
GPCTR0_OUT	DO	—	—	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu

Table 4-3. I/O Signal Summary for the DAQCard-AI-16E-4 (Continued)

Signal Name	Drive	Impedance Input/ Output	Protection (Volts) On/Off	Source (mA at V)	Sink (mA at V)	Rise Time (ns)	Bias
FREQ_OUT	DO	—	—	3.5 at (V_{cc}–0.4)	5 at 0.4	1.5	50 kΩ pu

pu = pull up, DO = Digital Output, ADIO = Analog/Digital Input/Output
[1] DIO <6..7> are also pulled up with a 10 kΩ resistor.
[2] Also pulled down with a 10 kΩ resistor.
Caution: Unless specifically indicated in the *Protection* column of Table 4-3, the outputs of DAQCard E Series devices are *not* short-circuit protected. Exceeding the output limit in the *Source* and *Sink* columns can damage the device.

Table 4-4 shows the I/O signal summary for the DAQCard-AI-16XE-50.

Table 4-4. I/O Signal Summary for the DAQCard-AI-16XE-50

Signal Name	Drive	Impedance Input/ Output	Protection (Volts) On/Off	Source (mA at V)	Sink (mA at V)	Rise Time (ns)	Bias
ACH<0..15>	AI	20 GΩ in parallel with 100 pF	25/15	—	—	—	±10 nA
AISENSE	AI	20 GΩ in parallel with 100 pF	25/15	—	—	—	±10 nA
AIGND	AI	—	—	—	—	—	—
DGND	DO	—	—	—	—	—	—
VCC	DO	0.45 Ω	Short-circuit to ground	250 at V_{cc}	—	—	—
DIO<0..7>	DIO	—	V_{cc} +0.5	13 at (V_{cc} –0.4)	24 at 0.4	1.1	50 kΩ pu[1]
SCANCLK	DO	—	—	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
EXTSTROBE*	DO	—	—	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
PFI0/TRIG1	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
PFI1/TRIG2	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
PFI2/CONVERT*	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
PFI3/GPCTR1_SOURCE	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
PFI4/GPCTR1_GATE	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu

Table 4-4. I/O Signal Summary for the DAQCard-AI-16XE-50 (Continued)

Signal Name	Drive	Impedance Input/ Output	Protection (Volts) On/Off	Source (mA at V)	Sink (mA at V)	Rise Time (ns)	Bias
GPCTR1_OUT	DO	—	—	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
PFI5/UPDATE*	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
PFI6/WFTRIG	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
PFI7/STARTSCAN	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
PFI8/GPCTR0_SOURCE	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
PFI9/GPCTR0_GATE	DIO	—	V_{cc} +0.5	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
GPCTR0_OUT	DO	—	—	3.5 at (V_{cc} –0.4)	5 at 0.4	1.5	50 kΩ pu
FREQ_OUT	DO	—	—	3.5 at (V_{cc}–0.4)	5 at 0.4	1.5	50 kΩ pu

pu = pull up, DO = digital output

[1] DIO <6..7> are also pulled up with a 10 kΩ resistor.

Caution: Unless specifically indicated in the *Protection* column of Table 4-4, the outputs of DAQCard E Series devices are *not* short-circuit protected. Exceeding the output limit in the *Source* and *Sink* columns can damage the device.

Analog Input Signal Connections

The AI signals are ACH<0..15>, AISENSE, and AIGND. The ACH<0..15> signals connect to the 16 AI channels of the DAQCard. In single-ended modes, signals connected to ACH<0..15> are routed to the positive input of the DAQCard PGIA. In DIFF input mode, signals connected to ACH<0..7> are routed to the positive input of the PGIA, and signals connected to ACH<8..15> are routed to the negative input of the PGIA.

⚠ **Caution**   Exceeding the differential and common-mode input ranges distorts the input signals[1]. Exceeding the maximum input voltage rating can damage the DAQCard and the computer. NI is *not* liable for any damage resulting from such signal connections. The maximum input voltage ratings are listed in the *Protection* column of Tables 4-3 through 4-4.

In NRSE mode, the AISENSE signal connects internally to the negative input of the DAQCard PGIA when the corresponding channels are selected. In DIFF and RSE modes, this signal is not connected.

AIGND is an AI common signal that is routed directly to the ground tie point on the DAQCards. You can use this signal for a general analog ground tie point to the DAQCard, if necessary.

Connection of AI signals to the DAQCard depends on the configuration of the AI channels you are using and the type of input signal source. With the different configurations, you can use the PGIA in different ways. Figure 4-2 shows a diagram of the DAQCard PGIA.

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[1] Exceeding input ranges on any channel can affect the measurements on a different channel, even if the other channel is well within the input range.
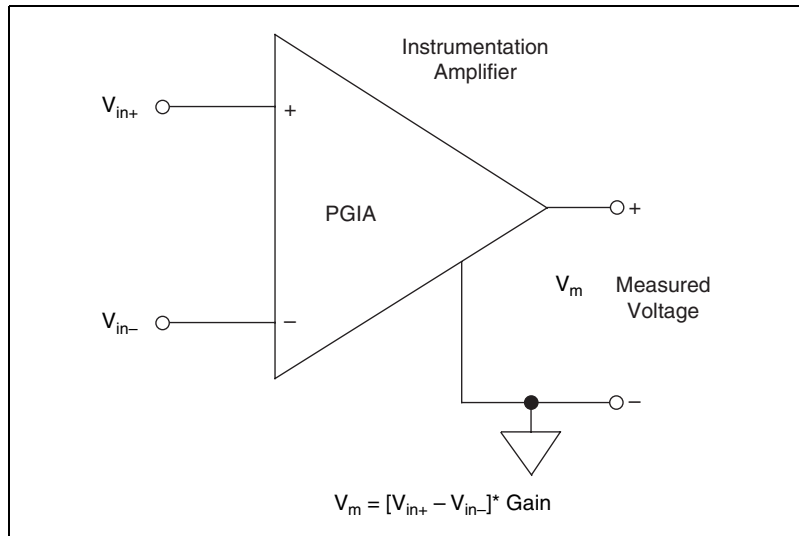
Figure 4-2. DAQCard E Series PGIA

The PGIA applies gain and common-mode voltage rejection and presents high-input impedance to the AI signals connected to the DAQCard. Signals are routed to the positive and negative inputs of the PGIA through input multiplexers on the DAQCard. The PGIA converts two input signals to a signal that is the difference between the two input signals multiplied by the gain setting of the amplifier. The amplifier output voltage is referenced to the ground for the DAQCard. The DAQCard ADC measures this output voltage when it performs A/D conversions.

You must reference all signals to ground either at the source device or at the DAQCard. If you have a floating source, reference the signal to ground by using the RSE input mode or the DIFF input configuration with bias resistors. (Refer to the *Differential Connections for Nonreferenced or Floating Signal Sources* section.) If you have a grounded source, do not reference the signal to AIGND. You can avoid this reference by using DIFF or NRSE input configurations.

Types of Signal Sources

When configuring the input channels and making signal connections, you must first determine whether the signal sources are floating or ground-referenced. The following sections describe these two signal types.

Floating Signal Sources

A floating signal source is one that is not connected in any way to the building ground system, instead it has an isolated ground-reference point. Some examples of floating signal sources are outputs of transformers, thermocouples, battery-powered devices, optical isolator output, and isolation amplifiers. An instrument or device that has an isolated output is a floating signal source. You must connect the ground reference of a floating signal to the DAQCard AI ground to establish a local or onboard reference for the signal. Otherwise, the measured input signal varies as the source floats out of the common-mode input range.

Ground-Referenced Signal Sources

A ground-referenced signal source is one that connects in some way to the building system ground and, therefore, already connects to a common ground point with respect to the DAQCard, assuming that the computer is plugged into the same power system. Nonisolated output of instruments and devices that plug into the building power system falls into this category.

The difference in ground potential between two instruments connected to the same building power system is typically between 1 and 100 mV, but it can be much higher if power distribution circuits are not properly connected. If a grounded signal source is incorrectly measured, this difference can appear as a measurement error. The connection instructions for grounded signal sources are designed to eliminate this ground potential difference from the measured signal.

Input Configurations

You can configure the DAQCard for NRSE, RSE, or DIFF input mode. The following sections discuss the use of single-ended and differential measurements and considerations for measuring both floating and ground-referenced signal sources.

Figure 4-3 summarizes the recommended input configuration for both types of signal sources.

Input	Signal Source Type	
	Floating Signal Source (Not Connected to Building Ground)	**Grounded Signal Source**
Input	Examples • Ungrounded Thermocouples • Signal Conditioning with Isolated Outputs • Battery Devices	Examples • Plug-in Instruments with Nonisolated Outputs
Differential (DIFF)	 See text for information on bias resistors.	
Single-Ended — Ground Referenced (RSE)		NOT RECOMMENDED Ground-loop losses, V_g, are added to measured signal.
Single-Ended — Nonreferenced (NRSE)	 See text for information on bias resistors.	

Figure 4-3. Summary of Analog Input Connections

Differential Connection Considerations (DIFF Input Mode)

A differential connection is one in which the DAQCard AI signal has its own reference signal or signal return path. These connections are available when the selected channel is configured in DIFF input mode. The input signal connects to the positive input of the PGIA, and its reference signal, or return, connects to the negative input of the PGIA.

When you configure a channel for DIFF input mode, each signal uses two multiplexer inputs—one for the signal and one for its reference signal. Therefore, with a differential configuration for every channel, up to eight AI channels are available. In DIFF input mode, the AI channels are paired, with ACH<*i*> as the signal input and ACH<*i*+8> as the signal reference. For example, ACH0 is paired with ACH8, ACH1 is paired with ACH9, and so on.

Use DIFF input connections for any channel that meets any of the following conditions:

- The input signal is low-level (less than 1 V).
- The leads connecting the signal to the DAQCard are greater than 3 m (10 ft).
- The input signal requires a separate ground-reference point or return signal.
- The signal leads travel through noisy environments.

DIFF signal connections reduce noise pickup and increase common-mode noise rejection. Differential signal connections also allow input signals to float within the common-mode limits of the PGIA.

Differential Connections for Ground-Referenced Signal Sources

Figure 4-4 shows how to connect a ground-referenced signal source to a channel on a DAQCard configured in DIFF input mode.
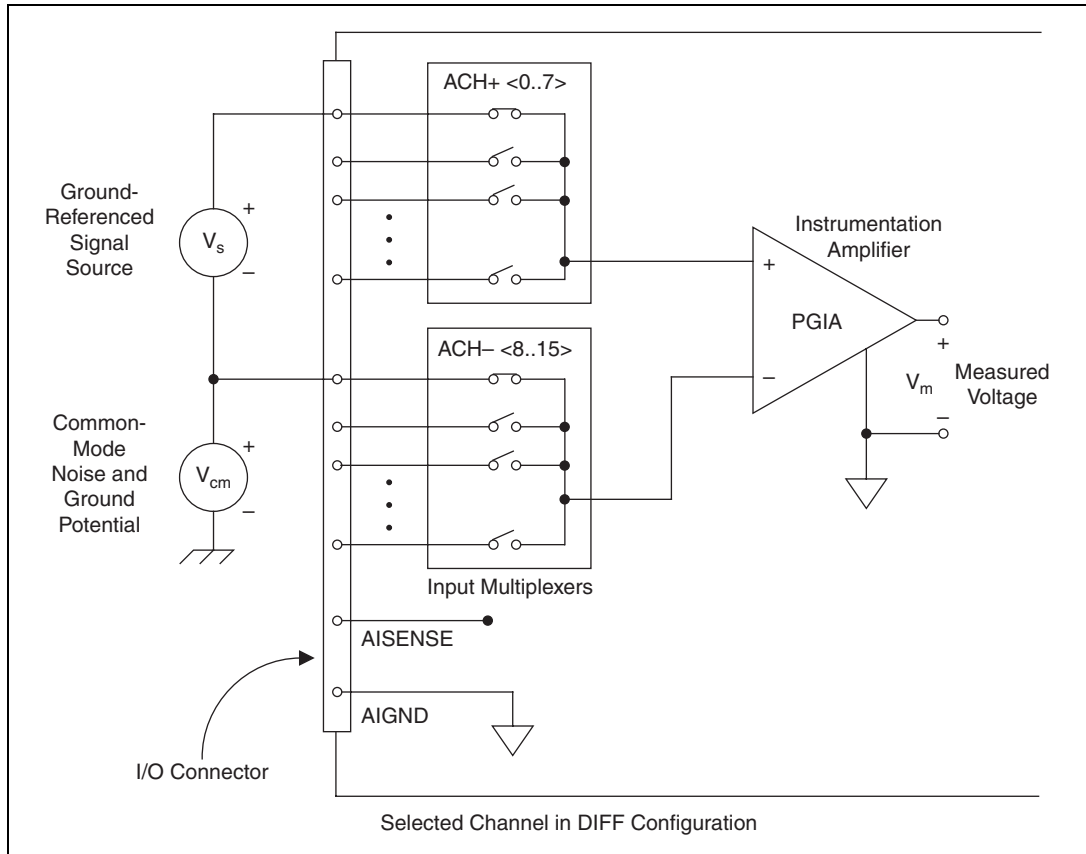
Figure 4-4. Differential Input Connections for Ground-Referenced Signals

With this type of connection, the PGIA rejects both the common-mode noise in the signal and the ground potential difference between the signal source and the DAQCard ground, shown as V_{cm} in Figure 4-4.

Differential Connections for Nonreferenced or Floating Signal Sources

Figure 4-5 shows how to connect a floating signal source to a channel on a DAQCard configured in DIFF input mode.
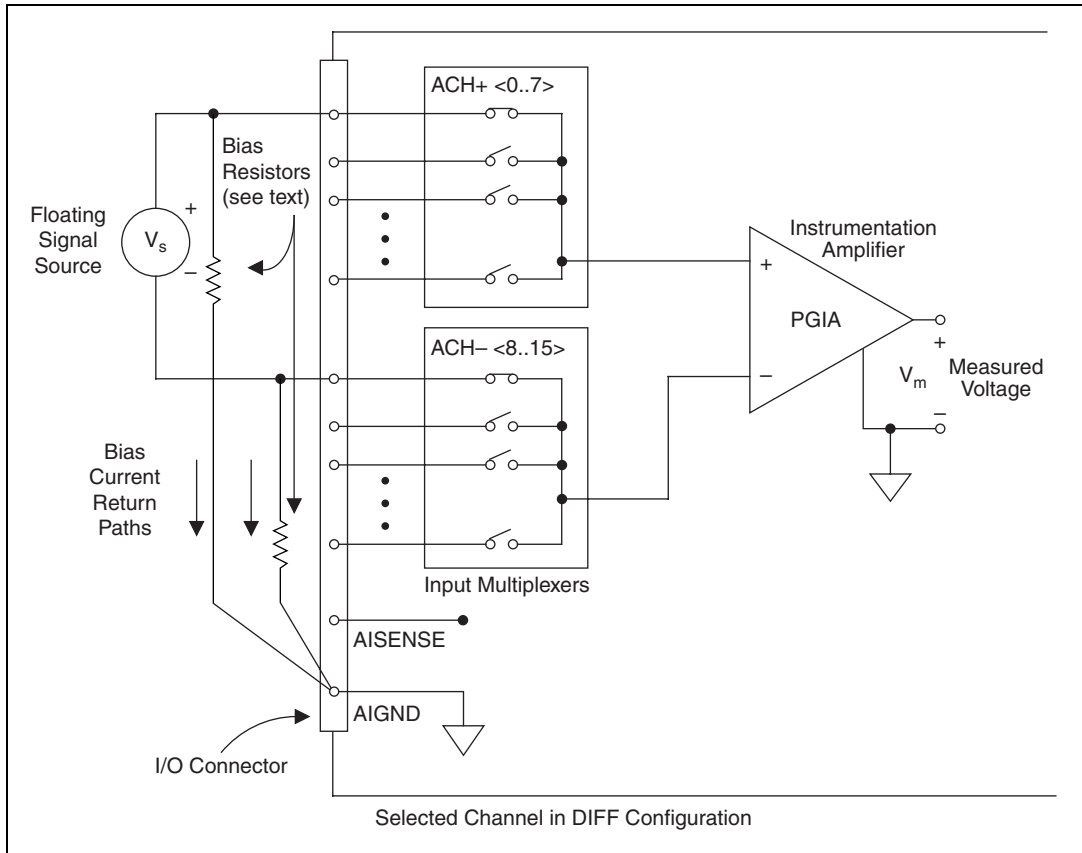
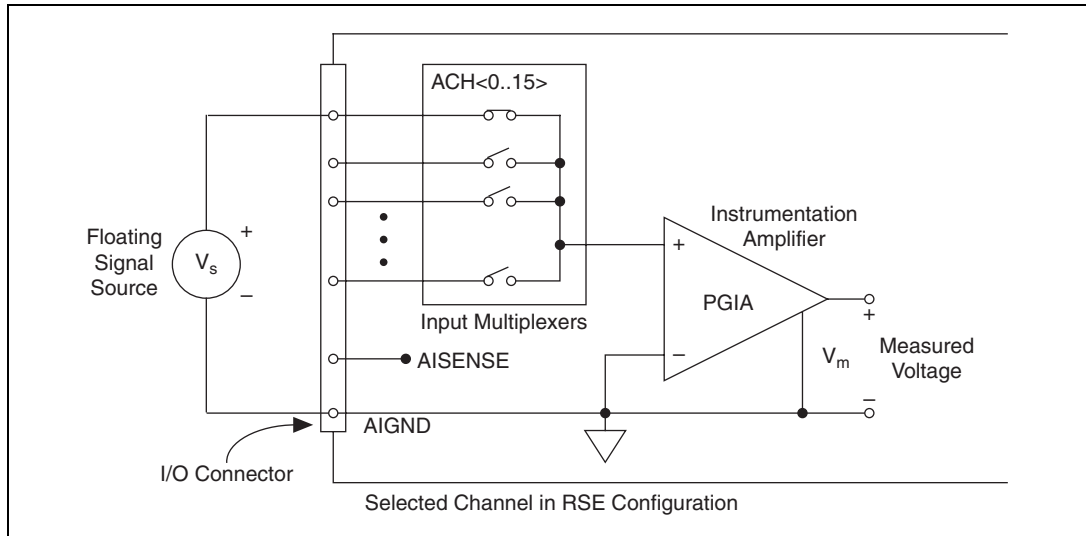**Figure 4-5.** Differential Input Connections for Nonreferenced Signals

Figure 4-5 shows two bias resistors connected in parallel with the signal leads of a floating signal source. If you do not use the resistors and the source is truly floating, the source is not likely to remain within the common-mode signal range of the PGIA, and the PGIA saturates, causing erroneous readings. You must reference the source to AIGND. The easiest way to make this reference is simply to connect the positive side of the signal to the positive input of the PGIA and connect the negative side of the signal to AIGND as well as to the negative input of the PGIA, without any

resistors at all. This connection works well for DC-coupled sources with low source impedance (less than 100 Ω).

For larger source impedances, this connection leaves the differential signal path significantly off balance. Noise that couples electrostatically onto the positive line does not couple onto the negative line because it connects to ground. Therefore, this noise appears as a differential-mode signal instead of a common-mode signal, so the PGIA does not reject it. In this case, instead of directly connecting the negative line to AIGND, connect it to AIGND through a resistor that is about 100 times the equivalent source impedance. The resistor puts the signal path nearly in balance, so about the same amount of noise couples onto both connections, yielding better rejection of electrostatically coupled noise. Also, this configuration does not load down the source (other than the very high-input impedance of the PGIA).

You can fully balance the signal path by connecting another resistor of the same value between the positive input and AIGND, as shown in Figure 4-5. This fully balanced configuration offers slightly better noise rejection, but has the disadvantage of loading the source down with the combination (sum) of the two resistors. For example, if the source impedance is 2 kΩ and each of the two resistors is 100 kΩ, the resistors load down the source with 200 kΩ and produce a –1% gain error.

Both inputs of the PGIA require a DC path to ground in order for the PGIA to work. If the source is AC coupled (capacitively coupled), the PGIA needs a resistor between the positive input and AIGND. If the source has low impedance, choose a resistor that is large enough not to significantly load the source, but small enough not to produce significant input offset voltage as a result of input bias current (typically 100 kΩ to 1 MΩ). In this case, you can connect the negative input directly to AIGND. If the source has high output impedance, balance the signal path as previously described using the same value resistor on both the positive and negative inputs; be aware that there is some gain error from loading down the source.

Single-Ended Connection Considerations

A single-ended connection is one in which the DAQCard E Series device AI signal is referenced to a ground that can be shared with other input signals. The input signal connects to the positive input of the PGIA, and the ground connects to the negative input of the PGIA.

When every channel is configured for single-ended input, up to 16 AI channels are available.

Use single-ended input connections for any input signal that meets the following conditions:

- The input signal is high-level (greater than 1 V).
- The leads connecting the signal to the DAQCard are less than 3 m (10 ft).
- The input signal can share a common reference point with other signals.

DIFF input connections are recommended for greater signal integrity for any input signal that does not meet the preceding conditions.

You can software-configure the DAQCard channels for two types of single-ended connections—RSE configuration and NRSE configuration. Use the RSE configuration for floating signal sources; in this case, the DAQCard provides the reference ground point for the external signal. Use the NRSE configuration for ground-referenced signal sources; in this case, the external signal supplies its own reference ground point and the DAQCard should not supply one.

In single-ended configurations, more electrostatic and magnetic noise couples into the signal connections than in differential configuration. The coupling is the result of differences in the signal path. Magnetic coupling is proportional to the area between the two signal conductors. Electrical coupling is a function of how much the electric field differs between the two conductors.

Single-Ended Connections for Floating Signal Sources (RSE Input Mode)

Figures 4-6 shows how to connect a floating signal source to a channel on a DAQCard configured for RSE input mode.

Figure 4-6. Single-Ended Input Connections for Nonreferenced or Floating Signals

Single-Ended Connections for Grounded Signal Sources (NRSE Input Mode)

To measure a grounded signal source with a single-ended configuration, you must configure the DAQCard for NRSE input mode. The signal is then connected to the positive input of the DAQCard PGIA, and the signal local ground reference is connected to the negative input of the PGIA. The ground point of the signal should, therefore, be connected to the AISENSE pin. Any potential difference between the DAQCard ground and the signal ground appears as a common-mode signal at both the positive and negative inputs of the PGIA, and this difference is rejected by the amplifier. If the input circuitry of a DAQCard were referenced to ground, in this situation as in the RSE input configuration, this difference in ground potentials appears as an error in the measured voltage.

Figure 4-7 shows how to connect a grounded signal source to a channel on a DAQCard configured for NRSE input mode.
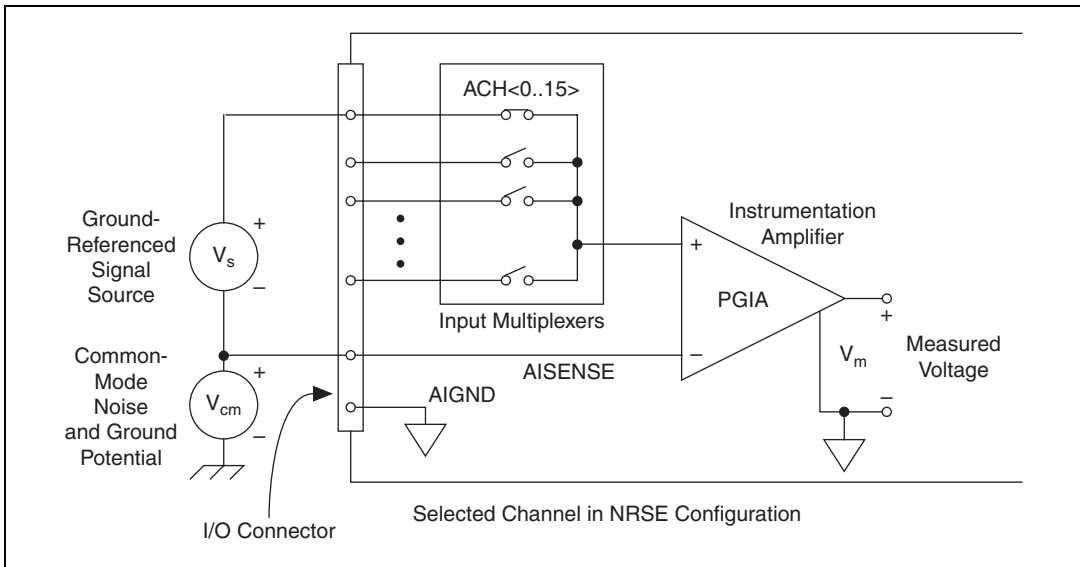
Figure 4-7. Single-Ended Input Connections for Ground-Referenced Signals

Common-Mode Signal Rejection Considerations

Figures 4-4 and 4-7 show connections for signal sources that are already referenced to some ground point with respect to the DAQCard. In these cases, the PGIA can reject any voltage caused by ground potential differences between the signal source and the DAQCard. In addition, with differential input connections, the PGIA can reject common-mode noise pickup in the leads connecting the signal sources to the DAQCard. The PGIA can reject common-mode signals as long as $V_{in}+$ and $V_{in}-$ are both within ±11 V of AIGND.

♦   DAQCard-AI-16XE-50

The DAQCard-AI-16XE-50 has the additional restriction that $(V_{in}+ + V_{in}-)$ added to the gain times $(V_{in}+ - V_{in}-)$ must be within ±26 V of AIGND. At gains of 10 and 100, this is roughly equivalent to restricting the two input voltages to within ±8 V of AIGND.

Digital I/O Signal Connections

The DIO signals are DIO<0..7> and DGND. The DIO<0..7> signals make up the DIO port, and DGND is the ground reference signal for this port. You can individually program all lines to be inputs or outputs.

⚠ **Caution**   Exceeding the maximum input voltage ratings, which are listed in Tables 4-3 and 4-4, can damage the DAQCard and the computer. NI is *not* liable for any damage resulting from such signal connections.

Figure 4-8 shows signal connections for three typical DIO applications.
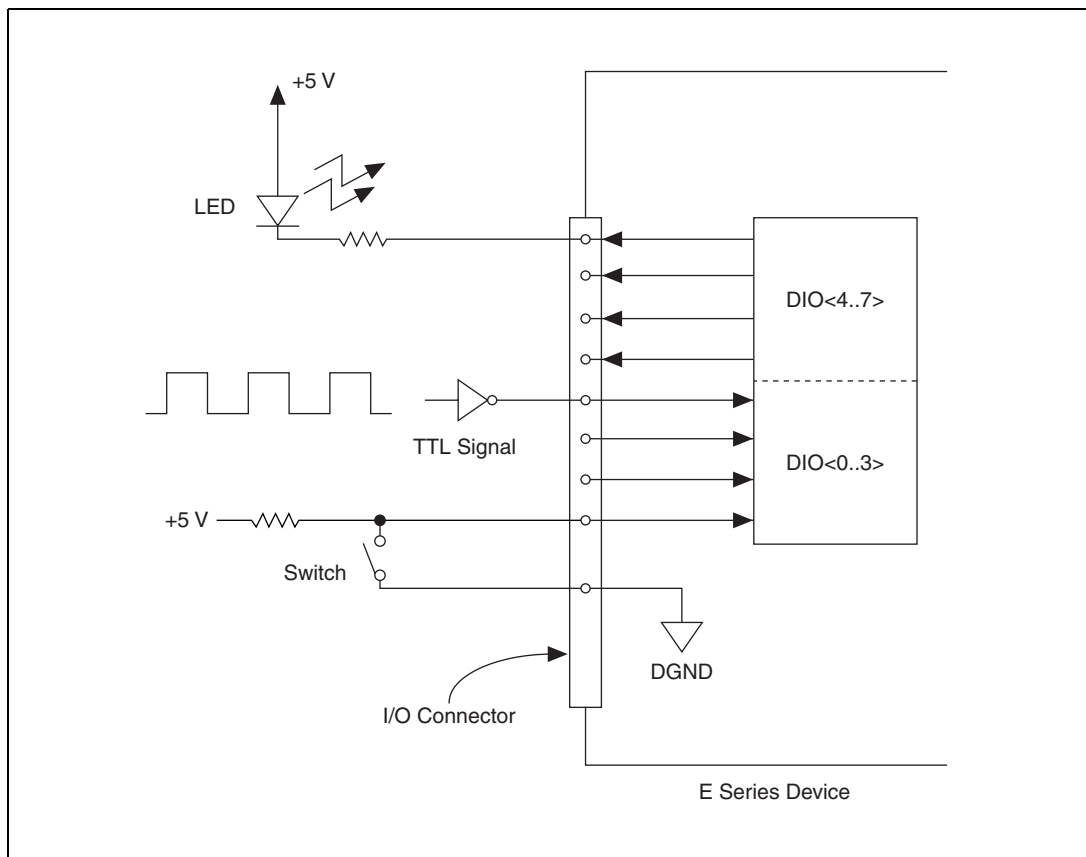
Figure 4-8. Digital I/O Connections

Figure 4-8 shows DIO<0..3> configured for digital input and DIO<4..7> configured for digital output. Digital input applications include receiving TTL signals and sensing external device states, such as the state of the switch shown in Figure 4-8. Digital output applications include sending TTL signals and driving external devices, such as the LED shown in Figure 4-8.

Power Connections

Two pins on the I/0 connector supply +5 V from the computer power supply through a self-resetting fuse. The fuse automatically resets within a few seconds after the overcurrent condition is removed. These pins are referenced to DGND and you can use them to power external digital circuitry.

⚠ **Caution**   Do *not*, under any circumstances, connect these +5 V power pins directly to analog or digital ground or to any other voltage source on the DAQCard or any other device. Doing so can damage the DAQCard and the computer. NI is *not* liable for damage resulting from such a connection.

Timing Connections

⚠ **Caution**   Exceeding the maximum input voltage ratings, which are listed in Tables 4-3 and 4-4, can damage the DAQCard and the computer. NI in *not* liable for any damage resulting from such signal connections.

All external control over the timing of the DAQCard is routed through the PFIs, labeled PFI0 through PFI9. These signals are explained in detail in the *Programmable Function Input Connections* section. These PFIs are bidirectional; as outputs they are not programmable and reflect the state of many DAQ and general-purpose timing signals. There are five other dedicated outputs for the remainder of the timing signals. As inputs, the PFI signals are programmable and can control many DAQ, waveform generation, and general-purpose timing signals.

The DAQ timing signals are explained in the *Data Acquisition Timing Connections* section. The general-purpose timing signals are explained in the *General-Purpose Timing Signal Connections* section.

All digital timing connections are referenced to DGND. This reference is demonstrated in Figure 4-9, which shows how to connect an external TRIG1 source and an external CONVERT* source to two of the DAQCard PFI pins.
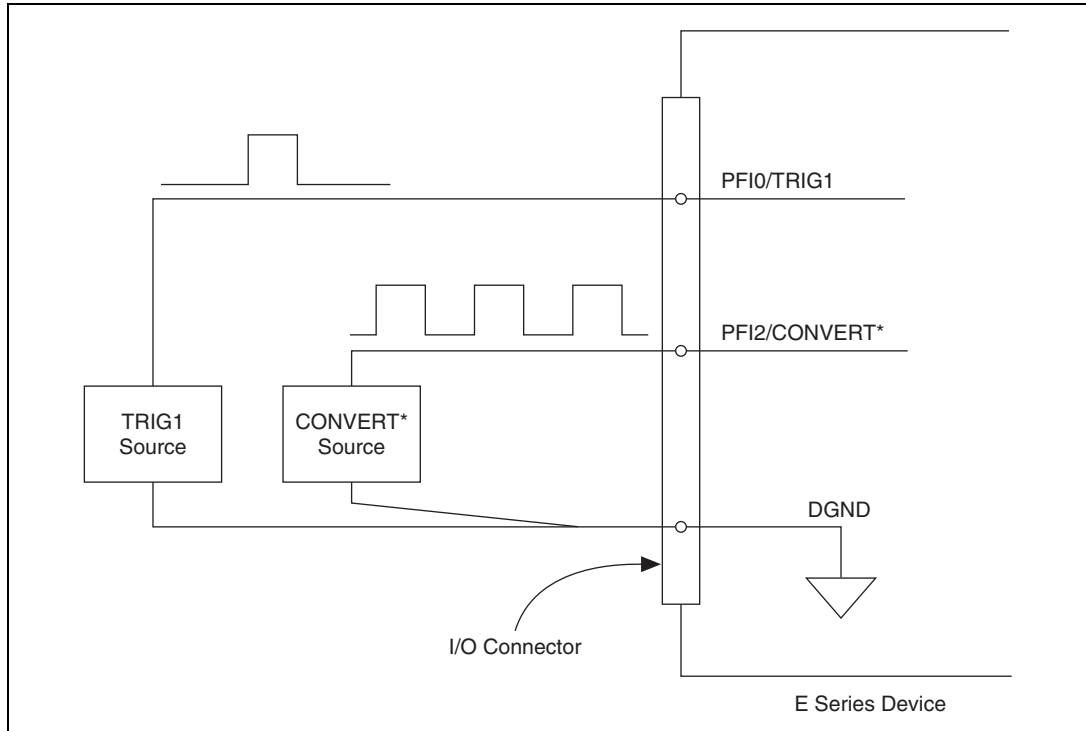
Figure 4-9. Timing I/O Connections

Programmable Function Input Connections

You can externally control 13 internal timing signals from the PFI pins. The source for each of these signals is software-selectable from any PFI when you want external control. This flexible routing scheme reduces the need to change the physical wiring to the DAQCard I/O connector for different applications requiring alternative wiring.

You can individually enable each PFI pin to output a specific internal timing signal. For example, if you need the CONVERT* signal as an output on the I/O connector, software can turn on the output driver for the PFI2/CONVERT* pin. Be careful not to drive a PFI signal externally when it is configured as an output.

As an input, you can individually configure each PFI for edge or level detection and for polarity selection. You can use the polarity selection for any of the 13 timing signals, but the edge or level detection depends upon the particular timing signal being controlled. The detection requirements for each timing signal are listed within the section that discusses that individual signal.

In edge-detection mode, the minimum pulse width required is 10 ns. This applies for both rising-edge and falling-edge polarity settings. There is no maximum pulse-width requirement in edge-detection mode.

In level-detection mode, there are no minimum or maximum pulse-width requirements imposed by the PFIs themselves, but there can be limits imposed by the particular timing signal being controlled. These requirements are listed in this chapter.

Data Acquisition Timing Connections

The data acquisition timing signals are TRIG1, TRIG2, STARTSCAN, CONVERT*, AIGATE, SISOURCE, UISOURCE, SCANCLK, and EXTSTROBE*.

Posttriggered data acquisition allows you to view only data that is acquired after a trigger event is received. A typical posttriggered DAQ sequence is shown in Figure 4-10.
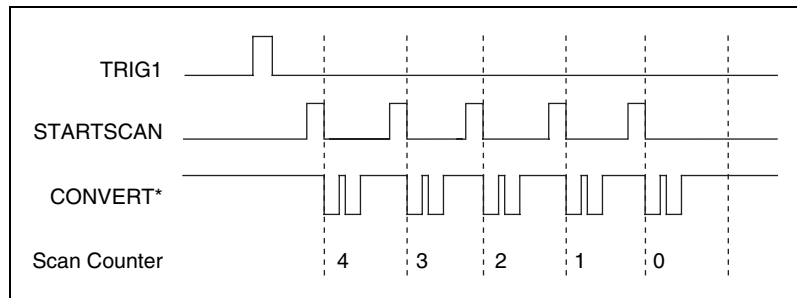
Figure 4-10. Typical Posttriggered Acquisition

Pretriggered data acquisition allows you to view data that is acquired before the trigger of interest in addition to data acquired after the trigger. Figure 4-11 shows a typical pretriggered DAQ sequence.
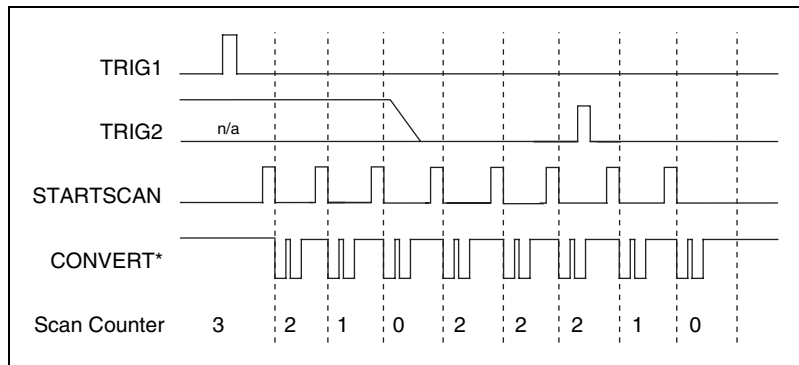
Figure 4-11. Typical Pretriggered Acquisition

The description for each signal shown in Figure 4-10 and 4-11 is included in this chapter.

TRIG1 Signal

Any PFI pin can externally input the TRIG1 signal, which is available as an output on the PFI0/TRIG1 pin.

Refer to Figures 4-10 and 4-11 for the relationship of TRIG1 to the DAQ sequence.

As an input, TRIG1 is configured in the edge-detection mode. You can select any PFI pin as the source for TRIG1 and configure the polarity selection for either rising or falling edge. The selected edge of TRIG1 starts the DAQ sequence for both posttriggered and pretriggered acquisitions. The DAQCards support analog triggering on the PFI0/TRIG1 pin. Refer to Chapter 3, *Hardware Overview*, for more information on analog triggering.

As an output, TRIG1 reflects the action that initiates a DAQ sequence, even if the acquisition is externally triggered by another PFI. The output is an active high pulse with a pulse width of 50 to 100 ns. This output is set to high-impedance at startup.

Figures 4-12 and 4-13 show the timing requirements for TRIG1.
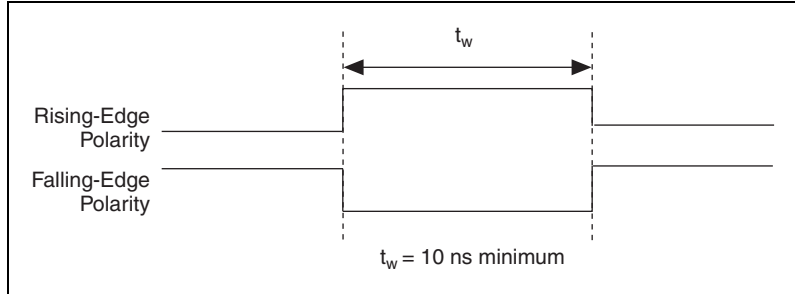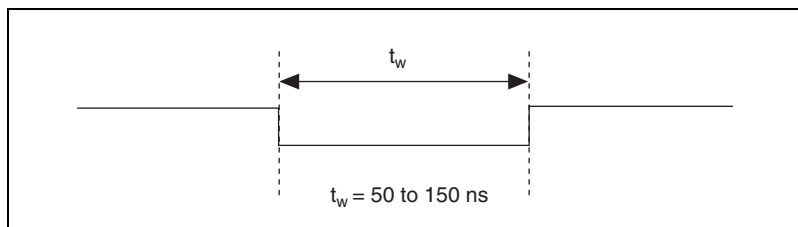

Figure 4-12. TRIG1 Input Signal Timing
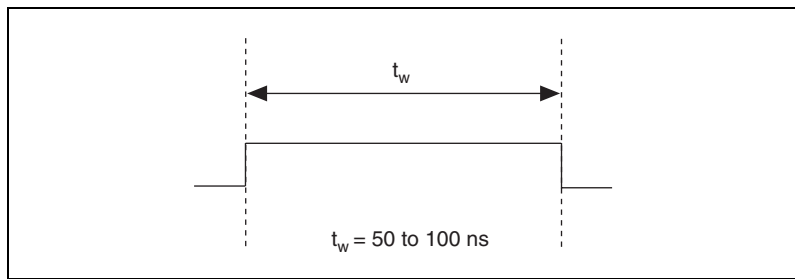
Figure 4-13. TRIG1 Output Signal Timing

The DAQCard also uses TRIG1 to initiate pretriggered DAQ operations. In most pretriggered applications, TRIG1 is generated by a software trigger. Refer to the TRIG2 signal description for a complete description of the use of TRIG1 and TRIG2 in a pretriggered DAQ operation.

TRIG2 Signal

Any PFI pin can externally input the TRIG2 signal, which is available as an output on the PFI1/TRIG2 pin.

Refer to Figure 4-11 for the relationship of TRIG2 to the DAQ sequence.

As an input, TRIG2 is configured in the edge-detection mode. You can select any PFI pin as the source for TRIG2 and configure the polarity selection for either rising or falling edge. The selected edge of TRIG2 initiates the posttriggered phase of a pretriggered DAQ sequence. In pretriggered mode, TRIG1 initiates the acquisition. The scan counter (SC) indicates the minimum number of scans before TRIG2 is recognized. After the SC decrements to zero, it is loaded with the number of posttrigger scans to acquire while the acquisition continues. The DAQCard ignores

TRIG2 if it is asserted prior to the SC decrementing to zero. After the selected edge of TRIG2 is received, the DAQCard acquires a fixed number of scans and the acquisition stops. This mode acquires data both before and after receiving TRIG2.

As an output, TRIG2 reflects the posttrigger in a pretriggered DAQ sequence, even if the acquisition is externally triggered by another PFI. TRIG2 is not used in posttriggered data acquisition. The output is an active high pulse with a pulse width of 50 to 100 ns. This signal is set to high-impedance at startup.

Figures 4-14 and 4-15 show the timing requirements for TRIG2.
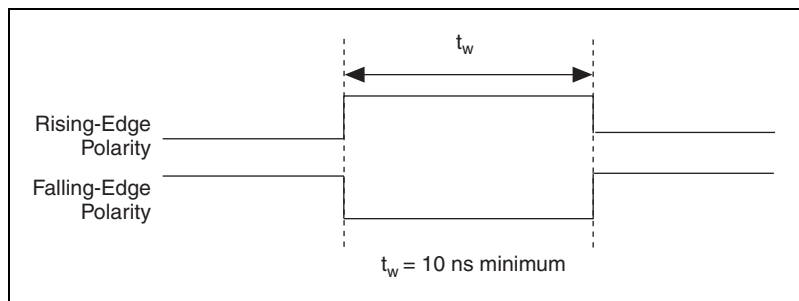
Figure 4-14. TRIG2 Input Signal Timing
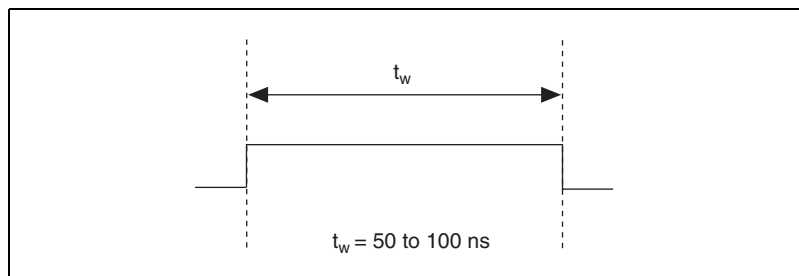
Figure 4-15. TRIG2 Output Signal Timing

STARTSCAN Signal

Any PFI pin can externally input the STARTSCAN signal, which is available as an output on the PFI7/STARTSCAN pin.

Refer to Figures 4-10 and 4-11 for the relationship of STARTSCAN to the DAQ sequence.

As an input, STARTSCAN is configured in the edge-detection mode. You can select any PFI pin as the source for STARTSCAN and configure the polarity selection for either rising or falling edge. The selected edge of STARTSCAN initiates a scan. The sample interval (SI2) counter starts if you select internally triggered CONVERT*.

As an output, STARTSCAN reflects the actual start pulse that initiates a scan, even if the starts are externally triggered by another PFI. You have two output options. The first is an active high pulse with a pulse width of 50 to 100 ns, which indicates the start of the scan. The second action is an active high pulse that terminates at the start of the last conversion in the scan, which indicates a scan in progress. STARTSCAN is deasserted, t_{off}, after the last conversion in the scan is initiated. This output is set to high-impedance at startup.

Figures 4-16 and 4-17 show the timing requirements for STARTSCAN.
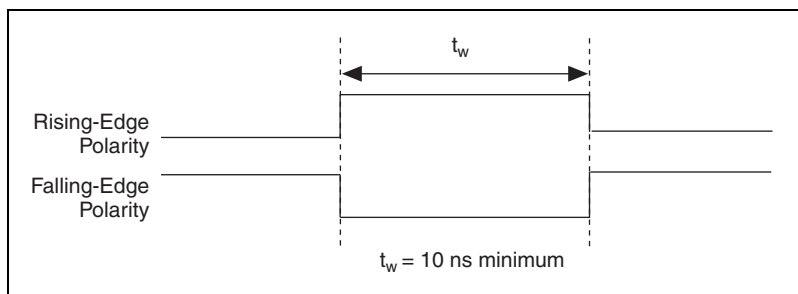
Figure 4-16. STARTSCAN Input Signal Timing
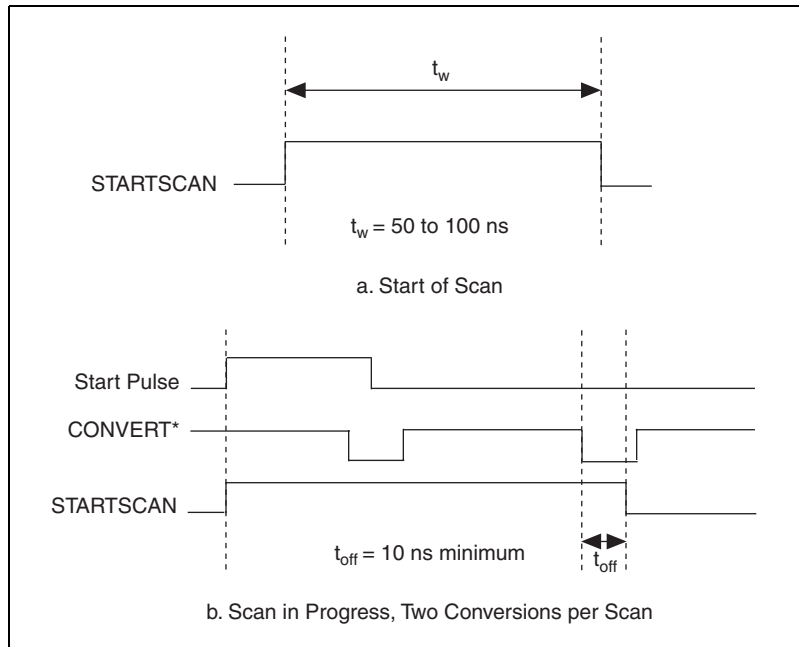
Figure 4-17. STARTSCAN Output Signal Timing

The CONVERT* pulses are masked off until the DAQCard generates the STARTSCAN signal. If you are using internally generated conversions, the first CONVERT* appears when the onboard SI2 counter reaches zero. If you select an external CONVERT*, the first external pulse after STARTSCAN generates a conversion. The STARTSCAN pulses should be separated by at least one scan period.

A counter on the DAQCard internally generates STARTSCAN unless you select some external source. This counter is started by the TRIG1 signal and is stopped either by software or by the SI2 counter.

Scans generated by either an internal or external STARTSCAN signal are inhibited unless they occur within a DAQ sequence. Scans occurring within a DAQ sequence can be gated by either the hardware signal AIGATE or the software command register gate.

CONVERT* Signal

Any PFI pin can externally input the CONVERT* signal, which is available as an output on the PFI2/CONVERT* pin.

Refer to Figures 4-10 and 4-11 for the relationship of CONVERT* to the DAQ sequence.

As an input, CONVERT* is configured in the edge-detection mode. You can select any PFI pin as the source for CONVERT* and configure the polarity selection for either rising or falling edge. The selected edge of CONVERT* initiates an A/D conversion.

As an output, CONVERT* reflects the actual convert pulse that connects to the ADC, even if the conversions are externally generated by another PFI. The output is an active low pulse with a pulse width of 50 to 100 ns. This signal is set to high-impedance at startup.

Figures 4-18 and 4-19 show the timing requirements for CONVERT*.
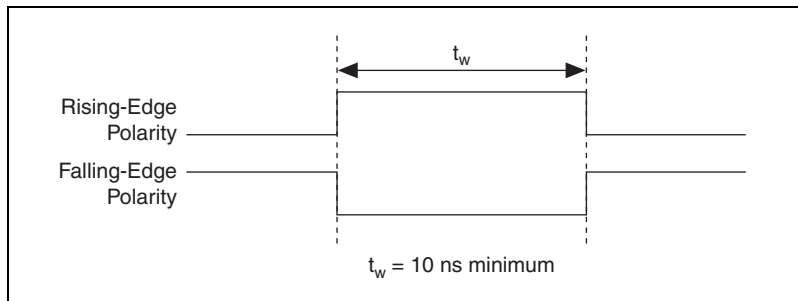
Figure 4-18. CONVERT* Input Signal Timing

Figure 4-19. CONVERT* Output Signal Timing

The ADC switches to hold mode within 60 ns of the selected edge. This hold-mode delay time is a function of temperature and does not vary from one conversion to the next. Separate the CONVERT* pulses by at least one conversion period.

The sample interval counter on the DAQCard normally generates the CONVERT* signal unless you select some external source. The counter is started by the STARTSCAN signal and continues to count down and reload itself until the scan is finished. It then reloads itself in readiness for the next STARTSCAN pulse.

A/D conversions generated by either an internal or external CONVERT* signal are inhibited unless they occur within a DAQ sequence. Scans occurring within a DAQ sequence can be gated by either the hardware signal AIGATE or the software command register gate.

AIGATE Signal

Any PFI pin can externally input the AIGATE signal, which is not available as an output on the I/O connector. AIGATE can mask off scans in a DAQ sequence. You can configure the PFI pin you select as the source for AIGATE in level-detection mode. You can configure the polarity selection for the PFI pin for either active high or active low.

In the level-detection mode if AIGATE is active, the STARTSCAN signal is masked off and no scans can occur.

The AIGATE signal can neither stop a scan in progress nor continue a previously gated-off scan; in other words, once a scan has started, AIGATE does not gate off conversions until the beginning of the next scan and, conversely, if conversions are being gated off, AIGATE does not gate them back on until the beginning of the next scan.

SISOURCE Signal

Any PFI pin can externally input the SISOURCE signal, which is not available as an output on the I/O connector. The onboard scan interval (SI) counter uses SISOURCE as a clock to time the generation of the STARTSCAN signal. You must configure the PFI pin you select as the source for SISOURCE in the level-detection mode. You can configure the polarity selection for the PFI pin for either active high or active low.
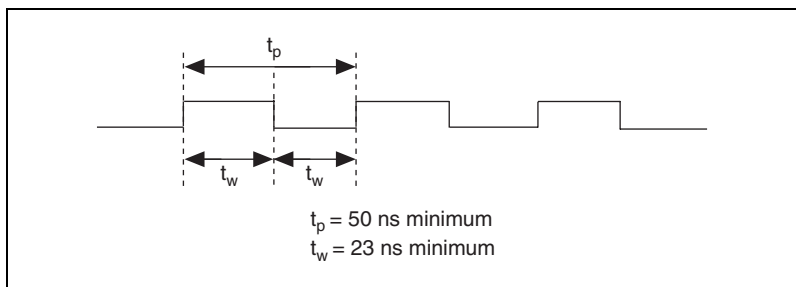
The maximum allowed frequency is 20 MHz, with a minimum pulse width of 23 ns high or low. There is no minimum frequency limitation.

Either the 20 MHz or 100 kHz internal timebase generates SISOURCE unless you select some external source. Figure 4-20 shows the timing requirements for SISOURCE.
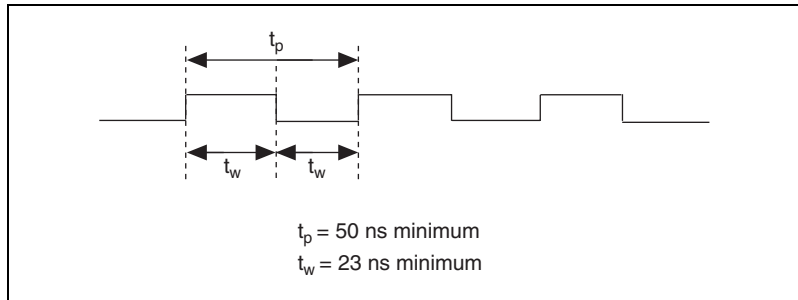
Figure 4-20. SISOURCE Signal Timing

UISOURCE Signal

Any PFI pin can externally input the UISOURCE signal, which is not available as an output on the I/O connector. The UI counter uses UISOURCE as a clock to time the generation of the UPDATE* signal. You must configure the PFI pin you select as the source for UISOURCE in the level-detection mode. You can configure the polarity selection for the PFI pin for either active high or active low. Figure 4-21 shows the timing requirements for UISOURCE.
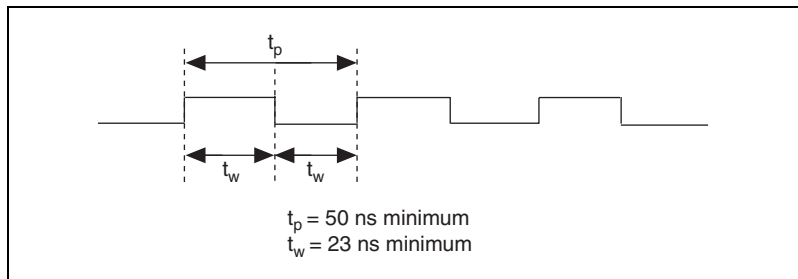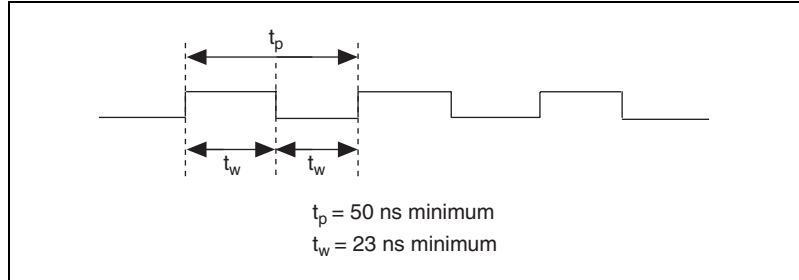

Figure 4-21. UISOURCE Signal Timing

The maximum allowed frequency is 20 MHz, with a minimum pulse width of 23 ns high or low. There is no minimum frequency limitation.

Either the 20 MHz or 100 kHz internal timebase normally generates UISOURCE unless you select some external source.

SCANCLK Signal

SCANCLK is an output-only signal that generates a pulse with the leading edge occurring approximately 50 to 100 ns after an A/D conversion begins. The polarity of this output is software-selectable, but is typically configured so that a low-to-high leading edge can clock external AI multiplexers indicating when the input signal has been sampled and can be removed. This signal has a 400 to 500 ns pulse width and is software enabled. Figure 4-22 shows the timing for SCANCLK.
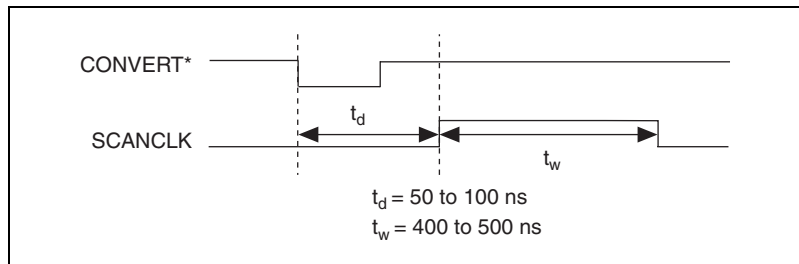
Figure 4-22. SCANCLK Signal Timing

✏️ **Note**   When using NI-DAQ, SCANCLK polarity is low-to-high and you cannot change it programmatically.

EXTSTROBE* Signal

EXTSTROBE* is an output-only signal that generates either a single pulse or a sequence of eight pulses in the hardware-strobe mode. An external device can use this signal to latch signals or to trigger events. In the single-pulse mode, software controls the level of the EXTSTROBE* signal. A 10 or 1.2 µs clock is available for generating a sequence of eight pulses in the hardware-strobe mode. This signal is primarily used for SCXI and AMUX-64T communication. To control this signal for general-purpose use, you must use register-level programming. Figure 4-23 shows the timing for the hardware-strobe mode EXTSTROBE* signal.

✏️ **Note**   You cannot enable EXTSTROBE through NI-DAQ.

$$V_{OH}$$

$$V_{OL}$$

t_w

t_w

t_w = 600 ns or 5 μs
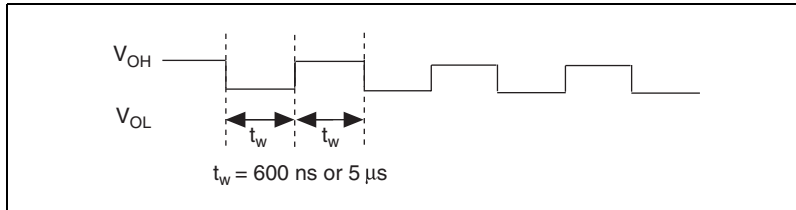
Figure 4-23. EXTSTROBE* Signal Timing

General-Purpose Timing Signal Connections

The general-purpose timing signals are GPCTR0_SOURCE, GPCTR0_GATE, GPCTR0_OUT, GPCTR0_UP_DOWN, GPCTR1_SOURCE, GPCTR1_GATE, GPCTR1_OUT, GPCTR1_UP_DOWN, and FREQ_OUT.

GPCTR0_SOURCE Signal

Any PFI pin can externally input the GPCTR0_SOURCE signal, which is available as an output on the PFI8/GPCTR0_SOURCE pin.

As an input, GPCTR0_SOURCE is configured in the edge-detection mode. You can select any PFI pin as the source for GPCTR0_SOURCE and configure the polarity selection for either rising or falling edge.

As an output, GPCTR0_SOURCE reflects the actual clock connected to general-purpose counter 0, even if another PFI is externally inputting the source clock. This signal is set to high-impedance at startup.

Figure 4-24 shows the timing requirements for GPCTR0_SOURCE.

t_p

t_w

t_w

t_p = 50 ns minimum
t_w = 23 ns minimum

Figure 4-24. GPCTR0_SOURCE Signal Timing

The maximum allowed frequency is 20 MHz, with a minimum pulse width of 23 ns high or low. There is no minimum frequency limitation.

The 20 MHz or 100 kHz timebase normally generates GPCTR0_SOURCE unless you select some external source.

GPCTR0_GATE Signal

Any PFI pin can externally input the GPCTR0_GATE signal, which is available as an output on the PFI9/GPCTR0_GATE pin.

As an input, the GPCTR0_GATE signal is configured in the edge-detection mode. You can select any PFI pin as the source for GPCTR0_GATE and configure the polarity selection for either rising or falling edge. You can use the gate signal in a variety of different applications to perform actions such as starting and stopping the counter, generating interrupts, saving the counter contents, and so on.

As an output, GPCTR0_GATE reflects the actual gate signal connected to general-purpose counter 0, even if the gate is externally generated by another PFI. This signal is set to high-impedance at startup.

Figure 4-25 shows the timing requirements for GPCTR0_GATE.
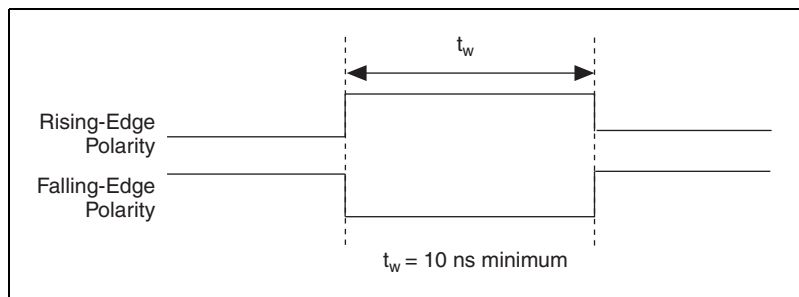
Figure 4-25. GPCTR0_GATE Signal Timing in Edge-Detection Mode

GPCTR0_OUT Signal

This signal is available only as an output on the GPCTR0_OUT pin. GPCTR0_OUT reflects the terminal count (TC) of general-purpose counter 0. You have two software-selectable output options—pulse on TC and toggle output polarity on TC. The output polarity is software-selectable for both options. This signal is set to high-impedance at startup. Figure 4-26 shows the timing of GPCTR0_OUT.
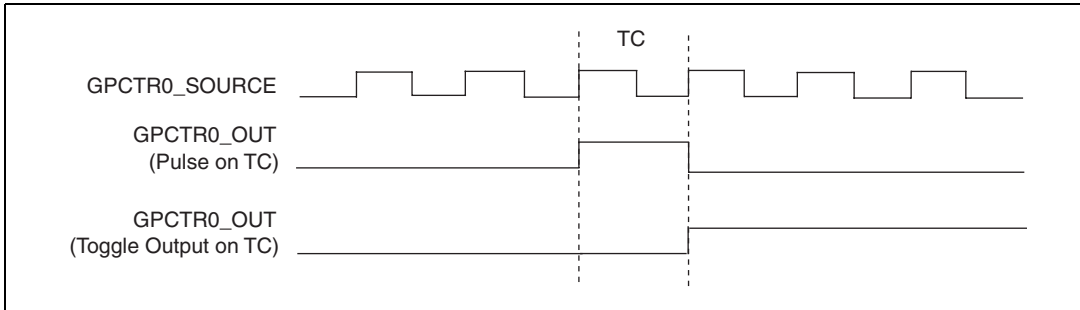
Figure 4-26. GPCTR0_OUT Signal Timing

GPCTR0_UP_DOWN Signal

This signal can be externally input on the DIO6 pin and is not available as an output on the I/O connector. The general-purpose counter 0 counts down when this pin is at a logic low and counts up when it is at a logic high. You can disable this input so that software can control the up-down functionality and leave the DIO6 pin free for general use.

GPCTR1_SOURCE Signal

Any PFI pin can externally input the GPCTR1_SOURCE signal, which is available as an output on the PFI3/GPCTR1_SOURCE pin.

As an input, GPCTR1_SOURCE is configured in the edge-detection mode. You can select any PFI as the source for GPCTR1_SOURCE and configure the polarity selection for either rising or falling edge.

As an output, GPCTR1_SOURCE monitors the actual clock connected to general-purpose counter 1, even if the source clock is externally generated by another PFI. This signal is set to high-impedance at startup.

Figure 4-27 shows the timing requirements for GPCTR1_SOURCE.

t_p = 50 ns minimum
t_w = 23 ns minimum

Figure 4-27. GPCTR1_SOURCE Signal Timing

The maximum allowed frequency is 20 MHz, with a minimum pulse width of 23 ns high or low. There is no minimum frequency limitation.

The 20 MHz or 100 kHz timebase normally generates GPCTR1_SOURCE unless you select some external source.

GPCTR1_GATE Signal

Any PFI pin can externally input the GPCTR1_GATE signal, which is available as an output on the PFI4/GPCTR1_GATE pin.

As an input, GPCTR1_GATE is configured in edge-detection mode. You can select any PFI as the source for GPCTR1_GATE and configure the polarity selection for either rising or falling edge. You can use the gate signal in a variety of different applications to perform such actions as starting and stopping the counter, generating interrupts, saving the counter contents, and so on.

As an output, GPCTR1_GATE monitors the actual gate signal connected to general-purpose counter 1, even if the gate is externally generated by another PFI. This signal is set to high-impedance at startup.

Figure 4-28 shows the timing requirements for GPCTR1_GATE.
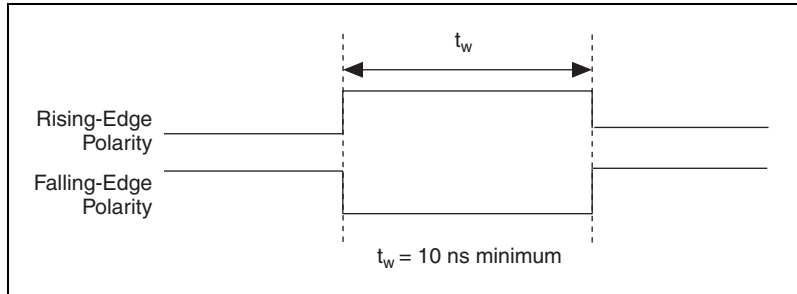
Figure 4-28. GPCTR1_GATE Signal Timing in Edge-Detection Mode

GPCTR1_OUT Signal

This signal is available only as an output on the GPCTR1_OUT pin. The
GPCTR1_OUT signal monitors the TC device general-purpose counter 1.
You have two software-selectable output options—pulse on TC and toggle
output polarity on TC. The output polarity is software-selectable for both
options. This signal is set to high-impedance at startup. Figure 4-29 shows
the timing requirements for GPCTR1_OUT.
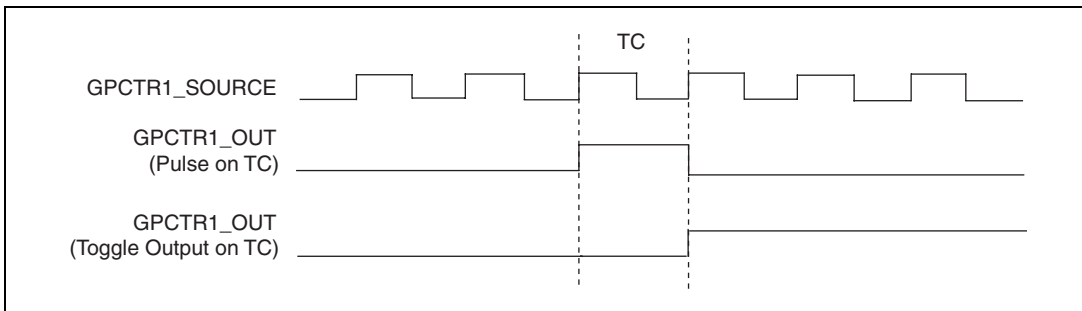
Figure 4-29. GPCTR1_OUT Signal Timing

GPCTR1_UP_DOWN Signal

This signal can be externally input on the DIO7 pin and is not available
as an output on the I/O connector. General-purpose counter 1 counts down
when this pin is at a logic low and counts up at a logic high. You can disable
this input so that software can control the up-down functionality and leave
the DIO7 pin free for general use. Figure 4-30 shows the timing
requirements for the GATE and SOURCE input signals and the timing
specifications for the OUT output signals of the DAQCard.

The figure shows a timing diagram with SOURCE, GATE, and OUT signals, followed by the parameter table:

Parameter	Symbol	Value
Source Clock Period	t_{sc}	50 ns minimum
Source Pulse Width	t_{sp}	23 ns minimum
Gate Setup Time	t_{gsu}	10 ns minimum
Gate Hold Time	t_{gh}	0 ns minimum
Gate Pulse Width	t_{gw}	10 ns minimum
Output Delay Time	t_{out}	80 ns maximum
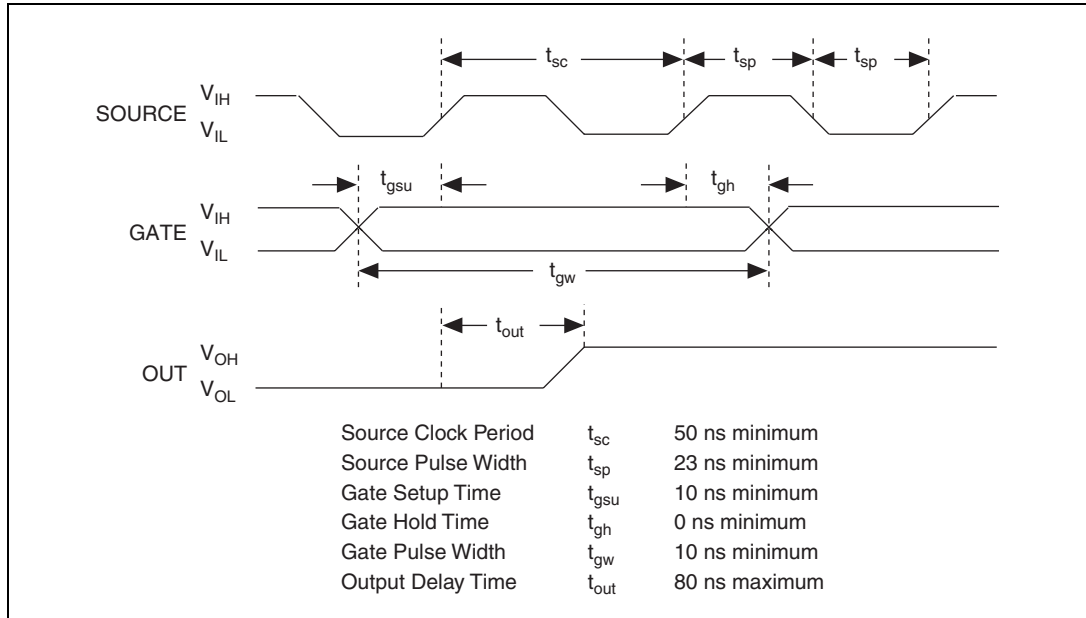
Figure 4-30. GPCTR Timing Summary

The GATE and OUT signal transitions shown in Figure 4-30 are referenced to the rising edge of the SOURCE signal. This timing diagram assumes that the counters are programmed to count rising edges. The same timing diagram, but with the source signal inverted and referenced to the falling edge of the source signal, would apply when the counter is programmed to count falling edges.

The GATE input timing parameters are referenced to the signal at the SOURCE input or to one of the internally generated signals on the DAQCard. Figure 4-30 shows the GATE signal referenced to the rising edge of a source signal. The gate must be valid (either high or low) for at least 10 ns before the rising or falling edge of a source signal for the gate to take effect at that source edge, as shown by t_{gsu} and t_{gh} in Figure 4-30. The gate signal is not required to be held after the active edge of the source signal.

If an internal timebase clock is used, the gate signal cannot be synchronized with the clock. In this case, gates applied close to a source edge take effect either on that source edge or on the next one. This arrangement results in an uncertainty of one source clock period with respect to unsynchronized gating sources.

The OUT output timing parameters are referenced to the signal at the SOURCE input or to one of the internally generated clock signals on the DAQCards. Figure 4-30 shows the OUT signal referenced to the rising edge of a source signal. Any OUT signal state changes occur within 80 ns after the rising or falling edge of the source signal.

FREQ_OUT Signal

This signal is available only as an output on the FREQ_OUT pin. The FREQ_OUT signal is the output of the DAQCard frequency generator. The frequency generator is a 4-bit counter that can divide its input clock by the numbers 1 through 16. The input clock of the frequency generator is software-selectable from the internal 10 MHz and 100 kHz timebases. The output polarity is software-selectable. This signal is set to high-impedance at startup.

Field Wiring Considerations

Environmental noise can seriously affect the accuracy of measurements made with the DAQCard if you do not take proper care when running signal wires between signal sources and the DAQCard. The following recommendations apply mainly to AI signal routing to the DAQCard, although they also apply to signal routing in general.

You can minimize noise pickup and maximize measurement accuracy by taking the following precautions:

*   Use differential AI connections to reject common-mode noise.

*   Use individually shielded, twisted-pair wires to connect AI signals to the DAQCard. With this type of wire, the signals attached to the CH+ and CH– inputs are twisted together and then covered with a shield. You then connect this shield only at one point to the signal source ground. This kind of connection is required for signals traveling through areas with large magnetic fields or high electromagnetic interference.

*   Route signals to the DAQCard carefully. Keep cabling away from noise sources. The most common noise source in a computer DAQ system is the video monitor. Separate the monitor from the analog signals as far as possible.

The following recommendations apply for all signal connections to the DAQCard:

- Separate DAQCard signal lines from high-current or high-voltage lines. These lines can induce currents in or voltages on the DAQCard signal lines if they run in parallel paths at a close distance. To reduce the magnetic coupling between lines, separate them by a reasonable distance if they run in parallel, or run the lines at right angles to each other.

- Do not run signal lines through conduits that also contain power lines.

- Protect signal lines from magnetic fields caused by electric motors, welding equipment, breakers, or transformers by running them through special metal conduits.

For more information, refer to the NI Developer Zone tutorial, *Field Wiring and Noise Considerations for Analog Signals*, available at `ni.com/zone`.

5

Calibration

This chapter discusses the calibration procedures for the DAQCard E Series device. If you are using NI-DAQ, that software includes calibration functions for performing all the steps in the calibration process.

Calibration refers to the process of minimizing measurement and output voltage errors by making small circuit adjustments. On the DAQCards, these adjustments take the form of writing values to onboard calibration DACs (CalDACs).

Some form of DAQCard calibration is required for most applications. If no DAQCard calibration were performed, signals and measurements could have very large offset, gain, and linearity errors.

Three levels of calibration are available to you, and these are described in this chapter. The first level is the fastest, easiest, and least accurate, whereas the last level is the slowest, most difficult, and most accurate.

Loading Calibration Constants

The DAQCard is factory calibrated before shipment at approximately 25 °C to the levels indicated in Appendix A, *Specifications*. The associated calibration constants—the values that were written to the CalDACs to achieve calibration in the factory—are stored in the EEPROM. Because the CalDACs have no memory capability, they do not retain calibration information when the DAQCard is unpowered. Loading calibration constants refers to the process of loading the CalDACs with the values stored in the EEPROM. NI-DAQ determines when this is necessary and does it automatically. If you are not using NI-DAQ, you must load these values yourself.

In the EEPROM there is a user-modifiable calibration area in addition to the permanent factory calibration area. This means that you can load the CalDACs with values either from the original factory calibration or from a calibration that you subsequently performed.

This method of calibration is not very accurate because it does not take into account the fact that the DAQCard measurement and output voltage errors

can vary with time and temperature. It is better to self-calibrate when the DAQCard is installed in the environment in which it is used.

Self-Calibration

The DAQCard can measure and correct for almost all of its calibration-related errors without any external signal connections. NI-DAQ provides a self-calibration method you can use. This self-calibration process, which generally takes less than a minute, is the preferred method of assuring accuracy in your application. Initiate self-calibration to minimize the effects of any offset, gain, and linearity drifts, particularly those due to warmup.

Immediately after self-calibration, the only significant residual calibration error could be gain error due to time or temperature drift of the onboard voltage reference. This error is addressed by external calibration, which is discussed in the following section. If you are interested primarily in relative measurements, you can ignore a small amount of gain error, and self-calibration should be sufficient.

External Calibration

The DAQCard has an onboard calibration reference to ensure the accuracy of self-calibration. Its specifications are listed in Appendix A, *Specifications*. The reference voltage is measured at the factory and stored in the EEPROM for subsequent self-calibrations. This voltage is stable enough for most applications, but if you are using the DAQCard at an extreme temperature or if the onboard reference has not been measured for a year or more, you may wish to externally calibrate the DAQCard.

An external calibration refers to calibrating the DAQCard with a known external reference rather than relying on the onboard reference. Redetermining the value of the onboard reference is part of this process and, you can save the results in the EEPROM, so you should not have to perform an external calibration very often. You can externally calibrate the DAQCard by calling the NI-DAQ calibration function.

To externally calibrate the DAQCard, use a very accurate external reference. The reference should be several times more accurate than the DAQCard itself. For example, to calibrate a 12-bit DAQCard, the external reference should be at least ±0.005% (±50 ppm) accurate. To calibrate a 16-bit DAQCard, the external reference should be at least ±0.001% (±10 ppm) accurate.

For a detailed calibration procedure for the DAQCard E Series devices, refer to the *E Series Calibration Procedure* by clicking **Manual Calibration Procedures** at `ni.com/calibration`.

A

Specifications

This appendix lists the specifications of DAQCard E Series devices.
These specifications are typical at 25 °C unless otherwise noted.

DAQCard-AI-16E-4

Analog Input

Input Characteristics

Number of channels .... 16 single-ended,
16 pseudodifferential, or
8 differential (software-selectable
on a per channel basis)

Type of ADC... Successive approximation

Resolution .... 12 bits, 1 in 4,096

Max sampling rate................................. 250 kS/s guaranteed

Input signal ranges

Device Gain (Software-Selectable)	Device Range (Software-Selectable)	
	Bipolar	**Unipolar**
0.5	±10 V	—
1	±5 V	0 to 10 V
2	±2.5 V	0 to 5 V
5	±1	0 to 2 V
10	±500 mV	0 to 1 V
20	±250 mV	0 to 500 mV

Device Gain (Software-Selectable)	Device Range (Software-Selectable)	
	Bipolar	**Unipolar**
50	±100 mV	0 to 200 mV
100	±50 mV	0 to 100 mV

Input coupling ....DC

Max working voltage
(signal + common mode).......................Each input should remain
within ±11 V of ground

Overvoltage protection ....±25 V powered on,
±15 V powered off

Inputs protected ....ACH<0..15>, AISENSE

FIFO buffer size.....................................1,024 samples

Data transfers ....Interrupts, programmed I/O

Configuration memory size ....512 words

Transfer Characteristics

Relative accuracy ....±0.5 LSB typ dithered,
±1.5 LSB max undithered

DNL ....±0.5 LSB typ, ±1.0 LSB max

No missing codes...................................12 bits, guaranteed

Offset error
Pregain error after calibration..........±16 µV max
Pregain error before calibration.......±4.0 mV max
Postgain error after calibration ....±1.0 mV max
Postgain error before calibration .....±265 mV max

Gain error (relative to calibration reference)
After calibration (gain = 1)..............±0.02% of reading max
Before calibration ....±2.5% of reading max

Gain ≠ 1 with gain error
adjusted to 0 at gain = 1 .... ±0.02% of reading max

Amplifier Characteristics

Input impedance

Normal powered on .... 100 GΩ in parallel with 100 pF

Powered off.................................... 1 kΩ min

Overload.. 1 kΩ min

Input bias current .... ±200 pA

Input offset current................................ ±100 pA

CMRR (all input ranges, DC to 60 Hz)

Gain	CCMR
≤1	85 dB
2	95 dB
≥5	100 dB

Dynamic Characteristics

Bandwidth

Small signal (–3 dB) .... 800 kHz

Large signal (1% THD) .... 400 kHz

Settling time for full-scale step

	Accuracy[1]	
Gain	±0.012% (±0.5 LSB)	±0.024% (±1 LSB)
0.5	4 µs typ, 8 µs max	4 µs max
[1] Accuracy values valid for source impedances < 1 kΩ. Refer to the *Multichannel Scanning Considerations* section of Chapter 3, *Hardware Overview*, for more information.		

System noise in LSB rms, not including quantization

Gain	Noise, Dither Off	Noise, Dither On
0.5 to 10	0.2	—
0.5 to 20	—	0.5
20	0.25	—
50	0.5	0.7
100	0.9	1.0

Crosstalk, DC to 100 kHz

    Adjacent channels............................–75 dB

    All other channels............................–90 dB

Stability

Offset temperature coefficient

    Pregain...±5 µV/°C

    Postgain ....±240 µV/°C

Gain temperature coefficient ....±20 ppm/°C

Onboard calibration reference level........5,000 V (±3.5 mV) (over full operating temperature, actual value stored in EEPROM)

Digital I/O

Number of channels................................8 input/output

Compatibility ....TTL/CMOS

Digital logic levels

Level	Min	Max
Input low voltage	0 V	0.8 V
Input high voltage	2 V	5 V
Input low current (V_{in} = 0 V)	—	–320 µA
Input high current (V_{in} = 5 V)	—	10 µA

Level	Min	Max
Output low voltage (I_{OL}= 24 mA)	—	0.4 V
Output high voltage (I_{OH}= 13 mA)	4.35 V	—

Power-on state.. Input (high-impedance)

Data transfers .... Programmed I/O

Max data transfer rate
(1 word = 8 bits).................................... 50 kwords/s

Constant, sustainable rate....................... 1 to 10 kwords/s,
system dependent

Timing I/O

Number of channels .... 2 up/down counter/timers,
1 frequency scaler

Resolution
Counter/timers .... 24 bits
Frequency scalers............................ 4 bits

Compatibility .... TTL/CMOS

Base clocks available
Counter/timers .... 20 MHz, 100 kHz
Frequency scalers............................ 10 MHz, 100 kHz

Base clock accuracy .... ±0.01%

Max source frequency .... 20 MHz

Min source pulse duration...................... 10 ns in edge-detection mode

Min gate pulse duration......................... 10 ns in edge-detection mode

Data transfers .... Interrupts, programmed I/O

Triggers

Analog Trigger

Source ....ACH<0..15>, external trigger
(PFI0/TRIG1)

Level ....± full-scale, internal;
±10 V, external

Slope ....Positive or negative
(software-selectable)

Resolution ....8 bits, 1 in 256

Hysteresis...Programmable

Bandwidth (–3 dB) ....2.0 MHz internal,
3.0 MHz external

External input (PFI0/TRIG1)

Impedance..10 kΩ
Coupling ....DC
Protection...±35 V powered off,
–0.5 to VCC when configured
as a digital signal,
±35 V when configured as an
analog trigger signal or disabled

Digital Trigger

Compatibility ....TTL

Response..Rising or falling edge

Pulse width ....10 ns min

Calibration

Recommended warm-up time.................15 min

Calibration interval ....1 year

External calibration reference.................>6 and <9.999 V

Onboard calibration reference

Level .... 5.000 V (±3.5 mV)
(over full operating temperature,
actual value stored in EEPROM)

Temperature coefficient................. ±5 ppm/°C max

Long-term stability .... ±15 ppm/$\sqrt{1,000\ h}$

Power Requirement (from PCMCIA I/O channel)

+5 VDC (±5%)...................................... 280 mA typ in operational mode,
400 mA max in operational mode,
70 mA in power down mode

Power available at I/O connector .... +4.65 to +5.25 V at 250 mA

Note   These power usage figures do not include the power used by external devices that are connected to the fused supply present on the I/O connector.

Physical

PC Card type .... Type II

I/O connector.. PCMCIA 68-position female connector

Maximum Working Voltage

Maximum working voltage refers to the signal voltage plus the common-mode voltage.

Channel-to-earth..................................... 42 V, Installation Category II

Channel-to-channel .... 0 V, Installation Category II

Environmental

Operating temperature............................ 0 to 55 °C

Storage temperature .... −20 to 70 °C

Humidity .... 10 to 90% RH, noncondensing

Maximum altitude................................. 2,000 meters

Pollution degree (indoor use only)......... 2

Safety

The DAQCard E Series devices meet the requirements of the following standards for safety and electrical equipment for measurement, control, and laboratory use:

- EN 61010-1:1993/A2:1995, IEC 61010-1:1990/A2:1995
- UL 3101-1:1993, UL 3111-1:1994, UL 3121:1998
- CAN/CSA c22.2 no. 1010.1:1992/A2:1997

Electromagnetic Compatibility

CE, C-Tick, and FCC Part 15 (Class A) Compliant

Electrical emissions ....EN 55011 Class A at 10 m
FCC Part 15A above 1 GHz

Electrical immunity ....Evaluated to EN 61326:1998,
Table 1

Note For full EMC compliance, you must operate this device with shielded cabling. In addition, all covers and filler panels must be installed. Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain the DoC for this product, click **Declaration of Conformity** at `ni.com/hardref.nsf/`. This Web site lists the DoCs by product family. Select the appropriate product family, followed by the product, and a link to the DoC appears in Adobe Acrobat format. Click the Acrobat icon to download or read the DoC.

DAQCard-AI-16XE-50

Analog Input

Input Characteristics

Number of channels .... 16 single-ended or 8 differential (software-selectable)

Type of ADC .... Successive approximation

Resolution .... 16 bits, 1 in 65,536

Maximum sampling rate .... 200 kS/s (single-channel), 20 kS/s guaranteed (scanning; gain = 1, 2, 10), 17 kS/s (scanning; gain = 100)

Input signal ranges

Device Gain (Software-Selectable)	Device Range (Software-Selectable)	
	Bipolar	**Unipolar**
1	±10 V	0 to 10 V
2	±5 V	0 to 5 V
10	±1 V	0 to 1 V
100	±0.1 V	0 to 0.1 V

Input coupling .... DC

Maximum working voltage
(signal + common mode) .... The average voltage of each differential pair should remain within ±8 V of ground

Overvoltage protection .... ±25 V powered on, ±15 V powered off

Inputs protected .... ACH<0..15>, AISENSE

FIFO buffer size .... 1,024 samples

Data transfers ....Interrupts, programmed I/O

Configuration memory size ....512 words

Transfer Characteristics

Relative accuracy....................................±2.0 LSB max, ±1.5 LSB typ

DNL ....+2.25 to –1 LSB max,
+1.5 to –0.75 LSB typ

No missing codes....................................16 bits, guaranteed

Offset error

    Pregain error after calibration..........±3 µV max

    Pregain error before calibration.......±280 µV max

    Postgain error after calibration ....±162 µV max (bipolar),
    ±81 µV max (unipolar)

    Postgain error before calibration .....±37.5 mV max (bipolar),
    ±175.75 mV max (unipolar)

Gain error (relative to calibration reference)

    After calibration (gain = 1)..............±7.6 ppm of reading max

    Before calibration ....±27,650 ppm of reading max

With gain error adjusted to 0 at gain = 1

    Gain = 2, 10 ....±100 ppm of reading

    Gain = 100 ....±250 ppm of reading

Amplifier Characteristics

Input impedance

    Normal, powered on ....7 GΩ in parallel with 100 pF

    Powered off ....1 kΩ min

    Overload ....1 kΩ min

Input bias current ....±10 nA

Input offset current ....±14 nA

CMRR, DC to 60 Hz

Gain	CMRR
1	80 dB
2	86 dB
10	100 dB
100	120 dB

Dynamic Characteristics

Bandwidth

Gain	Bandwidth
1, 2	69 kHz
10	66 kHz
100	39 kHz

Settling time for full-scale step

Gain	Settling Time[1]
1, 2, 10	50 µs max to ±2 LSB
100	60 µs max to ±2 LSB
	50 µs typ to ±4 LSB

[1] Accuracy values valid for source impedances < 1 kΩ. Refer to the *Multichannel Scanning Considerations* section of Chapter 3, *Hardware Overview*, for more information.

System noise (including quantization noise)

Gain	System Noise
1, 2, 10	1.0 LSB_{rms}
100	1.2 LSB_{rms} bipolar
	1.6 LSB_{rms} unipolar

Crosstalk, DC to 100 kHz

    Adjacent channels.............................–85 dB

    All other channels.............................–100 dB

Stability

Offset temperature coefficient

    Pregain...±1 µV/°C

    Postgain ....±120 µV/°C

Gain temperature coefficient ....±15 ppm/°C

Onboard calibration reference level........5,000 V (±3.5 mV) (over full operating temperature actual value stored in EEPROM)

Digital I/O

Number of channels................................8 input/output

Compatibility ....TTL/CMOS

Digital logic levels

Level	Min	Max
Input low voltage	0 V	0.8 V
Input high voltage	2 V	5 V
Input low current	—	–320 µA
Input high current	—	10 µA
Output low voltage (I_{OL} = 24 mA)	—	0.4 V
Output high voltage (I_{OH} = 13 mA)	4.35 V	—

Power-on state ....Input (high-impedance)

Data transfers...Programmed I/O

Max data transfer rate
(1 word = 8 bits) ....50 kwords/s

Constant, sustainable rate ....1 to 10 kwords/s, system dependent

Timing I/O

Number of channels .... 2 up/down counter/timers,
1 frequency scaler

Resolution

Counter/timers .... 24 bits

Frequency scaler .... 4 bits

Compatibility .... TTL/CMOS

Base clocks available

Counter/timers .... 20 MHz, 100 kHz

Frequency scaler .... 10 MHz, 100 kHz

Base clock accuracy .... ±0.01%

Max source frequency .... 20 MHz

Min source pulse duration .... 10 ns, edge-detection mode

Min gate pulse duration .... 10 ns, edge-detection mode

Data transfers .... Interrupts,
programmed I/O

Triggers

Digital Trigger

Compatibility .... TTL

Response .... Rising or falling edge

Pulse width... 10 ns min

Calibration

Recommended warm-up time .... 15 min

Calibration interval .... 1 year

External calibration reference .... >6 and <9.999 V

Onboard calibration reference

    Level ....5.000 V (±1.0 mV)
    (over full operating temperature,
    actual value stored in EEPROM)

    Temperature coefficient...................±5 ppm/ °C max

    Long-term stability ....$\pm 15 \text{ ppm}/\sqrt{1{,}000\text{ h}}$

Power Requirement

+5 VDC (±5%) ....230 mA active

Power available at I/O connector............+4.65 to +5.25 VDC
at 250 mA

Physical

PC Card type...Type II

I/O connector ....PCMCIA 68-position female
connector

Maximum Working Voltage

Maximum working voltage refers to the signal voltage plus the
common-mode voltage.

Channel-to-earth ....42 V, Installation Category II

Channel-to-channel.................................0 V, Installation Category II

Environmental

Operating temperature ....0 to 55 °C

Storage temperature ....–20 to 70 °C

Humidity ....10 to 90% RH, noncondensing

Maximum altitude...................................2,000 meters

Pollution degree (indoor use only) 2

Safety

The DAQCard E Series devices meet the requirements of the following standards for safety and electrical equipment for measurement, control, and laboratory use:

- EN 61010-1:1993/A2:1995, IEC 61010-1:1990/A2:1995

- UL 3101-1:1993, UL 3111-1:1994, UL 3121:1998

- CAN/CSA c22.2 no. 1010.1:1992/A2:1997

Electromagnetic Compatibility

CE, C-Tick, and FCC Part 15 (Class A) Compliant

Electrical emissions................................ EN 55011 Class A at 10 m
FCC Part 15A above 1 GHz

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Table 1

Note For full EMC compliance, you must operate this device with shielded cabling. In addition, all covers and filler panels must be installed. Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain the DoC for this product, click **Declaration of Conformity** at `ni.com/hardref.nsf/`. This Web site lists the DoCs by product family. Select the appropriate product family, followed by the product, and a link to the DoC appears in Adobe Acrobat format. Click the Acrobat icon to download or read the DoC.

B

Optional Cable Connector Descriptions

This appendix describes the connectors on the optional cables for the DAQCard E Series devices.

Figure B-1 shows the pin assignments for the 68-pin AI connector. This connector is available when you use the PSHR68-68M or PR6868 cable assemblies with the DAQCard-AI-16E-4 or DAQCard-AI-16XE-50.

ACH8	34	68	ACH0
ACH1	33	67	AIGND
AIGND	32	66	ACH9
ACH10	31	65	ACH2
ACH3	30	64	AIGND
AIGND	29	63	ACH11
ACH4	28	62	AISENSE
AIGND	27	61	ACH12
ACH13	26	60	ACH5
ACH6	25	59	AIGND
AIGND	24	58	ACH14
ACH15	23	57	ACH7
Reserved	22	56	AIGND
Reserved	21	55	Reserved
Reserved	20	54	Reserved
DIO4	19	53	DGND
DGND	18	52	DIO0
DIO1	17	51	DIO5
DIO6	16	50	DGND
DGND	15	49	DIO2
+5V	14	48	DIO7
DGND	13	47	DIO3
DGND	12	46	SCANCLK
PFI0/TRIG1	11	45	EXTSTROBE*
PFI1/TRIG2	10	44	DGND
DGND	9	43	PFI2/CONVERT*
+5V	8	42	PFI3/GPCTR1_SOURCE
DGND	7	41	PFI4/GPCTR1_GATE
PFI5	6	40	GPCTR1_OUT
PFI6	5	39	DGND
DGND	4	38	PFI7/STARTSCAN
PFI9/GPCTR0_GATE	3	37	PFI8/GPCTR0_SOURCE
GPCTR0_OUT	2	36	DGND
FREQ_OUT	1	35	DGND

Figure B-1. 68-Pin AI Connector Pin Assignments

Figure B-2 shows the pin assignments for the 50-pin AI connector. This connector is available when you use the SH6850 or R6850 cable assemblies with the PSHR68-68M.

AIGND	1	2	AIGND
ACH0	3	4	ACH8
ACH1	5	6	ACH9
ACH2	7	8	ACH10
ACH3	9	10	ACH11
ACH4	11	12	ACH12
ACH5	13	14	ACH13
ACH6	15	16	ACH14
ACH7	17	18	ACH15
AISENSE	19	20	Reserved
Reserved	21	22	Reserved
Reserved	23	24	DGND
DIO0	25	26	DIO4
DIO1	27	28	DIO5
DIO2	29	30	DIO6
DIO3	31	32	DIO7
DGND	33	34	+5V
+5V	35	36	SCANCLK
EXTSTROBE*	37	38	PFI0/TRIG1
PFI1/TRIG2	39	40	PFI2/CONVERT*
PFI3/GPCTR1_SOURCE	41	42	PFI4/GPCTR1_GATE
GPCTR1_OUT	43	44	PFI5
PFI6	45	46	PFI7/STARTSCAN
PFI8/GPCTR0_SOURCE	47	48	PFI9/GPCTR0_GATE
GPCTR0_OUT	49	50	FREQ_OUT

Figure B-2. 50-Pin AI Connector Pin Assignments

C

Common Questions

This appendix contains commonly asked questions and their answers relating to usage and special features of the DAQCard E Series device.

General Information

What are the DAQCard E Series devices?

The DAQCard E Series devices are switchless and jumperless, enhanced DAQCards that use the DAQ-STC for timing.

What is the DAQ-STC?

The DAQ-STC is the system timing control ASIC (application-specific integrated circuit) designed by NI and is the backbone of the DAQCard E Series devices. The DAQ-STC contains seven 24-bit counters and three 16-bit counters. The counters are divided into three groups:

- AI—two 24-bit, two 16-bit counters
- AO—three 24-bit, one 16-bit counters
- GPCTR—two 24-bit counters

You can independently configure the groups with timing resolutions of 50 ns or 10 μs. With the DAQ-STC, you can interconnect a wide variety of internal timing signals to other internal blocks. The interconnection scheme is quite flexible and completely software configurable. New capabilities such as buffered pulse generation, equivalent time sampling, and seamless changes to the sampling rate are possible.

How fast is each DAQCard E Series device?

The last numeral in the name of a DAQCard specifies the settling time in microseconds for that particular DAQCard. For example, the DAQCard-AI-16E-4 has a 4 μs settling time, which corresponds to a sampling rate of 250 kS/s. These sampling rates are aggregate: one channel at 250 kS/s or two channels at 125 kS/s per channel illustrates the relationship. Some DAQCard E Series devices have settling times that vary

with gain and accuracy. Refer to Appendix A, *Specifications*, for exact specifications.

What type of 5 V protection do the DAQCard E Series devices have?

The DAQCard E Series devices have 5 V lines equipped with a self-resetting 250 mA fuse.

How do I use the DAQCard E Series devices with the NI-DAQ C API?

The *NI-DAQ User Manual for PC Compatibles* describes the general programming flow when using the NI-DAQ C API as well as contains example code. For a list of functions that support the DAQCard E Series devices, you can refer to the NI-DAQ Help (NI-DAQ 6.7 or later) or the *NI-DAQ Function Reference Manual* (NI-DAQ 6.6. or earlier).

Installation and Configuration

Which NI document should I read first to get started using DAQ software?

The *DAQ Quick Start Guide* and the NI-DAQ or application software release notes documentation are good places to start.

What version of NI-DAQ must I have to program the DAQCard E Series device?

You must have version 4.9.0 or later for the DAQCard-AI-16E-4 and DAQCard-AI-16XE-50.

What is the best way to test the DAQCard without having to program the DAQCard?

If you are using Windows, MAX has a Test Panel option available by selecting **Devices and Interfaces** and then selecting the device. The Test Panels are excellent tools for performing simple functional tests of the device, such as AI, DIO, and counter/timer tests. If you are using the Mac OS, the NI-DAQ Configuration Utility provides the same functionality.

Analog Input

I'm using the DAQCard in DIFF input mode and I have connected a differential input signal, but the readings are random and drift rapidly. What's wrong?

Check the ground reference connections. The signal may be referenced to a level that is considered *floating* with reference to the DAQCard ground reference. Even if you are in DIFF input mode, the signal *must* still be referenced to the same ground level as the DAQCard reference. There are various methods of achieving this while maintaining a high CMRR. These methods are outlined in Chapter 4, *Signal Connections*.

Can I sample across a number of channels on a DAQCard E Series device while each channel is being sampled at a different rate?

NI-DAQ features a function called SCAN_Sequence_Setup, which allows for multirate scanning of the AI channels. Refer to the *NI-DAQ Function Reference Manual for PC Compatibles* for more details.

Can I programmatically enable different channels on an E Series device to acquire in different modes? For example, Channel 0 is differential and Channel 1 is RSE.

You can enable different channels on an E Series device to acquire in different modes. However, different pairs of channels are used in different modes. In the example configuration given above, you would configure ACH0 and ACH8 in differential mode, and ACH1 and AIGND in RSE mode. In this configuration, you cannot use ACH8 in a single-ended configuration. To enable multiple mode scanning in LabVIEW, use the **coupling & input config cluster** input of the **AI Config** VI. This input has a 1-to-1 correspondence with the channels array input of the **AI Config** VI. Therefore, you must list all channels either individually or in groups of channels with the same input configuration. For example, if you want Channel 0 to be differential and Channels 1 and 2 to be RSE, Figure C-1 demonstrates how to program this configuration in LabVIEW.
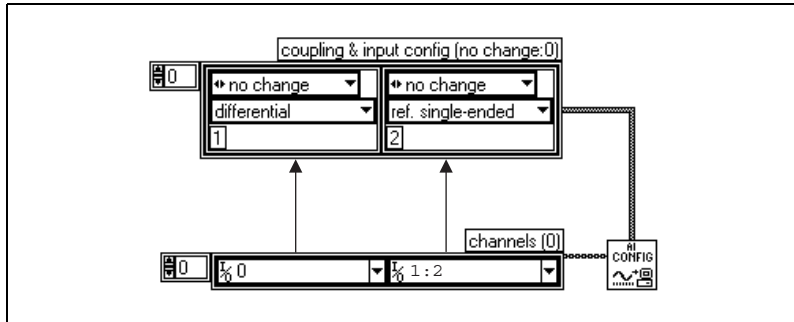
Figure C-1. Configuring Channels for Different Acquisition Modes in LabVIEW

To enable multiple mode scanning using NI-DAQ functions, call the
AI_Configure function for each channel.

**I am seeing crosstalk or ghost voltages when sampling multiple
channels. What does this mean?**

You may be experiencing a phenomenon called charge injection. Charge
injection occurs when you are sampling a series of high-output impedance
sources with a multiplexer. Multiplexers contain switches, usually made of
switched capacitors. When one of the channels, for example Channel 0, is
selected in a multiplexer, those capacitors accumulate charge. When the
next channel, for example Channel 1, is selected, the accumulated charge
(that is, current) leaks backward through that channel. If the output
impedance of the source connected to channel 1 is high enough, the
resulting reading can somewhat reflect the voltage trends in Channel 0.
To circumvent this problem, you must use a voltage follower (op-amp with
unity gain) for each of the high-impedance sources before connecting to the
DAQ device or decrease the rate at which each channel is sampled. Another
common cause of channel crosstalk is due to sampling among multiple
channels at various gains. In this situation, the settling times can increase.
For more information on charge injection and sampling channels at
different gains, refer to Chapter 3, *Hardware Overview*.

**How can I use STARTSCAN and CONVERT* on the DAQCard
E Series device to sample AI channel(s)?**

DAQCard E Series devices employ both the STARTSCAN and
CONVERT* signals to perform interval sampling. The STARTSCAN
signal of the DAQ-STC controls the scan interval (1/scan interval =
scan rate) shown in Figure C-2. The CONVERT* signal controls the
interchannel delay (1/interchannel delay = sampling rate). This method

allows you to sample multiple channels relatively quickly in relation to the overall scan rate providing a pseudo-simultaneous effect with a fixed delay between channels.
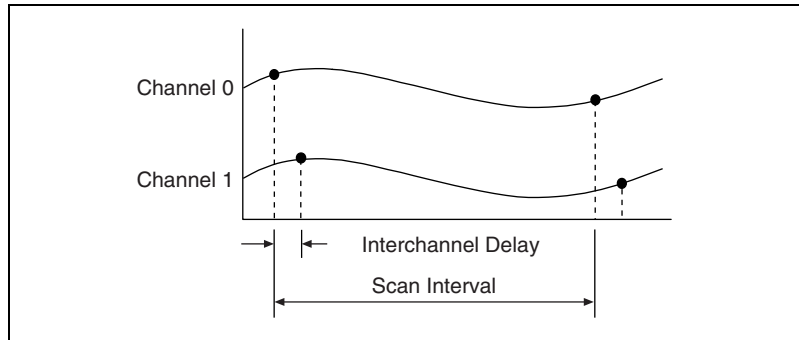
Figure C-2. Comparing Interchannel Delay and Scan Interval

Timing and Digital I/O

What types of triggering can I implement in hardware on the DAQCard E Series device?

Digital triggering is supported by hardware on every DAQCard E Series device. In addition, the DAQCard-AI-16E-4 supports analog triggering in hardware.

What added functionality does the DAQ-STC make possible in contrast to the Am9513?

The DAQ-STC incorporates much more than just 10 Am9513-style counters within one chip. In fact, the DAQ-STC has the complexity of more than 24 chips. The DAQ-STC makes possible PFI lines, analog triggering, selectable logic level, and frequency shift keying. The DAQ-STC also makes buffered operations possible, such as direct up/down control, single or pulse train generation, equivalent time sampling, buffered period, and buffered semiperiod measurement.

What is the difference in timebases between the Am9513 counter/timer and the DAQ-STC?

The DAQ-STC-based devices have a 20 MHz timebase.
The Am9513-based devices have a 1 or 5 MHz timebase.

Do the counter/timer applications that I wrote previously work with the DAQ-STC?

If you are using the NI-DAQ with LabVIEW, some of your applications drawn using the CTR VIs do still run. However, there are many differences in the counters between the DAQCard E Series and other devices; the counter numbers are different, timebase selections are different, the DAQ-STC counters are 24-bit counters (unlike the 16-bit counters on devices without the DAQ-STC).

If you are using the NI-DAQ language interface, such as LabWindows/CVI, the answer is, no, the counter/time applications that you wrote previously do not work with the DAQ-STC. You must use the GPCTR functions; ICTR and CTR functions do not work with the DAQ-STC. The GPCTR functions have the same capabilities as the ICTR and CTR functions, plus more, but you must rewrite the application with the GPCTR function calls.

I'm using one of the general-purpose counter/timers on the DAQCard E Series device, but I do not see the counter/timer output on the I/O connector. What am I doing wrong?

If you are using NI-DAQ language interface or LabWindows/CVI, you must configure the output line to output the signal to the I/O connector. Use the `Select_Signal` call in NI-DAQ to configure the output line. By default, all TIO lines except EXTSTROBE* are high-impedance.

What are the PFIs and how do I configure these lines?

PFIs are programmable function inputs. These lines serve as connections to virtually all internal timing signals.

If you are using NI-DAQ or LabWindows/CVI, use the `Select_Signal` function to route internal signals to the I/O connector, route external signals to internal timing sources, or tie internal timing signals together.

If you are using NI-DAQ with LabVIEW and you want to connect external signal sources to the PFI lines, you can use AI Clock Config, AI Trigger Config, and Counter Set Attribute advanced-level VIs to indicate which function the connected signal serves. Use the Route Signal VI to enable the PFI lines to output internal signals.

Table C-1. Signal Name Equivalencies

Hardware Signal Name	LabVIEW Route Signal	NI-DAQ Select_Signal
TRIG1	AI Start Trigger	ND_IN_START_TRIGGER
TRIG2	AI Stop Trigger	ND_IN_STOP_TRIGGER
STARTSCAN	AI Scan Start	ND_IN_SCAN_START
SISOURCE	—	ND_IN_SCAN_CLOCK_TIMEBASE
CONVERT*	AI Convert	ND_IN_CONVERT
AIGATE	—	ND_IN_EXTERNAL_GATE

⚠ **Caution**   If you enable a PFI line for output, do *not* connect any external signal source to it; if you do, you can damage the device, the computer, and the connected equipment.

D

Technical Support and Professional Services

Visit the following sections of the National Instruments Web site at `ni.com` for technical support and professional services:

- **Support**—Online technical support resources include the following:

    - **Self-Help Resources**—For immediate answers and solutions, visit our extensive library of technical support resources available in English, Japanese, and Spanish at `ni.com/support`. These resources are available for most products at no cost to registered users and include software drivers and updates, a KnowledgeBase, product manuals, step-by-step troubleshooting wizards, hardware schematics and conformity documentation, example code, tutorials and application notes, instrument drivers, discussion forums, a measurement glossary, and so on.

    - **Assisted Support Options**—Contact NI engineers and other measurement and automation professionals by visiting `ni.com/ask`. Our online system helps you define your question and connects you to the experts by phone, discussion forum, or email.

- **Training**—Visit `ni.com/custed` for self-paced tutorials, videos, and interactive CDs. You also can register for instructor-led, hands-on courses at locations around the world.

- **System Integration**—If you have time constraints, limited in-house technical resources, or other project challenges, NI Alliance Program members can help. To learn more, call your local NI office or visit `ni.com/alliance`.

If you searched `ni.com` and could not find the answers you need, contact your local office or NI corporate headquarters. Phone numbers for our worldwide offices are listed at the front of this manual. You also can visit the Worldwide Offices section of `ni.com/niglobal` to access the branch office Web sites, which provide up-to-date contact information, support phone numbers, email addresses, and current events.

Glossary

Prefix	Meanings	Value
p-	pico-	10^{-12}
n-	nano-	10^{-9}
μ-	micro-	10^{-6}
m-	milli-	10^{-3}
k-	kilo-	10^{3}
M-	mega-	10^{6}
G-	giga-	10^{9}

Numbers/Symbols

°	degrees
–	negative of, or minus
Ω	ohms
/	per
%	percent
±	plus or minus
+	positive of, or plus
$\sqrt{}$	square root of
+5V	+5 VDC source signal

A

A	amperes
A/D	analog-to-digital
AC	alternating current
ACH	analog input channel signal
ADC	A/D converter
ADE	application development environment
ADIO	analog/digital input/output
AI	analog input
AIGATE	analog input gate signal
AIGND	analog input ground signal
AISENSE	analog input sense signal
AO	analog output
AOGND	analog output ground signal
ASIC	application-specific integrated circuit

B

BIOS	basic input/output system or built-in operating system
bipolar	a signal range that includes both positive and negative values (for example, –5 V to +5 V)

C

C	Celsius
CalDAC	calibration DAC
CH	channel

channel rate	reciprocal of the interchannel delay
CIS	Card Information Structure
cm	centimeter
CMOS	complementary metal-oxide semiconductor
CMRR	common-mode rejection ratio
CONVERT*	convert signal
CTR	counter

D

D/A	digital-to-analog
DAC	D/A converter
DAC0OUT	analog channel 0 output signal
DAC1OUT	analog channel 1 output signal
DAQ	data acquisition
DAQCard	data acquisition card
DAQ-STC	data acquisition system timing controller chip
dB	decibels
DC	direct current
DGND	digital ground signal
DIFF	differential
DIO	digital input/output
DNL	differential nonlinearity
DO	digital output

DoC	Declaration of Conformity
DOC	Department of Communications

E

EEPROM	electrically erasable programmable read-only memory
EISA	Extended Industry Standard Architecture
EPROM	erasable programmable read-only memory
EXTREF	external reference signal
EXTSTROBE	external strobe signal

F

F	farads
FCC	Federal Communications Commission
FIFO	first-in-first-out
FREQ_OUT	frequency output signal
ft	feet

G

gain	factor by which a signal is amplified, often expressed in dB
GPCTR0_GATE	general purpose counter 0 gate signal
GPCTR1_GATE	general purpose counter 1 gate signal
GPCTR0_OUT	general purpose counter 0 output signal
GPCTR1_OUT	general purpose counter 1 output signal
GPCTR0_SOURCE	general purpose counter 0 clock source signal
GPCTR1_SOURCE	general purpose counter 1 clock source signal

GPTR0_UP_DOWN	general purpose counter 0 up down signal
GPTR1_UP_DOWN	general purpose counter 1 up down signal

H

h	hour
hex	hexadecimal
Hz	hertz

I

I/O	input/output
ICTR	input counter
interchannel delay	amount of time that passes between sampling consecutive channels. The interchannel delay must be short enough to allow sampling of all the channels in the channel list, within the scan interval. The greater the interchannel delay, the more time the PGIA is allowed to settle before the next channel is sampled. The interchannel delay is regulated by CONVERT*.
I_{OH}	current, output high
I_{OL}	current, output low
IRQ	interrupt request signal
ISA	Industry Standard Architecture

L

LED	light emitting diode
LSB	least significant bit

M

m	meter
MAX	Measurement & Automation Explorer
MB	megabytes of memory
MSB	most significant bit

N

NC	not connected internally
NI	National Instruments
NRSE	nonreferenced single-ended

O

OUT	output signal

P

PC	personal computer
PCMCIA	Personal Computer Memory Card Association
PFI	Programmable Function Input
PGIA	Programmable Gain Instrumentation Amplifier
ppm	parts per million
pu	pullup
PWRDOWN	power-down signal

R

RAM	random access memory
REF	reference
rms	root mean square
RSE	referenced single-ended
RTD	resistance temperature detector—a metallic probe that measures temperature based upon its coefficient of resistivity

S

s	seconds
S	samples
SC	scan counter
scan interval	controls how often a scan is initialized. The scan interval is regulated by STARTSCAN.
scan rate	reciprocal of the scan interval
SCANCLK	scan clock signal
SCXI	Signal Conditioning eXtensions for Instrumentation
SE	single-ended inputs
settling time	time required for an amplifier, relays, or other circuits to reach a stable mode of operation
SI	scan interval (counter)
SI2	sample interval (counter)
SISOURCE	SI counter clock signal
STARTSCAN	start scan signal

T

TC	terminal count
t_{gh}	gate hold time
t_{gsu}	gate setup time
t_{gw}	gate pulse width
THD	total harmonic distortion
TIO	timing I/O
t_{off}	an offset (delayed) pulse; the offset is t nanoseconds from the falling edge of the CONVERT* signal
t_{out}	output delay time
TRIG	trigger signal
t_{sc}	source clock period
t_{sp}	source pulse width
TTL	transistor-transistor logic
t_w	pulse width

U

UC	update counter
UI	update interval counter
UISOURCE	update interval counter clock signal
unipolar	a signal range that is always positive (for example, 0 to +10 V)
UPDATE*	update signal

V

V	volts
VCC	positive voltage supply
V_{cm}	common-mode noise
VDC	volts direct current
VI	virtual instrument
V_{IH}	volts, input high
V_{IL}	volts, input low
V_{in}	volts in
V_{o}	volts, output
V_{OH}	volts, output high
V_{OL}	volts, output low
V_{ref}	reference voltage
V_{s}	signal source

W

W	watts
WFTRIG	waveform generation trigger signal

Index

Symbols

+5V signal
    description, 4-3
    power connections, 4-20

A

ACH<0..15> signal
    analog input connections, 4-8
    DAQCard-AI-16E-4 (table), 4-5
    DAQCard-AI-16XE-50 (table), 4-6
    description, 4-3
AIGATE signal
    timing connections, 4-29
    using with CONVERT*, 4-29
    using with STARTSCAN, 4-27
AIGND signal
    analog input connections, 4-8
    DAQCard-AI-16E-4 (table), 4-5
    DAQCard-AI-16XE-50 (table), 4-6
    description, 4-3
    differential connections for floating signal
        sources, 4-14
AISENSE signal
    analog input connections, 4-8
    DAQCard-AI-16E-4 (table), 4-5
    DAQCard-AI-16XE-50 (table), 4-6
    description, 4-3
amplifier characteristic specifications
    DAQCard-AI-16E-4, A-3
    DAQCard-AI-16XE-50, A-10
analog input
    dither, 3-5
    input mode, 3-2
    input polarity and range
        DAQCard-AI-16E-4, 3-3
        DAQCard-AI-16Xe-50, 3-4

multichannel scanning considerations, 3-7
    questions about, C-3
    selection considerations, 3-5
    signal connections, 4-8
analog input specifications
    DAQCard-AI-16E-4
        amplifier characteristics, A-3
        dynamic characteristics, A-3
        input characteristics, A-1
        stability, A-4
        transfer characteristics, A-2
    DAQCard-AI-16XE-50
        amplifier characteristics, A-10
        dynamic characteristics, A-11
        input characteristics, A-9
        stability, A-12
        transfer characteristics, A-10
analog trigger
    above-high-level triggering mode
        (figure), 3-9
    below-low-level triggering mode
        (figure), 3-9
    block diagram, 3-8
    high-hysteresis triggering mode
        (figure), 3-10
    inside-region triggering mode (figure), 3-9
    low-hysteresis triggering mode
        (figure), 3-10
    PFI0/TRIG1 signal, 3-8

B

bipolar input
    DAQCard-AI-16E-4, 3-3
    DAQCard-AI-16XE-50, 3-4
    mixing bipolar and unipolar channels
        (note), 3-4

S

W

Web
    professional services, D-1
    technical support, D-1
wiring considerations, 4-38
worldwide technical support, D-1