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DAQ

DAQPad™-MIO-16XE-50
User Manual

16-Bit Data Acquisition and Control for the Parallel Port

NATIONAL INSTRUMENTS™

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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 `http://www.fcc.gov` for more information.



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 Federal Communications Commission (FCC) and the Canadian Department of Communications (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.

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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.

* 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.

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About This Manual

This manual describes the electrical and mechanical aspects of the DAQPad-MIO-16XE-50 and contains information concerning its operation and programming. The DAQPad-MIO-16XE-50 is a high-resolution, multifunction, portable data acquisition (DAQ) system that communicates with IBM PC/XT/AT and compatibles through the parallel port. The DAQPad-MIO-16XE-50 includes the DAQPad-TB-52, a detachable terminal block with screw terminals for convenient, compact signal connections.

Conventions

The following conventions appear 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, DIO<3..0>.

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

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

 This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash. When this symbol is marked on the device, see the *Safety Information* section of Chapter 1, *Introduction*, for precautions to take.

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

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,

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	programs, subprograms, subroutines, device names, functions, operations, variables, filenames and extensions, and code excerpts.
NI-DAQ	NI-DAQ is used throughout this manual to refer to the NI-DAQ software for PC compatibles, unless otherwise noted.
PC	PC refers to the IBM PC/XT, the IBM PC AT, and compatible computers.

NI Documentation

The *DAQPad-MIO-16XE-50 User Manual* is one piece of the documentation set for the system. You could have any of several types of manuals, depending on the hardware and software in the system. Use the different types of manuals you have as follows:

- The 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 manuals—Examples of software manuals you may have are the LabVIEW and Measurement Studio manual sets and the NI-DAQ manuals. After you set up the hardware system, use either the application software (LabVIEW or Measurement Studio) manuals or the NI-DAQ manuals to help you write your application. If you have a large and complicated system, it is worthwhile to look through the software manuals 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 or accessory board user manuals. They explain how to physically connect the relevant pieces of the system. Consult these guides when you are making your connections.

Related Documentation

The following National Instruments document contains information that you may find helpful as you read this manual:

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

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1 Introduction

This chapter describes the DAQPad-MIO-16XE-50, lists what you need to get started with the DAQPad-MIO-16XE-50, and describes the software programming choices and optional equipment.

About the DAQPad-MIO-16XE-50

The DAQPad-MIO-16XE-50 is a high-resolution, multifunction, portable DAQ system that communicates through the parallel port on IBM PC/XT/AT and compatible computers. The DAQPad-MIO-16XE-50 features 16 analog input (AI) channels that you can configure as 16 single-ended or eight differential inputs, a 16-bit successive-approximation ADC, two 12-bit DACs with voltage outputs, one constant current source for powering RTDs or thermistors, eight lines of TTL-compatible digital I/O (DIO), and two 24-bit counter/timers for timing I/O (TIO). The DAQPad-MIO-16XE-50 analog I/O circuitry is completely software-configurable and self-calibrated.

The DAQPad-MIO-16XE-50 uses the National Instruments DAQ-STC system timing controller for time-related functions. The DAQ-STC consists of three timing groups that control AI, AO, and general-purpose counter/timer functions. These groups include a total of seven 24-bit and three 16-bit counters and a maximum timing resolution of 50 ns.

The DAQPad-MIO-16XE-50 includes the DAQPad-TB-52, a detachable terminal block with screw terminals for convenient, compact signal connections. Because the DAQPad-TB-52 is built into the enclosure of the DAQPad-MIO-16XE-50, you do not need additional cables or external termination accessories. The terminal block includes screw terminals for all I/O signals, strain-relief for reliable wiring, and a temperature sensor for cold-junction compensation with thermocouples.

The DAQPad-MIO-16XE-50 is Enhanced Parallel Port (EPP) compatible with IEEE 1284, a standard for high-performance PC parallel ports. The DAQPad-MIO-16XE-50 has two parallel port connectors. The first parallel port connector communicates with two different computer parallel port types—the original Centronics or unidirectional port for printers and

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the EPP. The DAQPad-MIO-16XE-50 has a second parallel port connector for transparent pass-through connection to a standard parallel port device.

You can power the DAQPad-MIO-16XE-50 from the included AC adapter, the optional BP-1 rechargeable DAQPad battery pack, or any 9 to 42 VDC source, such as a standard 12 V car battery.

By combining multifunction analog, digital, and timing I/O capabilities in a compact, lightweight unit, the DAQPad-MIO-16XE-50 is ideal for portable applications using notebook computers or any PC with a parallel printer port. Because the DAQPad-MIO-16XE-50 can take advantage of the high throughput capabilities of the PC parallel port, the unit delivers high-performance data acquisition and control for any application.

Detailed specifications of the DAQPad-MIO-16XE-50 are in Appendix A, *Specifications*.

What You Need to Get Started

To set up and use the DAQPad-MIO-16XE-50, you need the following:

- ❑ DAQPad-MIO-16XE-50
- ❑ *DAQPad-MIO-16XE-50 User Manual*
- ❑ One of the following software packages and documentation:
  - LabVIEW for Windows
  - NI-DAQ for PC compatibles (Windows XP not supported)
  - Measurement Studio
  - VI Logger
- ❑ A parallel port cable
- ❑ 120 or 230 VAC wall-mount power supply adapter, the BP-1 battery power supply, or any 9 to 42 VDC power supply
- ❑ An IBM PC/XT/AT or compatible computer

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Software Programming Choices

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

NI-DAQ

NI-DAQ, which shipped with the AT 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 AT 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 are using LabVIEW, Measurement Studio, VI Logger, or other ADEs, your application uses NI-DAQ, as illustrated in Figure 1-1.

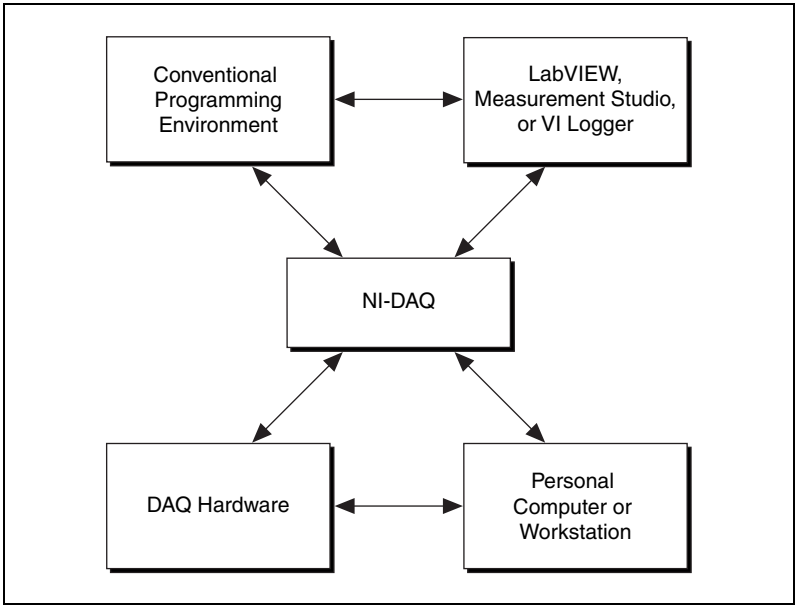


Figure 1-1. The Relationship Among the Programming Environment, NI-DAQ, and the Hardware

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

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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.

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

Optional Equipment

You can use the following NI products with the DAQPad-MIO-16XE-50:

- BP-1 battery pack with a 110 or 230 VAC charger
- 6 ft parallel port cable
- 6 in. adapter parallel port cable

For more information about optional equipment available from NI, refer to the NI catalog at `ni.com/catalog` or call the office nearest you.

BP-1 Battery Pack

For total portability, you can power the DAQPad-MIO-16XE-50 with the optional BP-1 battery pack. The BP-1 includes a 12 V, 3.2 Ahr battery packaged in an enclosure with the same dimensions as the DAQPad-MIO-16XE-50. A fully charged BP-1 typically powers the DAQPad-MIO-16XE-50 for 9 hours. A charger unit is included with the BP-1.

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Adding an Enhanced Parallel Port

If you have a slot available in your PC, you can add an EPP card to achieve higher DAQ rates. You can order one such card, the F/Port Enhanced Parallel Port Card, from Far Point Communications. You can use the card in a PC/AT 386, 486, or compatible computer.

If you have a PCMCIA type II slot available in your PC, you can add a PCMCIA to an EPP card to achieve higher DAQ rates. Two options are the SPP-100 from Quatech and the ExpressPort from Far Point. Both cards comply with the PCMCIA PC Standard Specification 2.1.

Parallel Port Cables

The DAQPad-MIO-16XE-50 two rear connectors (the parallel and transparent parallel port connectors) are 36-pin MDR 1284-C female connectors.

You can use 36-pin MDR 1284-C male connectors as mating connectors for the DAQPad-MIO-16XE-50 rear connector, or you can use the NI adapter parallel port cable, which allows you to use a standard DB-25-style male connector as a mating connector.

Unpacking

The DAQ 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 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 DAQ device in the antistatic envelope when not in use.

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Safety Information

The following section contains important safety information that you *must* follow during installation and use of 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 NI for repair.

If the product is rated for use with hazardous voltages (>30 V_{rms}, 42.4 V_{pk}, or 60 V_{dc}), you may need to connect a safety earth-ground wire according to the installation instructions. Refer to Appendix *A, Specifications,* for maximum voltage ratings.

Do *not* substitute parts or modify the product. 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 produce a reduction of 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, which becomes conductive due to condensation.

Clean the product with a soft nonmetallic brush. The product *must* be 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 connection to or disconnection from the product.

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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.

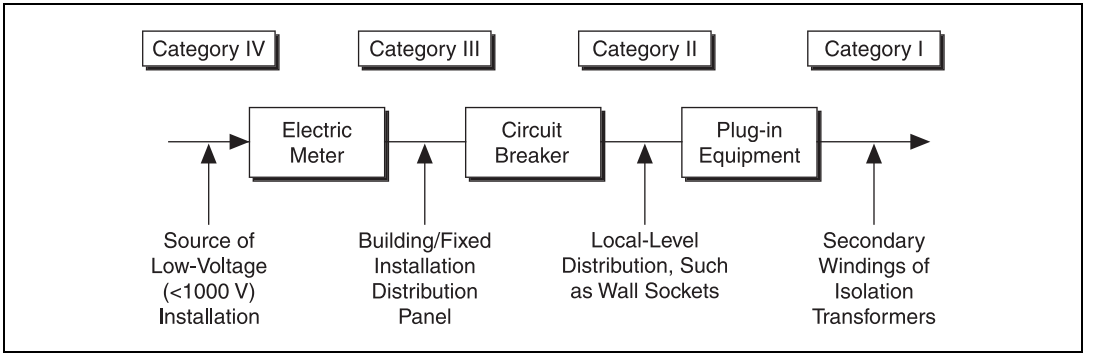
- Installation Category IV is for measurements performed at the source of the low-voltage (<1,000 V) installation.

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

[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.

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Below is a diagram of a sample installation



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2

Installing and Configuring the DAQPad-MIO-16XE-50

This chapter describes how to install and configure the DAQPad-MIO-16XE-50.

Installing the Software

Complete the following steps to install the software before installing the DAQPad-MIO-16XE-50.

1. Install the application development environment (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 DAQPad-MIO-16XE-50 to ensure that the device is properly detected.

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Hardware Installation

There are five basic steps to installing the DAQPad-MIO-16XE-50. Refer to Figure 2-1 as you perform the following steps.

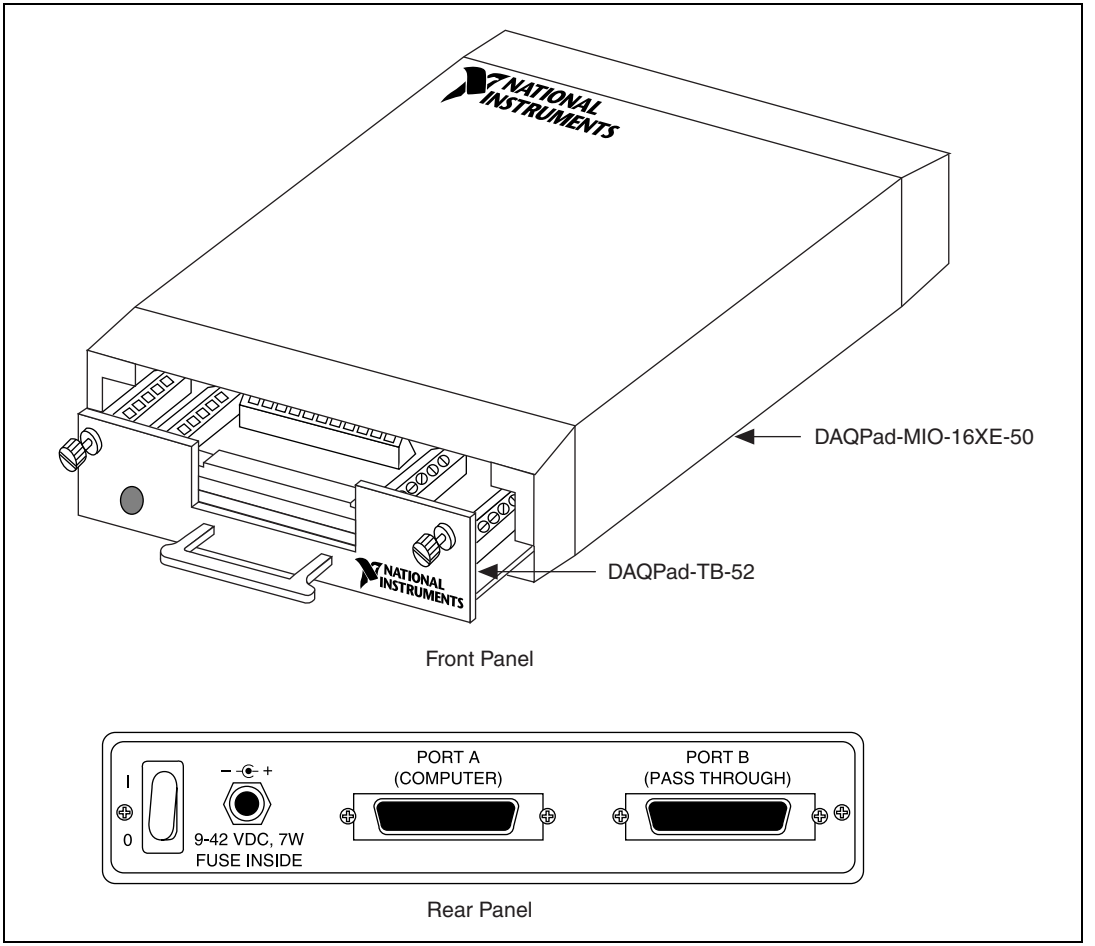


Figure 2-1. Front and Rear View of a DAQPad-MIO-16XE-50

Note If you are using the BP-1 battery pack, follow the installation instructions in the BP-1 installation guide instead of steps 1 and 2. The maximum recommended discharge time for a fully charged battery pack is nine hours for an unloaded DAQPad-MIO-16XE-50.

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Before installing the DAQPad-MIO-16XE-50, ground yourself using a grounding strap or by holding a grounded object. Follow the ESD protection precautions described in the *Unpacking* section of Chapter 1, *Introduction*.

1. Verify that the voltage on the wall-mount power supply matches the voltage supplied in your area.
2. Connect one end of the wall-mount power supply to an electrical outlet. Connect the other end to the rear panel jack and screw in the plug to lock the power supply in place.
3. Connect the DB-25 connector (on one end of the parallel port cable) to the PC parallel port and screw in the mounting screws on the connectors to establish a firm connection. Connect the other end of the parallel port cable to port A on the DAQPad-MIO-16XE-50.
4. If you are using the transparent parallel port, connect another parallel port cable to port B on the DAQPad-MIO-16XE-50. Connect the other end of the second parallel port cable to any standard parallel port device.
5. Push the rear panel rocker switch to power up the DAQPad-MIO-16XE-50. The power LED on the DAQPad-TB-52 should light up immediately. If the power LED does not light up immediately, check the polarity of the power connections. The power input of the DAQPad-MIO-16XE-50 is protected by a positive temperature coefficient (PTC) resistor. It takes approximately 20 s for the PTC resistor to reset after being tripped. Contact NI if the power LED does not light up after correcting any faulty power connections.

Note The LED on the DAQPad-TB-52 lights up only when the DAQPad-TB-52 is firmly connected to the DAQPad-MIO-16XE-50.

The DAQPad-MIO-16XE-50 unit is installed. You are now ready to install and configure the software.

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Configuring the DAQPad-MIO-16XE-50

This section describes how to configure the DAQPad-MIO-16XE-50.

Parallel Port

During configuration, you must know the parallel port I/O address and interrupt channel. Common parallel port I/O addresses are 0x378, 0x278, 0x3BC, 0x280 and 0x290. The DAQPad-MIO-16XE-50 can use the parallel port hardware interrupts for interrupt-driven data acquisition. Interrupt levels 7 and 5 are commonly used for parallel ports. Refer to the computer reference manual for details about interrupt selection and address assignment. For configuration problems, refer to Appendix B, *Troubleshooting for Configuring Parallel Ports*.

Analog Input

The AI section of the DAQPad-MIO-16XE-50 is software configurable. You can select different AI configurations through application software designed to control the DAQPad-MIO-16XE-50. The following sections describe in detail each of the AI categories.

Input Mode

The DAQPad-MIO-16XE-50 has three different input modes—nonreferenced single-ended (NRSE) input mode, referenced single-ended (RSE) input mode, and differential (DIFF) input mode. The single-ended input configurations use up to 16 channels. The differential input configuration uses up to eight channels. Input modes are programmed on a per channel basis for multimode scanning. For example, you can configure the circuitry to scan 12 channels—four differentially configured channels and eight single-ended channels. Table 2-1 describes the three input configurations.

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Table 2-1. Available Input Configurations for the DAQPad-MIO-16XE-50

Configuration	Description
DIFF	A channel configured in DIFF mode uses two analog channel input lines. One line connects to the positive input of the board 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 is internally tied to analog input 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 analog input sense (AISENSE) input.

For more information about the three types of input configuration, refer to the *Input Configurations* section of Chapter 3, *Connecting the Signals*, which contains diagrams showing the signal paths for the three configurations.

Input Polarity and Input Range

The DAQPad-MIO-16XE-50 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 DAQPad-MIO-16XE-50 has a unipolar input range of 10 V (0 to 10 V) and a bipolar input range of 20 V (±10 V).

The software-programmable gain on this board increases its overall flexibility by matching the input signal ranges to those that the ADC can accommodate. The DAQPad-MIO-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 2-2 shows the overall input range and precision according to the input range configuration and gain used. You can program polarity and range settings on a per channel basis so that you can configure each input channel uniquely.

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Note You can calibrate the AI circuitry for either a unipolar or bipolar polarity. If you mix unipolar and bipolar channels in the scan list and you are using NI-DAQ, NI-DAQ will load the calibration constants appropriate to the polarity for which analog input channel 0 is configured.

Table 2-2. Actual Range and Measurement Precision for the DAQPad-MIO-16XE-50

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

[1] The value of 1 LSB of the 16-bit ADC; that is, the voltage increment corresponding to a change of 1 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, you should 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

The addition of dither adds approximately 0.5 LSB_{rms} of white Gaussian noise to the signal to be converted by the ADC. This addition is useful for applications involving averaging to increase the resolution of the DAQPad-MIO-16XE-50, as in calibration or spectral analysis. In such applications, noise modulation is decreased and differential linearity is improved by the addition of the dither. When taking DC measurements, such as when checking the board calibration, average about 1,000 points to take a single reading. This process removes the effects of quantization and

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reduces measurement noise, resulting in improved resolution. Dither, or additive white noise, has the effect of forcing quantization noise to become a zero-mean random variable rather than a deterministic function of the input signal.

Figure 2-2 illustrates the effect of dither on signal acquisition. Figure 2-2a shows a small (±4 LSB) sine wave acquired with dither off. The quantization of the ADC is clearly visible. Figure 2-2b shows what happens when 50 such acquisitions are averaged together; quantization is still plainly visible. In Figure 2-2c, the sine wave is acquired with dither on. There is a considerable amount of noise 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.

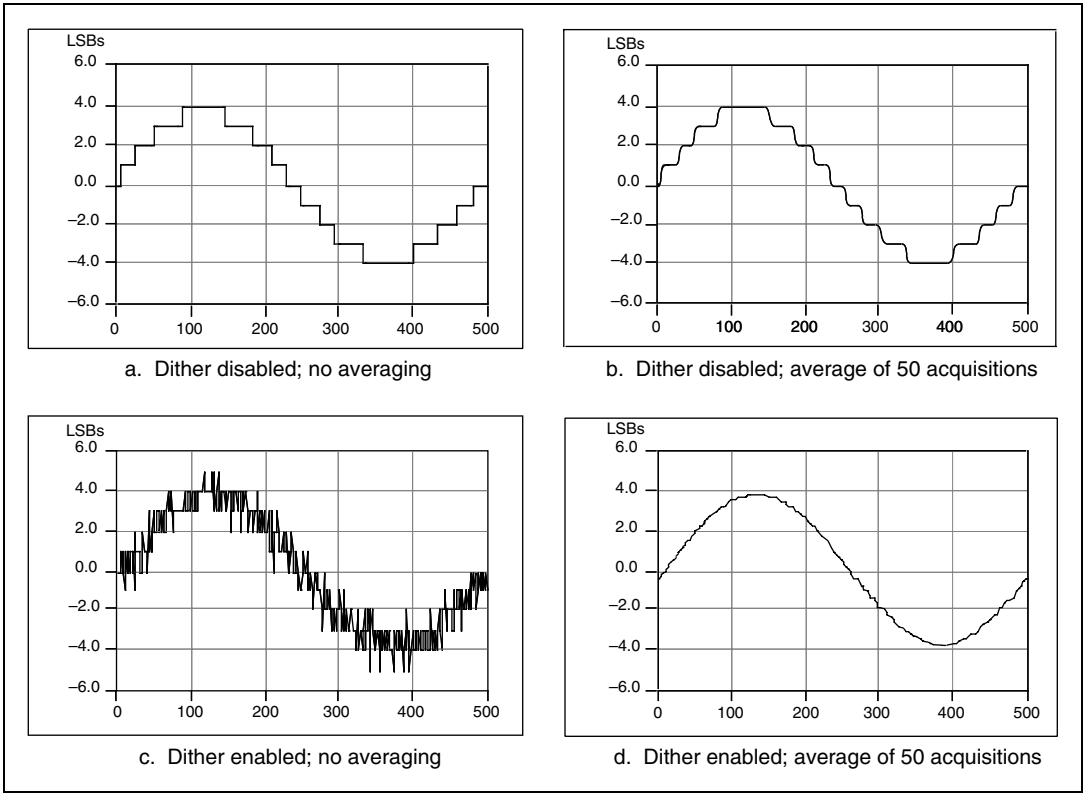


Figure 2-2. Dither

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You cannot disable dither on the DAQPad-MIO-16XE-50 because the resolution of the ADC is so fine that the ADC and the PGIA inherently produce almost 0.5 LSB_{rms} of noise. This is equivalent to having a dither circuit that is always enabled.

Multiple-Channel Scanning Considerations

The maximum multiple-channel scanning acquisition rate is identical to the single-channel acquisition rate for all gains. No extra settling time is necessary between channels as long as the gain is constant and source impedances are low.

When scanning among channels at various gains, the settling times may increase. When the PGIA switches to a higher gain, the signal on the previous channel may be well outside the new, smaller range. For instance, 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 1 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 16-bit board 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 may 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 impedance of the source is not low enough, the effect of the charge—a voltage error—has not decayed by the time the ADC samples the signal. For this reason, you should keep source impedances under 10 kΩ to perform high-speed scanning.

Due to the previously described limitations of settling times resulting from these conditions, multiple-channel 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).

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Analog Output

The DAQPad-MIO-16XE-50 supplies two channels of AO voltage on the DAQPad-TB-52. The range is fixed at bipolar ±10 V.

Cold-Junction Sensing

The DAQPad-MIO-16XE-50 includes a high accuracy thermistor temperature sensor for cold-junction compensation when you measure with thermocouples. The temperature sensor is read on a separate dedicated AI channel. In other words, you do not use any of the 16 AI channels to read the temperature sensor. However, you will need to consider both dither and multiple-channel scanning as discussed in the AI section.

To read the temperature sensor in LabVIEW, specify channel string `cjtemp`. When using any other programming language with NI-DAQ, use the pre-defined constant `ND_CJ_TEMP` to read the temperature sensor channel.

The temperature sensor channel is automatically configured in differential input mode. You can configure this channel for either unipolar or bipolar input polarity. You should configure the temperature sensor channel gain such that the input range of this channel matches as closely as possible the expected range of the temperature sensor reading. From 0 to 55 °C, the temperature sensor reading varies from approximately 0.1 to 1.7 V.



Note If you do not need external current excitation but want to perform cold-junction sensor measurements, you must keep the slide switch in the OFF position.

Use the following steps to convert a temperature sensor reading to thermistor temperature.

1. Compute R_T using the following equation:

$$R_T = \frac{V_{temp\ sensor}}{100\mu A}$$

where R_T = the resistance of the thermistor in ohms,
$V_{temp\ sensor}$ = the temperature sensor reading in volts.

2. Compute T_K using the following equation:

$$T_K = \frac{1}{\left[a + b(\ln R_T) + c(\ln R_T)^3\right]}$$

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where T_K = the thermistor temperature in Kelvin,
$a = 1.295361 \times 10^{-3}$
$b = 2.343159 \times 10^{-4}$
$c = 1.018703 \times 10^{-7}$

3. Compute T_C or T_F using one of the following equations:

$$T_C = T_K - 273.15$$

$$T_F = \left(\frac{9}{5}\right)T_C + 32$$

where T_C = thermistor temperature in Celsius,
T_F = thermistor temperature in Fahrenheit.

Note For further information on using thermocouples, refer to NI Developer Zone tutorial, *Measuring Temperature with Thermocouples*, at `ni.com/zone`.

Digital I/O

The DAQPad-MIO-16XE-50 contains eight lines of DIO for general-purpose use. You can individually configure each line through software for either input or output.

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 are input only and do not affect the operation of the DIO lines.

Programmable Function Inputs

The DAQ-STC provides a very flexible interface for connecting timing signals to external circuitry. The DAQPad-MIO-16XE-50 uses the Programmable Function Input (PFI) signals on the DAQPad-TB-52 for connecting to external circuitry. These connections are designed to enable the DAQPad-MIO-16XE-50 to both control and be controlled by other circuits.

There are a total of 13 timing signals internal to the DAQ-STC 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 2-3.

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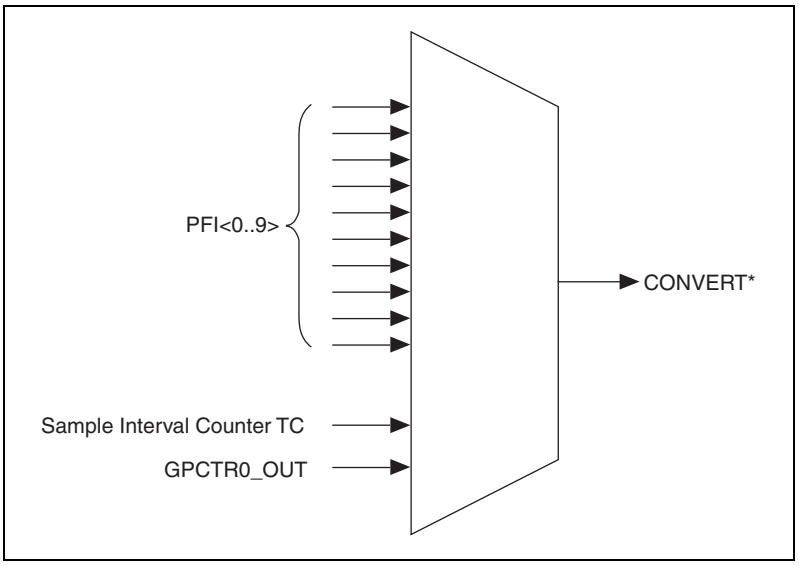


Figure 2-3. CONVERT* Signal Routing

This figure shows that CONVERT* can be generated from a number of sources, including the external signals PFI<0..9> and the internal signals Sample Interval Counter TC and GPCTR0_OUT.

Notice that any of the PFIs can be used as an input by any of the timing signals and that multiple timing signals can use the same PFI simultaneously. This flexible routing scheme reduces the need to change physical connections to the DAQPad-TB-52 for different applications.

You can also individually enable each of the PFI signals to output a specific internal timing signal. For example, if you need the UPDATE* signal as an output on the DAQPad-TB-52, software can turn on the output driver for the PFI5/UPDATE* pin.

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3

Connecting the Signals

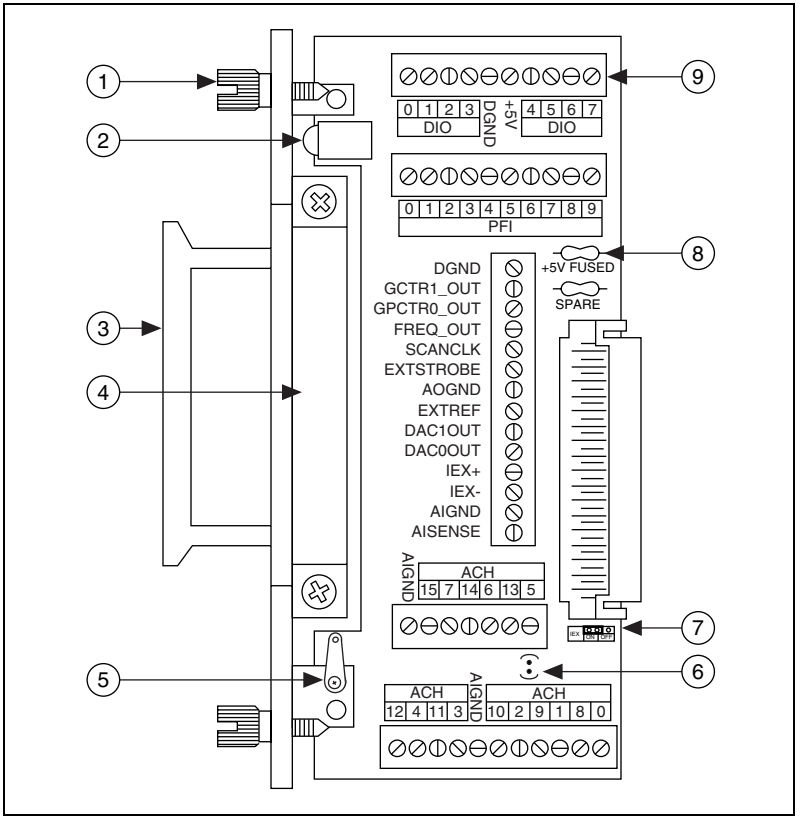
This chapter describes the connection of a standard parallel port device to the rear panel transparent parallel port connector and describes how to make signal connections to the DAQPad-MIO-16XE-50 using the DAQPad-TB-52.

DAQPad-TB-52 Terminal Block

The DAQPad-TB-52 is a detachable terminal block with 52 screw terminals designed to interface with the DAQPad-MIO-16XE-50. Figure 3-1 illustrates the 52 screw terminals and their corresponding signal assignments. The fuse labeled *F1* or *+5 V FUSED* limits the +5 V power output current. The fuse labeled *F2* or *SPARE* is placed on the terminal block for your convenience in case of accidental fusing of fuse F1. The slide switch labeled *IEX* turns external current excitation on and off. A signal description follows the terminal block layout.

Note If you do not need external current excitation but want to perform cold-junction sensor measurements, you must keep the slide switch in the OFF position.

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1	Front Panel Thumbscrew	4	Strain-Relief Bar	7	Current Excitation Switch
2	Power LED	5	Grounding Lug	8	+5 V Fuse
3	Front Panel Handle	6	Cold-Junction Sensor	9	Screw Terminals

Figure 3-1. DAQPad-TB-52 Screw Terminal Layout

Caution Connections that exceed any of the maximum ratings of input or output signals on the DAQPad-MIO-16XE-50 can damage the DAQPad-MIO-16XE-50 and the PC. Maximum input ratings for each signal are given in this chapter under the discussion of that signal. NI is *not* liable for any damage resulting from such signal connections.

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Table 3-1. DAQPad-TB-52 Signal Descriptions

Signal Name	Reference	Direction	Description
AIGND	—	—	Analog Input Ground—These signals are the reference point for single-ended measurements and the bias current return point for differential measurements. All three ground references—AIGND, AOGND, and DGND—are connected together on the DAQPad-MIO-16XE-50.
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 signal serves as the reference node for any of channels ACH <0..15> in NRSE configuration.
DAC0OUT	AOGND	Output	Analog Channel 0 Output—This signal supplies the voltage output of AO channel 0.
DAC1OUT	AOGND	Output	Analog Channel 1 Output—This signal supplies the voltage output of AO channel 1.
EXTREF	AOGND	Input	External Reference—This is the external reference input for the AO circuitry. This functionality is *not* available on the DAQPad-MIO-16XE-50.
AOGND	—	—	Analog Output Ground—The AO voltages are referenced to this node. All three ground references—AIGND, AOGND, and DGND—are connected together on the DAQPad-MIO-16XE-50.
IEX+	IEX–	Output	Current excitation—This signal provides 100 µA of external current excitation.
IEX–	—	—	Current excitation return—This signal provides the current return point for the external current excitation.
DGND	—	—	Digital Ground—These signals supply the reference for the digital signals at the DAQPad-TB-52 as well as the +5 VDC supply. All three ground references—AIGND, AOGND, and DGND—are connected together on the DAQPad-MIO-16XE-50.
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—This signal is fused for up to 250 mA of +5 V supply.
SCANCLK	DGND	Output	Scan Clock—This signal 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.

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Table 3-1. DAQPad-TB-52 Signal Descriptions (Continued)

Signal Name	Reference	Direction	Description
EXTSTROBE*	DGND	Output	External Strobe—This output can be toggled under software control to latch signals or trigger events on external devices.
PF10/TRIG1	DGND	Input	PF10/Trigger1—As an input, this is one of the Programmable Function Inputs (PFIs). PFI signals are explained in the *Timing Connections* section later in this chapter.
		Output	As an output, this is the TRIG1 signal. In posttrigger DAQ sequences, a low-to-high transition indicates the initiation of the acquisition sequence. In pretrigger applications, a low-to-high transition indicates the initiation of the pretrigger conversions.
PFI1/TRIG2	DGND	Input	PFI1/Trigger2—As an input, this is one of the PFIs.
		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.
PFI2/CONVERT*	DGND	Input	PFI2/Convert—As an input, this is one of the PFIs.
		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 one of the PFIs.
		Output	As an output, this is the GPCTR1_SOURCE signal. This signal reflects the actual source connected to the general-purpose counter 1.
PFI4/GPCTR1_GATE	DGND	Input	PFI4/Counter 1 Gate—As an input, this is one of the PFIs.
		Output	As an output, this is the GPCTR1_GATE signal. This signal reflects the actual gate signal connected to the general-purpose counter 1.
GPCTR1_OUT	DGND	Output	Counter 1 Output—This output is from the general-purpose counter 1 output.
PFI5/UPDATE*	DGND	Input	PFI5/Update—As an input, this is one of the PFIs.
		Output	As an output, this is the UPDATE* signal. A high-to-low edge on UPDATE* indicates that the AO primary group is being updated.

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Table 3-1. DAQPad-TB-52 Signal Descriptions (Continued)

Signal Name	Reference	Direction	Description
PFI6/WFTRIG	DGND	Input Output	PFI6/Waveform Trigger—As an input, this is one of the PFIs. As an output, this is the WFTRIG signal. In timed AO sequences, a low-to-high transition indicates the initiation of the waveform generation.
PFI7/STARTSCAN	DGND	Input Output	PFI7/Start of Scan—As an input, this is one of the PFIs. As an output, this is the STARTSCAN signal. This signal 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 Output	PFI8/Counter 0 Source—As an input, this is one of the PFIs. As an output, this is the GPCTR0_SOURCE signal. This signal reflects the actual source connected to the general-purpose counter 0.
PFI9/GPCTR0_GATE	DGND	Input Output	PFI9/Counter 0 Gate—As an input, this is one of the PFIs. As an output, this is the GPCTR0_GATE signal. This signal reflects the actual gate signal connected to the 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 3-2. I/O Signal Summary of the DAQPad-TB-52

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	—	—	—	±3 nA
AISENSE	AI	20 GΩ in parallel with 100 pF	25/15	—	—	—	±3 nA
AIGND	AO	—	—	—	—	—	—
DAC0OUT	AO	0.1 Ω	Short-circuit to ground	5 at 10	5 at 10	2 V/µs	—

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Table 3-2. I/O Signal Summary of the DAQPad-TB-52 (Continued)

Signal Name	Drive	Impedance Input/ Output	Protection (Volts) On/Off	Source (mA at V)	Sink (mA at V)	Rise Time (ns)	Bias
DAC1OUT	AO	0.1 Ω	Short-circuit to ground	5 at 10	5 at 10	2 V/µs	—
AOGND	AO	—	—	—	—	—	—
IEX+	AO	—	+14 to –40 V	100 µA	—	—	—
IEX–	AI	1.5–16.3 kΩ	±12 V	—	—	—	—
DGND	DO	—	—	—	—	—	—
VCC	DO	0.1 Ω	Short-circuit to ground	Fused at 250 mA	—	—	—
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
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

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Table 3-2. I/O Signal Summary of the DAQPad-TB-52 (Continued)

Signal Name	Drive	Impedance Input/ Output	Protection (Volts) On/Off	Source (mA at V)	Sink (mA at V)	Rise Time (ns)	Bias
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

[1] DIO <6..7> are also pulled down with a 50 kΩ resistor.

AI = Analog Input DIO = Digital Input/Output pu = pull up
AO = Analog Output DO = Digital Output

DAQPad-TB-52 Signal Connections



Note You do not have to turn off the DAQPad-MIO-16XE-50 before removing the DAQPad-TB-52.

To connect signals to the DAQPad-TB-52, perform the following steps:

1. Disconnect and remove the DAQPad-TB-52 from the DAQPad-MIO-16XE-50 by unscrewing the front panel thumbscrews and then gently pulling on the front panel handle.
2. Remove the strain-relief bar by unscrewing and removing the strain-relief screws with a flathead screwdriver (3/16 in. maximum).
3. Connect the signals to the screw terminals by inserting the wires into the appropriate terminals and tightening the screws with a flathead screwdriver (1/10 in. maximum).
4. Flatten the wires to lay across the strain-relief opening. Replace the strain-relief bar over the wires and tighten the strain-relief screws.
5. Slide the DAQPad-TB-52 back into the DAQPad-MIO-16XE-50 until the terminal block is firmly connected. Retighten the front panel thumbscrews.

If the system (the DAQPad-MIO-16XE-50 and PC) is floating with respect to earth ground, for both safety and shielding reasons you should ground the system to earth ground using the grounding lug provided on the inside of the DAQ-TB-52 front panel, shown in Figure 3-1.

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Analog Input Signal Connections

The AI signals are ACH<0..15>, AISENSE, and AIGND. The ACH<0..15> signals are tied to the 16 AI channels of the DAQPad-MIO-16XE-50. In single-ended mode, signals connected to ACH<0..15> are routed to the positive input of the device PGIA. In differential 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 input signals. Exceeding the maximum input voltage rating can damage the DAQPad-MIO-16XE-50 and the PC. NI is *not* liable for any damage resulting from such signal connections.

In NRSE mode, the AISENSE signal is connected internally to the negative input of the DAQPad-MIO-16XE-50 PGIA. In DIFF and RSE modes, this signal is left unconnected.

AIGND is an AI common signal that is routed directly to the ground tie point on the DAQPad-MIO-16XE-50. You can use this signal for a general analog ground tie point to the DAQPad-MIO-16XE-50 if necessary.

Connection of AI signals to the DAQPad-MIO-16XE-50 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 3-2 shows a diagram of the DAQPad-MIO-16XE-50 PGIA.

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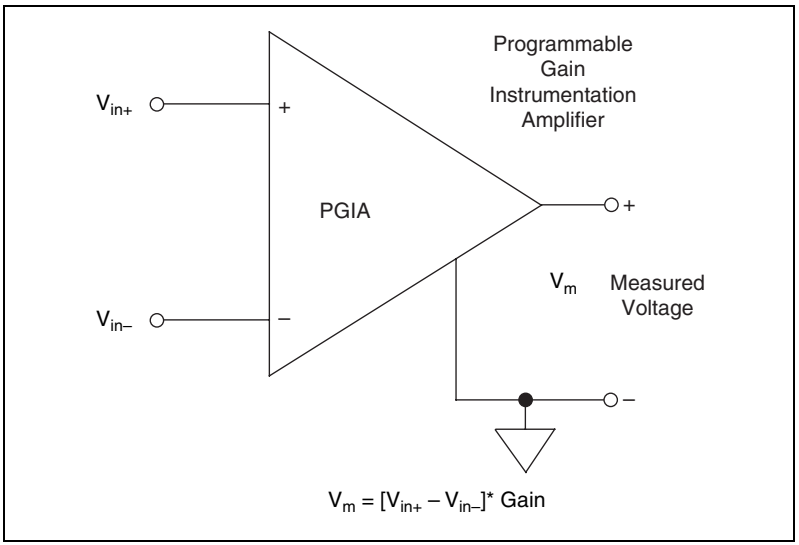


Figure 3-2. DAQPad-MIO-16XE-50 PGIA

The PGIA applies gain and common-mode voltage rejection and presents high-input impedance to the AI signals connected to the DAQPad-MIO-16XE-50. Signals are routed to the positive and negative inputs of the PGIA through input multiplexers on the board. 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 board. The DAQPad-MIO-16XE-50 A/D converter (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 board. If you have a floating source, you should 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 later in this chapter.) If you have a grounded source, you should 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 types of signals.

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Floating Signal Sources

A floating signal source is one that is not connected in any way to the building ground system but, rather, has an isolated ground-reference point. Some examples of floating signal sources are outputs of transformers, thermocouples, battery-powered devices, optical isolator outputs, and isolation amplifiers. An instrument or device that has an isolated output is a floating signal source. You must tie the ground reference of a floating signal to the DAQPad-MIO-16XE-50 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 is connected in some way to the building system ground and is, therefore, already connected to a common ground point with respect to the DAQPad-MIO-16XE-50, assuming that the PC is plugged into the same power system. Nonisolated outputs of instruments and devices that plug into the building power system fall 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 can be much higher if power distribution circuits are not properly connected. If a grounded signal source is improperly measured, this difference may appear as an error in the measurement. The connection instructions for grounded signal sources are designed to eliminate this ground potential difference from the measured signal.

Note If you power both the DAQPad-MIO-16XE-50 and the PC with a floating power source (such as a battery) and you are not tying the DAQPad-TB-52 grounding lug to earth ground, the system is floating with respect to earth ground. In this case, treat all of the signal sources as floating sources.

Input Configurations

You can configure the DAQPad-MIO-16XE-50 for one of three input modes—NRSE, RSE, or DIFF. The following sections discuss the use of single-ended and differential measurements and considerations for measuring both floating and ground-referenced signal sources. Figure 3-3 summarizes the recommended input configuration for both types of signal sources.

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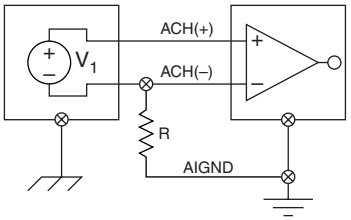
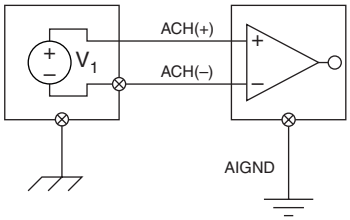
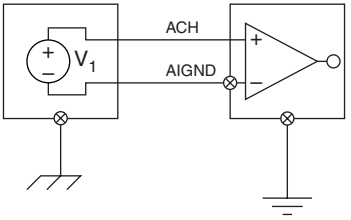
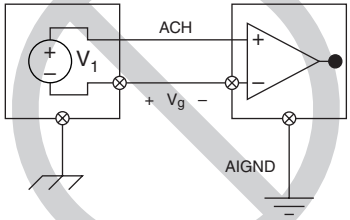
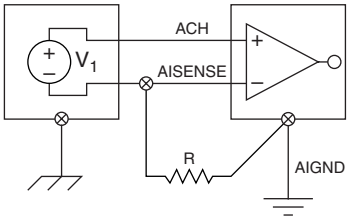
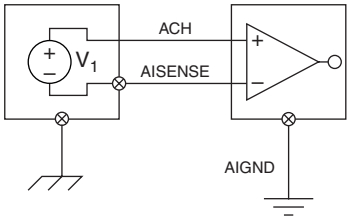
Input	Signal Source Type	
	Floating Signal Source (Not Connected to Building Ground)	**Grounded Signal Source**
	Examples • Ungrounded Thermocouples • Signal Conditioning with Isolated Outputs • Battery Devices	Examples • Plug-in Instruments with Nonisolated Outputs
Differential (DIFF)	 See text for 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 3-3. Summary of AI Connections

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Differential Connection Considerations

A differential connection is one in which the DAQPad-MIO-16XE-50 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 is tied to the positive input of the PGIA, and its reference signal, or return, is tied to the negative input of the PGIA.

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. Therefore, with a differential configuration for every channel, up to eight AI channels are available.

You should use differential 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 DAQPad-MIO-16XE-50 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.

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

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Differential Connections for Ground-Referenced Signal Sources

Figure 3-4 shows how to connect a ground-referenced signal source to a DAQPad-MIO-16XE-50 channel configured in DIFF input mode.

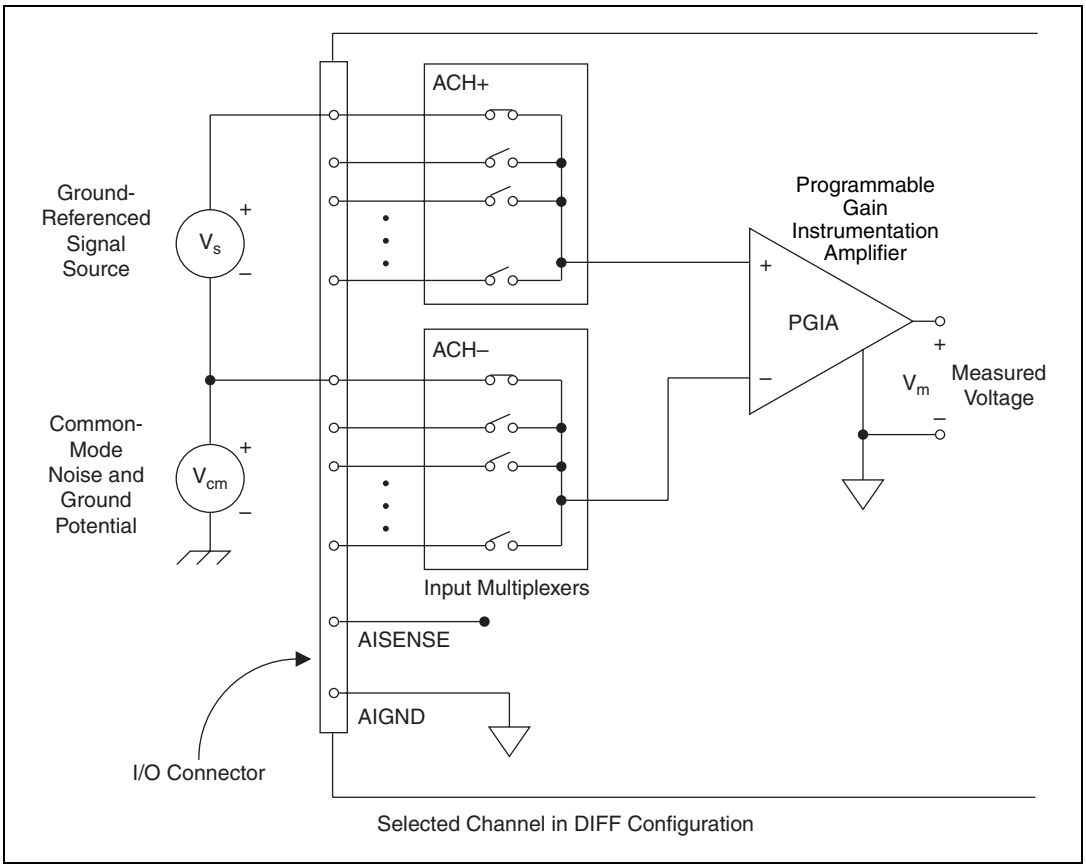


Figure 3-4. Differential Input Connections for Ground-Referenced Signals

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 DAQPad-MIO-16XE-50 ground, shown as V_{cm} in Figure 3-4.

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Differential Connections for Nonreferenced or Floating Signal Sources

Figure 3-5 shows how to connect a floating signal source to a DAQPad-MIO-16XE-50 channel configured in DIFF input mode.

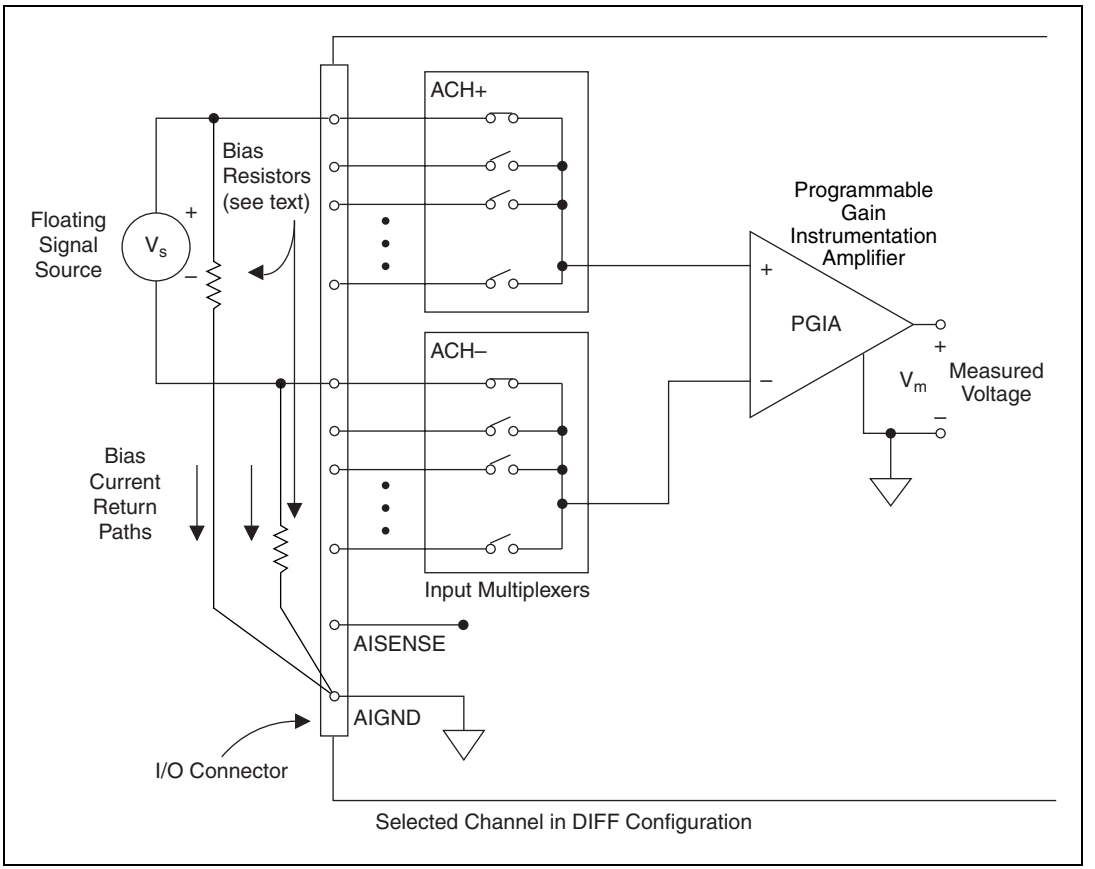


Figure 3-5. Differential Input Connections for Nonreferenced Signals

Figure 3-5 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 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

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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).

However, for larger source impedances, this connection leaves the differential signal path significantly out of balance. Noise that couples electrostatically onto the positive line does not couple onto the negative line because it is connected to ground. Hence, this noise appears as a differential-mode signal instead of a common-mode signal, and 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 that 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 3-5. This fully balanced configuration offers slightly better noise rejection but has the disadvantage of loading the source down with the series combination (sum) of the two resistors. If, for example, 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 tie the negative input directly to AIGND. If the source has high output impedance, you should balance the signal path as previously described using the same value resistor on both the positive and negative inputs; you should be aware that there is some gain error from loading down the source.

Note These same issues regarding bias resistors also apply to a single-ended connection (NRSE configuration) for floating signal sources.

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Single-Ended Connection Considerations

A single-ended connection is one in which the DAQPad-MIO-16XE-50 AI signal is referenced to a ground that can be shared with other input signals. The input signal is tied to the positive input of the PGIA, and the ground is tied to the negative input of the PGIA.

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

You can 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 DAQPad-MIO-16XE-50 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 DAQPad-MIO-16XE-50 channels for two different types of single-ended connections—RSE configuration and NRSE configuration. Use the RSE configuration for floating signal sources; in this case, the DAQPad-MIO-16XE-50 provides the reference ground point for the external signal. Use the NRSE input configuration for ground-referenced signal sources; in this case, the external signal supplies its own reference ground point and the DAQPad-MIO-16XE-50 should not supply one.

In single-ended configurations, more electrostatic and magnetic noise couples into the signal connections than in differential configurations. 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.

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Single-Ended Connections for Floating Signal Sources (RSE Configuration)

Figure 3-6 shows how to connect a floating signal source to a DAQPad-MIO-16XE-50 channel configured for RSE mode.

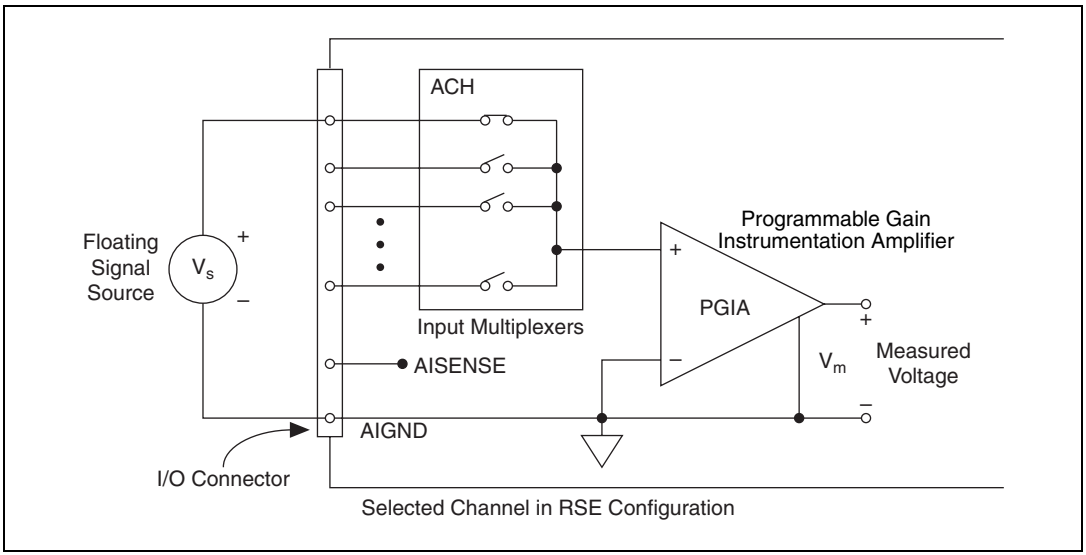


Figure 3-6. Single-Ended Input Connections for Nonreferenced or Floating Signals

Single-Ended Connections for Grounded Signal Sources (NRSE Configuration)

To measure a grounded signal source with a single-ended configuration, you must configure the DAQPad-MIO-16XE-50 for NRSE input. Connect the grounded signal to the positive input of the DAQPad-MIO-16XE-50 PGIA, and connect the signal local ground reference to the negative input of the DAQPad-MIO-16XE-50 PGIA. The ground point of the signal should, therefore, be connected to the AISENSE pin. Any potential difference between the DAQPad-MIO-16XE-50 ground and the signal ground appears as a common-mode signal at both the positive and negative inputs of the PGIA, and the amplifier rejects this difference. If the input circuitry of the DAQPad-MIO-16XE-50 were referenced to ground, in this situation as in the RSE input configuration, this difference in ground potential would appear as an error in the measured voltage.

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Figure 3-7 shows how to connect a grounded signal source to a DAQPad-MIO-16XE-50 channel configured for NRSE mode.

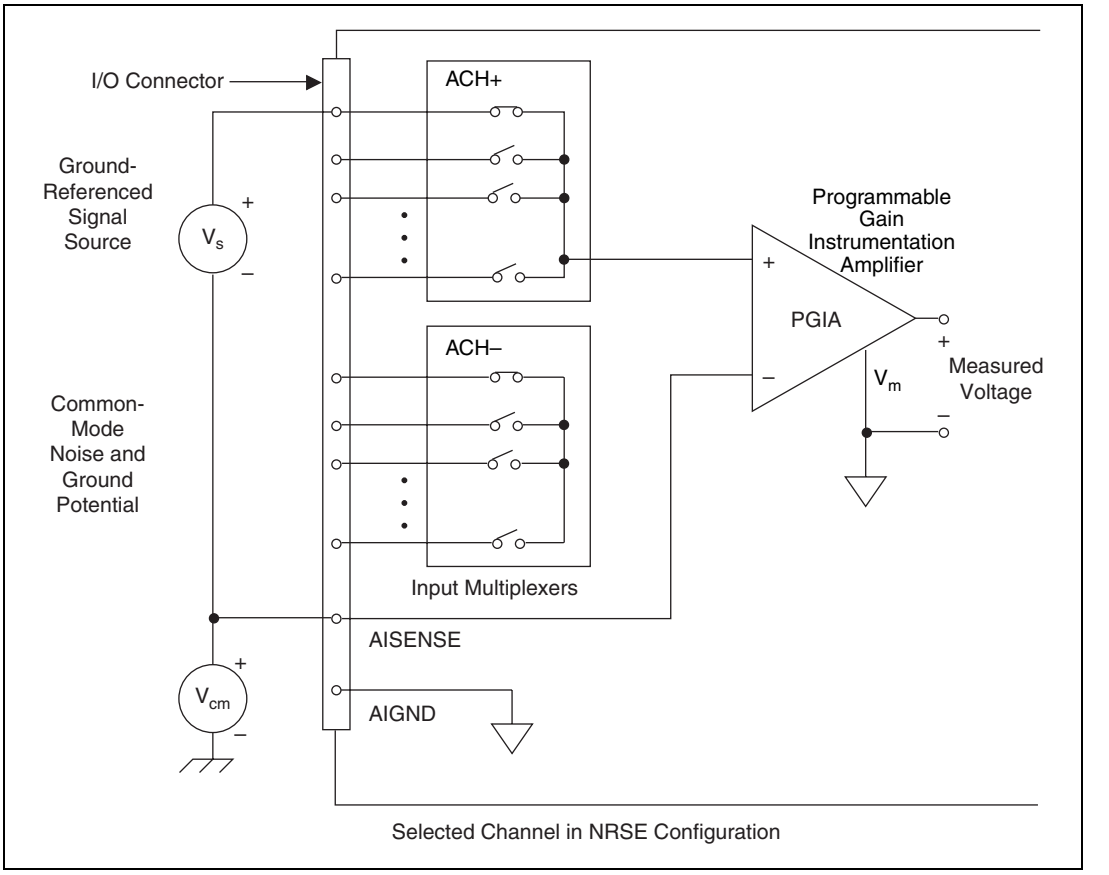


Figure 3-7. Single-Ended Input Connections for Ground-Referenced Signals

Common-Mode Signal Rejection Considerations

Figures 3-4 and 3-7 show connections for signal sources that are already referenced to some ground point with respect to the DAQPad-MIO-16XE-50. In these cases, the PGIA can reject any voltage caused by ground potential differences between the signal source and the DAQPad-MIO-16XE-50. In addition, with differential input connections, the PGIA can reject common-mode noise pickup in the leads connecting the signal sources to the DAQPad-MIO-16XE-50. The PGIA can reject common-mode signals as long as V_{in}+ and V_{in}– are both within ±11 V of AIGND. The DAQPad-MIO-16XE-50 has the additional restriction that

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(V_{in}+) + (V_{in}–) added to the gain times (V_{in}+) – (V_{in}–) is within ±26 V of AIGND. At gains of 1 and 2, this restriction is of little or no consequence, but at gains of 10 and 100, this is roughly equivalent to restricting the two input voltages to within ±8 V of AIGND.

External Current Excitation

The screw terminals labeled IEX+ and IEX– provide external current excitation for temperature measurements using RTDs or thermistors. IEX+ is the current output and IEX– is the current return. The constant current source provides 100 µA of external excitation.

Figure 3-8 suggests how you can connect several RTDs in series to the DAQPad-MIO-16XE-50 using four-wire measurement techniques. To connect the current excitation to IEX+ and IEX– terminals, push the slide switch labeled IEX to the ON position.

Note If you do not externally connect IEX+ to IEX– and you want to perform cold-junction sensor measurements, you must push the slide switch to the OFF position.

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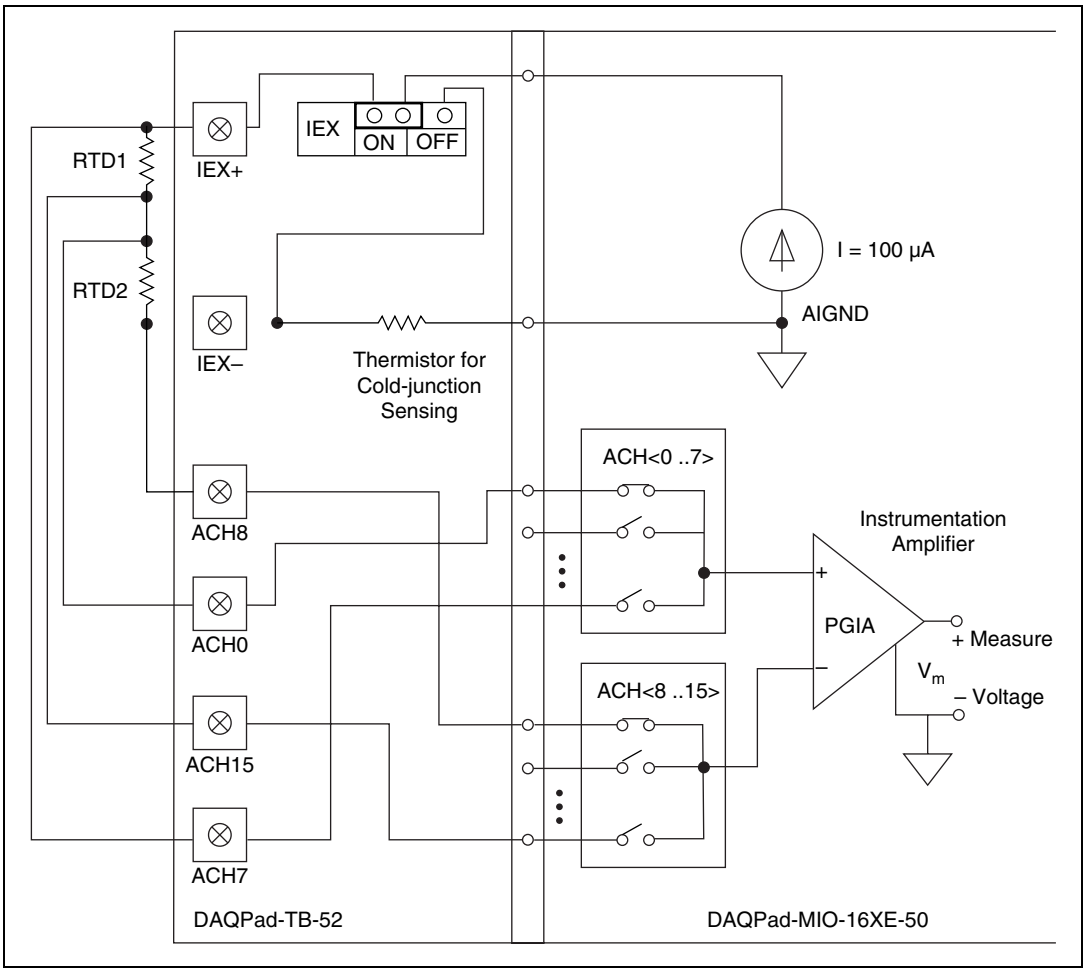


Figure 3-8. RTD Connection Using External Current Excitation

Configure the AI channels for differential input mode. You can configure the AI for either a unipolar or bipolar polarity. The signal sources are not floating; therefore, do not connect bias resistors between the signal sources and AIGND. The voltage potential at IEX– varies between 1.7 and 0.1 V from 0 to 55 °C. You must take this voltage into account when realizing the common-mode signal rejection considerations discussed in the *Common-Mode Signal Rejection Considerations* section.

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Analog Output Signal Connections

The AO signals are DAC0OUT, DAC1OUT, and AOGND.

DAC0OUT is the voltage output signal for AO channel 0. DAC1OUT is the voltage output signal for AO channel 1.

AOGND is the ground-reference signal for both AO channels and for the external reference signal.

Figure 3-9 shows how to make AO connections and the external reference input connection to the DAQPad-MIO-16XE-50.

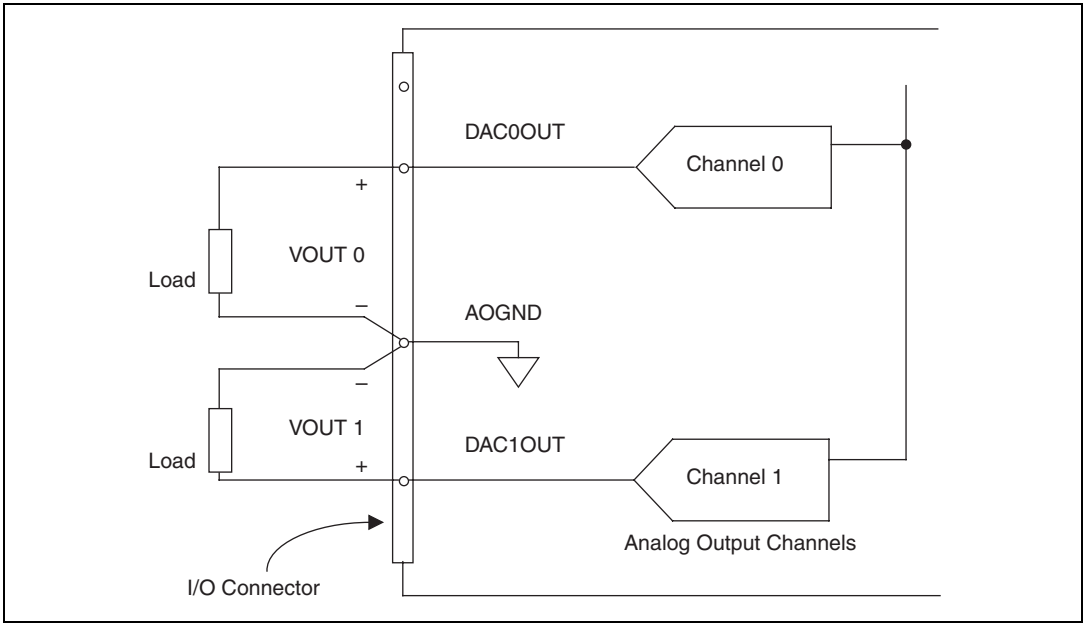


Figure 3-9. AO Connections

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Digital I/O Signal Connections

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

Figure 3-10 shows signal connections for three typical DIO applications.

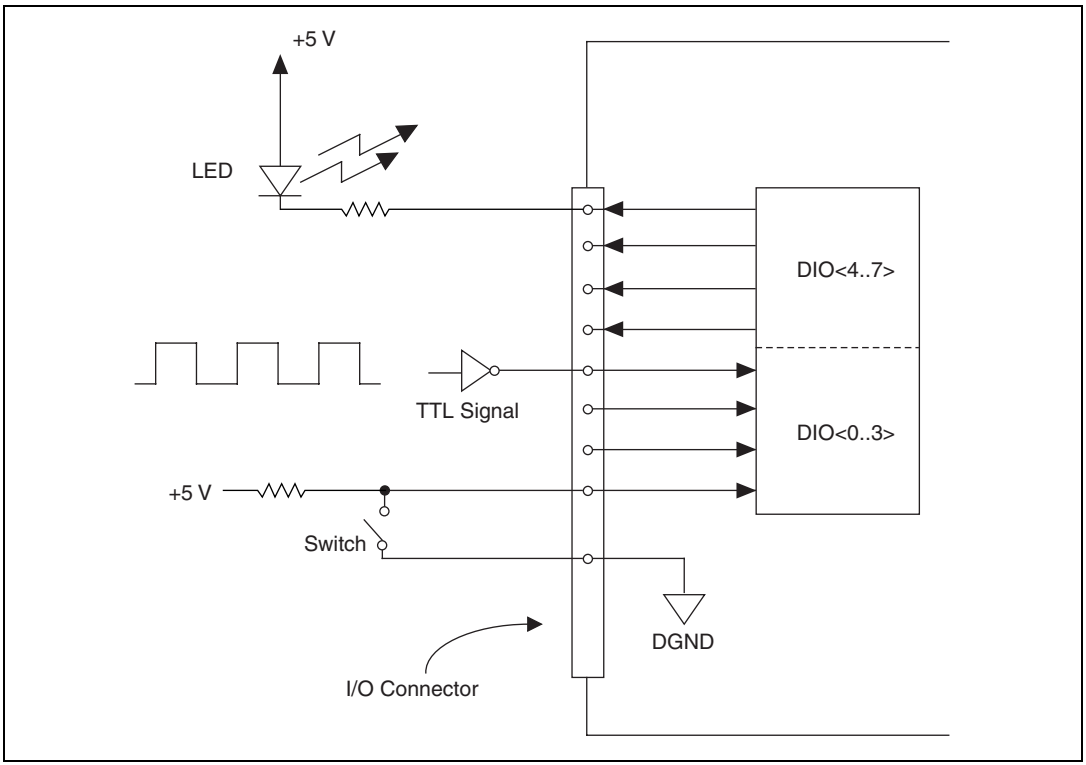


Figure 3-10. DIO Connections

Figure 3-10 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 in Figure 3-10. Digital output applications include sending TTL signals and driving external devices such as the LED shown in Figure 3-10.

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Power Connections

The power signal +5 V supplies +5 V from the DAQPad-MIO-16XE-50 power supply. This pin is referenced to DGND and you can use the +5 V to power external digital circuitry.

- Power rating 250 mA at +5 V maximum

The +5 V signal is fused for up to 250 mA. Blowing this fuse by shorting +5 V to ground does not damage the DAQPad-MIO-16XE-50. If you do not receive +5 V from this screw terminal, make sure that the rear panel rocker switch is turned on, that the DAQPad-TB-52 is firmly connected to the DAQPad-MIO-16XE-50, and that there are no shorts between the +5 V power pin and ground. You can replace a blown fuse with the spare fuse located on the DAQPad-TB-52 or you can use a 250 mA, fast-acting Pico II fuse from Littelfuse.

Caution Under *no* circumstances should you connect this +5 V power signal directly to any other voltage source on the DAQPad-MIO-16XE-50 or any other device. Doing so can damage the DAQPad-MIO-16XE-50 and the PC. NI is *not* liable for damage resulting from such a connection.

Timing Connections

All external control over the timing of the DAQPad-MIO-16XE-50 is routed through the 10 programmable function inputs 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, waveform generation, 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 any DAQ, waveform generation, and general-purpose timing signals.

The DAQ signals are explained in the *DAQ Timing Connections* section later in this chapter. The waveform generation signals are explained in the *Waveform Generation Timing Connections* section later in this chapter. The general-purpose timing signals are explained in the *General-Purpose Timing Signal Connections* section later in this chapter.

All digital timing connections are referenced to DGND. This connection is demonstrated in Figure 3-11, which shows how to connect an external TRIG1 source and an external CONVERT* source to two of the DAQPad-MIO-16XE-50 PFI signals.

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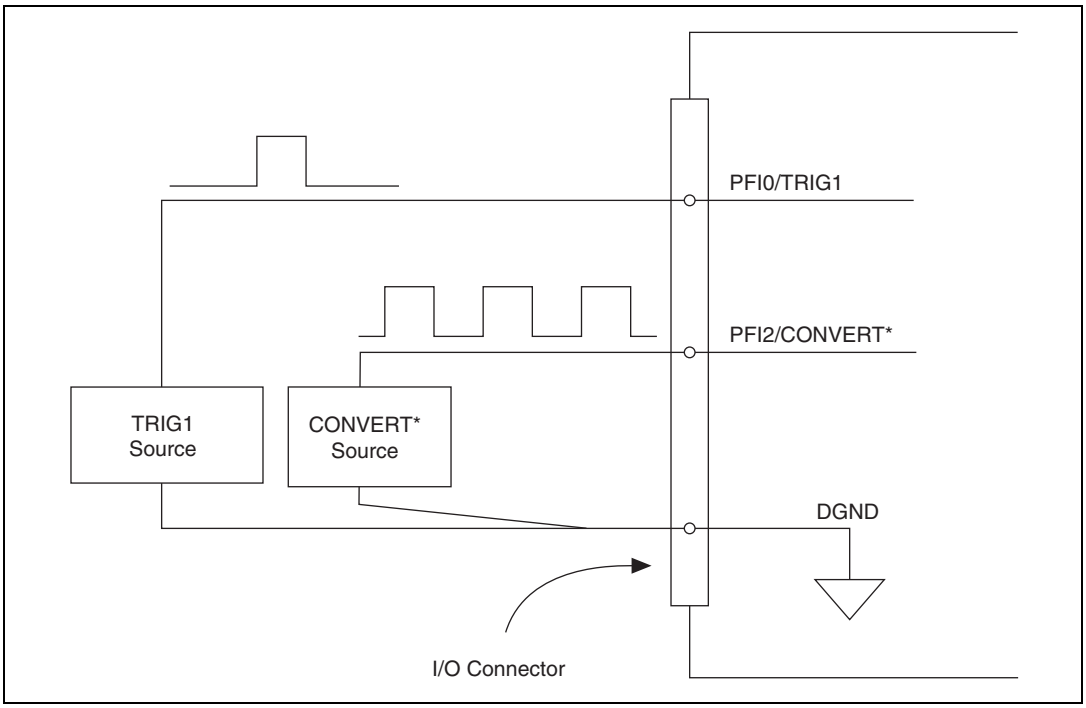


Figure 3-11. TIO Connections

Programmable Function Input Connections

There are a total of 13 internal timing signals that you can externally control from the 10 PFI signals on the DAQPad-TB-52. The source for each of these signals is software selectable from any of the PFIs when you want external control. This flexible routing scheme reduces the need to change the physical wiring to the DAQPad-TB-52 for different applications.

You can individually enable each of the PFI signals to output a specific internal timing signal. For example, if you need the CONVERT* signal as an output on the DAQPad-TB-52, software can turn on the output driver for the PFI2/CONVERT* signal. You must 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 as well. You can use the polarity selection for any of the 13 timing signals, but using 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.

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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 pulsewidth requirement in edge-detection mode.

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

DAQ Timing Connections

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

Posttriggered DAQ allows you to view only data that is acquired after a trigger event is received. A typical posttriggered DAQ sequence is shown in Figure 3-12. Pretriggered DAQ allows you to view data that is acquired before the trigger of interest in addition to a fixed number of data points acquired after the trigger. Figure 3-13 shows a typical pretriggered DAQ sequence. The description for each signal shown in these figures is included later in this chapter.

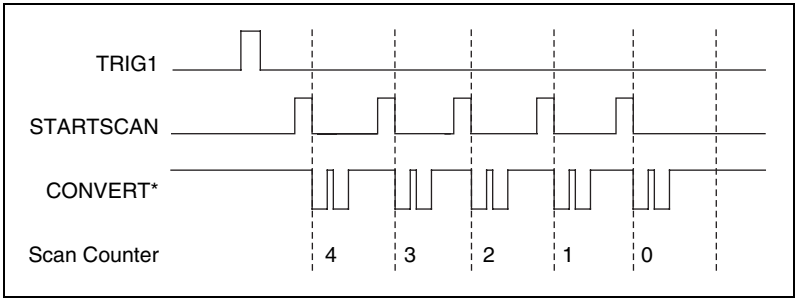


Figure 3-12. Typical Posttriggered Acquisition

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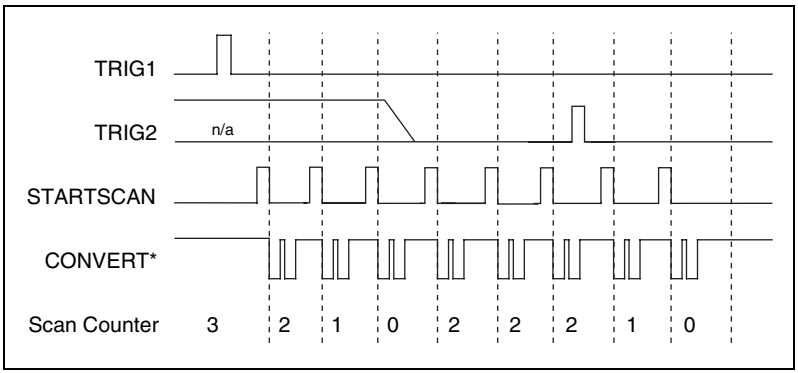


Figure 3-13. Typical Pretriggered Acquisition

TRIG1 Signal

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

Refer to Figures 3-12 and 3-13 for the relationship of TRIG1 to the DAQ sequence.

As an input, the TRIG1 signal 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 the TRIG1 signal starts the DAQ sequence for both posttriggered and pretriggered acquisitions.

As an output, the TRIG1 signal reflects the action that initiates a DAQ sequence, even if the acquisition is being 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 start up.

Figures 3-14 and 3-15 show the input and output timing requirements for the TRIG1 signal.

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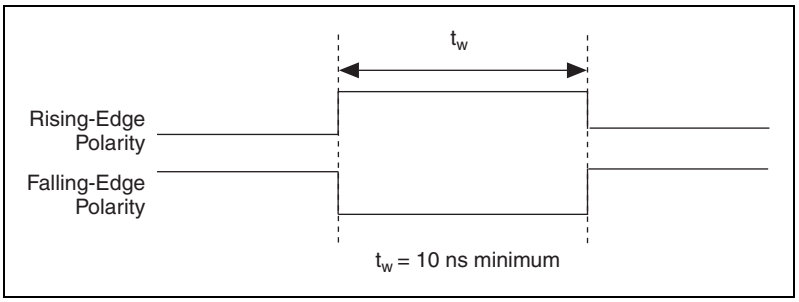


Figure 3-14. TRIG1 and TRIG2 Input Signal Timing

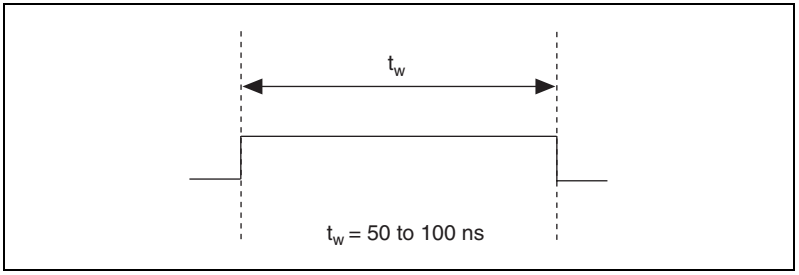


Figure 3-15. TRIG1 and TRIG2 Output Signal Timing

TRIG2 Signal

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

Refer to Figure 3-13 for the relationship of TRIG2 to the DAQ sequence.

As an input, the TRIG2 signal is configured in the edge-detection mode. You can select any PFI signal as the source for TRIG2 and configure the polarity selection for either rising or falling edge. The selected edge of the TRIG2 signal initiates the posttriggered phase of a pretriggered acquisition sequence.

In pretriggered mode, the TRIG1 signal initiates the data acquisition. The scan counter indicates the minimum number of scans before TRIG2 can be recognized. After the scan counter decrements to zero, it is loaded with the number of posttrigger scans to acquire while the acquisition continues. The board ignores the TRIG2 signal if it is asserted prior to the scan counter decrementing to zero. After the selected edge of TRIG2 is received, the board acquires a fixed number of scans and the acquisition stops. This mode acquires data both before and after TRIG2 is received.

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As an output, the TRIG2 signal reflects the posttrigger in a pretriggered acquisition sequence, even if the acquisition is being externally triggered by another PFI. The TRIG2 signal is not used in posttriggered DAQ. 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 3-14 and 3-15 show the input and output timing requirement for the TRIG2 signal.

STARTSCAN Signal

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

Refer to Figures 3-12 and 3-13 for the relationship of STARTSCAN to the DAQ sequence.

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

As an output, the STARTSCAN signal reflects the actual start pulse that initiates a scan, even if the starts are being 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 option 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 start up.

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Figures 3-16 and 3-17 show the input and output timing requirements for the STARTSCAN signal.

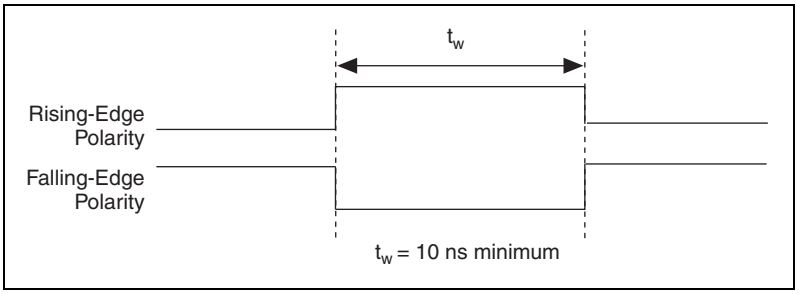


Figure 3-16. STARTSCAN Input Signal Timing

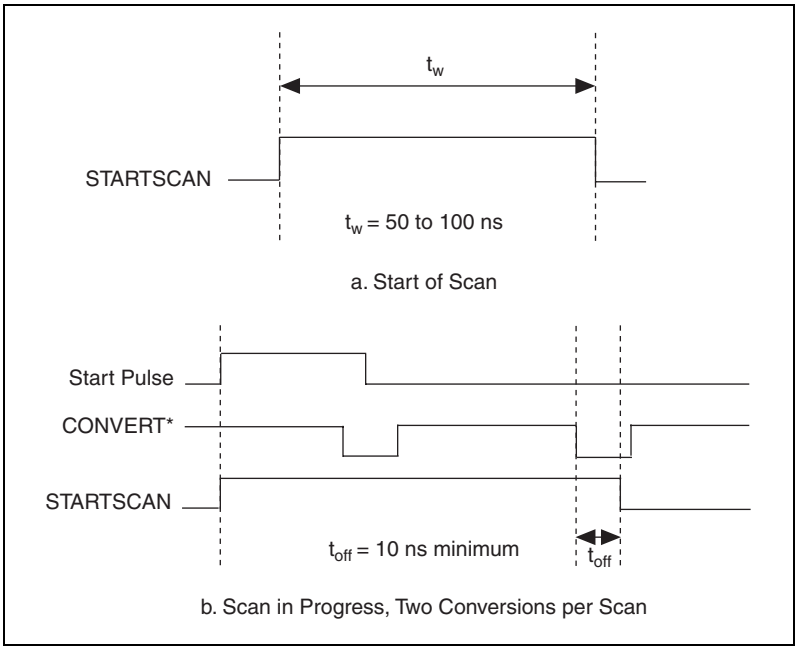


Figure 3-17. STARTSCAN Output Signal Timing

The CONVERT* pulses are masked off until the board generates the STARTSCAN signal. If you are using internally generated conversions, the first CONVERT* appears when the onboard sample interval 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.

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A counter on the DAQPad-MIO-16XE-50 internally generates the STARTSCAN signal unless you select some external source. This counter is started by the TRIG1 signal and is stopped either by software or the sample 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 may be gated by either the hardware (AIGATE) signal or software gate.

CONVERT* Signal

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

Refer to Figures 3-12 and 3-13 for the relationship of CONVERT* to the DAQ sequence.

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

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

Figures 3-18 and 3-19 show the input and output timing requirements for the CONVERT* signal.

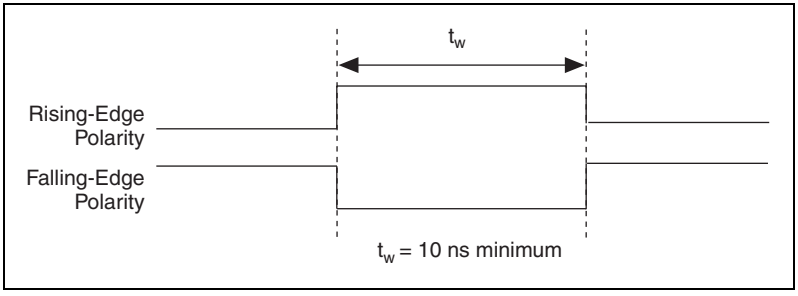


Figure 3-18. CONVERT* Input Signal Timing

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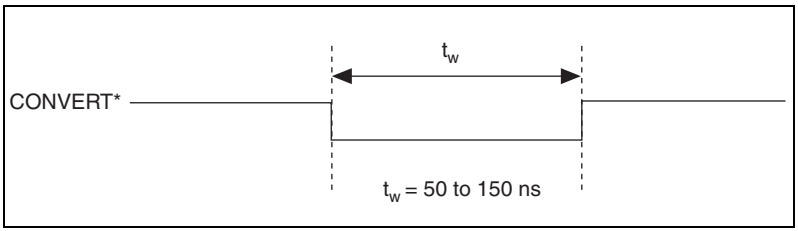


Figure 3-19. CONVERT* Output Signal Timing

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 DAQPad-MIO-16XE-50 sample interval counter 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 may be gated by either the hardware (AIGATE) signal or software gate.

AIGATE Signal

Any PFI signal can externally input AIGATE, which is not available as an output on the DAQPad-TB-52. The AIGATE signal can mask off scans in a DAQ sequence. You can configure the PFI signal you select as the source for the AIGATE signal in level-detection mode. You can configure the polarity selection for the PFI signal 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.

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SISOURCE Signal

Any PFI signal can externally input SISOURCE, which is not available as an output on the DAQPad-TB-52. The onboard scan interval counter uses the SISOURCE signal as a clock to time the generation of the STARTSCAN signal. You must configure the PFI signal you select as the source for the SISOURCE signal in the level-detection mode. You can configure the polarity selection for the PFI signal 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 the SISOURCE signal unless you select some external source. Figure 3-20 shows the timing requirements for the SISOURCE signal.

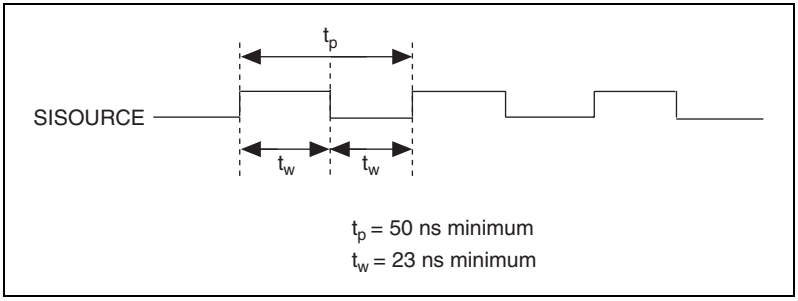


Figure 3-20. SISOURCE Signal Timing

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 3-21 shows the timing for the SCANCLK signal. In this figure, the falling edge of CONVERT* indicates the initiation of an A/D conversion.

Note When using NI-DAQ, SCANCLK polarity is low-to-high and cannot be changed programmatically.

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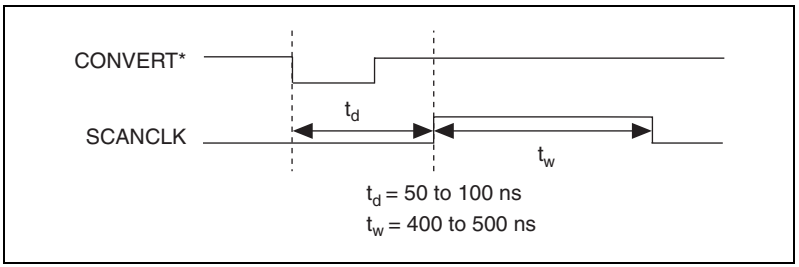


Figure 3-21. SCANCLK Signal Timing

EXTSTROBE* Signal

EXTSTROBE* is an output-only signal that generates either a single pulse in the single-pulse mode or a sequence of eight pulses in the hardware-strobe mode. These two modes are software selectable. An external device can use this signal to latch signals or to trigger events. In the single-pulse mode, software sets the level of the EXTSTROBE* signal high or low. Both a 10 µs and a 1.2 µs clock are available for generating a sequence of eight pulses in the hardware-strobe mode. Figure 3-22 shows the timing for the hardware-strobe mode EXTSTROBE* signal.

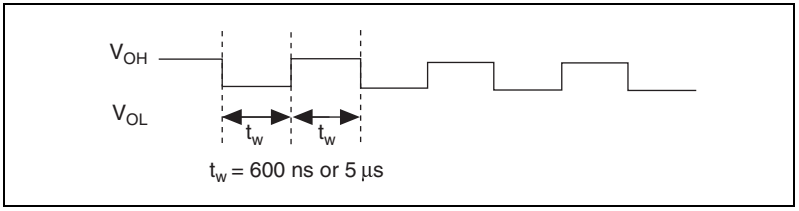


Figure 3-22. EXTSTROBE* Signal Timing

Note EXTSTROBE cannot be enabled through NI-DAQ.

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Waveform Generation Timing Connections

The analog group defined for the DAQPad-MIO-16XE-50 is controlled by WFTRIG, UPDATE*, and UISOURCE.

WFTRIG Signal

Any PFI signal can externally input WFTRIG, which is available as an output on the PFI6/WFTRIG screw terminal.

As an input, the WFTRIG signal is configured in the edge-detection mode. You can select any PFI signal as the source for WFTRIG and configure the polarity selection for either rising or falling edge. The selected edge of the WFTRIG signal starts the waveform generation for the DACs. The update interval (UI) counter is started if you select internally generated UPDATE*.

As an output, the WFTRIG signal reflects the trigger that initiates waveform generation, even if the waveform generation is being 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 start up.

Figures 3-23 and 3-24 show the input and output timing requirements for the WFTRIG signal.

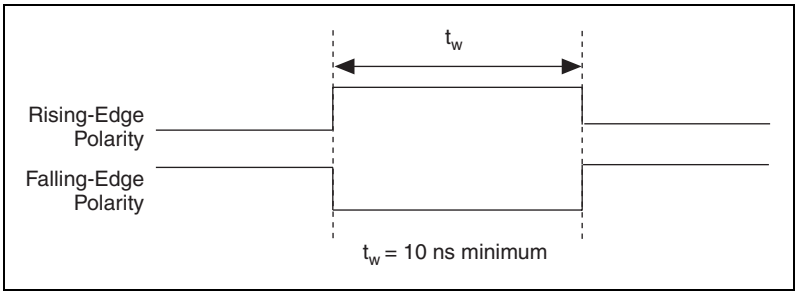


Figure 3-23. WFTRIG Input Signal Timing

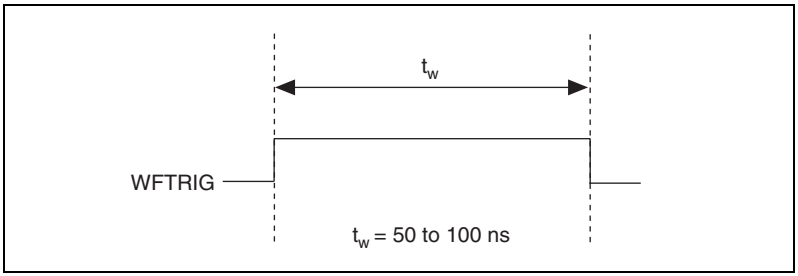


Figure 3-24. WFTRIG Output Signal Timing

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UPDATE* Signal

Any PFI signal can externally input UPDATE*, which is available as an output on the PFI5/UPDATE* screw terminal.

As an input, the UPDATE* signal is configured in the edge-detection mode. You can select any PFI signal as the source for UPDATE* and configure the polarity selection for either rising or falling edge. The selected edge of the UPDATE* signal updates the outputs of the DACs. In order to use UPDATE*, you must set the DACs to posted-update mode.

As an output, the UPDATE* signal reflects the actual update pulse that is connected to the DACs, even if the updates are being externally generated by another PFI. The output is an active low pulse with a pulse width of 300 to 350 ns. This output is set to high-impedance at start up.

Figures 3-25 and 3-26 show the input and output timing requirements for the UPDATE* signal.

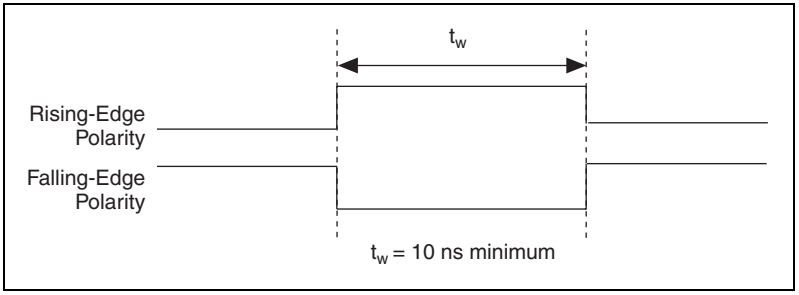


Figure 3-25. UPDATE* Input Signal Timing

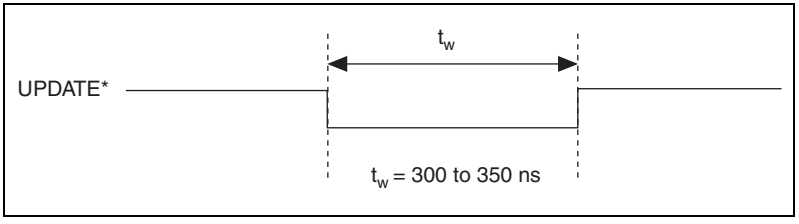


Figure 3-26. UPDATE* Output Signal Timing

The DACs are updated within 100 ns of the leading edge. Separate the UPDATE* pulses with enough time so that new data can be written to the DAC latches.

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The DAQPad-MIO-16XE-50 UI counter normally generates the UPDATE* signal unless you select some external source. The UI counter is started by the WFTRIG signal and can be stopped by software or the internal Buffer Counter.

D/A conversions generated by either an internal or external UPDATE* signal do not occur when gated by the software command register gate.

UISOURCE Signal

Any PFI signal can externally input UISOURCE, which is not available as an output on the DAQPad-TB-52. The UI counter uses the UISOURCE signal as a clock to time the generation of the UPDATE* signal. You must configure the PFI signal you select as the source for the UISOURCE signal in the level-detection mode. You can configure the polarity selection for the PFI signal for either active high or active low. Figure 3-27 shows the timing requirements for the UISOURCE signal.

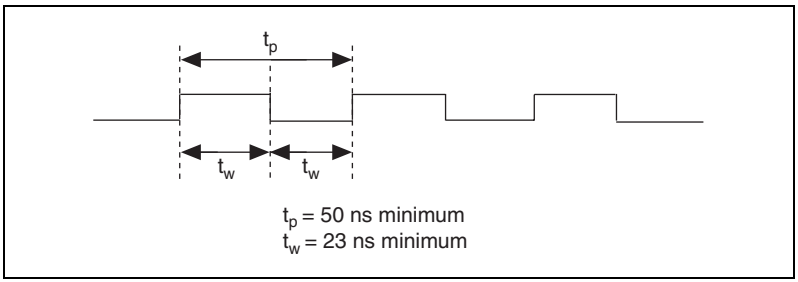


Figure 3-27. UISOURCE Signal Timing

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 the UISOURCE signal unless you select some external source.

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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 signal can externally input GPCTR0_SOURCE, which is available as an output on the PFI8/GPCTR0_SOURCE screw terminal.

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

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

Figure 3-28 shows the timing requirements for the GPCTR0_SOURCE signal.

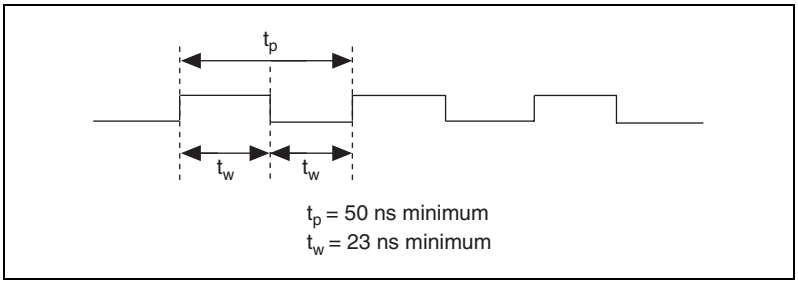


Figure 3-28. GPCTR0_SOURCE Signal Timing

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 the GPCTR0_SOURCE signal unless you select some external source.

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GPCTR0_GATE Signal

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

As an input, the GPCTR0_GATE signal is configured in the edge-detection mode. You can select any PFI signal 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, the GPCTR0_GATE signal reflects the actual gate signal connected to general-purpose counter 0, even if the gate is being externally generated by another PFI. This output is set to high-impedance at start up.

Figure 3-29 shows the timing requirements for the GPCTR0_GATE signal.

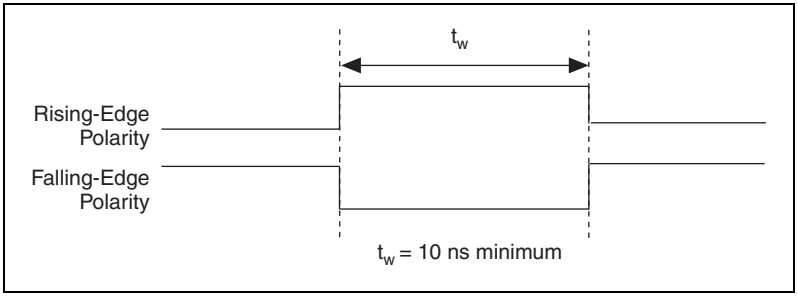


Figure 3-29. GPCTR0_GATE Signal Timing

GPCTR0_OUT Signal

This signal is available only as an output on the GPCTR0_OUT screw terminal. The GPCTR0_OUT signal 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 output is set to high-impedance at start up. Figure 3-30 shows the timing of the GPCTR0_OUT signal.

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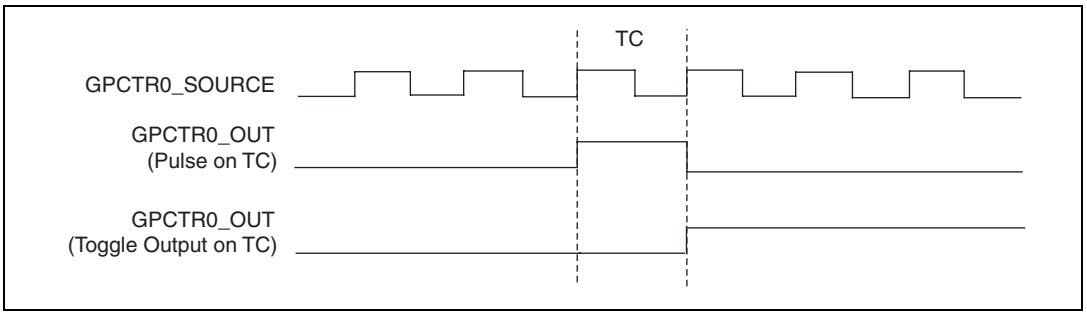


Figure 3-30. GPCTR0_OUT Signal Timing

GPCTR0_UP_DOWN Signal

This signal can be externally input on the DIO6 signal and is not available as an output on the DAQPad-TB-52. The general-purpose counter 0 counts down when this pin is at a logic low and count up when at a logic high. You can disable this input so that software can control the up-down functionality and leave the DIO6 signal free for general use.

GPCTR1_SOURCE Signal

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

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

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

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Figure 3-31 shows the timing requirements for the GPCTR1_SOURCE signal.

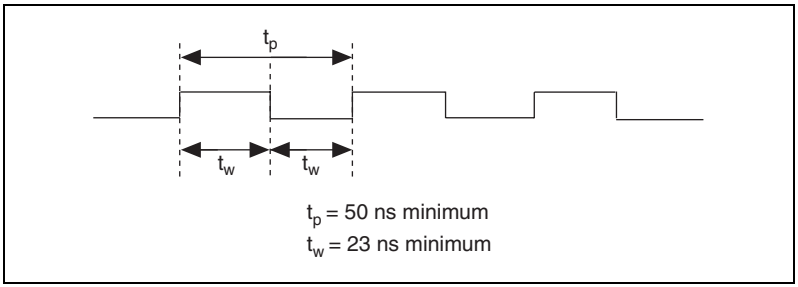


Figure 3-31. GPCTR1_SOURCE Signal Timing

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 the GPCTR1_SOURCE unless you select some external source.

GPCTR1_GATE Signal

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

As an input, the GPCTR1_GATE signal is configured in edge-detection mode. You can select any PFI screw terminal 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, the GPCTR1_GATE signal monitors the actual gate signal connected to general-purpose counter 1, even if the gate is being externally generated by another PFI. This output is set to high-impedance at start up.

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Figure 3-32 shows the timing requirements for the GPCTR1_GATE signal.

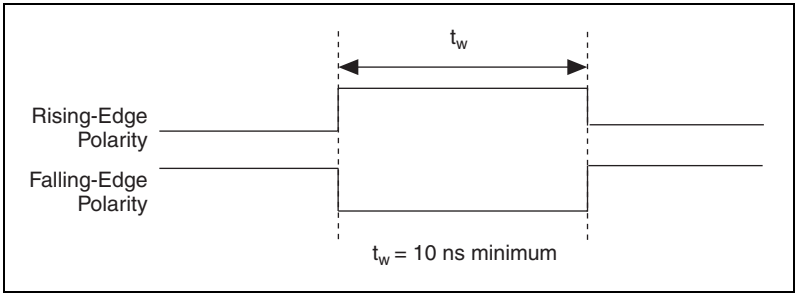


Figure 3-32. GPCTR1_GATE Signal Timing

GPCTR1_OUT Signal

This signal is available only as an output on GPCTR1_OUT. The GPCTR1_OUT signal monitors the TC board 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 output is set to high-impedance at start up. Figure 3-33 shows the timing requirements for the GPCTR1_OUT signal.

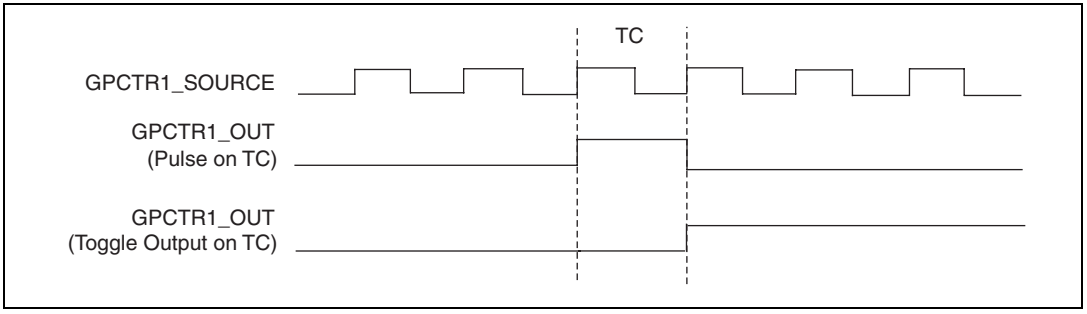


Figure 3-33. GPCTR1_OUT Signal Timing

GPCTR1_UP_DOWN Signal

This signal can be externally input on the DIO7 signal and is not available as an output on the DAQPad-TB-52. General-purpose counter 1 counts down when this signal is at a logic low and counts up at a logic high. This input can be disabled so that software can control the up-down functionality and leave the DIO7 signal free for general use.

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Figure 3-34 shows the timing requirements for the GATE and SOURCE input signals and the timing specifications for the OUT output signals of the DAQPad-MIO-16XE-50.

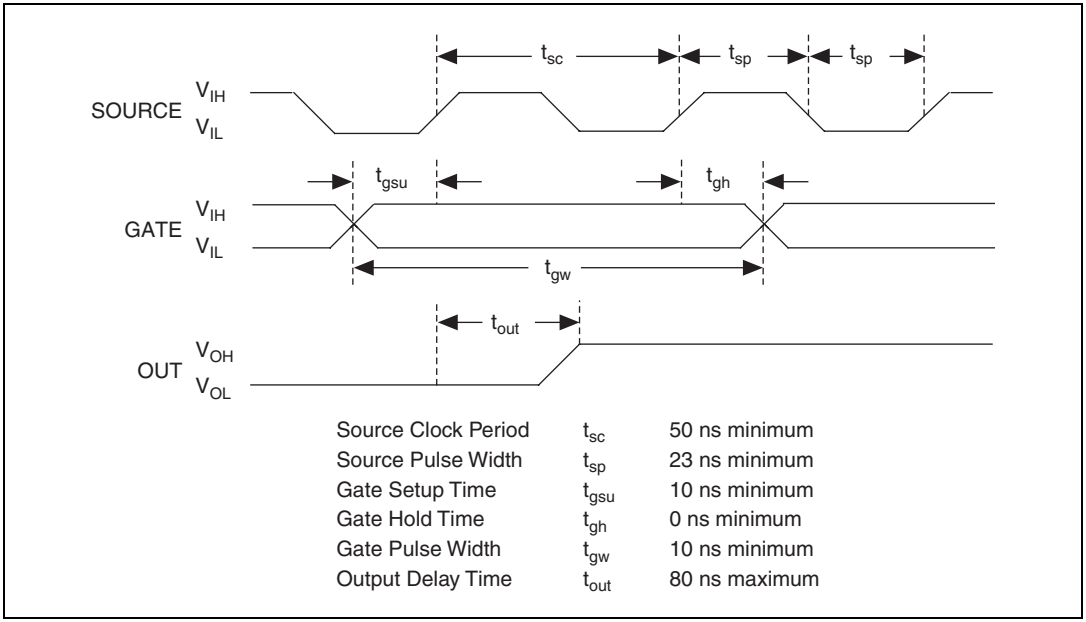


Figure 3-34. GPCTR Timing Summary

The GATE and OUT signal transitions shown in Figure 3-34 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 DAQPad-MIO-16XE-50. Figure 3-34 shows the GATE signal referenced to the rising edge of a source signal. The gate must be valid (either high or low) 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 3-34. 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

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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 DAQPad-MIO-16XE-50. Figure 3-34 shows the OUT signal referenced to the rising edge of a source signal. Any OUT signal state changes occur within 80 ns after the source signal rising or falling edge.

FREQ_OUT Signal

This signal is available only as an output on FREQ_OUT. The FREQ_OUT signal is the output of the DAQPad-MIO-16XE-50 frequency generator. The frequency generator is a 4-bit counter that can divide its input clock by 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 output is set to high-impedance at startup.

Field Wiring Considerations

Environmental noise can seriously affect the accuracy of measurements made with the DAQPad-MIO-16XE-50 if you do not take proper care when running signal wires between signal sources and the device. The following recommendations apply mainly to AI signal routing to the device, 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 DAQPad-TB-52. With this type of wire, the signals attached to the ACH+ and ACH– 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 board carefully. Keep cabling away from noise sources. The most common noise source in a PC DAQ system is the video monitor. Separate the monitor from the analog signals as much as possible.

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The following recommendations apply for all signal connections to the DAQPad-MIO-16XE-50:

- Separate DAQPad-MIO-16XE-50 signal lines from high-current or high-voltage lines. These lines are capable of inducing currents in or voltages on the DAQPad-MIO-16XE-50 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*, at `ni.com/zone`.

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4

Calibration

This chapter discusses the calibration procedures for the analog I/O circuitry on the DAQPad-MIO-16XE-50. NI-DAQ includes calibration functions for performing all of the steps in the calibration process for the analog I/O circuitry.

You cannot calibrate the constant current source used for cold-junction sensing and external current excitation. The constant current source is factory calibrated, and NI can recalibrate the unit if needed. To maintain the cold-junction sensor accuracy, NI recommends recalibrating the current source every year.

Calibration refers to the process of minimizing measurement and output voltage errors by making small circuit adjustments. On the DAQPad-MIO-16XE-50, these adjustments take the form of writing values to onboard calibration DACs (CalDACs).

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

This chapter describes three levels of calibration: loading calibration constants, self-calibration and external calibration. 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 DAQPad-MIO-16XE-50 is factory calibrated before shipment 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 onboard nonvolatile memory (EEPROM). Because the CalDACs have no memory capability, they do not retain calibration information when the device 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.

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This method of calibration is not very accurate because it does not take into account the fact that the device measurement and output voltage errors can vary with time and temperature. It is better to self-calibrate when the device is installed in the environment in which it is to be used.

Self-Calibration

There is room in the EEPROM for several modifiable user calibration areas 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.

The DAQPad-MIO-16XE-50 can measure and correct for almost all of its calibration-related errors without any external signal connections. The NI software provides a self-calibration method you can use. This self-calibration process, which takes only a few seconds, is the preferred method of assuring accuracy in your application. You should initiate self-calibration to ensure that the effects of any offset, gain, and linearity drifts, particularly those due to warmup, are minimized.

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 DAQPad-MIO-16XE-50 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 device 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 device.

An external calibration refers to calibrating the device 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 the results can be saved in the EEPROM, so you should not have to

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perform an external calibration very often. You can externally calibrate the device by calling the NI-DAQ `Calibrate_E_Series` function.

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

To manually calibrate the DAQPad-MIO-16XE-50, refer to the *E Series Calibration Procedure* at `ni.com/calibration`.

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A

Specifications

This appendix lists the DAQPad-MIO-16XE-50 specifications. These specifications are typical at 25 °C unless otherwise noted.

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 ..... 20 kS/s guaranteed

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 and common mode)..... Each input should remain within ±11 V of ground and the average of V_{in}+ and V_{in}– should remain within ±8 V of ground

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

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

FIFO buffer size.....512 samples

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

Configuration memory size .....512 words

Transfer Characteristics

Relative accuracy.....±0.5 LSB typ, ±1 LSB max

DNL .....±0.5 LSB typ, ±1 LSB max

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

Offset error

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

Pregain error before calibration.....±1 mV max

Postgain error after calibration .....±76 µV max

Postgain error before calibration .....±4 mV max

Gain error (relative to calibration reference)

After calibration (gain = 1).....±30.5 ppm of reading max

Before calibration .....±2,250 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 .....20 GΩ in parallel with 100 pF

Powered off .....820 Ω min

Overload .....820 Ω min

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Input bias current

for ACH<0> and ACH<8> ..... ±3.5 nA

for ACH<1..7> and ACH<9..15> ... ±3 nA

Input offset current ..... ±4 nA

CMRR, DC to 60 Hz

Gain = 1 ..... 80 dB

Gain = 2 ..... 86 dB

Gain = 10 ..... 100 dB

Gain = 100 ..... 120 dB

Dynamic Characteristics

Bandwidth

Gain = 1, 2 ..... 63 kHz

Gain = 10 ..... 60 kHz

Gain = 100 ..... 42 kHz

Settling time for full-scale step

Range	Accuracy[1]	
	±0.0015% (±1 LSB)	**±0.0061% (±4 LSB)**
1 to 20 V	50 µs max	50 µs max
200 mV (bipolar)	75 µs max	50 µs max
100 mV (unipolar)	75 µs max	50 µs max

[1] Accuracy values valid for source impedances < 1 kW.

System noise (including quantization noise)

Gain = 1, 2, 10 ..... 0.5 LSB_{rms}

Gain = 100 ..... 0.8 LSB_{rms} bipolar, 1.4 LSB_{rms} unipolar

Crosstalk (DC to 100 kHz)

Adjacent channels ..... –85 dB

All other channels ..... –100 dB

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Stability

Offset temperature coefficient

Pregain.....±1 µV/°C

Postgain.....±12 µV/°C

Gain temperature coefficient.....±5 ppm/°C

Analog Output

Output Characteristics

Number of channels.....2

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

Update rate.....400 S/s, system dependent

Type of DAC.....Double-buffered, multiplying

FIFO buffer size.....None

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

Transfer Characteristics

Relative accuracy (INL).....±0.5 LSB max

DNL.....±1 LSB max

Monotonicity.....12 bits, guaranteed

Offset error

After calibration.....±0.5 mV max

Before calibration.....±85 mV max

Gain error (relative to calibration reference)

After calibration.....±0.01% of output max

Before calibration.....±1% of output max

Voltage Output

Range.....±10 V

Output coupling.....DC

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Output impedance ..... 0.1 Ω max

Current drive ..... ±5 mA

Protection ..... Short-circuit to ground

Power-on state..... 0 V (± 85 mV)

Dynamic Characteristics

Settling time for full-scale step ..... 50 µs to ±0.5 LSB accuracy

Slew rate..... 2 V/µs

Noise ..... 40 μV_{rms}, DC to 1 MHz

Glitch energy (at mid-scale transition)

Magnitude ..... ±30 mV

Duration ..... 10 µs

Stability

Offset temperature coefficient ..... ±25 µV/°C

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

Excitation

Current Output Characteristics

Channels..... 1

Level..... 100 µA ±50 nA

Max load resistance..... 80 kΩ

Temperature coefficient ..... ±20 ppm/°C

Long-term stability..... ±2,530 ppm/$\sqrt{1{,}000\ h}$

Digital I/O

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

Compatibility ..... TTL/CMOS

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

Power-on state .....High-impedance

Data transfers .....Programmed I/O

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-detect mode

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

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

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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 (±3.0 mV) (over full operating temperature, actual value stored in EEPROM)
- Temperature coefficient ..... ±2 ppm/°C max
- Long-term stability ..... ±15 ppm/$\sqrt{1{,}000\ \text{h}}$

Power Requirement

Voltage ..... 9 to 42 VDC max

Reverse voltage protection ..... –42 VDC max

Power ..... 325 mA at 12 VDC

Discharge time
with BP-1 battery pack ..... 9 h

Physical

Dimensions ..... 3.8 by 14.6 by 21.3 cm (1.5 by 5.8 by 8.4 in.)

Connector ..... Two 36-pin female MDR 1284-C rear connectors

Weight ..... 0.8 kg (1.9 lb)

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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.....42 V, Installation Category II

Environmental

Operating temperature .....0 to 55 °C

Storage temperature .....–55 to 70 °C

Humidity .....5 to 90% RH, noncondensing

Maximum altitude.....2,000 meters

Pollution degree (indoor use only) 2

Safety

The DAQ device meets 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

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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.

DAQPad-TB-52 Screw Terminal Block

I/O connections	52 labeled screw terminals, with strain relief
Field wire gauge	26–16 AWG
Fuse on +5 V screw terminal	250 mA, 125 V, Pico II, fast-acting from Littelfuse

DAQPad-TB-52 Cold-Junction Temperature Sensor

Absolute accuracy	2.0 °C[1]
Relative accuracy	0.5 °C[1]
Output	0.15 V (at 55 °C) to 1.63 V (at 0 °C)
Connection	Independent AI channel (does not reserve any ACH inputs)

Parallel Port Cable

- Unbalanced impedance of each signal and ground pair of 62 Ω ±6 Ω, 4 to 16 MHz
- Unbalanced capacitance of each cable pair less than 107 pF/m at 1 MHz
- DC resistance of each cable wire less than 0.22 Ω/m
- Total propagation delay less than 150 ns

[1] Includes errors from analog input, excitation current source with one-year calibration, cold-junction sensor thermistor and thermal gradient over screw terminals.

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B

Troubleshooting for Configuring Parallel Ports

This appendix contains parallel port configuration troubleshooting information. If you are using NI-DAQ for Windows, refer to `ni.com/support/daq` for installation and troubleshooting instructions.

The configuration utility reports an error when I try to save the settings or test the device.

If you receive a base address or communication error, complete the following steps:

1. Make sure your chassis is switched on and the screws of the cable are tightly fastened.
2. Make sure you have connected the parallel port cable from the computer to port A of the DAQPad-MIO-16XE-50.
3. Check that your base address is correct. This can be done either by checking your computer technical manual or, in some cases, by checking the base address jumper. In Windows applications, you may have a Hardware Control panel that allows you to enable and disable the parallel port. Common parallel port addresses are 0x378, 0x278, 0x3BC, 0x280, and 0x290 hex.
4. Check that you are using the included 1 m parallel port cable. If you suspect that you have a bad parallel port cable, replace it with a new cable or one that you know works with another peripheral. If you are using another parallel port cable, check to make sure it meets the required specifications. Refer to the *Parallel Port Cable* section of Appendix A, *Specifications*, for these specifications.
5. If you are still having problems, please report the computer make and model number to National Instruments. If you have a noncompatible parallel port, try adding an enhanced parallel port as described in the *Optional Equipment* section of Chapter 1, *Introduction*.

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If you receive an interrupt conflict error, complete the following steps:

1. IRQ levels 7 and 5 are the most common interrupt levels reserved for the parallel port. Try saving your configuration for both IRQ7 and IRQ5.

Note If either IRQ level 7 or level 5 is unselectable under the IRQ menu in `WDAQCONF`, another NI device is using this interrupt. You must free the appropriate IRQ level to allocate it for your parallel port.

2. You may have an interrupt conflict with a non-NI device. If you have installed a PCMCIA card or a plug-in board, you must ensure that neither IRQ5 nor IRQ7 has been allocated for these devices.

Note For some PCMCIA cards installed with Cardware, it may be possible to exclude your parallel port interrupt level by including the line `XIRQ=7`, `E for IRQ 7` or `XIRQ=5`, `E for IRQ 5` in the `cardware.ini` file.

3. You may have an interrupt conflict with a Windows-based application. You must ensure that neither IRQ5 nor IRQ7 has been allocated for this application. One place to search is your `system.ini` file under Windows.
4. If you are still having problems, please report the computer make and model number to National Instruments.

The configuration utility works fine when I use a 3 ft parallel port cable but reports an error when I try to use a longer parallel port cable.

Ensure that your parallel port cable meets the required specifications. Refer to the *Parallel Port Cable* section of Appendix A, *Specifications*, for these specifications.

You may have to use a unidirectional parallel port extender in order to achieve long distance solutions (one such extender is made by BRAVO Communications). Your parallel port is recognized as a Centronics port with this extender.

Note NI does not guarantee functionality with parallel port cables longer than 6 ft.

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I have an EPP port, but the configuration utility reports that I have a Centronics port when I try to save the configuration settings.

You may have to enable your parallel port as an EPP port. Check for configuration utilities and ensure that your port is configured for EPP.

It is possible that the DAQPad-MIO-16XE-50 and NI-DAQ software are not compatible with your EPP port. In this case, your parallel port is treated as a Centronics port.

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C

Common Questions

This appendix contains a list of commonly asked questions and their answers relating to usage and special features of the DAQPad-MIO-16XE-50.

General Information

How do I use the DAQPad-MIO-16XE-50 with the C API in NI-DAQ?

The *NI-DAQ User Manual for PC Compatibles* contains example code and describes the general programming flow when using the NI-DAQ C API. For a list of functions that support the DAQPad-MIO-16XE-50, refer to the *NI-DAQ Function Reference Help* (NI-DAQ version 6.7 or later) or the *NI-DAQ Function Reference Manual for PC Compatibles* (NI-DAQ version 6.6 or earlier).

Refer to `ni.com/manuals` for the *NI-DAQ User Manual for PC Compatibles*, and refer to `ni.com/downloads` to download the version of NI-DAQ that your application requires.

Analog Input

Can I programmatically enable channels on the DAQPad-MIO-16XE-50 to aquire in different modes? For example, can I configure ACH0 in DIFF input mode and ACH1 in RSE input mode?

Channels on the DAQPad-MIO-16XE-50 can be enabled to acquire in different modes, but different pairs of channels are used in different modes. In the example configuration given above, ACH0 and ACH8 are configured in DIFF mode and ACH1 and AIGND are configured in RSE mode. In this configuration, ACH8 is not used in a single-ended configuration. To enable multimode scanning in LabVIEW, use the coupling and input configuration cluster input of the AI Config VI. This input has a one-to-one correspondence with the channel array input of the AI Config VI. You must list all channels either individually or in groups of channels with the same input configuration. For example, if you want ACH0 to be differential, and

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ACH1 and ACH2 to be RSE, Figure C-1 demonstrates how to program this configuration in LabVIEW.

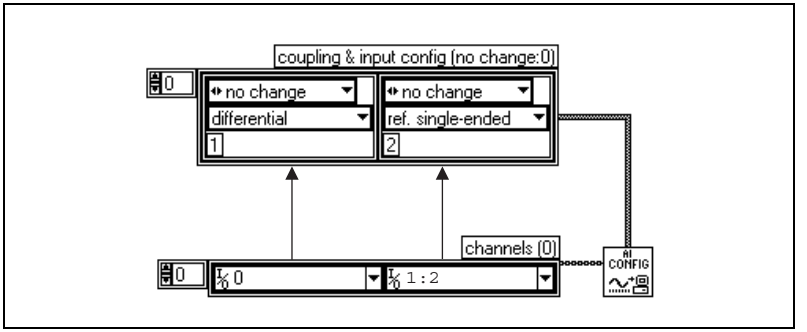


Figure C-1. Configuring Channels for Different Acquisition Modes in LabVIEW

To enable multimode scanning in 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 maybe experiencing a phenomenon called *charge injection*, which occurs when you sample a series of high-output impedance sources with a multiplexer. Multiplexers contain switches, usually made of switched capacitors. When a channel, for example ACH0, is selected in a multiplexer, those capacitors accumulate charge. When the next channel, for example ACH1, is selected, the accumulated current, or charge, leaks backward through that channel. If the output impedance of the source connected to ACH1 is high enough, the resulting reading can somewhat reflect the voltage trends in ACH0. To circumvent this problem, you must use a voltage follower that has operational amplifiers (op-amps) with unity gain for each high-impedance source before connecting to the DAQ device. Otherwise, you must 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 may increase.

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How can I use the STARTSCAN and CONVERT* signals on the DAQPad-MIO-16XE-50 device to sample the AI channel(s)?

The DAQPad-MIO-16XE-50 uses the STARTSCAN and CONVERT* signals to perform interval sampling. As Figure C-2 shows, STARTSCAN controls the scan interval, which is determined by the following equality:

$$\frac{1}{scan\ interval} = scan\ rate$$

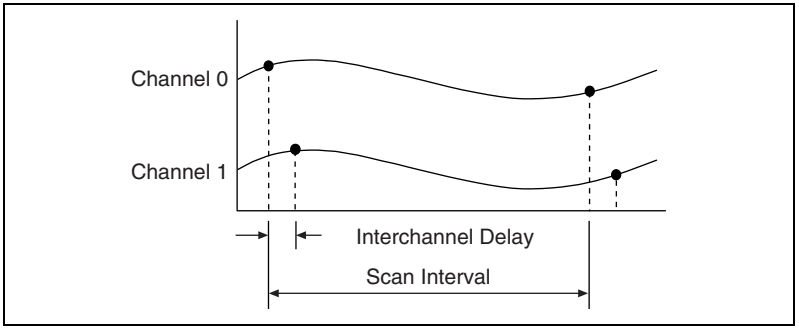


Figure C-2. Comparing Interchannel Delay and Scan Interval

CONVERT* controls the interchannel delay, which is determined by the following equality:

$$\frac{1}{interchannel\ delay} = sampling\ rate$$

This method allows multiple channels to be sampled relatively quickly in relationship to the overall scan rate, providing a nearly simultaneous effect with a fixed delay between channels.

Timing and Digital I/O

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 Measurement Studio, 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 the AI Clock Config, AI Trigger

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Config, AO Clock Config, AO Trigger and Gate 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.

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

Table C-1 corresponds the hardware signal names to the software signal names in LabVIEW and NI-DAQ.

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
WFTRIG	AO Start Trigger	ND_OUT_START_TRIGGER
UPDATE*	AO Update	ND_OUT_UPDATE
UISOURCE	—	ND_OUT_UPDATE_CLOCK_TIMEBASE
AOGATE	—	ND_OUT_EXTERNAL_GATE

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Installing and Configuring the Device

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

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

What is the best way to test the DAQPad-MIO-16XE-50 without programming the device?

If you are using Windows, Measurement & Automation Explorer (MAX) has a Test Panel option that is 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 Mac OS, the NI-DAQ Configuration Utility provides the same functionality.

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D

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Glossary

Prefix	Meaning	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
Ω	ohms
+5V	+5 volts signal

A

A	amperes
A/D	analog-to-digital
AC	alternating current
ACH <0..7>	Analog Channel 0 through 7 signals
ADC	analog-to-digital converter
AIGATE	analog input gate signal
AIGND	analog input ground signal
AISENSE	analog input sense signal

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ANSI	American National Standards Institute
AOGND	analog output ground signal
AWG	American Wire Gauge

C

C	Celsius
channel rate	reciprocal of the interchannel delay
CJTEMP	temperature sensor channel
CONVERT*	convert signal

D

D/A	digital-to-analog
DAC	digital-to-analog converter
DAQ	data acquisition
DAC0OUT, DAC1OUT	voltage output signals for channels 0 and 1
dB	decibels
DC	direct current
DIFF	differential
DIN	Deutsche Industrie Norme
DIO<0..7>	digital I/O signals
DMA	direct memory access

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E

EEPROM	electrically erased programmable read-only memory
EPP	Enhanced Parallel Port
EXTREF	external reference signal
EXTSTROBE*	external strobe signal

F

FREQ_OUT	frequency output signal
ft	feet

G

GPCTR0 GATE	counter 0 gate signal
GPCTR0_OUT	counter 0 output signal
GPCTR0_SOURCE	counter 0 source signal
GPCTR0_UP_DOWN	counter 1 up/down signal
GPCTR1 GATE	counter 1 gate signal
GPCTR1_OUT	counter 1 output signal
GPCTR1_SOURCE	counter 1 source signal
GPCTR1_UP_DOWN	counter 1 up/down signal

H

hex	hexadecimal

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I

I/O	input/output
$I_{EX}+$	current excitation signal
$I_{EX}-$	current excitation return signal
in.	inches
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*.

L

LED	light-emitting diode
LSB	least significant bit

M

m	meters
max	maximum
MB	megabytes of memory
min	minimum
MIO	multifunction I/O
MSB	most significant bit

N

NRSE	nonreferenced single-ended

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P

PA, PB, PC <0..7>	Port A, B, or C 0 through 7 signals
PFI<0..9>	programmable function input signals
PGIA	programmable gain instrumentation amplifier
PTC	positive temperature coefficient

R

rms	root mean square
RSE	referenced single-ended
R_T	thermisor resistance in ohms
RTD	resistance temperature device
RTSI	Real-Time System Integration

S

s	seconds
scan interval	controls how often a scan is initiated; is regulated by STARTSCAN
scan rate	reciprocal of the scan interval
SCANCLK	scan clock signal
SCXI	Signal Conditioning eXtensions for Instrumentation (bus)
STARTSCAN	start of scan signal

T

T_C	thermistor temperature in Celsius
T_F	thermistor temperature in Fahrenheit

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T_K	thermistor temperature in Kelvin
TRIG1, TRIG2	trigger 1, 2 signals
TTL	transistor-transistor logic
typ	typical

U

U1SOURCE	counter 1 update interval source signal
UPDATE*	update signal

V

V	volts
V_{cm}	common-mode noise
V_{diff}	differential input voltage
V_{EXT}	external voltage
VI	virtual instrument
$V_{in}\pm$	positive/negative input voltage
V_m	measured voltage
V_{rms}	volts, root-mean-square
V_s	signal source
$V_{temp\ sensor}$	temperature sensor in volts

W

W	watts
WFTRIG	waveform trigger signal

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