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USER GUIDE

NI USB-6000

USB Multifunction DAQ Device

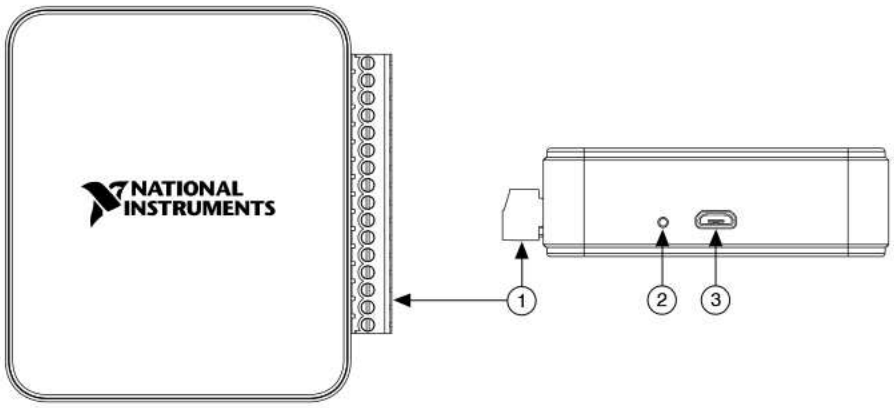
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ni.com/manuals

This user guide describes how to use the National Instruments USB-6000 data acquisition (DAQ) device.

The NI USB-6000 is a USB device that provides eight single-ended analog input (AI) channels, four digital input/output (DIO) channels, and a 32-bit counter.

Figure 1. NI USB-6000 Top and Back Views



1 Screw Terminal Connector Plug
2 LED Indicator
3 Micro-B USB Connector

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Safety Guidelines

Operate the NI USB-6000 only as described in this document.

Caution Refer to the *Read Me First: Safety and Electromagnetic Compatibility* document for important safety and electromagnetic compatibility information. To obtain a copy of this document online, visit `ni com/manuals` and search for the document title.

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

Caution Do *not* substitute parts or modify the device except as described in this document. Use the device only with the chassis, modules, accessories, and cables specified in the installation instructions.

Caution Do *not* operate the device in an explosive atmosphere or where there may be flammable gases or fumes. If you must operate the device in such an environment, it must be in a suitably rated enclosure.

Electromagnetic Compatibility Guidelines

This product was tested and complies with the regulatory requirements and limits for electromagnetic compatibility (EMC) stated in the product specifications. These requirements and limits provide reasonable protection against harmful interference when the product is operated in the intended operational electromagnetic environment.

This product is intended for use in industrial locations. However, harmful interference may occur in some installations, when the product is connected to a peripheral device or test object, or if the product is used in residential or commercial areas. To minimize interference with radio and television reception and prevent unacceptable performance degradation, install and use this product in strict accordance with the instructions in the product documentation.

Furthermore, any modifications to the product not expressly approved by National Instruments could void your authority to operate it under your local regulatory rules.

Caution To ensure the specified EMC performance, the length of any wire or cable connected to the screw terminal connector must be no longer than 0.5 m (20 in.).

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Unpacking

The NI USB-6000 ships in an antistatic package to prevent electrostatic discharge (ESD). ESD can damage several components on the device.

Caution *Never* touch the exposed pins of connectors.

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

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

Remove the device from the package and inspect it for loose components or any other signs of damage. Notify NI if the device appears damaged in any way. Do not install a damaged device in your computer.

Store the device in the antistatic package when the device is not in use.

Packing List

The NI USB-6000 is shipped in a box that contains:

- NI USB-6000
- Screw terminal connector plug
- Hi-Speed USB Cable
- NI-DAQmx DVD
- *NI USB-6000 Quick Start*

Setting Up the Device

Complete the following steps to get started with the device.

Note For instructions applicable to all NI DAQ devices, refer to `ni.com/gettingstarted`.

Installing the Software

1. Install the application software, as described in the installation instructions that accompany your software. Refer to Table 1 for available application software you can use with your device.
2. Install NI-DAQmx, version 9.8 or later.
3. Register your products when the NI Product Registration Wizard appears.

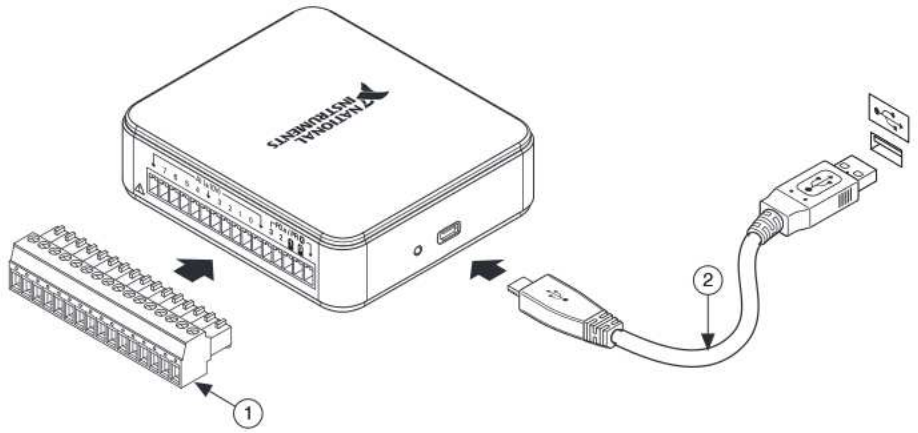
Note Latest NI software releases are available for download at `ni.com/support`.

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Preparing the Hardware

1. Insert the screw terminal connector plug into the connector jack on the device. Refer to Figure 2.
2. The Hi-Speed USB cable has two different connectors on each end. Plug the smaller Micro-B USB connector into the device, and plug the larger USB connector into a USB port. Refer to Figure 2.

Figure 2. Hardware Setup for NI USB-6000



1 Screw Terminal Connector Plug 2 Hi-Speed USB Cable

Verifying the Installation

1. Launch Measurement & Automation Explorer (MAX) by double-clicking the **NI MAX** icon on the desktop, or **(Windows 8)** by clicking **Measurement & Automation Explorer** from NI Launcher.
2. Expand **My System»Devices and Interfaces** and verify that the NI USB-6000 is listed. If your device does not appear, press <F5> to refresh the view in MAX. If your device is still not recognized, refer to `ni com/support/daqmx` for troubleshooting information.
3. Right-click your device and select **Self-Test**. When the self-test finishes, a message indicates successful verification or if an error occurred. If an error occurs, refer to `ni com/support/daqmx`.
4. Connect the wires (1.31 to 0.08 mm^2, or 16 to 28 AWG) to the screw terminals by stripping 6.35 mm (0.25 in.) of insulation, inserting the wires into the screw terminals, and securely tightening the screws. Refer to Figure 4 for the NI USB-6000 pinout.
5. Right-click your device and select **Test Panels**. A test panel appears.
6. Click **Start** to test the device functions, or **Help** for operating instructions. If an error message is displayed, refer to `ni com/support/daqmx`.
7. Click **Close** to exit the test panel.

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Using the NI USB-6000 in an Application

You can use the DAQ Assistant through many NI application software programs to configure virtual and measurement channels. Table 1 lists DAQ Assistant tutorial locations for NI applications.

Table 1. DAQ Assistant Tutorial Locations

NI Application Software	Tutorial Location
LabVIEW	Go to **Help»LabVIEW Help**. Next, go to **Getting Started with LabVIEW»Getting Started with DAQ»Taking an NI-DAQmx Measurement in LabVIEW**.
LabWindows™/CVI™	Go to **Help»Contents**. Next, go to **Using LabWindows/CVI» Data Acquisition»Taking an NI-DAQmx Measurement in LabWindows/CVI**.
Measurement Studio	Go to **NI Measurement Studio Help»NI Measurement Studio Help**. Next, go to **Developing Projects with Measurement Studio»Getting Started with the Measurement Studio Class Libraries»Measurement Studio Walkthroughs» Walkthrough: Creating a Measurement Studio NI-DAQmx Application**.
SignalExpress	Go to **Help»Taking an NI-DAQmx Measurement in SignalExpress**.

Refer to the *Where to Go from Here* section for information about programming examples for NI-DAQmx.

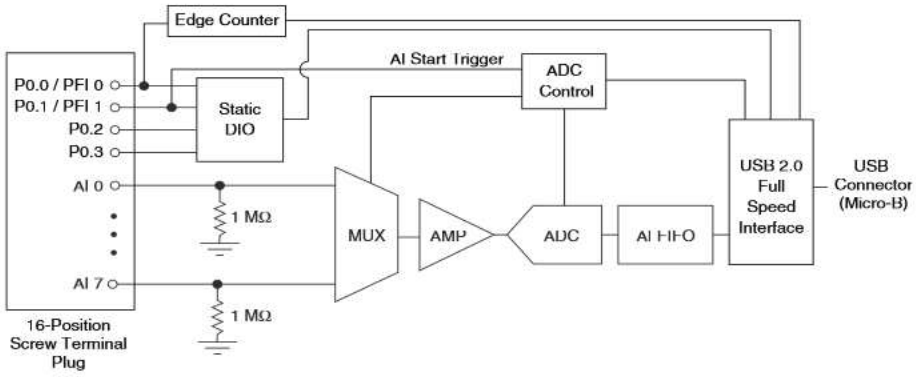
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Features

Block Diagram

Figure 3 shows key functional components of the NI USB-6000.

Figure 3. NI USB-6000 Block Diagram



LED Indicator

The NI USB-6000 has a blue LED indicator that indicates device status, as listed in Table 2.

Table 2. LED State/Device Status

LED State	Device Status
Off	Device not connected or in suspend.
On, not blinking	Device connected and functioning normally.
Blinking	Device has encountered an error. Wait 10 seconds to allow the device to attempt to recover from the error. If the LED keeps blinking, disconnect and reconnect the device. If the error persists, contact National Instruments. Refer to the *Where to Go for Support* section for contact information.

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Cables and Accessories

Table 3 contains information about cables and accessories available for the NI USB-6000.

Note For a complete list of accessories and ordering information, refer to the pricing section of the NI USB-6000 product page at ni com.

Table 3. NI USB-6000 Cables and Accessories

Accessory	Part Number	Description
USB-6000 Accessory Kit	782703-01	Four additional screw-terminal connectors and a screwdriver
USB-6000 Series Prototyping Accessory	779511-01	Unshielded breadboarding accessory for custom-defined signal conditioning and prototyping.
Hi-Speed USB Cable, A to Micro-B, 1 m	782909-01	—
Hi-Speed USB Cable, A to Micro-B, 2 m	782909-02	—

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Pinout and Signal Descriptions

Figure 4 shows the pinout of the NI USB-6000. Refer to Table 4 for a detailed description of each signal.

Figure 4. NI USB-6000 Pinout

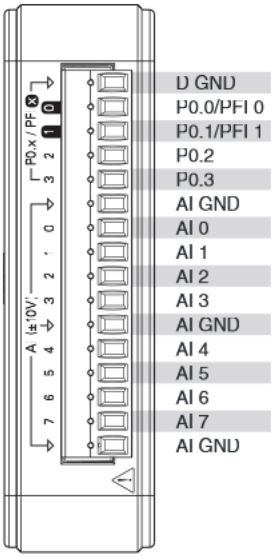


Table 4. Signal Descriptions

Signal Name	Reference	Direction	Description
D GND	—	—	**Digital Ground**—The reference point for digital signals.
AI GND	—	—	**Analog Input Ground**—The reference point for analog input measurements.
P0.<0..3>	D GND	Input or Output	**Port 0 Digital I/O Channels 0 to 3**—Configure each signal individually as an input or output. Refer to the *Digital I/O* section for more information.
PFI 0	D GND	Input	**PFI 0**—An edge counter input. Refer to the *Using PFI 0 as a Counter Source* section for more information.

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Table 4. Signal Descriptions (Continued)

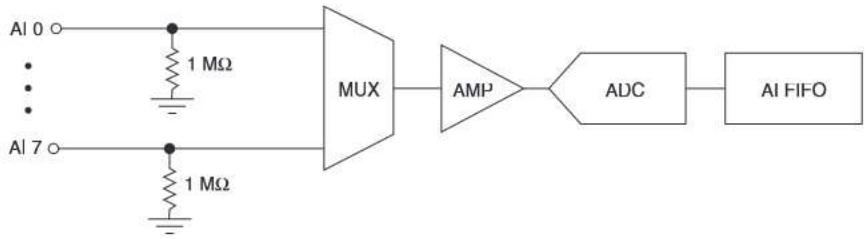
Signal Name	Reference	Direction	Description
PFI 1	D GND	Input	**PFI 1**—A digital trigger input. Refer to the *Using PFI 1 to Trigger an Analog Input Acquisition* section for more information.
AI <0..7>	AI GND	Input	**Analog Input Channels 0 to 7**—Analog input voltage channels. Refer to the *Analog Input* section for more information.

Analog Input

The NI USB-6000 has eight ±10 V fixed-range analog input channels for single-ended analog input measurements.

Figure 5 shows the analog input circuitry of the NI USB-6000.

Figure 5. NI USB-6000 Analog Input Circuitry



The main blocks featured in the analog input circuitry are as follows:

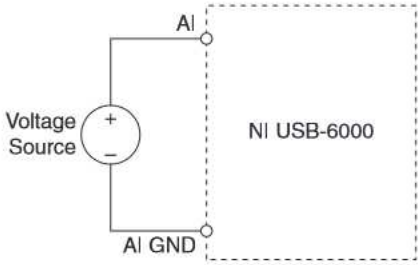
- **MUX**—The multiplexer (MUX) routes one AI channel at a time to the amplifier (AMP).
- **AMP**—The amplifier (AMP) buffers analog input signal, before the signal is sampled by the analog-to-digital converter (ADC).
- **ADC**—The analog-to-digital converter (ADC) digitizes the AI signal by converting the analog voltage into digital code.
- **AI FIFO**—The NI USB-6000 can perform both single and multiple analog-to-digital conversions of a fixed or infinite number of samples. A first-in-first-out (FIFO) buffer holds data during AI acquisitions to ensure that no data is lost.

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Connecting Analog Input Signals

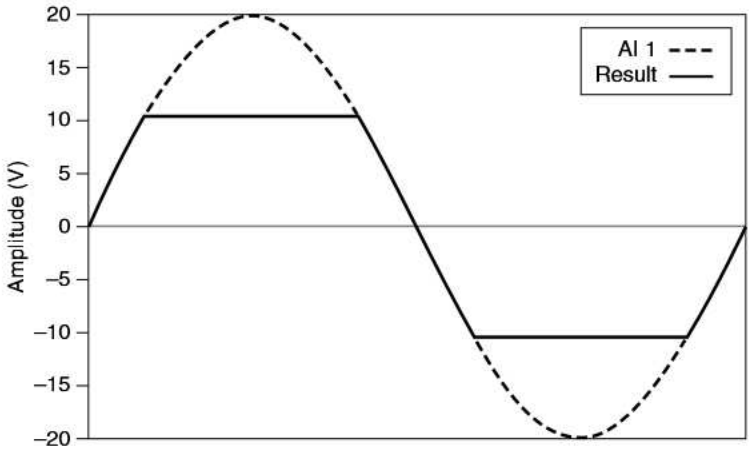
To connect voltage signals to the NI USB-6000, connect the positive voltage signal to an AI terminal, and the ground signal to an AI GND terminal, as shown in Figure 6.

Figure 6. Connecting a Referenced Single-Ended Voltage Signal



Signals of ±10 V at any analog input pin with respect to AI GND are accurately measured. Beyond ±10 V, the input signal will begin clipping as shown in Figure 7. Typically, this clipping begins at ±10.5 V.

Figure 7. Exceeding ±10 V on AI Returns Clipped Measurement Result

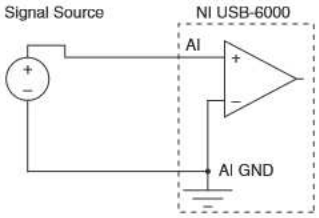
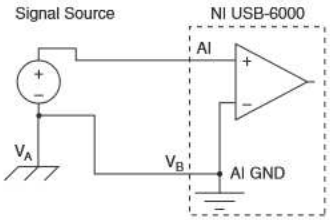


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Wiring Considerations

The following sections describe how to wire floating and ground-referenced signals to minimize measurement errors.

Table 5. Analog Input Configurations

Floating Signal Sources (Not Connected to Building Ground)	Ground-Referenced Signal Sources
Examples: • Ungrounded thermocouples • Signal conditioning with isolated outputs • Battery devices	Example: • Plug-in instruments with non-isolated outputs
	 Ground-loop potential ($V_A - V_B$) are added to measured signal.

Floating Signal Sources

A floating signal source is not connected to the building ground system, but instead has an isolated ground-reference point, as shown in Table 5. Some examples of floating signal sources are outputs of transformers, thermocouples, battery-powered devices, optical isolators, and isolation amplifiers. An instrument or device that has an isolated output is a floating signal source.

Wiring Floating Signal Sources

The AI channels on the NI USB-6000 share a common reference point, AI GND. This type of AI is known as Referenced Single-Ended (RSE). For input signals that requires a separate ground-reference point or return signal, consider using an NI DAQ device with differential inputs.

Noise coupling is one of the main error sources in measurements. Electrostatic and magnetic noise coupling are 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. To reduce these noises, NI recommends the following wiring methods:

- Reduce the wire length between leads connecting the signals to the device.
- Twist each input signal with an AI GND to minimize the area between conductors.

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When using RSE connections with floating signal sources, the AMP rejects both the common-mode noise in the signal and the ground potential difference between the signal source and the device ground.

Refer to the NI Developer Zone document, *Field Wiring and Noise Considerations for Analog Signals*, for more information. To access this document, go to `ni com/info` and enter the Info Code `rdfwn3`.

Ground-Referenced Signal Sources

A ground-referenced signal source is a signal source connected to the building system ground, as shown in Table 5. It is already connected to a common ground point with respect to the device, assuming that the computer is plugged into the same power system as the source. Non-isolated 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 the difference can be much higher if power distribution circuits are improperly connected. If a grounded signal source is incorrectly measured, this difference can appear as measurement error. Follow the connection instructions for grounded signal sources to eliminate this ground potential difference from the measured signal

Wiring Ground-Referenced Signal Sources

The AI channels on the NI USB-6000 share a common reference point, AI GND. This type of AI is known as Referenced Single-Ended (RSE).

When using RSE connections with ground-referenced signal sources, there can be a potential difference between AI GND and the ground of the sensor as shown in the bottom-rightmost cell of Table 5. This ground loop causes measurement errors, and care must be taken to minimize this error.

For static ground loop error, measuring the potential difference between AI GND (VB) and the ground of the sensor (VA) prior to signal measurement and then subtracting it from the signal measurement helps to minimize the error.

For dynamic ground loop errors, using an NI DAQ product that has differential input capability helps to fully minimize the error.

Refer to the NI Developer Zone document, *Field Wiring and Noise Considerations for Analog Signals*, for more information. To access this document, go to `ni com/info` and enter the Info Code `rdfwn3`.

AI Start Trigger

You can configure PFI 1 as the AI Start Trigger for analog input tasks. Refer to the *Using PFI 1 to Trigger an Analog Input Acquisition* section for more information.

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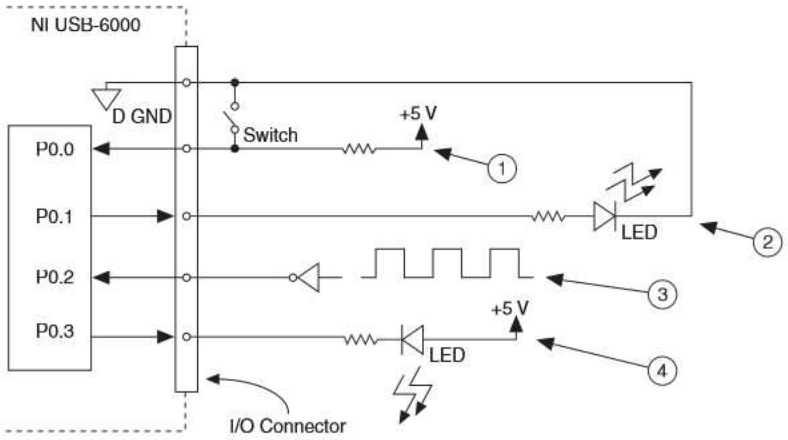
Digital I/O

The NI USB-6000 has four digital lines, P0.<0..3>. D GND is the ground-reference signal for digital I/O. You can individually program each line as input or output.

All digital I/O updates and samples are software-timed.

Figure 8 shows P0.<0..3> connected to signals configured as digital inputs and digital outputs.

Figure 8. Example of Connecting a Load



1 P0.0 configured as a **digital input** receiving a 0 V or 5 V signal from a switch
2 P0.1 configured as an **active drive digital output** driving an LED
3 P0.2 configured as a **digital input** receiving a TTL signal
4 P0.3 configured as an **open collector digital output** driving an LED

Caution Exceeding the maximum input voltage ratings or maximum output ratings, which are listed in the *NI USB-6000 Specifications* document, can damage the device and the computer. National Instruments is *not* liable for any damage resulting from such signal connections.

Power-On States

At system startup and reset, the hardware sets all DIO lines to high-impedance inputs. The DAQ device does not drive the signal high or low. Each line has a weak pull-down resistor connected to it.

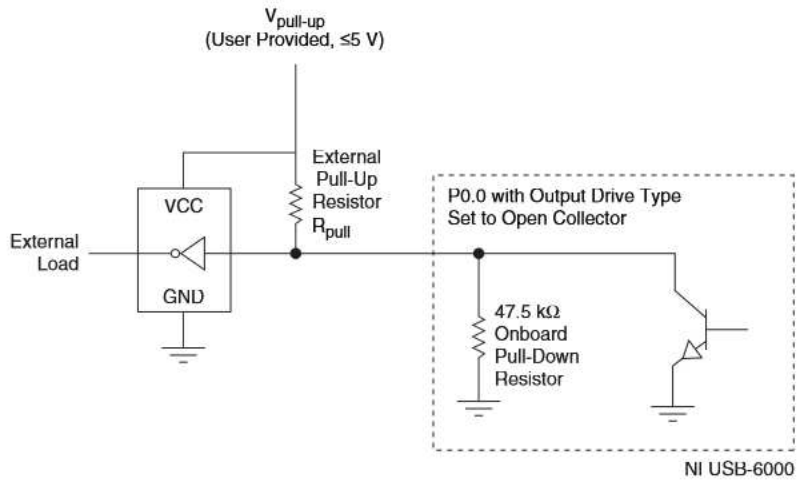
Source/Sink Information

The default configuration of the digital I/O ports is active drive, allowing 3.3 V operation, with a source/sink current limit of ±4 mA.

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The ports can be configured as open collector using NI-DAQmx API, allowing operation with a different voltage level when used in conjunction with an external user-provided pull-up resistor. The connection for such a situation is as shown in Figure 9.

Figure 9. Example of Connecting an External User-Provided Resistor



Note: Ensure that the current flowing across R_{pull} does not violate the maximum sinking current specifications (4 mA).

For more information about how to set the DIO configuration, refer to the KnowledgeBase document, *Configuring NI Devices to be Open-Drain (Open Collector) or Push-Pull (Active Drive)*. To access this document, go to `ni com/info` and enter the Info Code `ex52sp`.

I/O Protection

To protect the NI USB-6000 against overvoltage, undervoltage, and overcurrent conditions, as well as ESD events, you should use the following guidelines:

- If you configure a DIO line as an output, do *not* connect it to any external signal source, ground signal, or power supply.
- If you configure a DIO line as an output, understand the current requirements of the load connected to these signals. Do *not* exceed the specified current output limits of the DAQ device.

  National Instruments has several signal conditioning solutions for digital applications requiring high current drive.
- If you configure a DIO line as an input, do *not* drive the line with voltages outside of its normal operating range. The DIO lines have a smaller operating range than the AI signals.
- Treat the DAQ device as you would treat any static-sensitive device. Always properly ground yourself and the equipment when handling the DAQ device or connecting to it.

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PFI 0 and PFI 1

Using PFI 0 as a Counter Source

You can configure PFI 0 as a source for counting digital edges. In this mode, rising- or falling-edges are counted using a 32-bit counter. For more information, refer to the *NI USB-6000 Specifications* document.

Using PFI 1 to Trigger an Analog Input Acquisition

You can configure an analog input task to wait for an edge on PFI 1 before starting the acquisition. To do this, configure the AI Start Trigger source to be PFI 1 and specify either rising- or falling-edge.

Where to Go from Here

This section lists where you can find example programs for the NI USB-6000 and relevant documentation.

Example Programs

NI-DAQmx driver software includes example programs to help you get started programming with the NI USB-6000. Modify example code and save it in an application, or use examples to develop a new application, or add example code to an existing application.

To locate NI software examples, go to `ni com/info` and enter the Info Code `daqmxexp`. For additional examples, refer to `zone ni com`.

To run examples without the device installed, use an NI-DAQmx simulated device. For more information, in Measurement & Automation Explorer (MAX), select **Help»Help Topics» NI-DAQmx» MAX Help for NI-DAQmx** and search for simulated devices.

Related Documentation

Note You can download these documents at `ni com/manuals`.

Each application software package and driver includes information about writing applications for taking measurements and controlling measurement devices. The following references to documents assume you have NI-DAQmx 9.8 or later, and where applicable, version 8.5 or later of the NI application software.

NI USB-6000

The *NI USB-6000 Quick Start* packaged with the NI USB-6000 describes how to install NI-DAQmx and NI application software, install the device, and confirm that your device is operating properly.

The *NI USB-6000 Specifications* lists the specifications to which the device complies with.

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NI-DAQmx

The *NI-DAQ Readme* lists which devices, ADEs, and NI application software are supported by this version of NI-DAQ. Select **Start»All Programs»National Instruments»NI-DAQ» NI-DAQ Readme**.

The *NI-DAQmx Help* contains API overviews, general information about measurement concepts, key NI-DAQmx concepts, and common applications that are applicable to all programming environments. Select **Start»All Programs»National Instruments»NI-DAQ» NI-DAQmx Help**.

LabVIEW

If you are a new user, use the *Getting Started with LabVIEW* manual to familiarize yourself with the LabVIEW graphical programming environment and the basic LabVIEW features you use to build data acquisition and instrument control applications. Open the *Getting Started with LabVIEW* manual by selecting **Start»All Programs»National Instruments»LabVIEW» LabVIEW Manuals** or by navigating to the `labview\manuals` directory and opening `LV_Getting_Started pdf`.

Use the *LabVIEW Help*, available by selecting **Help»LabVIEW Help** in LabVIEW, to access information about LabVIEW programming concepts, step-by-step instructions for using LabVIEW, and reference information about LabVIEW VIs, functions, palettes, menus, and tools. Refer to the following locations on the **Contents** tab of the *LabVIEW Help* for information about NI-DAQmx:

- **Getting Started with LabVIEW»Getting Started with DAQ**—Includes overview information and a tutorial to learn how to take an NI-DAQmx measurement in LabVIEW using the DAQ Assistant.
- **VI and Function Reference»Measurement I/O VIs and Functions»DAQmx - Data Acquisition VIs and Functions**—Describes the LabVIEW NI-DAQmx VIs and functions.
- **Property and Method Reference»NI-DAQmx Properties** contains the property reference.
- **Taking Measurements**—Contains the conceptual and how-to information you need to acquire and analyze measurement data in LabVIEW, including common measurements, measurement fundamentals, NI-DAQmx key concepts, and device considerations.

LabWindows/CVI

The **Data Acquisition** book of the *LabWindows/CVI Help* contains *Taking an NI-DAQmx Measurement in LabWindows/CVI*, which includes step-by-step instructions about creating a measurement task using the DAQ Assistant. In LabWindows/CVI, select **Help»Contents**, then select **Using LabWindows/CVI»Data Acquisition**. This book also contains information about accessing detailed information through the *NI-DAQmx Help*.

The **NI-DAQmx Library** book of the *LabWindows/CVI Help* contains API overviews and function reference for NI-DAQmx. Select **Library Reference»NI-DAQmx Library** in the *LabWindows/CVI Help*.

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Measurement Studio

If you program your NI-DAQmx-supported device in Measurement Studio using Visual C# or Visual Basic .NET, you can interactively create channels and tasks by launching the DAQ Assistant from MAX or from within Visual Studio. You can use Measurement Studio to generate the configuration code based on your task or channel. Refer to the *DAQ Assistant Help* for additional information about generating code.

The *NI Measurement Studio Help* is fully integrated with the Microsoft Visual Studio help. To view this help file from within Visual Studio, select **Measurement Studio»NI Measurement Studio Help**. For information related to developing with NI-DAQmx, refer to the following topics within the *NI Measurement Studio Help*:

- For step-by-step instructions on how to create an NI-DAQmx application using the Measurement Studio Application Wizard and the DAQ Assistant, refer to *Walkthrough: Creating a Measurement Studio NI-DAQmx Application*.
- For help with NI-DAQmx methods and properties, refer to *NationalInstruments.DAQmx* namespace and *NationalInstruments.DAQmx.ComponentModel* namespace.
- For conceptual help with NI-DAQmx, refer to *Using the Measurement Studio NI-DAQmx .NET Library* and *Creating Projects with Measurement Studio NI-DAQmx*.
- For general help with programming in Measurement Studio, refer to *Getting Started with the Measurement Studio Class Libraries*.

To create an NI-DAQmx application using Visual Basic .NET or Visual C#, follow these general steps:

1. In Visual Studio, select **File»New»Project** to launch the New Project dialog box.
2. Choose a programming language (Visual C# or Visual Basic .NET) then select **Measurement Studio** to see a list of project templates.
3. Select **NI DAQ Windows Application**. You add DAQ tasks as part of this step.

ANSI C without NI Application Software

The *NI-DAQmx Help* contains API overviews and general information about measurement concepts. Select **Start»All Programs»National Instruments»NI-DAQ»NI-DAQmx Help**.

The *NI-DAQmx C Reference Help* describes the NI-DAQmx Library functions, which you can use with National Instruments data acquisition devices to develop instrumentation, acquisition, and control applications. Select **Start»All Programs»National Instruments»NI-DAQ» Text-Based Code Support»NI-DAQmx C Reference Help**.

.NET Languages without NI Application Software

You can use NI-DAQmx to create .NET applications in Visual C# and Visual Basic .NET without installing Measurement Studio. You install NI-DAQmx .NET support from the NI-DAQmx installer. Expand the Application Development Support feature and enable the .NET Framework [version] Languages Support sub-feature to install this support on your machine. To view the NI-DAQmx .NET documentation, go to **Start»All Programs»National Instruments»NI-DAQ»Text-Based Code Support**. The documentation includes the NI-DAQmx API overview, measurement tasks and concepts, and function reference. For

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function reference, refer to the *NationalInstruments.DAQmx* namespace and *NationalInstruments.DAQmx.ComponentModel* namespace topics. For conceptual help, refer to the *Using the Measurement Studio NI-DAQmx .NET Library* and *Developing with Measurement Studio NI-DAQmx* sections.

Training Courses

If you need more help getting started developing an application with NI products, NI offers training courses. To enroll in a course or obtain a detailed course outline, refer to `ni.com/training`.

Technical Support on the Web

For additional support, refer to `ni.com/support` or `zone.ni.com`.

Many DAQ specifications and user guides/manuals are available as PDFs. You must have Adobe Reader 7.0 or later (PDF 1.6 or later) installed to view the PDFs. Refer to the Adobe Systems Incorporated Web site at `www.adobe.com` to download Acrobat Reader. Refer to the National Instruments Product Manuals Library at `ni.com/manuals` for updated documentation resources.

Where to Go for Support

The National Instruments Web site is your complete resource for technical support. At `ni.com/support` you have access to everything from troubleshooting and application development self-help resources to email and phone assistance from NI Application Engineers.

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