

## USER GUIDE

# NI USB-6501

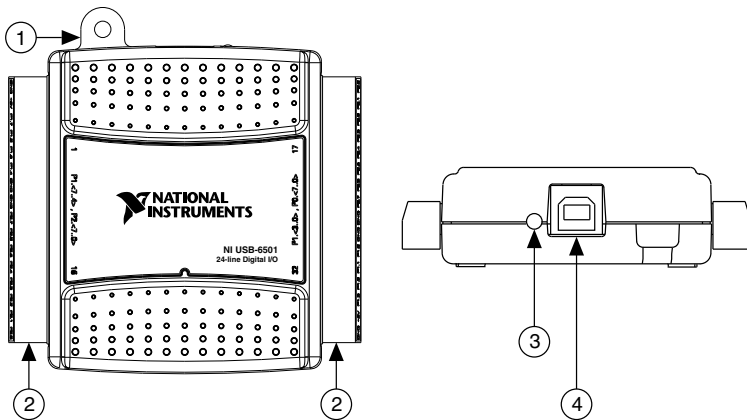
## 24-Channel, 32-Bit Counter Digital I/O Device

The National Instruments USB-6501 is a Full Speed USB 2.0 device that provides 24 DIO channels and a 32-bit counter. This user guide describes how to use the device.

For specifications, refer to the *NI USB-6501 Device Specifications* document available at [ni.com/manuals](http://ni.com/manuals).

The following figure shows key functional components of the NI USB-6501.

**Figure 1.** NI USB-6501 Top and Back Views

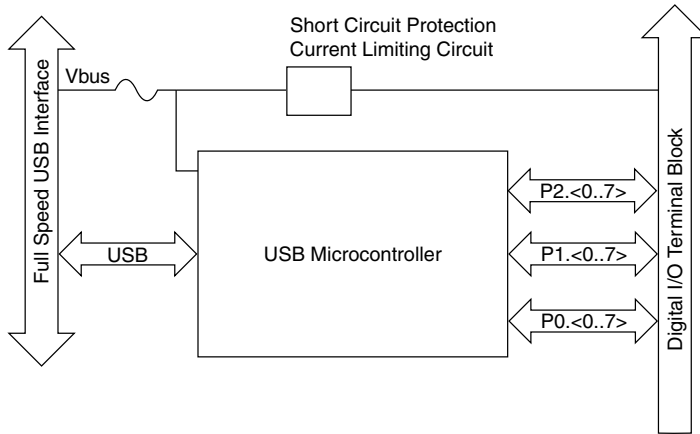


1. USB Cable Strain Relief
2. Screw Terminal Connector Plug

3. LED Indicator
4. USB Connector

The following figure shows key functional components of the NI USB-6501.

**Figure 2. NI USB-6501 Device Block Diagram**



## Safety Guidelines

The following section contains important safety information that you must follow when installing and using the NI USB-6501.



**Caution** Operate the NI USB-6501 only as described in these operating instructions. 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 user guide. Use the device only with the accessories 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.

If you need to clean the device, use a dry cloth. Make sure that the device is completely dry and free from contaminants before returning it to service.

Operate the device only at or below Pollution Degree 2. Pollution is foreign matter in a solid, liquid, or gaseous state that can reduce dielectric strength or surface resistivity. The following is a description of pollution degrees:

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

You must insulate signal connections for the maximum voltage for which the device is rated. Do not exceed the maximum ratings for the device. Do not install wiring while the device is live with electrical signals.

Operate the device at or below the Measurement Category I<sup>1</sup>. Measurement circuits are subjected to working voltages<sup>2</sup> and transient stresses (overvoltage) from the circuit to which they are connected during measurement or test. Measurement categories establish standard impulse withstand voltage levels that commonly occur in electrical distribution systems. The following is a description of measurement categories:

- Measurement Category I is for measurements performed on circuits not directly connected to the electrical distribution system referred to as MAINS<sup>3</sup> voltage. This category is for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.
- Measurement Category II is for measurements performed on circuits directly connected to the electrical distribution system. This category refers to local-level electrical distribution, such as that provided by a standard wall outlet (for example, 115 V for U.S. or 230 V for Europe). Examples of Measurement Category II are measurements performed on household appliances, portable tools, and similar E Series devices.
- Measurement Category III is for measurements performed in the building installation at the distribution level. This category refers to measurements on hard-wired equipment such as equipment in fixed installations, distribution boards, and circuit breakers. Other examples are wiring, including cables, bus-bars, junction boxes, switches, socket-outlets

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<sup>1</sup> Measurement Category is defined in electrical safety standard IEC 61010-1. Measurement Category is also referred to as Installation Category.

<sup>2</sup> Working voltage is the highest rms value of an AC or DC voltage that can occur across any particular insulation.

<sup>3</sup> MAINS is defined as a hazardous live electrical supply system that powers equipment. Suitably rated measuring circuits may be connected to the MAINS for measuring purposes.

in the fixed installation, and stationary motors with permanent connections to fixed installations.

- Measurement Category IV is for measurements performed at the primary electrical supply installation (<1,000 V). Examples include electricity meters and measurements on primary overcurrent protection devices and on ripple control units.

## Installing the Software

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Software support for the NI USB-6501 is provided by NI-DAQmx or NI-DAQmx Base.

Back up any applications before upgrading your software. You must be an administrator to install NI software on your computer. Refer to the *NI-DAQmx Readme* or the *NI-DAQmx Base Readme* on the software media for supported application software and versions.

Complete the following steps to install software:

1. If applicable, install an application development environment (ADE), such as LabVIEW, Microsoft Visual Studio, or LabWindows™/CVI™.
2. Install the NI-DAQmx driver or the NI-DAQmx Base driver.

## Connecting the Device

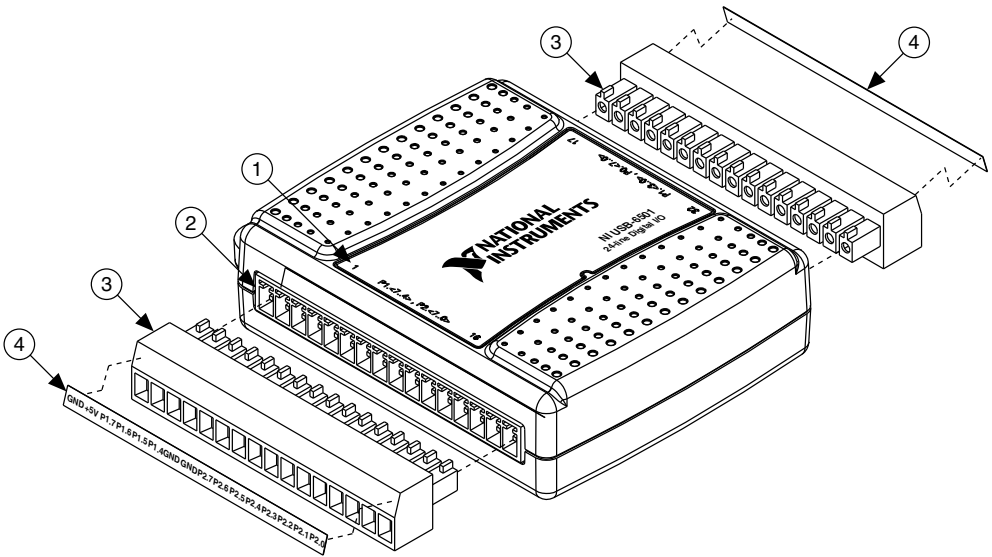
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Before installing the NI USB-6501, you must install the software you plan to use with it.

Complete the following steps to set up the NI USB-6501 device:

1. Install the combicon screw terminal blocks by inserting them into the combicon jacks.
2. Affix the provided signal labels to the screw terminal blocks, as shown in the following figure. Once you label the connector plugs, you must only insert them into the matching combicon jack, as indicated by the overlay label on the device.

**Figure 3. Signal Name Label Application**



- |  |                                   |
|--|-----------------------------------|
| 1. Overlay Label with Pin Orientation Guides | 3. Screw Terminal Connector Plugs |
| 2. Combicon Jack                             | 4. Signal Name Labels             |

3. Connect the wiring to the appropriate screw terminals.
4. Use the provided USB cable to connect the NI USB-6501 device to your computer.

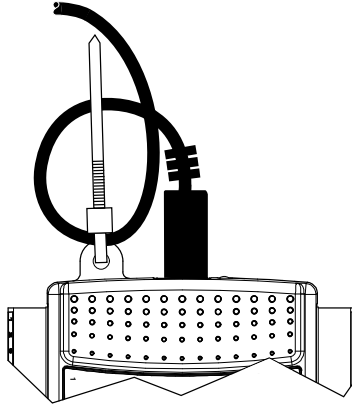
## Features

The NI USB-6501 features USB cable strain relief, an LED indicator, and two screw terminal connector plugs for I/O.

### USB Cable Strain Relief

You can provide strain relief for the USB cable by threading a zip tie through the USB cable strain relief ring and tightening it around a looped USB cable, as shown in the following figure.

**Figure 4. USB Cable Strain Relief**



## LED Indicator

The green LED next to the USB connector on the NI USB-6501 device indicates device status, as listed in the following table. When the device is connected to a USB port, the LED blinks steadily to indicate that the device is initialized and is receiving power from the connection.

**Table 1. LED State/Device Status**

LED State	Device Status
Not lit	Device is not connected or is in suspend mode
On, not blinking	Device is connected but not initialized, or the computer is in standby mode. In order for the device to be recognized, it must be connected to a computer that has NI-DAQmx or NI-DAQmx Base installed.
Single-blink	Device is operating normally

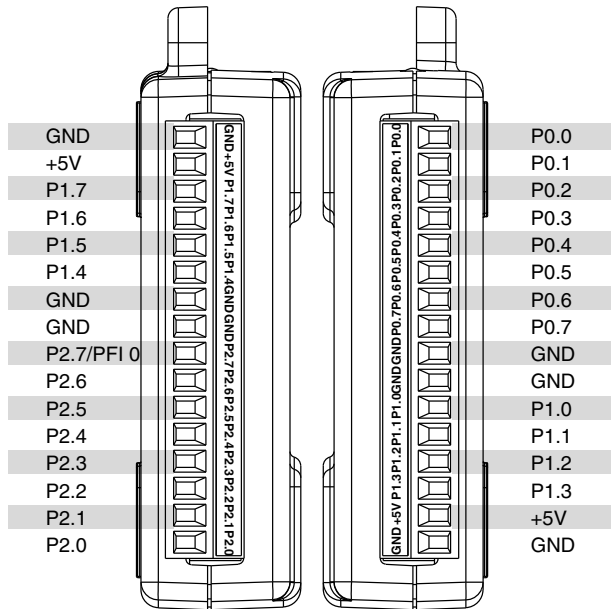
## Screw Terminal Connector Plugs

The NI USB-6501 ships with two detachable screw terminal connector plugs for digital signals. These screw terminal connectors accept 16 AWG to 28 AWG wire.

## Device Pinout and Signal Descriptions

The following figure shows the digital terminal assignments.

**Figure 5. NI USB-6501 Device Pinout**



The following table describes the signals available on the I/O connectors.

**Table 2. Signal Descriptions**

Signal Name	Direction	Description
P0.<0..7>, P1.<0..7>, P2.<0..6>	Input or Output	<b>Digital I/O Signals:</b> You can individually configure each signal as an input or output.
P2.7/PFI 0	Input or Output	This pin is configurable as either a digital line or an event counter.  <b>Digital I/O Signal:</b> As a digital line, this signal can be used as an input or output.  <b>CTR:</b> As a counter, this signal can be used as an event counter input source.

**Table 2.** Signal Descriptions (Continued)

Signal Name	Direction	Description
+5 V	Output	The voltage source provided by the USB host. The voltage is nominally 5 V, but varies from system to system.
GND	—	<b>Ground:</b> The reference for the digital signals and the +5 VDC supply.

## Digital I/O

The NI USB-6501 device has 24 single-ended digital lines that comprise the three DIO ports: P0.<0..7>, P1.<0..7>, and P2.<0..7>. P2.7/PFI 0 can also function as a 32-bit event counter.

### Static DIO

Each DIO line can be individually programmed as a static DI or DO line. You can use static DIO lines to monitor or control digital signals. All samples of static DI lines and updates of DO lines are software-timed.

### Digital Output

The following table shows the correlation between terminology used for hardware functionality and for NI-DAQmx.

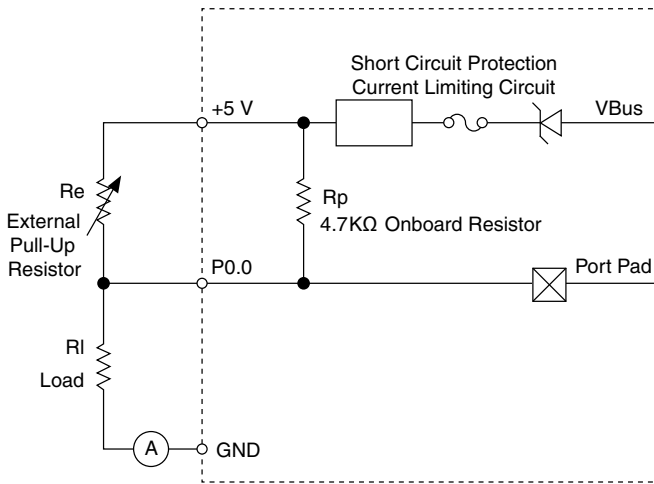
**Table 3.** Hardware and NI-DAQmx Terminology

Hardware Functionality	NI-DAQmx Terminology
Open-drain	Open collector
Push-pull	Active drive

The default configuration of the NI USB-6501 DIO ports is open collector, allowing 5 V operation, with an onboard 4.7 k $\Omega$  pull-up resistor. An external, user-provided pull-up resistor can be added to increase the source current drive up to a 8.5 mA limit per line, as shown in the following figure.



**Figure 6.** Example of Connecting an External, User-Provided Resistor



Additionally, you can configure the DIO ports as active drive. When configured as active drive, the total current sourced by all DO lines simultaneously should not exceed 65 mA.

## Determining the Pull-Up Resistor Value

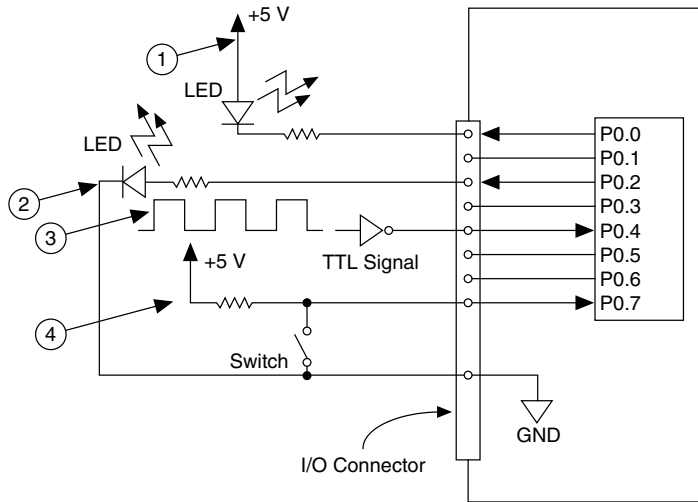
Complete the following steps to determine the value of the user-provided pull-up resistor:

1. Place an ammeter in series with the load
2. Place a variable resistor between the digital output line and the +5 V.
3. Adjust the variable resistor until the ammeter current reads as the intended current. The intended current must be less than 8.5 mA.
4. Remove the ammeter and variable resistor from your circuit.
5. Measure the resistance of the variable resistor. The measured resistance is the ideal value of the pull-up resistor.
6. Select a static resistor value for your pull-up resistor that is greater than or equal to the ideal resistance.
7. Reconnect the load circuit and the pull-up resistor.

## Digital I/O Circuitry

The following figure shows some common examples of connections of DIO lines with standard circuits. In the figure, P0.<0..7> is connected to example signals configured as digital inputs and digital outputs. You can configure P1.<0..7> and P2.<0..7> similarly.

**Figure 7. Example of Connecting a Load**



1. P0.0 configured as an open collector digital output driving an LED
2. P0.2 configured as an active drive digital output driving an LED
3. P0.4 configured as a digital input receiving a TTL signal from a gated inverter
4. P0.7 configured as a digital input receiving a 0 V or 5 V signal from a switch



**Caution** Exceeding the maximum input voltage ratings or maximum output ratings listed in the device specifications can damage the DAQ device and the computer. National Instruments is not liable for any damage resulting from such signal connections.

## I/O Protection

Each DIO signal is protected against overvoltage, undervoltage, and overcurrent conditions, as well as ESD events. However, you should avoid these fault conditions by using 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.
- If you configure a DIO line as an input, do not drive the line with voltages outside of its normal operating range.
- 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.

# 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-up resistor connected to it.

## P2.7/PFI 0 Event Counter

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You can configure P2.7/PFI 0 as the source for a 32-bit counter. In this mode, the device counts high to low transitions on P2.7/PFI 0. The counter can be armed and disarmed and the count can be read or reset through software. Refer to your software documentation for more information about counter programming techniques.

## +5 V Power Source

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The NI USB-6501 supplies a nominal 5 V from two pins, one on each screw terminal block. The voltage source is provided by the USB host. The voltage is nominally 5 V but varies from system to system. Refer to the *NI USB-6501 Device Specifications* for more information about USB bus power specifications. This source can be used to power external components.



**Note** Output is disabled when the device is in USB suspend.



**Caution** When using the 5 V source, understand the current requirements of the load connected. Do not exceed the specified limits of the +5 V output current specification.

## Where to Go from Here

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This section lists where you can find example programs and additional documentation for the NI USB-6501.

### Example Programs

The NI-DAQmx and NI-DAQmx Base software includes examples you can use to get started programming with your device. Examples are also available from [ni.com/support](http://ni.com/support). Modify example code and save it in an application, use examples to develop a new application, or add example code to an existing application.

### NI-DAQmx Example Programs

NI-DAQmx examples are available on the software media and from [ni.com/support](http://ni.com/support). 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.

## NI-DAQmx Base Example Programs

NI-DAQmx Base examples are available on the software media, from [ni.com/support](http://ni.com/support), and are accessible from **Start»All Programs»National Instruments»NI-DAQmx Base»Examples**.

## Related Documentation

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 8.7 or later, NI-DAQmx Base 3.x, and where applicable, version 7.1 or later of the NI application software

Refer to [ni.com/manuals](http://ni.com/manuals) for the most recent documentation.

### NI-DAQmx

The *NI USB-6501 Quick Start* included with the NI USB-6501 describes how to install NI-DAQmx software, install the device, and confirm that your device is operating properly.

The *NI-DAQmx Readme* is available from the Windows Start menu and lists which application software, devices, and ADEs are supported by this version of NI-DAQ.

The *NI-DAQmx Help* is available from the Windows Start menu and contains API overviews, general information about measurement concepts, key NI-DAQmx concepts, and common applications that are applicable to all programming environments.

### NI-DAQmx Base (Linux/Mac OS X/LabVIEW PDA 8.x)

The *Getting Started with NI-DAQmx Base* document describes how to install the NI-DAQmx Base software, the NI-DAQmx Base-supported DAQ device, and how to confirm that the device is operating properly on your Windows, Linux, or Mac machine. In Windows, select **Start»All Programs»National Instruments»NI-DAQmx Base»Documentation»Getting Started with NI-DAQmx Base**.

The *NI-DAQmx Base Readme* lists devices supported in different versions of NI-DAQmx Base. In Windows, select **Start»All Programs»National Instruments»NI-DAQmx Base»DAQmx Base Readme**.

The *NI-DAQmx Base VI Reference Help* contains VI reference and general information about measurement concepts. In LabVIEW, select **Help»NI-DAQmx Base VI Reference Help**.

The *NI-DAQmx Base C Function Reference Help* contains C reference and general information about measurement concepts. In Windows, select **Start»All Programs»National Instruments»NI-DAQmx Base»Documentation»C Function Reference Help**.



**Note** All NI-DAQmx Base documentation for Linux is installed at `/usr/local/natinst/nidaqmxbase/documentation`. All NI-DAQmx Base documentation for Mac OS X is installed at `/Applications/National Instruments/NI-DAQmx Base/documentation`.

## 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:

### LabWindows/CVI

The **Data Acquisition** section of the *LabWindows/CVI Help* contains *Taking an NI-DAQmx Measurement in LabWindows/CVI*, which includes step-by-step instructions for creating a measurement task using the DAQ Assistant. In LabWindows/CVI, select **Help»Contents**, and 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** section 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*.

### 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 in 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 *Developing 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 application in Visual Basic .NET or Visual C#, follow these general steps:

## 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

With the Microsoft .NET Framework version 2.0 or later, you can use NI-DAQmx to create applications using Visual C# and Visual Basic .NET without Measurement Studio. You need Microsoft Visual Studio .NET 2005 or later for the API documentation to be installed.

The installed documentation contains the NI-DAQmx API overview, measurement tasks and concepts, and function reference. This help is fully integrated into the Visual Studio documentation. To view the NI-DAQmx .NET documentation, go to **Start»All Programs»National Instruments»NI-DAQ»Text-Based Code Support**. For 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.

To get to the same help topics from within Visual Studio 2005 or 2008, go to **Help»Contents** and select **Measurement Studio** from the **Filtered By** drop-down list. To get to the same help topics from within Visual Studio 2010, go to **Help»View Help** and select **NI Measurement Studio Help** from the **Related Links** section.

## 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](http://ni.com/training).

## Worldwide Support and Services

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The National Instruments website is your complete resource for technical support. At [ni.com/support](http://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.

Visit [ni.com/services](https://ni.com/services) for NI Factory Installation Services, repairs, extended warranty, and other services.

Visit [ni.com/register](https://ni.com/register) to register your National Instruments product. Product registration facilitates technical support and ensures that you receive important information updates from NI.

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