PXIe-4311 User Manual

2026-08-07

Contents

PXIe-4311 User Manual

The PXIe-4311 User Manual provides detailed descriptions of the product functionality and the step by step processes for use.

Looking for Something Else?

For information not found in the User Manual for your product, such as specifications and API reference, browse *Related Information*.

Related information:

- PXIe-4311 Specifications
- Field Wiring and Noise Considerations for Analog Signals
- NI-DAQmx User Manual
- NI-DAQmx C Reference
- NI-DAQmx VI and Function Reference
- NI-DAQmx .NET Framework 4.0 API Reference
- NI-DAQmx .NET Framework 4.5 API Reference
- NI-DAQmx Properties
- NI-DAQmx Python Reference
- NI-DAQmx and LabVIEW Compatibility
- LabVIEW User Manual
- Software and Driver Downloads
- NI DSA, SC Express and DAQ Firmware Version Information and Download
- Release Notes
- License Setup and Activation
- Dimensional Drawings
- Product Certifications
- Letter of Volatility
- Discussion Forums
- NI Learning Center
- NI Support

PXIe-4311 Overview

The PXIe-4311 is a 32-channel, high-speed analog input module designed for precision voltage measurements across a 0 V to 25 V input range. It features flexible resolution from 16 to 22 bits, allowing users to optimize for either speed or accuracy, depending on their application needs. The module supports simultaneous sampling on all channels at rates up to 4 MS/s. The PXIe-4311 is ideal for applications requiring scalable, high-resolution data acquisition across a wide dynamic range.

Key Features

The PXIe-4311 has the following features and capabilities:

- 32 high-speed analog input channels
- 4.0 MS/s/ch maximum input sampling rate, simultaneous
- Measurement resolution: 16-bit to 22-bit
- Voltage ranges: 0 V to 25 V, 0 V to 6 V, ±150 mV
- 16 calculated power channels
- Digital triggering
- Lowpass filtering
- Overvoltage protection

PXIe-4311 Driver Support

Determine the earliest driver version supported for your product.

Tip To optimize product performance, update to the most recent driver version.

Table 1. PXIe-4311 Earliest Driver Version Support

Driver Name	Earliest Version Support
NI-DAQmx	2026 Q2.1

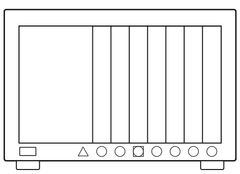
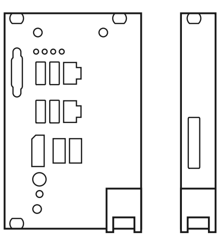
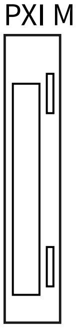
Note Only NI-DAQmx 2026 Q3 and later supports automatic detection of compatible accessories, terminal blocks, and PFI lines.

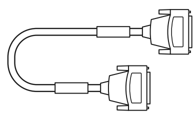
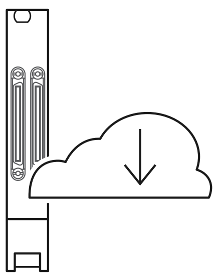
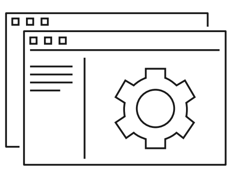
Components of a PXIe-4311 System

PXIe-4311 is designed for use in a system that might require hardware, drivers, and software to optimize PXIe-4311 for your application. Use the minimum required PXIe-4311 system components as a starting point for building your system.

Note A system and the surrounding environment must meet any requirements defined in *PXIe-4311 Specifications*.

Table 2. Minimum Required PXIe-4311 System Components

Component	Description and Recommendations
PXI Chassis 	A PXI chassis houses the PXIe-4311 and supplies power, communication, and timing for PXIe-4311 functions.
PXI Controller or PXI Remote Control Module 	You can install a PXI controller or a PXI remote control (MXI) module depending on your system requirements. These components, installed in the same PXI chassis as the PXIe-4311, interface with the instrument using NI device drivers.
PXI Module 	Your PXI analog input module.

Component	Description and Recommendations
Cables and Accessories 	Cables and accessories allow connectivity to/from your instrument for measurements. Refer to *Part Numbers for Recommended Cables and Accessories* for recommended cables and accessories and guidance.
NI-DAQmx 	Device driver software that provides functions to interact with the PXIe-4311 and execute measurements using the PXIe-4311. **Note** NI recommends always using the most current version of NI-DAQmx with the PXIe-4311. You can find the NI-DAQmx driver requirements in the *NI-DAQmx Release Notes*.
NI Applications 	NI-DAQmx offers driver support for the following applications: • LabVIEW • LabVIEW Real-Time Module • FlexLogger • LabWindows/CVI • LabWindows/CVI Real-Time Module • NI-DAQmx Measurement Studio Integration (Measurement Studio 2019) • ANSI C • .NET • Python

Related reference:

- Part Numbers for Recommended Cables and Accessories
- PXIe-4311 Driver Support

Part Numbers for Recommended Cables and Accessories

Purchase the cables and the accessories that optimize the performance of PXIe-4311.

Notice For compliance with Electromagnetic Compatibility (EMC) requirements, operate the PXIe-4311 with shielded cables and accessories. If unshielded cables or accessories are used, the EMC specifications are no longer guaranteed unless all unshielded cables and/or accessories are installed in a shielded enclosure with properly designed and shielded input/output ports.

Table 3. Bundle A — Part Numbers for Recommended Cables and Accessories

Accessories and Cables	Part Number	Quantity
TB-4309 (ST) Screw Terminal Block	784956-01	1
Twisted Pair Cable	—	—

Note For more information on these cables and accessories, refer to the following documentation.

- *Connecting Signals to the TB-4309 (ST) Terminal Block*
- *TB-4309 Terminal Block Pinouts*

Table 4. Bundle B — Part Numbers for Recommended Cables and Accessories

Accessories and Cables	Part Number	Quantity
TB-4309 (MT) VHDCI Terminal Block	784957-01	1
SHC68-C68-EPM Shielded Cable, 68 pin VHDCI to 68 pin VHDCI	190233-0R5/01/02	4

Note For more information on these cables and accessories, refer to *Connecting Signals to the TB-4309 (MT) Terminal Block*.

Table 5. Bundle C — Part Numbers for Recommended Cables and Accessories

Accessories and Cables	Part Number	Quantity
TB-4309 (MT) VHDCI Terminal Block	784957-01	1
SHC68-68-EPM Shielded Cable, 68 D-Type to 68 VHDCI Offset	192061-0R5/01/02	4
SCB-68A Noise Rejecting, Shielded I/O Connector Block	782536-01	4

Note For more information on these cables and accessories, refer to the following documentation.

- *Connecting Signals to the TB-4309 (MT) Terminal Block*
- *NI 43xx Pinout Labels for the SCB-68 Note to Users*

- *SCB-68 and SCB-68A : DAQ Multifunction I/O Accessory Guide*

Table 6. Part Numbers for Additional Recommended Accessories

Accessories and Cables	Part Number	Quantity
68-Connector (Plug) Position Offset IDC Cable, 0.8mm	—	—
PXI slot blockers	199198-01	5
Ferrite	782803-01	—

Note For more information on these cables and accessories, refer to the following documentation.

- *NI DAQ Device Custom Cables, Replacement Connectors, and Screws*
- *ni.com/r/pxiblocker*
- *Ferrite Installation*

Related concepts:

- Installing Noise Suppression Ferrites

Related tasks:

- Connecting Signals to the TB-4309 (ST) Terminal Block
- Connecting Signals to the TB-4309 (MT) Terminal Block

Related reference:

- TB-4309 Terminal Block Pinouts

Related information:

- Installing Filler Panels and Slot Blockers
- NI DAQ Device Custom Cables, Replacement Connectors, and Screws
- NI 43xx Pinout Labels for the SCB-68 Note to Users
- SCB-68 and SCB-68A : DAQ Multifunction I/O Accessory Guide
- NI DAQ Device Custom Cables, Replacement Connectors, and Screws

Programming Options

You can communicate with and control the PXIe-4311 using the NI-DAQmx instrument driver to program your device in the supported ADE of your choice.

- **NI-DAQmx Driver** —The NI-DAQmx driver includes a library of functions and VIs you can call from your application software to program your module.
  - LabVIEW or LabWindows/CVI—Available on the LabVIEW Functions palette at **Measurement I/O » NI DAQmx**. Examples are available from the **Start** menu in the **National Instruments** folder.
  - ANSI C—Examples are available from the `Users\Public\Documents\National Instruments\NI-DAQ\Examples` folder. Refer to the NI-DAQmx topic *ANSI C Application without LabWindows/CVI* for instructions to manually add all required include and library files to your project.
- **NI-DAQmx Package for Python**—The `nidaqmx` package allows you to develop instrumentation, acquisition, and control applications with NI data acquisition (DAQ) devices in Python. For more information, refer to the online *NI-DAQmx Python Documentation*.

Related information:

- NI-DAQmx Python Documentation
- ANSI C Application without LabWindows/CVI
- Measurement Studio with Visual C++, Visual C#, or Visual Basic .NET

PXIe-4311 Block Diagram

Block diagrams describe the hardware architecture of your instrument and the paths that signals take through components of the instrument.

Figure 1. PXIe-4311 Block Diagram

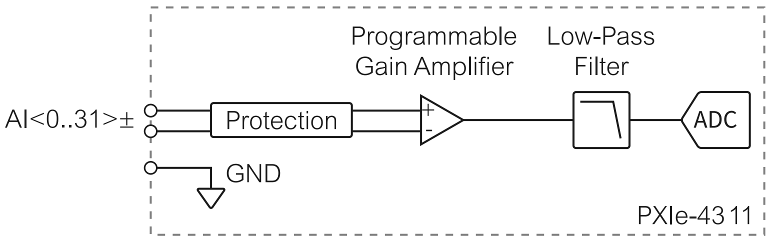
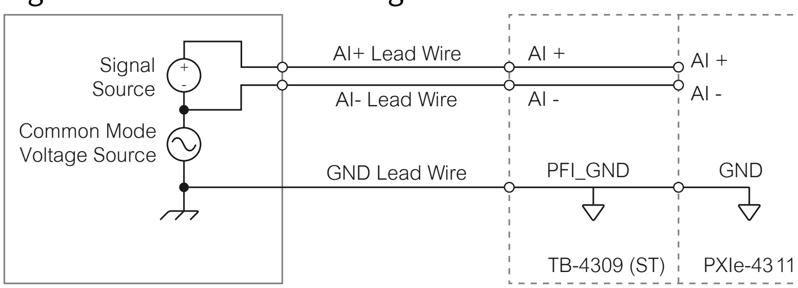


Figure 2. PXIe-4311 Block Diagram with the TB-4309 Terminal Block



Finding Examples for the PXIe-4311

NI-DAQmx includes several example applications that demonstrate the functionality of your device and can serve as interactive tools, programming models, and building blocks for your own applications. Access examples depending on your programming environment and the driver APIs you use to control your device.

Related concepts:

- Calculated Power Channels

NI Example Finder

The NI Example Finder is a utility that organizes examples into categories and allows you to browse and search installed examples. For example, search for "`DAQmx`" to locate all NI multifunction DAQ examples. You can see descriptions and compatible hardware models for each example or see all the examples compatible with one particular hardware model.

To locate examples using the NI Example Finder within LabVIEW or LabWindows/CVI, select **Help » Find Examples** and navigate to **Hardware Input and Output » DAQmx**.

Installed Example Locations

The installation location for NI-DAQmx example programs differs by programming language and development environment. Refer to the following table for information about example program installation locations.

Table 7. Installed NI-DAQmx Example Locations

Software Application	Installed Example Locations
LabVIEW	**Help » Find Examples**
LabWindows/CVI	`C:\Users\Public\Documents\National Instruments\CVI\Samples\DAQmx`
SignalExpress	`Program Files\National Instruments\SignalExpress\Examples`

Software Application	Installed Example Locations
ANSI C	`Users\Public\Public Documents\National Instruments\NI-DAQ\Examples\DAQmx ANSI C.`
.NET 4.0	`Users\Public\Public Documents\National Instruments\NI-DAQ\Examples\DotNET 4.0`
.NET 4.5	`Users\Public\Public Documents\National Instruments\NI-DAQ\Examples\DotNET 4.5`

Common Example Programs

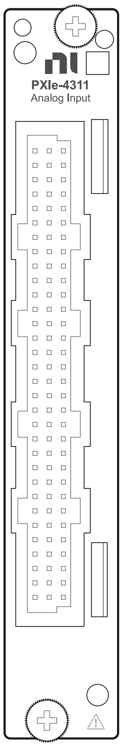
The following NI-DAQmx example programs demonstrate common functions and operations.

The PXIe-4311 uses the NI-DAQmx driver. NI-DAQmx includes a collection of programming examples to help you get started developing an application. You can modify example code and save it in an application. You can use examples to develop a new application or add example code to an existing application.

- **Analog Input Example Programs**—Demonstrates how to acquire analog measurements. Options include continuous or finite acquisitions, software or hardware timing, and simultaneous sampling. You can perform analog input applications through DMA or programmed I/O data transfer mechanisms. Some of the applications also use start and reference pause triggers.
- **Synchronization Example Programs**—Demonstrates how to continuously acquire data. Options include acquiring buffered voltage and thermocouple measurements in a single task, and acquiring waveform data from two modules.
- **Calculated Power Example Programs**—Demonstrates how to acquire calculated power measurements. Options include continuous and finite acquisitions.

PXIe-4311 Front Panel

Figure 3. PXIe-4311 Front Panel



Related reference:

- PXIe-4311 Pinout
- TB-4309 Terminal Block Pinouts

PXIe-4311 Pinout

The following figure shows the terminals on the PXIe-4311 I/O connector.

Figure 4. PXIe-4311 Connector Pinout

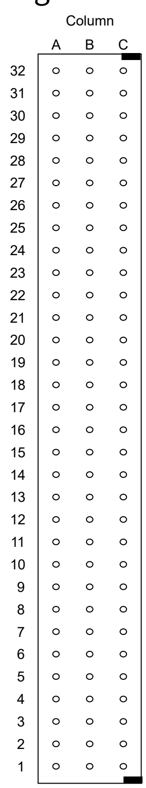


Table 8. Connector Signal Pin Assignments

Row Number	Column A	Column B	Column C
32	GND	AI16+	AI0+
31	AI8+	AI16-	AI0-
30	AI8-	AI24-	AI24+
29	GND	AI20+	AI4+
28	AI12+	AI20-	AI4-
27	AI12-	AI28-	AI28+
26	GND	AI21+	AI5+
25	AI13+	AI21-	AI5-

Row Number	Column A	Column B	Column C
24	AI13-	AI29-	AI29+
23	GND	AI17+	AI1+
22	AI9+	AI17-	AI1-
21	AI9-	AI25-	AI25+
20	GND	NC	NC
19	NC	NC	NC
18	GND	NC	NC
17	GND	AI18+	AI2+
16	AI10+	AI18-	AI2-
15	AI10-	AI26-	AI26+
14	GND	AI22+	AI6+
13	AI14+	AI22-	AI6-
12	AI14-	AI30-	AI30+
11	GND	AI23+	AI7+
10	AI15+	AI23-	AI7-
9	AI15-	AI31-	AI31+
8	GND	AI19+	AI3+
7	AI11+	AI19-	AI3-
6	AI11-	AI27-	AI27+
5	PFI GND	PFI0	PFI1
4	NC	GND	GND
3	NC	NC	NC
2	RSVD	RSVD	RSVD
1	RSVD	RSVD	RSVD

Table 9. Signal Descriptions

Signal	Description
AI<0..31>+	Positive inputs of differential analog input channels 0 to 31.
AI<0..31>–	Negative inputs of differential analog input channels 0 to 31.
PFI <0..1>	Programmable Function Interface I/O channels 0 and 1. Configurable 5.0 V tolerant digital input or 3.3 V digital output for sending or receiving trigger and synchronization signals. PFI lines are referenced to PFI GND.
PFI GND	Digital ground reference for PFI lines. The TB-4309 only has PFI_GND to serve as the ground pin. You may use PFI_GND as the signal ground reference between two systems.
GND	Ground
RSVD	Reserved for communication with the accessory.
NC	No connection

Note When using the TB-4309 (ST) screw terminal variant, you must connect the PFI_GND pin as the signal ground reference for all AI+ and AI− connections. This is a requirement because the TB-4309 (ST) does not expose the dedicated ground terminals. This requirement does not impact the safety of the system. PFI_GND and GND are internally common in the PXIe-4311.

The PXIe-4311 automatically detects compatible accessories or terminal blocks. The RSVD pins on the I/O connector provide power to the accessories and digital communication lines. This allows software to detect when accessories are inserted or removed. In addition, software automatically identifies the specific terminal block as well as accesses any calibration or scaling information associated with the terminal block.

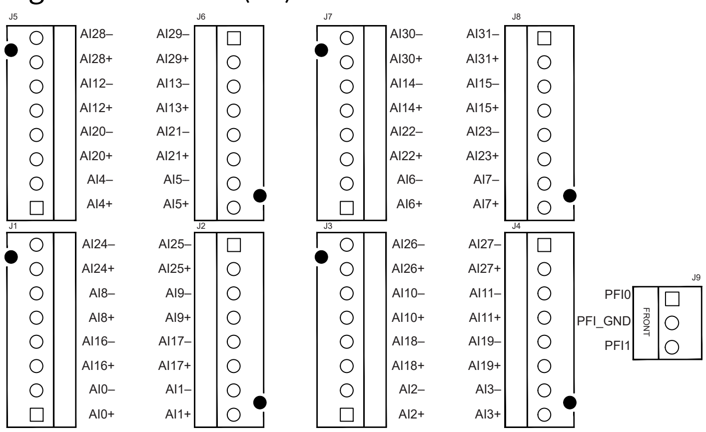
> **Note** Only NI-DAQmx 2026 Q3 and later supports automatic detection of compatible accessories, terminal blocks, and PFI lines.

TB-4309 Terminal Block Pinouts

> **Note** Pin descriptions and signal mappings to the PXIe-4311 front panel I/O connectors are listed in *PXIe-4311 Pinout*.

TB-4309 (ST) Screw Terminal Connectors

Figure 5. TB-4309 (ST) Pinouts



TB-4309 (MT) VHDCI Terminal Connectors

Figure 6. TB-4309 (MT) Connector 0 and 2 Pinout

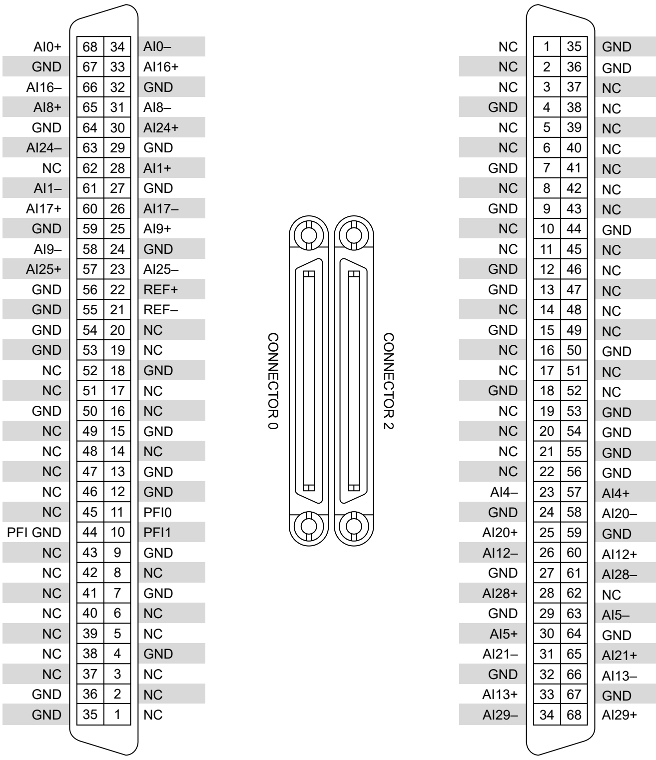
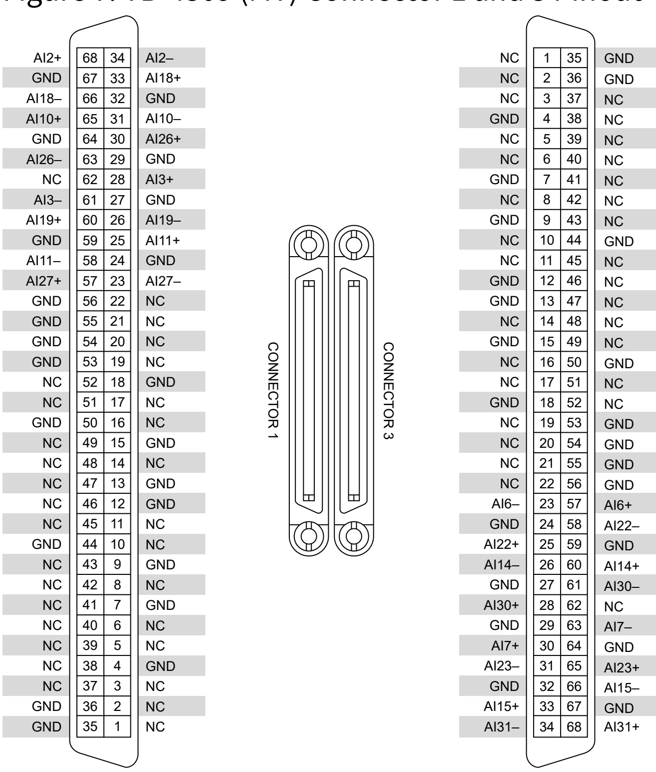


Figure 7. TB-4309 (MT) Connector 1 and 3 Pinout



Grounding

The PXIe 4311 is a non-isolated module. The module GND connects to the PXI chassis ground. Meanwhile, the chassis ground connects to the earth ground through the system.

When setting up a ground connection, NI recommends the following guidelines.

- Never leave a GND floating.
- Always connect the GND to your signal source ground reference.
- On the TB-4309 (ST), use the PFI_GND as the GND.

> **Note** For more information on grounding, shielding, and guard guidance, refer to the *Common Mode Voltage* section of the PXIe-4311 User Manual.

Related concepts:

- Common Mode Voltage

Related reference:

- PXIe-4311 Pinout
- Part Numbers for Recommended Cables and Accessories

PXIe-4311 Kit Contents

Identify the contents of the PXIe-4311 kit.

1. PXIe-4311 Module
2. *PXIe-4311 Safety, Environmental, and Regulatory Information*

PXIe-4311 Safety Guidelines

Follow these guidelines to use the PXIe-4311 safely.

> **Notice** For comprehensive safety information, refer to the safety, environmental, and regulatory information document that shipped with your hardware.

> **Caution** Observe all instructions and cautions in the user documentation. Using the product in a manner not specified can damage the product and compromise the built-in safety protection.

Product Certifications and Declarations

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for NI products, visit `ni.com/product-certifications`, search by model number, and click the appropriate link.

Related information:

- Product Certifications

PXIe-4311 Safety Voltages

Table 10. Rated Voltages

AI+, AI− to GND	+25 V DC, −2 V DC
AI+ to AI−	+25 V DC, −2 V DC
PFI to GND	0 to +5 V DC

Caution Any external sources must be limited to not exceed these maximum rated voltages.

Table 11. Overvoltage Protection

AI+, AI− to GND, device on	+60 V DC, −34 V DC
AI+, AI− to GND, device off	±30 V DC
AI+ to AI−	±30 V DC
PFI to GND	±30 V DC

Caution Voltages beyond these levels might cause permanent damage.

Table 12. Current Ratings

PFI maximum continuous current, per channel	30 mA

Setting up the PXIe-4311

Install the PXIe-4311 into a chassis and prepare it for use.

1. Unpacking the Kit
   Take precautions to prevent electrostatic discharge when unpacking and inspecting your hardware.
2. Installing the Software
   You must be an Administrator to install NI software on your computer.
3. Installing the Hardware
   To install the hardware, install the PXIe-4311 module in the chassis first, connect your signals to the terminal block, then attach the TB-4309 terminal block to the PXIe-4311 module.
4. Verifying the Installation
   Before using the PXIe-4311, verify that it is installed correctly through Hardware Configuration Utility or Measurement & Automation Explorer (MAX).

Unpacking the Kit

Take precautions to prevent electrostatic discharge when unpacking and inspecting your hardware.

> **Notice** To prevent electrostatic discharge (ESD) from damaging the device, ground yourself using a grounding strap or by holding a grounded object, such as your computer chassis.

1. Touch the antistatic package to a metal part of the computer chassis.
2. Remove the device from the package and inspect the device for loose components or any other sign of damage.

   > **Notice** Never touch the exposed pins of connectors.

   > **Note** Do not install a device if it appears damaged in any way.

3. Unpack any other items and documentation from the kit.

> **Note** Store the device in the antistatic package when the device is not in use.

Installing the Software

You must be an Administrator to install NI software on your computer.

1. Install an ADE, such as LabVIEW or LabWindows™/CVI™.
2. Download the driver software installer from `ni.com/downloads`.
   Package Manager downloads with the driver software to handle the installation. Refer to the *Package Manager User Manual* for more information about installing, removing, and upgrading NI software using Package Manager.
3. Follow the instructions in the installation prompts.

   > **Note** Windows users may see access and security messages during installation. Accept the prompts to complete the installation.

4. When the installer completes, select **Restart** in the dialog box that prompts you to restart, shut down, or restart later.

Related concepts:

- Programming Options

Related reference:

- PXIe-4311 Driver Support

Installing the Hardware

To install the hardware, install the PXIe-4311 module in the chassis first, connect your signals to the terminal block, then attach the TB-4309 terminal block to the PXIe-4311 module.

1. Installing the PXIe-4311 into a Chassis
   Install the PXI Express module in a supported chassis slot while ensuring ESD

protection, backplane integrity, and proper forced-air cooling.
2. Connecting Signals
Connect the PXIe-4311 with up to 32 differential analog input channels and two Programmable Function Interface (PFI) terminals.
3. Installing the TB-4309 Terminal Block
Install the terminal block on the device module to provide a secure, keyed electrical connection for compatible terminal blocks and cables.

Installing the PXIe-4311 into a Chassis

Install the PXI Express module in a supported chassis slot while ensuring ESD protection, backplane integrity, and proper forced-air cooling.

> **Notice** To prevent damage to the PXIe-4311 caused by ESD or contamination, handle the module using the edges or the metal bracket.

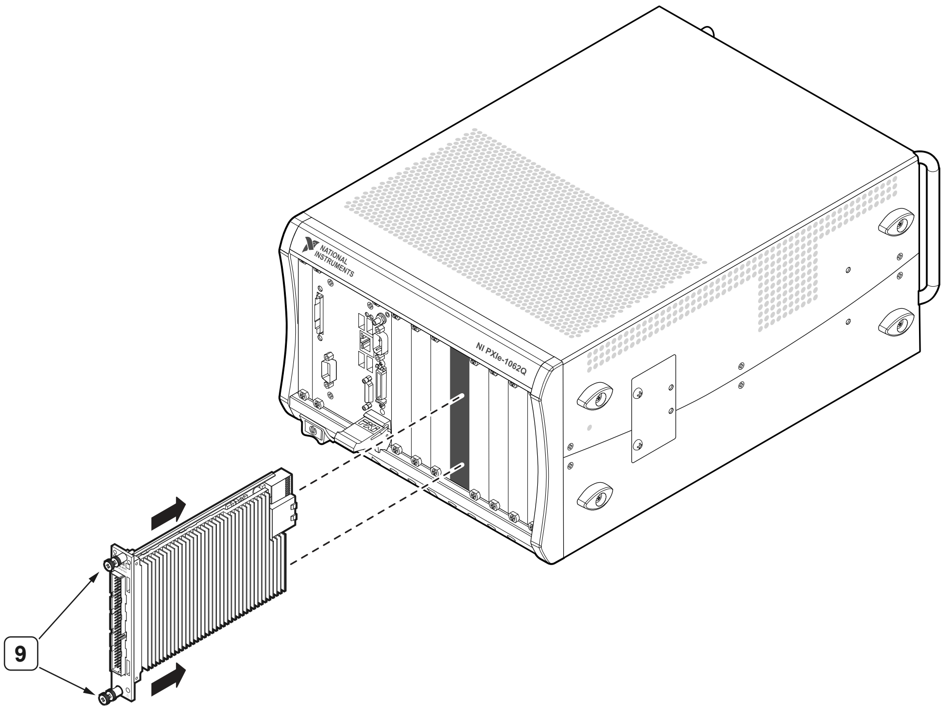
> **Note** To maintain forced air cooling in the PXI Express system, refer to *Maintaining Forced-Air Cooling*.

1. Ensure the AC power source is connected to the chassis before installing the module.
The AC power cord grounds the chassis and protects it from electrical damage while you install the module.
2. Power off the chassis.
3. Touch any metal part of the chassis to discharge static electricity.
4. Inspect the slot pins on the chassis backplane for any bends or damage prior to installation. Do not install a module if the backplane is damaged.
5. Position the chassis so that inlet and outlet vents are not obstructed.
For more information about optimal chassis positioning, refer to the chassis documentation.
6. Remove the black plastic covers from all the captive screws on the module front panel.
7. Identify a supported slot in the chassis. The PXIe-4311 module can be placed in PXI Express hybrid peripheral slots (●H), PXI Express system timing slots (●), or PXI Express peripheral slots (●).

If you plan to use an optional Timing and Synchronization Module, reserve the PXI Express system timing slots for its placement in the chassis.

8. Place the module edges into the module guides at the top and bottom of the chassis. Slide the module into the slot until it is fully inserted.

Figure 8. Module Installation



9. Secure the module front panel to the chassis using the front-panel mounting screws.

> **Note** Tightening the top and bottom mounting screws increases mechanical stability and also electrically connects the front panel to the chassis, which might improve the signal quality and electromagnetic performance.

10. Cover all empty slots using either filler panels (standard or EMC) or slot blockers with filler panels, depending on your application.

> **Note** For more information about installing slot blockers and filler panels, refer to *ni.com/r/pxiblocker*.

11. Power on the chassis.

Related information:

- Maintaining Forced-Air Cooling

Connecting Signals

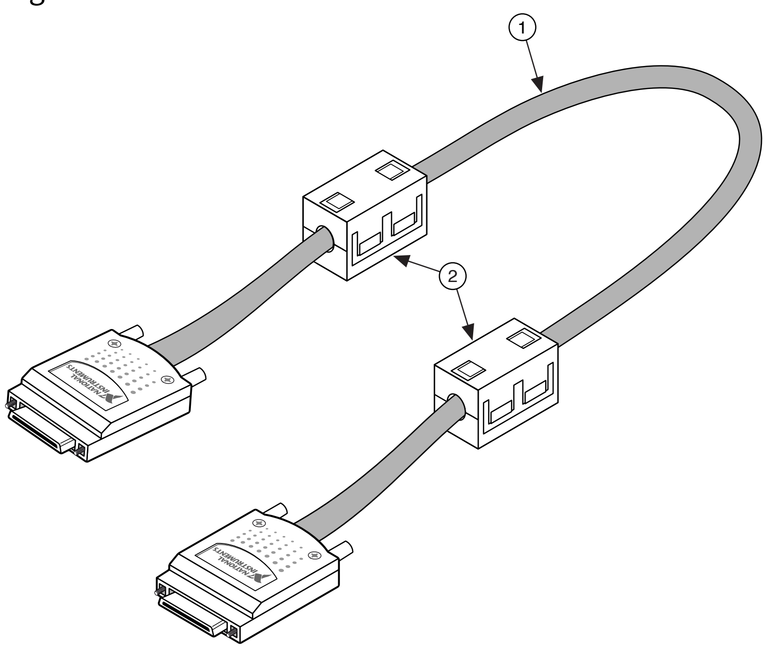
Connect the PXIe-4311 with up to 32 differential analog input channels and two Programmable Function Interface (PFI) terminals.

Use the TB-4309 terminal block to measure voltage. This terminal block is available with screw terminals (TB-4309 (ST)) or VHDCI terminals (TB-4309 (MT)).

Installing Noise Suppression Ferrites

For each connected I/O cable, install two snap-on ferrites (782803-01). Install the ferrites at each end of the cable, as close to the connector as practical.

Figure 9. Ferrite Installation



1. I/O Cable
2. Ferrites

The ferrites (782803-01) can be installed on the following recommended cables:

- SHC68-C68-EPM Cable, 0.5 m (190233-0R5)
- SHC68-C68-EPM Cable, 1 m (190233-01)

- SHC68-C68-EPM Cable, 2 m (190233-02)

Related reference:

- Part Numbers for Recommended Cables and Accessories

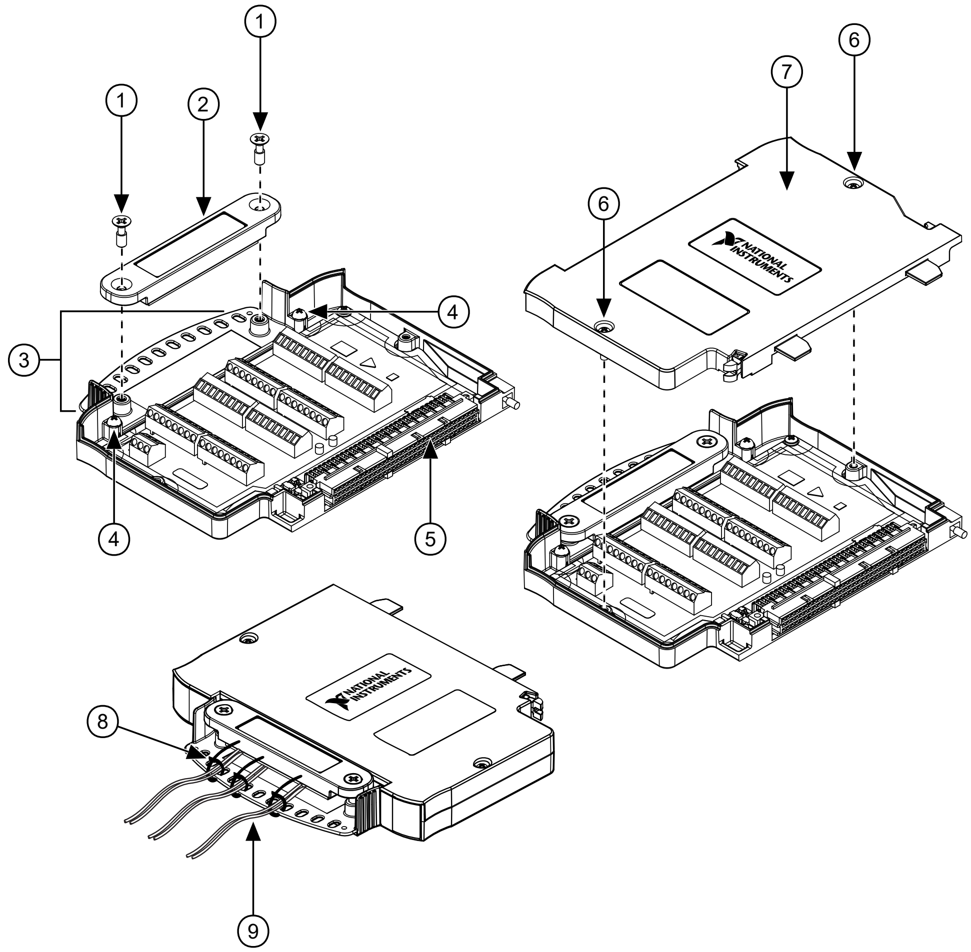
Connecting Signals to the TB-4309 (ST) Terminal Block

> **Note** You can use Measurement & Automation Explorer (MAX) to find the pinout names and locations by right-clicking the device name under **Devices and Interfaces** and selecting **Device Pinouts**.

Use shielded signal wire to connect signals to the TB-4309 (ST) terminal block.

1. Loosen the captive top cover screws and remove the top cover.
2. Loosen the captive strain-relief screws and remove the strain-relief bar.
3. Prepare the shielded signal wire by stripping the insulation no more than 7 mm (0.28 in.).
4. Run the shielded signal wires through the strain-relief opening.

Figure 10. TB-4309 (ST) Parts Locator Diagram



1. Captive Strain-Relief Screw
2. Strain-Relief Bar
3. Tie Wrap Holes
4. Chassis Ground Screw
5. Terminal Block to Module Connector
6. Captive Top Cover Screw
7. Top Cover
8. Tie Wraps
9. Shielded Signal Wires

> **Notice** Make sure no exposed wire extends past the screw terminal. Exposed wire increases the risk of a short circuit that can cause circuit failure.

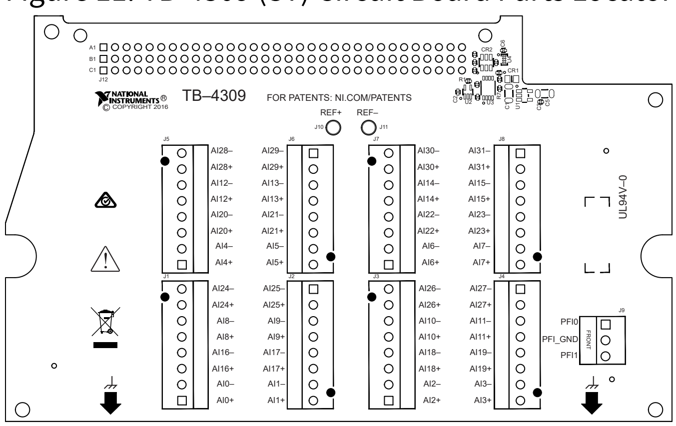
5. Insert the stripped end of the shielded signal wires into the appropriate terminal. Refer to the label next to each screw terminal to determine its function.

6. Tighten the mounting screws to a torque of 0.2 N · m to 0.25 N · m (1.77 lb · in. to 2.21 lb · in.).

> **Notice** Ensure that any wires connected to ground are sufficiently insulated from any voltage present.

7. Attach a ring terminal to the signal-wire shielding and secure the ring terminal using one of the chassis ground screws.
8. Reinstall the strain-relief bar and tighten the captive strain-relief screws.
9. Use tie wraps to connect the shielded signal wires to the tie-wrap holes for additional strain relief when necessary.
10. Reinstall the top cover and tighten the captive top cover screws.

Figure 11. TB-4309 (ST) Circuit Board Parts Locator Diagram



Related concepts:

- Shielding

Related reference:

- TB-4309 Terminal Block Pinouts
- Part Numbers for Recommended Cables and Accessories

Connecting Signals to the TB-4309 (MT) Terminal Block

Connect signals to the TB-4309 (MT) terminal block with a 68-pin cable with VHDCI connector and breakout accessory.

> **Note** Recommended accessories are the SHC68-68-EPM cable and SCB-68A terminal block.

Related reference:

- TB-4309 Terminal Block Pinouts
- Part Numbers for Recommended Cables and Accessories

Related information:

- NI 43xx Pinout Labels for the SCB-68 Note to Users
- SCB-68 and SCB-68A : DAQ Multifunction I/O Accessory Guide

Connecting to PFI Signals

The PXIe-4311 provides two Programmable Function Interface (PFI) signals.

PFI connections are referenced to PFI GND. You can configure each PFI terminal to send or receive a trigger or synchronization signal.

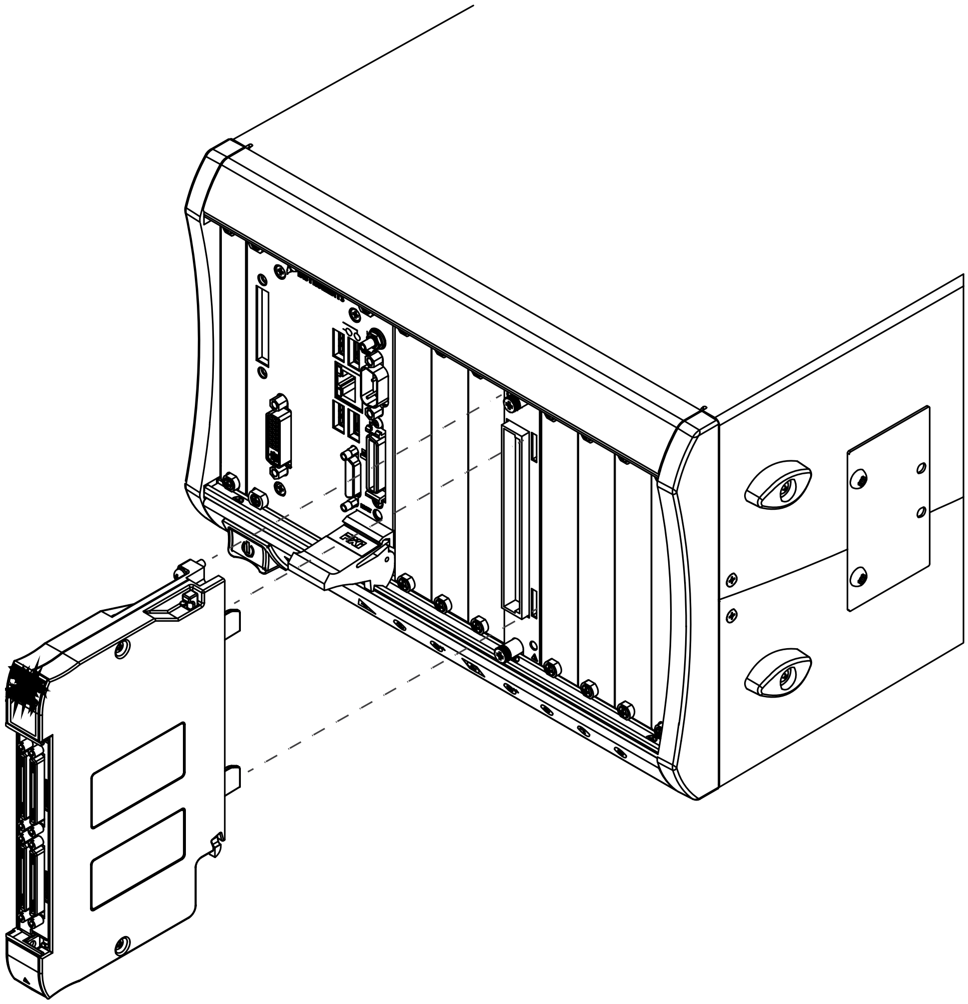
Installing the TB-4309 Terminal Block

Install the terminal block on the device module to provide a secure, keyed electrical connection for compatible terminal blocks and cables.

1. Remove the protective plastic cover from the TB-4309 terminal block mounting screw.
2. Move the terminal block in front of the PXIe-4311 and engage the alignment feature at the rear of the terminal block.

   > **Notice** For safety purposes and to prevent damage to equipment, all PXIe-4311 modules and TB-4309 (ST)/TB-4309 (MT) terminal blocks are keyed to prevent connection between incompatible terminal blocks, modules, and/or cables.

Figure 12. Aligning the TB-4309 Terminal Block, TB-4309 (ST) Shown



3. Push the TB-4309 terminal block straight into the PXIe-4311. A spring mechanism locks in the bottom of the terminal block.
4. Tighten the mounting screw at the top of the terminal block to secure it to the PXIe-4311.
5. Power on the chassis.

Verifying the Installation

Before using the PXIe-4311, verify that it is installed correctly through Hardware Configuration Utility or Measurement & Automation Explorer (MAX).

Verifying the Installation Using Hardware Configuration Utility

Before using the PXIe-4311, verify that it is installed correctly through Hardware

Configuration Utility.

1. Verifying the Installation in Hardware Configuration Utility
   NI recommends using Hardware Configuration Utility to perform and to validate initial hardware configuration.
2. Self-Calibrating the PXIe-4311 in Hardware Configuration Utility
   Performing self-calibration adjusts the PXIe-4311 for variations in the environment. The PXIe-4311 devices are externally calibrated at the factory. However you should perform a complete self-calibration after installation.

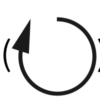
Verifying the Installation in Hardware Configuration Utility

NI recommends using Hardware Configuration Utility to perform and to validate initial hardware configuration.

1. Open Hardware Configuration Utility.
   The PXIe-4311 appears in the system pane automatically.
2. Record the name that Hardware Configuration Utility assigns to the PXIe-4311 or provide a custom name.
   Use this name when programming the PXIe-4311.
3. Validate that your instrument is installed correctly: select the PXIe-4311 module in the system pane, expand the **Troubleshooting** area of the configuration pane, and click **Self-test**.
   Hardware Configuration Utility reports when it has validated the hardware setup.

What Should I Do If the PXIe-4311 Does Not Appear in Hardware Configuration Utility?

Check if you must refresh the connection between the hardware and the software in Hardware Configuration Utility.

1. Click the refresh button ().
2. If the PXIe-4311 is still not listed, complete the following steps.
   a. Power off the system.
   b. Ensure that all hardware is correctly installed.
   c. Restart the system.
3. Right-click the **Start** button and select **Device Manager**.

4. Depending on your controller type, verify the Device Manager settings.

Controller type	Description
PXI controller	a. Verify that a **National Instruments** entry appears in the system device list. b. If error conditions appear in the list, right-click the module you are using in the **Device Manager** and select **Update Driver**.
MXI controller	a. Right-click **PCI-to-PCI Bridge** and select **Properties**. b. Verify that you enabled the bridge. c. Verify that no error conditions appear.

   If error conditions persist, reinstall the driver.
5. Restart your computer.

What Should I Do If the PXIe-4311 Fails the Self-Test in Hardware Configuration Utility?

1. Reset the PXIe-4311 through Hardware Configuration Utility and then perform the self-test again.
2. Restart the system, and then perform the self-test again.
3. Power off the chassis.
4. Reinstall the failed module in a different slot.
5. Power on the chassis.
6. Perform the self-test again.

> **Note** If the module fails the self-test again, contact NI or visit ni.com/support for further troubleshooting information.

Self-Calibrating the PXIe-4311 in Hardware Configuration Utility

Performing self-calibration adjusts the PXIe-4311 for variations in the environment. The PXIe-4311 devices are externally calibrated at the factory. However you should perform a complete self-calibration after installation.

1. Install the PXIe-4311 and let the device warm up for the recommended amount of

time listed in the *PXIe-4311 Specifications*.
2. Self-calibrate the PXIe-4311 in Hardware Configuration Utility by selecting the PXIe-4311 and clicking **Self-Calibrate**.

Verifying the Installation Using Measurement & Automation Explorer (MAX)

Before using the PXIe-4311, verify that it is installed correctly through MAX.

1. Verifying the Installation in MAX
   To configure your NI hardware, use Measurement & Automation Explorer (MAX).
2. Self-Calibrating the PXIe-4311 in MAX

Verifying the Installation in MAX

To configure your NI hardware, use Measurement & Automation Explorer (MAX).

MAX informs other programs about the NI hardware products in the system and their hardware configuration. MAX is automatically installed with the driver.

> **Note** MAX is not available on Linux.

1. Launch MAX.
2. In the configuration tree, expand **Devices and Interfaces** to see the list of installed NI hardware.
   Installed modules appear under the name of their associated chassis.
3. Expand your **Chassis** tree item.
   MAX lists all modules installed in the chassis. Your default names might vary.

   > **Note** If you do not see your module in the list, press <F5> to refresh the list of installed modules. If the module is still not listed, power off the system, ensure that the module is correctly installed, and restart.

4. Record the name MAX assigns to the hardware. Use this identifier when programming the PXIe-4311.
5. Self-test the hardware by selecting the item in the configuration tree and clicking

Self-Test in the MAX toolbar.
The MAX self-test performs a basic verification of hardware resources.

What Should I Do If the PXIe-4311 Does Not Appear in MAX?

Check if you must refresh the connection between the hardware and the software in MAX.

1. In the MAX configuration tree, expand **Devices and Interfaces**.
2. To see the list of installed hardware, expand the **Chassis** tree and press **<F5>** to refresh the list.
3. If the PXIe-4311 is still not listed, complete the following steps.
   a. Power off the system.
   b. Ensure that all hardware is correctly installed.
   c. Restart the system.
4. Right-click the **Start** button and select **Device Manager**.
5. Depending on your controller type, verify the Device Manager settings.

Controller type	Description
PXI controller	a. Verify that a **National Instruments** entry appears in the system device list. b. If error conditions appear in the list, right-click the module you are using in the **Device Manager** and select **Update Driver**.
MXI controller	a. Right-click **PCI-to-PCI Bridge** and select **Properties**. b. Verify that you enabled the bridge. c. Verify that no error conditions appear.

   If error conditions persist, reinstall the driver.
6. Restart your computer.

What Should I Do If the PXIe-4311 Fails the Self-Test in MAX?

1. Reset the PXIe-4311 through MAX and then perform the self-test again.
2. Restart the system, and then perform the self-test again.
3. Power off the chassis.

4. Reinstall the failed module in a different slot.
5. Power on the chassis.
6. Perform the self-test again.

> **Note** If the module fails the self-test again, contact NI or visit ni.com/support for further troubleshooting information.

Self-Calibrating the PXIe-4311 in MAX

Self-calibration adjusts the PXIe-4311 for variations in the module environment. The PXIe-4311 is externally calibrated at the factory, however you should perform a complete self-calibration after you install the module and whenever the ambient temperature changes.

1. Install the PXIe-4311 and let it warm up for the recommended warm-up time listed in the *PXIe-4311 Specifications*.

   > **Note** Warm up begins when the PXI chassis has been powered on and the operating system has completely loaded.

   > **Note** Remove all sensors and accessories from the PXIe-4311 before self-calibrating.

2. Launch MAX.
3. Click the **Self-Calibrate** button in the upper right corner of MAX.
4. Right-click the name of the module in the MAX configuration tree and select **Self-Calibrate** from the drop-down menu.

   > **Note** You can programmatically self-calibrate your device with NI-DAQmx. Refer to *Device Calibration* for more information.

Related information:

- Device Calibration
- PXIe-4311 Specifications

Removing the PXIe-4311

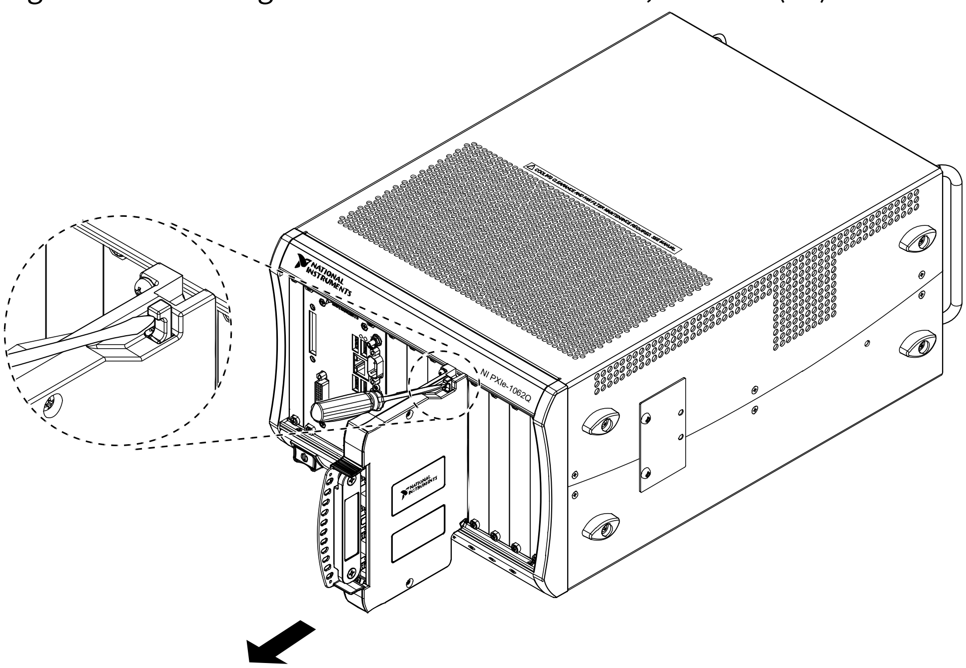
Detach the TB-4309 terminal block from the PXIe-4311 before removing the PXIe-4311 from the chassis.

Removing the TB-4309 Terminal Block

> **Notice** The chassis can be powered on or off when removing the TB-4309 terminal block.

1. Power off any devices and circuits connected to the TB-4309 terminal block.
2. Loosen the terminal block mounting screw located at the top of the terminal block
3. Using a flathead screwdriver, raise the latch release to disengage the latch.
4. With the latch release raised, grasp the TB-4309 terminal block and pull it away from the PXIe-4311.

Figure 13. Removing the TB-4309 Terminal Block, TB-4309 (ST) Shown



Removing the PXIe-4311 Module from the Chassis

> **Notice** Do not remove the PXIe-4311 with the chassis power on or the

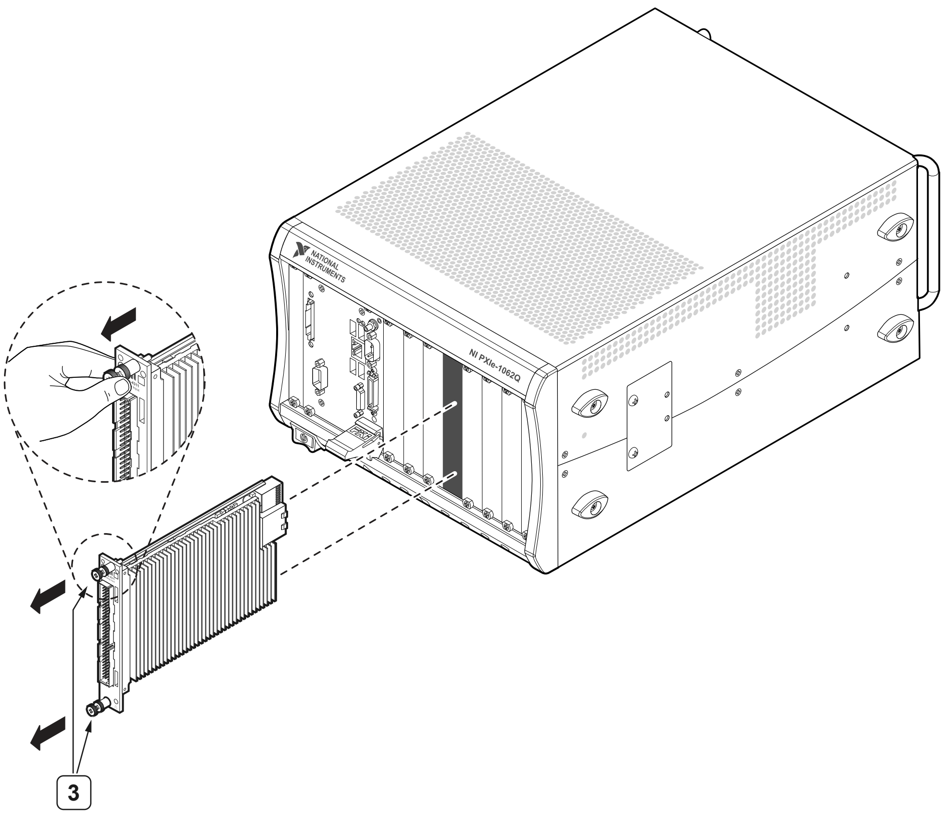
module may be damaged.

Note To maintain forced air cooling in the PXI Express system, refer to *Maintaining Forced-Air Cooling*.

1. Power off the chassis.
2. Loosen the captive screws on the top and bottom of the PXIe-4311.

   Notice Do not pull the front panel to remove the PXIe-4311. Doing so might cause module components to come into contact with adjacent modules and damage the modules.

   Figure 14. Removing the PXIe-4311 Module from the Chassis

3. Pull the captive screws to unseat the PXIe-4311 and slowly slide the PXIe-4311 along the guides.
4. Replace the filler panel in the empty slot.
5. Store the PXIe-4311 in an antistatic protective bag.

Related information:

- Maintaining Forced-Air Cooling

Analog Input

The PXIe-4311 samples up to 32 differential channels simultaneously.

The PXIe-4311 has the following features:

- Overvoltage protection for each channel ensures reliable operation even in cases where the input signal exceeds the expected range.
- A programmable gain amplifier for each channel. This gain amplifier allows for the configuration of input range to best suit the needs of your application. You can configure the following ranges on the PXIe-4311:
  - 0 V to 25 V
  - 0 V to 6 V
  - ±150 mV
- An analog lowpass filter that you can enable or disable as needed. A lowpass filter suppresses high-frequency components with a high roll-off.
- 32 independent and simultaneous signal conditioning paths with a dedicated analog-to-digital converter (ADC) for each path. These dedicated ADCs allow for synchronized data collection across multiple input signals, because you can sample all 32 channels at the same time.
- 16 calculated power channels computed through V × I multiplication in the device. These power channels return alongside the physical channel data.

Non-Isolated Architecture

The PXIe 4311 is a non-isolated module. All analog inputs are measured with respect to the module GND terminal.

> **Note** Do not leave the GND floating. Connect GND to the signal source ground reference. A floating GND can result in undefined common mode voltages and unreliable measurements.

When using the TB-4309 (ST), PFI_GND must connect as the GND. This connector variant does not have GND pins. Use PFI_GND as the ground reference for all AI+ and AI− connections on the TB-4309 (ST).

Source Impedance

Each AI+ and AI− terminal of the PXIe-4311 uses dedicated per-channel signal conditioning with high-input-impedance buffer amplifiers.

Unlike multiplexed architectures, the PXIe-4311 does not switch input channels through a shared ADC path. There is no charge injection artifact from channel switching.

As a result, the PXIe-4311 does not impose a strict low source impedance requirement. Typical power rail and shunt measurement sources are within the input capability of the module.

Related information:

- PXIe-4311 Specifications

Flexible Resolution

The PXIe-4311 supports flexible resolution for a higher effective resolution at lower sample rates.

At reduced sample rates, the module averages multiple internal conversions per output sample, reducing random noise and improving effective resolution.

When you select a sample rate for your application, the module automatically applies the appropriate level of averaging. For sample rate and resolution details, refer to the *Sampling, Flexible Resolution, and Throughput* section.

Common Mode Voltage

The PXIe-4311 measures the differential voltage between the AI+ and AI− terminals of each channel.

For valid measurements, both AI+ and AI− must independently remain within −0.5 V to 25 V relative to GND. The differential voltage between AI+ and AI− must also remain within the measurement range.

Common Mode for Measuring Power Rails and Shunts

In power rail measurements and shunt measurements, the common mode voltage is the rail voltage. Possible uses for common mode include the following examples.

Table 13. Common Mode Examples

Example	Description	Support
Measuring a shunt on a 12 V rail	The common mode voltage is approximately 12 V. The AI+ connects to the rail. The AI− connects to the other side of the shunt or to a reference point.	Within the supported range.
Measuring a shunt on a 24 V rail	The common mode at the shunt location is approximately 24 V.	Upper limit of the supported range.
Measuring a shunt on a -5 V rail	The common mode voltage is approximately -5 V.	Outside the supported range. The PXIe-4311 is not designed for negative rail measurements.

Common Mode Rejection Ratio (CMRR)

CMRR describes how well the module rejects the common mode voltage and measures only the differential signal. Higher CMRR means there is better rejection of common mode interference.

In a non-isolated module like the PXIe-4311, CMRR is important for the following reasons.

- All channels share the same GND reference.
- Ground potential differences between the signal source and the module appear as

common mode voltage.
- The PXIe-4311 filters out common mode noise, or equal noise on the AI+ and AI- terminals. However, imperfect CMRR allows some of the noise to appear as a differential measurement error.

CMRR performance varies by input range and across frequency. For CMRR values at specific ranges and specific frequencies, refer to the PXIe-4311 Specifications.

Wiring Best Practices for CMRR

To improve common mode rejection and measurement accuracy, consider the following wiring best practices.

Table 14. Wiring Best Practices

Best Practice	Description
Use twisted-pair wiring for the AI+ and AI− terminals	• Ensures equal noise coupling to both terminals. • Improving common mode rejection.
Keep the lead lengths as short as possible	• Reduces noise pickup area. • Minimizes impedance imbalance.
Maintain wiring symmetry	• Balances the impedance of the AI+ terminal and the AI− terminal. • Maximizes CMRR.
Apply a common mode voltage to the cable shield for shunt measurement channels	Connect the cable shield to a voltage near the shunt common-mode voltage instead of GND. **Note** For high-side shunt measurements, this voltage is typically the measured power rail near the shunt. Performing this action reduces AC leakage, reduces capacitive coupling, and improves AC

Best Practice	Description
	CMRR. You must isolate the guarded shield from the chassis GND to avoid shorting the rail to GND.

Related reference:

- TB-4309 Terminal Block Pinouts

Shielding

For the best EMC immunity and interference rejection, cover the entire TB-4309 and the cable assembly with a chassis GND/shield connection. The PXIe-4311 chassis ground is common with the PXIe chassis ground.

However, connecting the cable shield to chassis GND affects AC CMRR. Any voltage change toward chassis GND appears as a changing common mode voltage on the shielded channels. This type of voltage change is internally common with the signal GND of the PXIe-4311.

Figure 15. Recommended Wiring for a Floating Source

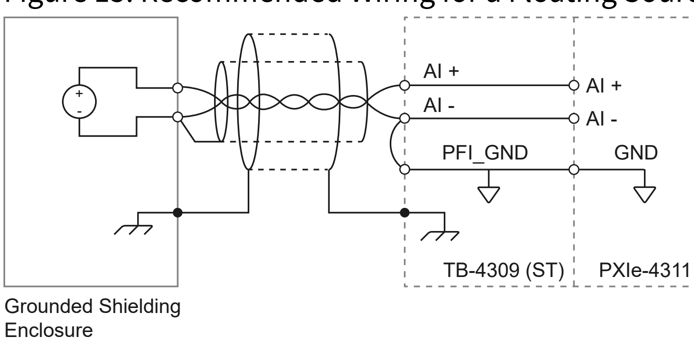
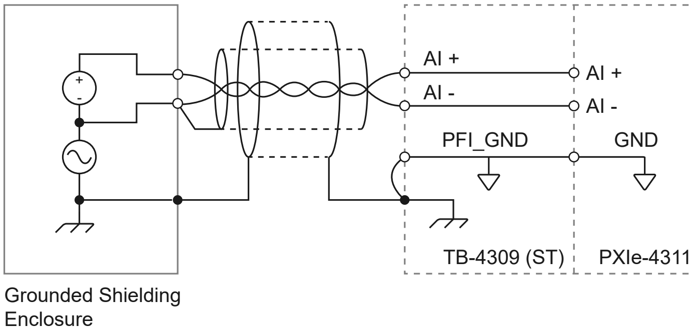


Figure 16. Recommended Wiring for a Grounded Source with Common-Mode



Analog Lowpass Filter

The PXIe-4311 provides an analog lowpass filter for each analog input channel. The filter applies to the analog signal path before the ADC digitizes the signal.

NI-DAQmx disables the analog lowpass filter by default. To enable the filter, set the following NI-DAQmx property: Analog Input::Filter::Analog Filter::Lowpass:Enable.

Because NI-DAQmx applies the filter before digitization, measurements and power calculations are based on the filtered signal. Signal content that the filter attenuates is not a part of the digitized data. Enabling the filter can affect the measured dynamic power.

Use the analog lowpass filter to reduce high frequency noise that is not part of the measurement. The following can generate high frequency switching noise.

- Power supplies
- Switching regulators
- DC to DC converters
- Other power supply circuits

Enabling the filter attenuates unwanted noise before the signal enters the digital data path.

For power measurements, the filter is typically most useful on current measurement channels, where switching noise can affect the measured current and calculated power.

NI recommends leaving the analog lowpass filter disabled when measuring fast dynamic power changes or signal content greater than 100 kHz. Enabling the filter might attenuate the signal content and cause the measured dynamic power to be different than the actual dynamic power.

You can enable or disable the analog lowpass filter independently for each channel. For example, you can enable the filter on current channels to reduce high frequency noise while leaving voltage channels unfiltered.

Calculated Power Channels

In NI-DAQmx, virtual power channels are also known as *AI - Calculated Power* channels. The PXIe-4311 produces a calculated power channel. This hardware-computed data channel is not a physical analog input terminal.

> **Note** NI-DAQmx includes example programs that use calculated power channels. For more information, refer to *Finding Examples for the PXIe-4311*.

The PXIe-4311 multiplies two physical channel measurements in hardware to calculate the power in Watts (W). The module can return the following.

- Return only the calculated power data.
- Return the calculated power data along with either or both chosen physical channel measurements.

Power depends on measuring the voltage and current at the same point in time. The PXIe-4311 calculates power from each time-aligned voltage and current sample.

$$Power\ \ Sample(n) = Voltage\ \ Sample(n) \times Current\ \ Sample(n)$$

When using hardware averaging, the PXIe-4311 calculates the power samples first before averaging the calculated power result. This method is different from averaging voltage and current separately before multiplying the averages.

Calculating power before averaging helps preserve the contribution of fast voltage or current changes while improving measurement resolution. Examples of rapid changes include load transients and switching activities.

Averaging voltage and current separately before the power calculation reduces the fast dynamic content before multiplication. This method can cause the calculated power to under represent dynamic power.

For applications that require accurate dynamic power measurements, use calculated power channels. These channels preserve the time aligned relationship between voltage samples and current samples.

Related reference:

- Finding Examples for the PXIe-4311

PXIe-4311 Configuration

The PXIe-4311 supports up to 16 calculated power channels.

Use a single physical channel as the source for multiple calculated power channels. Each calculated power channel is independently configurable. You can select the physical channel pair for the multiplication operation.

Interpreting Unscaled Data

The PXIe-4311 returns unscaled data for analog input and calculated power channels as 32-bit signed integer values (I32). To read unscaled data, configure the NI-DAQmx Read function or VI to return data in I32 format.

> **Note** The returned I32 values are fixed-point encoded and do not directly represent units such as Volts, Amps, or Watts.

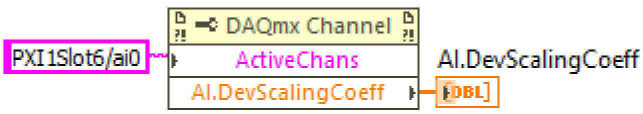
Voltage and current channels use signed 32-bit fixed-point values with 15 fractional bits. Power channels use signed 32-bit values with 0 fractional bits. For unscaled power data, multiply the raw value by 2 to compensate for the internal divide-by-2 scaling of the device.

For example, if the ADC is measuring 1 LSB for the voltage channel, the unscaled data return by the device is 0x8000.

Converting Unscaled Data to Volts, Amps, and Watts

To convert the unscaled values to scaled values, use the device scaling coefficients for the corresponding channel.

To query the scaling coefficients for a specific channel, set the desired channel as the active channel. Use the ActiveChans property and then read the AI.DevScalingCoeff property. This query returns the offset and the gain constants for the selected channel.



- To convert the unscaled data into voltage, apply the following formula.

$$Scaled\ \ Voltage(V) = Unscaled\ \ I32\ \ Data(LSB) \times Gain\left(\frac{V}{LSB}\right)$$

- To convert the unscaled data into current, apply the following formula.

$$Scaled\ \ Current(A) = \frac{Unscaled\ \ I32\ \ Data(LSB) \times Gain\left(\frac{V}{LSB}\right)}{Shunt\ \ Value(\Omega)}$$

- To convert the unscaled data into calculated power, apply the following formula.

$$Scaled\ \ Power(W) = \frac{Unscaled\ \ I32\ \ Data\left(LSB^2\right) \times Gain\left(\frac{V^2}{LSB^2}\right)}{Shunt\ \ Value(\Omega)}$$

NI-DAQmx Configuration

Use the DAQmx Create Channel (AI - Calculated Power) VI to create a calculated power channel.

This function accepts a list of voltage channels and a list of matching current channels. The function uses these channels for calculated power. The channels are paired positionally. For example, NI-DAQmx multiplies the first channel in Input 1 with the first channel in Input 2.

Typical Use Cases

Typical use cases for the PXIe-4311 include power rail consumption and multi-rail power profiling.

Use Case	Channel A (Voltage)	Channel B (Current-Related)	Result
Power rail consumption	Physical channel measuring a voltage rail (0–25 V or 0–6 V range).	Physical channel measuring shunt voltage (±150 mV range), scaled to the current.	Instantaneous power at each sample.
Multi-rail power profiling	Multiple voltage rail channels.	Corresponding shunt/current channels.	Up to 16 simultaneous power calculations.

To obtain a power result in Watts, one of the two source channels must represent the current. If you are measuring a shunt voltage, configure the measurement type as current and provide the shunt resistance value. The device internally performs the V × I multiplication using I32 values. The driver scales the data by multiplying the data by the appropriate weight.

Note General best practices apply to this method. Very high source impedance combined with long cable runs can increase susceptibility to noise pickup. Wherever practical, use short, twisted-pair wiring.

Sample Modes

The PXIe-4311 supports averaging and single-sample acquisition sampling modes.

The sampling mode is selected based on the timing mode.

In this section *convert* is a single ADC quantized digitization of the input signal, and *sample* is the data returned from hardware.

Related reference:

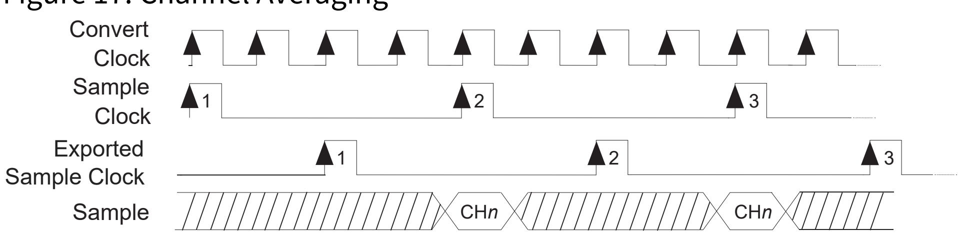
- Sample Timing Modes

Channel Averaging

The PXIe-4311 supports averaging in hardware. Based on the sample rate, the PXIe-4311 averages as many converts per sample as possible to deliver the best resolution for a given sample rate. For more information on noise versus sample rate, see *PXIe-4311 Specifications*.

The following figure shows the channel averaging of four samples of a single channel.

Figure 17. Channel Averaging



If channel averaging is done through multiple channels, the samples for all channels are taken at the same time.

To produce an average, the PXIe-4311 converts n samples into digital values. The *n* variable represents the number of samples to average together. The PXIe-4311 averages the n ADC samples. Then the PXIe-4311 averages the samples into a single sample. DAQmx Read accesses this sample.

The PXIe-4311 represents the time to acquire the averaged sample as the midpoint of the averaged samples. This method matches the group delay through an averaging filter. The exported sample clock aligns to the midpoint of the averaged samples with the resolution of the 100 MHz timebase ticks. This alignment occurs so that other devices can align their sampling to the averaged samples of the PXIe-4311.

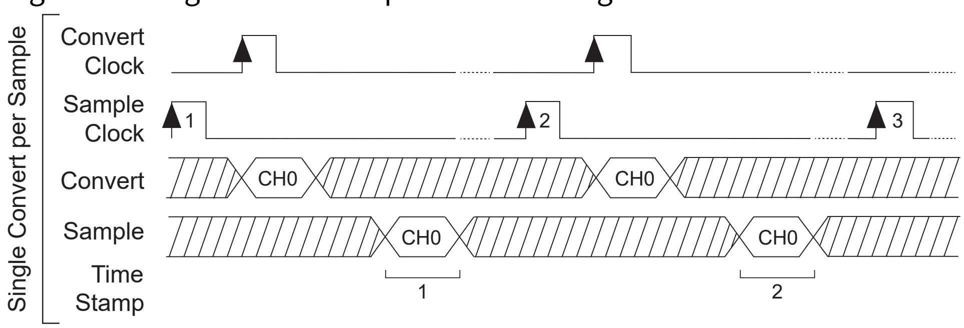
Related information:

- PXIe-4311 Specifications

Single Convert Acquisition

The PXIe-4311 takes a single convert for each channel and returns that as a sample.

Figure 18. Single Convert Acquisition of a Single Channel



Sample Timing Modes

The PXIe-4311 supports software-timed and hardware-timed acquisitions.

> **Note** Software-timed clocks and external sample clocks use single sample acquisition to minimize latency. For more information, refer to *Single Convert Acquisition*.

In this section the following terminology is used:
- **Convert**—A single ADC-quantized digitization of the input signal.
- **Sample**—The data that is returned from the hardware.

Software-Timed Acquisitions

Software controls the rate of the acquisition. Software sends a separate command to the hardware to acquire each sample. In NI-DAQmx, software-timed acquisitions are referred to as having *on-demand timing*. Software-timed acquisitions are also referred to as *immediate* or *static* acquisitions and are typically used for reading a single sample of data.

> **Note** NI-DAQmx disables channel averaging for software-timed acquisitions.

Hardware-Timed Acquisitions

With hardware-timed acquisitions, a digital hardware signal (AI Sample Clock) controls the rate of the acquisition. This signal can be generated internally on the device or provided externally.

Hardware-timed acquisitions have the following advantages over software-timed acquisitions:

- The time between samples can be much shorter.
- The timing between samples is deterministic.
- Hardware-timed acquisitions can use hardware triggering.

Hardware-timed acquisitions can be buffered or hardware-timed single point (HWTSP). The PXIe-4311 supports both types of operation.

A *buffer* is a temporary storage in computer memory for samples that are not transferred yet. Data is first moved from the onboard FIFO memory of the PXIe-4311 to a PC buffer through DMA. The data is then transferred to application memory. Buffered acquisition typically allows for faster transfer rates because data is moved in large blocks.

One property of buffered I/O operations is the sample mode. The sample mode can be either finite or continuous:

- **Finite sample mode acquisition**—The acquisition of a specific, predetermined number of data samples. Once the specified number of samples has been read in, the acquisition stops. If you use a reference trigger, you must use finite sample mode.
- **Continuous acquisition**—The acquisition of an unspecified number of samples. Instead of acquiring a set number of data samples and stopping, a continuous acquisition continues until you stop the operation. Continuous acquisition is also referred to as double-buffered or circular-buffered acquisition.

> **Note** If data cannot be transferred across the bus fast enough, the FIFO becomes full. New acquisitions overwrite data in the FIFO before it can be transferred to host memory. This issue generates an error message on the device. If the user program does not read data from the PC buffer fast enough to keep up with the data transfer, the buffer might overflow. This overflow generates an error message on the device.

Typically, HWTSP operations are used to write single samples at known time intervals. While buffered operations are optimized for high throughput, HWTSP operations are optimized for low latency and low jitter. HWTSP can notify software if it falls behind hardware. These features make HWTSP ideal for real time control applications. HWTSP operations, in conjunction with the Wait For Next Sample Clock function, provide tight synchronization between the software layer and the hardware layer. For more information, refer to the document *NI-DAQmx Hardware-Timed Single Point Lateness Checking*.

Related reference:

- Single Convert Acquisition

Related information:

- NI-DAQmx Hardware-Timed Single Point Lateness Checking

Timing and Triggering

This section contains information about timing and triggering for the PXIe-4311.

Sample Clock Timebase

The PXIe-4311 derives the sample clock from the onboard 100 MHz clock. You can lock the onboard clock to the PXIe_CLK100 clock to synchronize multiple modules.

External Clock

The PXIe-4311 sample clock can be driven from the following external sources:

- PFI <0,1>
- PXI_TRIG <0..7>
- PXI_Star
- PXIe_DStar <A,B>

> **Note** Using a sample clock from an external source disables sample averaging.

Digital Triggering

The PXIe-4311 supports acquisition start in response to a digital trigger signal. This signal can come from one of the PXI Express trigger lines or the Programmable Function Interface (PFI) lines. The trigger circuit can respond to a rising or a falling edge.

Synchronization

Synchronization is important to minimize skew between channels and to eliminate clock drift between modules in long-duration operations.

Some applications require tight synchronization between input operations and output operations on multiple modules. Synchronization is important to minimize skew between channels and to eliminate clock drift between modules in long-duration operations. You can synchronize the analog input operations on two or more PXIe-4311 modules to extend the channel count for your measurements.

Tip

An NI-DAQmx multidevice task expands DAQ device channels to include other DAQ device channels. NI-DAQmx only supports multidevice tasks between PXIe-4311 devices. Use multidevice tasks to accomplish the following objectives.

- Include multiple devices in a single task.
- Let NI-DAQmx synchronize multiple devices automatically.
- Enable trigger skew correction for multiple devices.

Enabling trigger skew correction through NI-DAQmx allows the driver to compensate for the skew of a trigger signal across multiple devices. The compensation locks the trigger to the reference clock. Locking the trigger allows the devices to respond to a trigger on a subsequent edge of that clock rather than immediately.

Related information:

- DAQmx Multidevice Tasks
- Trigger Skew Correction

Reference Clock Synchronization

With reference clock synchronization, modules generate their ADC sample clock from the shared 100 MHz reference clock on the PXI Express module (`PXIe_CLK100`). The `PXIe_CLK100` supplies an identical copy of this clock to each peripheral slot. In addition, multiple chassis can be synchronized by using a timing and synchronization board to lock the 100 MHz clock across chassis.

When acquiring data from multiple modules within the same NI-DAQmx task, NI-DAQmx automatically handles all of the Reference Clock Synchronization details required to synchronize the modules within the task. This is known as a *multidevice task*.

To perform reference clock synchronization when using multiple NI-DAQmx tasks that are acquiring at the same rate, complete the following steps to synchronize the hardware.

1. Specify `PXIe_CLK100` as the reference clock source for all modules to force all the modules to lock to the reference clock on the PXIe chassis.
2. Choose one module to provide the start trigger.
3. Configure the rest of the modules in your system to receive their start trigger from the start trigger module. This ensures that all modules will begin returning data on the same sample.
4. Set the synchronization type of the modules receiving the Start Trigger at **DAQmx Trigger » Advanced » Synchronization » Synchronization Type** to Slave and the module providing the start trigger to Master.
5. Start all of the modules using the start trigger. This sets them up to expect the master start trigger.
6. Start the master start trigger module task. You can now acquire data.

Note Consider using a multidevice task when synchronizing multiple devices at the same rate.

Note You can find example VIs in the NI Example Finder. Select **Help » Find Examples** to launch the NI Example Finder.

Clock and Trigger Signals

This section provides information about reference clocks and trigger buses.

PXIe_CLK100

PXIe_CLK100 is a common, low-skew 100 MHz reference clock used for synchronization of multiple modules in a PXI Express measurement or control system. The PXIe backplane is responsible for generating PXIe_CLK100 independently to each peripheral slot in a PXI Express chassis. For more information, refer to the *PXI Express Specification*.

PXI_CLK10

PXI_CLK10 is a common, low-skew 10 MHz reference clock for synchronization of multiple modules in a PXI measurement or control system. The PXI backplane is responsible for generating PXI_CLK10 independently to each peripheral slot in a PXI chassis. In PXIe chassis, the PXI_CLK10 signal is in phase with PXIe_CLK100.

Note PXI_CLK10 cannot be used as a reference clock.

PXI Triggers

A PXI/PXIe chassis provides eight bused trigger lines to each module in a system. Triggers may be passed from one module to another, allowing precisely timed responses to asynchronous external events that are being monitored or controlled. Triggers can be used to synchronize the operation of several different PXI peripheral modules.

PXI_STAR Trigger

In a PXI Express system, the Star Trigger bus implements a dedicated trigger line between the system timing slot and the other peripheral slots. The Star Trigger can be used to synchronize multiple modules or to share a common trigger signal among modules.

A system timing controller can be installed in the system timing slot to provide trigger signals to other peripheral modules. Systems that do not require this functionality can install any standard peripheral module in this system timing slot.

The PXIe-4311 receives the Star Trigger signal (PXI_STAR) from a System timing controller. PXI_STAR can be used as a trigger signal for input operations.

Note The PXIe-4311 is not a System timing controller. The PXIe-4311 module can be used in the system timing slot of a PXI system, but the system will not be able to use the Star Trigger feature.

PXIe_DSTAR<A..C>

PXI Express devices can provide high-quality and high-frequency point-to-point connections between each slot and a system timing slot. These connections come in the form of three low-voltage differential star triggers that route between a PXI Express system timing controller and a peripheral device. Using multiple connections simplifies the creation of applications because of the increased routing capabilities.

The following table describes the three differential star (DSTAR) lines and how they are used.

Table 15. Debouncing Filters

Trigger Line	Purpose
PXIe_DSTARA	Distributes high-speed, high-quality clock signals from the system timing slot to the peripherals (input).
PXIe_DSTARB	Distributes high-speed, high-quality trigger signals from the system timing slot to the peripherals (input).
PXIe_DSTARC	Sends high-speed, high-quality trigger or clock signals from the peripherals to the system timing slot (output).

The DSTAR lines are only available for PXI Express devices when used with a PXI Express system timing module. Refer to the *PXI Express Specification* for more information.

Throughput Considerations

Carefully plan your PXIe-4311 to handle high data volumes, streaming, and large finite acquisitions.

The PXIe-4311 has a high sampling rate and supports many channels. Selecting the proper PXI Express chassis is critical for handling high data volumes. Consider the following factors that might limit the available bandwidth.

- DAQ task configuration
- PXI Express backplane bandwidth
- PCIe switches within the chassis
- Remote controller connection (for example, MXI link to host PC)

Different PXI Express chassis provide varying architectures and per-slot bandwidth. When selecting a slot, ensure that the slot meets the required data throughput.

The PXIe-4311 uses a Gen 1 x4 PCIe connection to the backplane. Applications using multiple channels at high sampling rates must verify that throughput requirements are within the bandwidth available.

Table 16. Throughput Considerations

Channel Configuration	Up to 48 total channels • 32 analog input channels • 16 calculated power channels
Example Streaming Requirements	1. 4 MS/s × 1 ch × 32-bits = 16 MB/s 2. 1 MS/s × 48 ch × 32-bits = 192 MB/s 3. 4 MS/s × 32 ch × 32-bits = 512 MB/s 4. 4 MS/s × 48 ch × 32-bits = 768 MB/s **Note** Each channel consists of 32-bits data. For more information on the data format, refer to *Interpreting Unscaled Data*.

Bandwidth Considerations	Consider the following when slotting the PXIe-4311 into a peripheral slot, where N is the PCIe generation.
	
	• Gen N x1 PCIe (250 MB/s theoretical)
	    ◦ Sufficient for lower-throughput cases. Refer to examples 1 and 2.
	• Gen N x4 PCIe (1 GB/s theoretical)
	    ◦ Required for high-throughput streaming. Refer to examples 3 and 4.
	
	Note The PXIe-4311 is limited to PCIe Gen 1 speed. Even if you install the PXIe-4311 in a Gen 2 or higher PXIe slot, the device operates at Gen 1 speed. Do not expect a bandwidth improvement.

> **Note** Attempting to stream data beyond the available bandwidth might result in a buffer overflow error. For applications with a high data rate, ensure that the system uses a slot and chassis with adequate PCIe bandwidth.

To determine whether a PXIe chassis slot can support the required PXIe-4311 streaming bandwidth, refer to the chassis user manual. Review the PCI Express backplane diagram or peripheral slot specifications. The effective bandwidth depends on the following factors.

- The PCIe generation.
- The number of lanes supported by the module.
- The number of lanes supported by the chassis slot.

For example, in the NI PXIe-1088 chassis, slots 4, 6, and 8 provide up to Gen 2 x4 links to the controller. When installing the PXIe-4311 in these slots, the link negotiates to the maximum of the PXIe-4311. This negotiation provides sufficient bandwidth for full data throughput.

By contrast, slots 2, 3, 5, 7, and 9 provide only Gen 2 x1 links. The module and the slot limit the PXIe-4311 link. Installing the device in these slots results in a lower-bandwidth x1 connection. Using these slots might limit continuous streaming performance.

For the NI PXIe-1092 chassis, the compatible peripheral slots support up to Gen 3 x8 links. These slots provide more bandwidth than the PXIe-4311 requires. You can install the PXIe-4311 in any compatible peripheral slot to achieve the maximum data throughput.

Related concepts:

- Interpreting Unscaled Data

PXIe-4311 Calibration

You must perform calibration to ensure and maximize the accuracy of the PXIe-4311.

PXIe-4311 supports two types of calibration: external calibration and self-calibration.

You externally calibrate PXIe-4311 modules. The onboard EEPROM holds the Factory-calibration constants. These constants are permanent and incapable of modification. When you perform an external calibration or a self-calibration on the PXIe-4311, software stores new constants in a user-modifiable section of the EEPROM.

The PXIe-4311 uses software compensation to adjust the software scaling of signals the device measures. The PXIe-4311 calculates scaling constants for analog input using onboard calibration.

External Calibration

For the following information about your instrument, refer to the *PXIe-4311 Specifications*.

- Recommended operating temperature range
- Recommended calibration interval

Self-Calibration

Use the self-calibration function to reduce errors caused by time and temperature drift. Self-calibration only corrects the offset on the ±150 mV range. Self-calibration does not apply to the 0 V to 6 V or 0 V to 25 V ranges.

> **Note** Self-calibration is often used as the first step in debugging measurement errors.

Table 17. Calibration Options

Calibration Option	Application	Recommended Frequency
External calibration	Recalibrates for time drift of onboard calibration constants.	Every two years
Self-calibration	Adjusts for drift and temperature with respect to the onboard reference.	For more information on allowable temperature changes, refer to *PXIe-4311 Specifications*.

The PXIe-4311 receives NMI-traceable calibration before shipping.

Related information:

- PXIe-4311 Specifications

When to Perform PXIe-4311 Self-Calibration

A self-calibration uses internal elements to adjust the PXIe-4311 for variations in the environment.

NI recommends that you perform a self-calibration in any of the following situations:

- After first installing and interconnecting your PXIe-4311 instrument
- After any module that is in the same chassis as the PXIe-4311 is installed, uninstalled, or moved
- After intermodule cabling changes, reconnects, or repositions
- When the system is in an environment where the ambient temperature varies. Refer to *PXIe-4311 Specifications* for the allowable ambient temperature range for this instrument.
- The module temperature has drifted too far from the specified T_{cal} temperature value since the last self-calibration. Refer to *PXIe-4311 Specifications* for the allowable difference from T_{cal} for this instrument.
- Once 24 hours pass after a previous self-calibration

Related tasks:

- Self-Calibrating the PXIe-4311 in MAX

- Self-Calibrating the PXIe-4311 in Hardware Configuration Utility

Related information:

- PXIe-4311 Specifications

Self-Calibrating the PXIe-4311

Use the self-calibration function to reduce errors caused by time and temperature drift.

Self-calibration recalculates the offsets relative to the module internal ground reference. This calibration method improves accuracy over the full operating temperature range of the device. Self-calibration does not correct errors from an external common-mode voltage.

For example, when measuring a shunt on a powered rail, the rail voltage can introduce a common-mode error. The error can occur even when no current is flowing through the shunt. Remove or account for the common-mode voltage when verifying zero offset. You can also include the applicable CMRR error in the measurement uncertainty.

Every measurement instrument performs within the specifications over a finite temperature range. For performance close to the specifications when the temperature excursions exceed those specified, recalibrate the instrument at the new temperature. The NI-DAQmx self-calibration function allows you to perform a calibration at the temperature you are making your measurements.

Self-calibration calibrates the analog input offset voltage of the 150 mV range.

> **Note** DAQmx Self Calibrate calls a device reset.

The PXIe-4311 incorporates a temperature sensor that you can read to determine how much temperature has drifted from the previous calibration. You can also read the previous self-calibration time and date.

During self-calibration, the internal circuitry is automatically disconnected from the input. Therefore, for the majority of applications, you do not need to disconnect the input signals during self-calibration. However, excessive signal levels may generate a self-calibration error. Disconnecting the input signals during a self-calibration prevents the error from occurring.

Cleaning and Maintaining the PXIe-4311

NI recommends the following to clean and maintain your instrument's system.

- Clean the fan filters on the chassis regularly to prevent fan blockage and to ensure efficient air circulation. Cleaning frequency depends on the amount of use and the operating environment. For specific information about cleaning procedures and other recommended maintenance, refer to the chassis user documentation.
- Clean the hardware with a soft, nonmetallic brush. Make sure that the hardware is completely dry and free from contaminants before returning it to service.