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SCXI™

SCXI-1520 User Manual

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NATIONAL INSTRUMENTS™

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Conventions

The following conventions are used in this manual:

<>	Angle brackets that contain numbers separated by an ellipsis represent a range of values associated with a bit or signal name—for example, AO <3..0>.
»	The » symbol leads you through nested menu items and dialog box options to a final action. The sequence **File»Page Setup»Options** directs you to pull down the **File** menu, select the **Page Setup** item, and select **Options** from the last dialog box.
	This icon denotes a note, which alerts you to important information.
	This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash. When this symbol is marked on a product, refer to the *Read Me First: Safety and Radio-Frequency Interference* for information about precautions to take.
bold	Bold text denotes items that you must select or click in the software, such as menu items and dialog box options. Bold text also denotes parameter names.
italic	Italic text denotes variables, emphasis, a cross reference, or an introduction to a key concept. Italic text also denotes text that is a placeholder for a word or value that you must supply.
`monospace`	Text in this font denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames, and extensions.
`monospace bold`	Bold text in this font denotes the messages and responses that the computer automatically prints to the screen. This font also emphasizes lines of code that are different from the other examples.
`monospace italic`	Italic text in this font denotes text that is a placeholder for a word or value that you must supply.

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About the SCXI-1520

The SCXI-1520 module is an eight-channel module for interfacing to strain-gauge bridges and other Wheatstone-bridge based sensors.

Note Descriptions in this chapter explicitly refer to the first channel (channel 0); however, the same descriptions are applicable to channels <1..7>.

You can configure all settings on a per channel basis in software. The SCXI-1520 is configured using Measurement & Automation Explorer (MAX) or through NI-DAQmx property nodes.

With the SCXI-1520 and the accessory SCXI-1314 terminal block, you can do the following:

- Connect sensors of all bridge configurations, including quarter-, half-, and full-bridge
- Set the DC voltage excitation between 0 and 10 V (increments dependent upon the driver software)
- Programmatically offset null bridge circuits connected to the SCXI-1520
- Set the analog input lowpass filter cut-off frequency to 10 Hz, 100 Hz, 1 kHz, 10 kHz, or bypass
- Set the analog input gain between 1 and 1000 at any one of 49 settings
- Implement shunt calibration using two independent circuits
- Connect the bridge for remote-sense voltage excitation

What You Need to Get Started

To set up and use the SCXI-1520, you need the following:

- ❑ Hardware
  - SCXI-1520 module
  - One of the following terminal blocks:
    - SCXI-1314 terminal block
    - SCXI-1314T terminal block
  - SCXI or PXI/SCXI combo chassis
  - E/M Series DAQ device
  - Computer, if using an SCXI chassis
  - Cabling, cable adapter, and sensors as required for your application
- ❑ Software
  - NI-DAQ 7.0 or later
  - Application software, such as LabVIEW, LabWindows™/CVI™, Measurement Studio, or other programming environments
- ❑ Documentation
  - *Read Me First: Safety and Radio-Frequency Interference*
  - *DAQ Getting Started Guide*
  - *SCXI Quick Start Guide*
  - *SCXI-1520 User Manual*
  - Documentation for your hardware
  - Documentation for your software

The optional accessories listed in Table 1-1 are available for the SCXI-1520.

Table 1-1. Accessories Available for the SCXI-1520

Accessory	Description
SCXI-1314†	Screw terminal block—Mounts on the front of the SCXI-1520 module. It includes connections and sockets for two shunt calibration resistors and a quarter-bridge completion resistor per channel.
SCXI-1314T††	RJ-50 terminal block—Mounts on the front of the SCXI-1520 module. It features eight RJ-50 10-position/10-conductor (10p10c) modular plugs for connection to hardware TEDS smart sensors.
SCXI-1310‡	Connector and shell assembly—The SCXI-1310 provides 96 eyelet-type terminals for easy hook-and-solder signal connection and custom mass termination connectivity.
TBX-96‡	DIN-rail mounted terminal block with 96 generic screw terminals. One of the following cables is required to connect the TBX-96 to an SCXI module: • SH96-96 shielded cable, 1 m • R96-96 unshielded ribbon cable, 1 m

† You must wire a shunt resistor between the pins that correspond to the SCA on the SCXI-1314 and the appropriate legs of the bridge sensor. Refer to Chapter 4, *Theory of Operation*, for more information.

†† The SCXI-1314T only supports SCA. It does not support SCB. There are no quarter-bridge completion resistors in the SCXI-1314T. If you are connecting a quarter-bridge sensor to an SCXI-1520 using an SCXI-1314T, you must place an external resistor between the pins that correspond to P*X*– and S*X*+ on the terminals. Refer to Chapter 2, *Connecting Signals*, for more information.

‡ There are no quarter-bridge completion resistors in the SCXI-1310 or TBX-96. If you are connecting a quarter-bridge sensor to an SCXI-1520 using an SCXI-1310 or TBX-96, you must place an external resistor between the pins that correspond to P*X*– and S*X*+ on the terminals. Refer to Chapter 2, *Connecting Signals*, for more information.

National Instruments Documentation

The *SCXI-1520 User Manual* is one piece of the documentation set for data acquisition (DAQ) systems. You could have any of several types of manuals depending on the hardware and software in the system. Use the manuals you have as follows:

- *Getting Started with SCXI*—This is the first manual you should read. It gives an overview of the SCXI system and contains the most commonly needed information for the modules, chassis, and software.
- SCXI or PXI/SCXI chassis manual—Read this manual for maintenance information on the chassis and for installation instructions.
- The *DAQ Getting Started Guide*—This document has information on installing NI-DAQ and the E/M Series DAQ device. Install these before you install the SCXI module.
- The *SCXI Quick Start Guide*—This document contains a quick overview for setting up an SCXI chassis, installing SCXI modules and terminal blocks, and attaching sensors. It also describes setting up the SCXI system in MAX.
- The SCXI hardware user manuals—Read these manuals for detailed information about signal connections and module configuration. They also explain, in greater detail, how the module works and contain application hints.
- Accessory installation guides or manuals—Read the terminal block and cable assembly installation guides. They explain how to physically connect the relevant pieces of the system. Consult these guides when you are making the connections.
- The E/M Series DAQ device documentation—This documentation has detailed information about the DAQ device that plugs into or is connected to the computer. Use this documentation for hardware installation and configuration instructions, specification information about the DAQ device, and application hints.
- Software documentation—You may have both application software and NI-DAQ software documentation. National Instruments (NI) application software includes LabVIEW, LabWindows/CVI, and Measurement Studio. After you set up the hardware system, use either your application software documentation or the NI-DAQ documentation to help you write your application. If you have a large, complex system, it is worthwhile to look through the software documentation before you configure the hardware.

- One or more of the following help files for software information:
  - **Start»Programs»National Instruments»NI-DAQ» NI-DAQmx Help**
  - **Start»Programs»National Instruments»NI-DAQ» Traditional NI-DAQ User Manual**
  - **Start»Programs»National Instruments»NI-DAQ» Traditional NI-DAQ Function Reference Help**
- NI strain-gauge application notes or tutorials—NI has additional material about strain gauges and strain measurements available at `ni.com/support`.

You can download NI documents from `ni.com/manuals`. To download the latest version of NI-DAQ, click **Download Software** at `ni.com`.

Installing Application Software, NI-DAQ, and the E/M Series DAQ Device

Refer to the *DAQ Getting Started Guide* packaged with the NI-DAQ software to install your application software, NI-DAQ driver software, and the DAQ device to which you will connect the SCXI-1520. NI-DAQ 7.0 or later is required to configure and program the SCXI-1520 module. If you do not have NI-DAQ 7.0 or later, you can either contact a NI sales representative to request it on a CD or download the latest NI-DAQ version from `ni.com`.

Note Refer to the *Read Me First: Radio-Frequency Interference* document before removing equipment covers or connecting or disconnecting any signal wires.

Installing the SCXI-1520 Module into the SCXI Chassis

Refer to the *SCXI Quick Start Guide* to install your SCXI-1520 module.

Connecting the SCXI-1520 in an SCXI Chassis to an E/M Series DAQ Device for Multiplexed Scanning

Refer to the *SCXI Quick Start Guide* to install the cable adapter and connect the SCXI modules to the DAQ device.

If you have already installed the appropriate software, refer to Chapter 3, *Configuring and Testing*, to configure the SCXI-1520 module(s).

Connecting the SCXI-1520 in a PXI/SCXI Combination Chassis to an E/M Series DAQ Device for Multiplexed Scanning

Refer to the *SCXI Quick Start Guide* to connect the SCXI modules to the DAQ device.

If you have already installed the appropriate software, refer to Chapter 3, *Configuring and Testing*, to configure the SCXI-1520 module(s).

Verifying the SCXI-1520 Installation in Software

Refer to the *SCXI Quick Start Guide* for information on verifying the SCXI installation.

Installing SCXI Using NI-DAQmx in Software

Refer to the *SCXI Quick Start Guide* for information on installing modules using NI-DAQmx in software.

Manually Adding Modules in NI-DAQmx

If you did not auto-detect the SCXI modules, you must manually add each of the modules. Refer to the *SCXI Quick Start Guide* to manually add modules.

Note NI recommends auto-detecting modules for the first time configuration of the chassis.

Installing SCXI Using Traditional NI-DAQ (Legacy) in Software

Refer to the *SCXI Quick Start Guide* for information on installing modules using Traditional NI-DAQ (Legacy) in software.

Manually Adding Modules in Traditional NI-DAQ (Legacy)

If you did not auto-detect the SCXI modules, you must manually add each of the modules. Refer to the *SCXI Quick Start Guide* to manually add modules.

Note NI recommends auto-detecting modules for the first time configuration of the chassis.

Verifying and Self-Testing the Installation

The verification procedure for the SCXI chassis is the same for both NI-DAQmx and Traditional NI-DAQ (Legacy). To test the successful installation for the SCXI chassis, refer to the *SCXI Quick Start Guide.* Verify that the chassis is powered on and correctly connected to an E/M Series DAQ device.

After verifying and self-testing the installation, the SCXI system should operate properly with your ADE software. If the test did not complete successfully, refer to Chapter 3, *Configuring and Testing*, for troubleshooting steps.

Troubleshooting the Self-Test Verification

If the Self-Test Verification did not verify the chassis configuration, complete the steps in this section to troubleshoot the SCXI configuration.

Troubleshooting in NI-DAQmx

- If you get a **Verify SCXI Chassis** message box showing the SCXI chassis model number, **Chassis ID: *x***, and one or more messages stating **Slot Number: *x* Configuration has module: SCXI-*XXXX*** or **1520, hardware in chassis is: Empty**, take the following troubleshooting actions:
  - Make sure the SCXI chassis is powered on.
  - Make sure all SCXI modules are properly installed in the chassis. Refer to the *SCXI Quick Start Guide* for proper installation instructions.
  - Make sure the cable between the SCXI chassis and E/M Series DAQ device is properly connected.
  - Inspect the cable connectors for bent pins.
  - Make sure you are using the correct NI cable assembly.
  - Test the DAQ device to verify it is working properly. Refer to the DAQ device help file for more information.

- If you get a **Verify SCXI Chassis** message box showing the SCXI chassis model number, **Chassis ID: *x***, and the message **Slot Number: *x* Configuration has module: SCXI-*XXXX*** or **1520, hardware in chassis is: SCXI-*YYYY***, **1520**, or **Empty**, complete the following troubleshooting steps to correct the error.
  1. Expand the list of NI-DAQmx devices by clicking the **+** next to **NI-DAQmx Devices**.
  2. Right-click the SCXI chassis and click **Properties** to load the chassis configurator.
  3. Under the **Modules** tab, ensure that the cabled module is listed in the correct slot.
  4. If the cabled module is not listed in the correct slot, complete the following troubleshooting steps:
     a. If the cabled module is not listed in the correct slot and the slot is empty, click the drop-down listbox next to the correct slot and select the cabled module. Configure the cabled module following the steps listed in the *SCXI Quick Start Guide*. Click **OK**.
     b. If another module appears where the cabled module should be, click the drop-down listbox next to the correct slot and select the cabled module. A message box appears asking you to confirm the module replacement. Click **OK**. Configure the cabled module following the steps listed in the *SCXI Quick Start Guide*. Click **OK**.
- Ensure that you have the highest priority SCXI module cabled to the E/M Series DAQ device. Refer to the *SCXI Quick Start Guide* to find out which SCXI module in the chassis should be cabled to the DAQ device.
- After checking the preceding items, return to the *Troubleshooting the Self-Test Verification* section and retest the SCXI chassis.

If these measures do not successfully configure the SCXI system, contact NI. Refer to the *Technical Support Information* document for contact information.

Troubleshooting in Traditional NI-DAQ (Legacy)

- If you get the message **`Unable to test chassis at this time`**, you have not designated at least one module as connected to a E Series DAQ device. Refer to the *Traditional NI-DAQ (Legacy)* section of Chapter 3, *Configuring and Testing*, and change the configuration of the cabled module in the system from **Connected to: None** to **Connected to: Device *x***.
- If you get the message **`Failed to find`** followed by the module codes and the message **`Unable to communicate with chassis`**, take the following troubleshooting actions:
  - Make sure the SCXI chassis is powered on.
  - Make sure the cable between the SCXI chassis and E Series DAQ device is properly connected.
  - Inspect the cable connectors for bent pins.
  - Make sure you are using the correct NI cable assembly.
  - Test the DAQ device to verify it is working properly. Refer to the DAQ device help file for more information.
- If you get the message **`Failed to find`**, followed by module codes and the message **`Instead found: module with ID 0Xxx`**, refer to the *Traditional NI-DAQ (Legacy)* section of Chapter 3, *Configuring and Testing*, and make sure the correct module is in the specified slot. Delete the incorrect module as described in Appendix C, *Removing the SCXI-1520*, and add the correct module as described in the *Traditional NI-DAQ (Legacy)* section of Chapter 3, *Configuring and Testing*.
- If you get the message **`Failed to find`**, followed by a module code and the message **`Slot x is empty`**, make sure the configured module is installed in the specified slot. If not, install the module by following the instructions in the *Installing the SCXI-1520 Module into the SCXI Chassis* section. If the module is installed in the correct slot, power off the chassis, remove the module as specified in Appendix C, *Removing the SCXI-1520*, and verify that no connector pins are bent on the rear signal connector. Reinstall the module as described in the *Installing the SCXI-1520 Module into the SCXI Chassis* section, ensuring the module is fully inserted and properly aligned in the slot.
- After checking the preceding items, return to the *Troubleshooting the Self-Test Verification* section and retest the SCXI chassis.

If these measures do not successfully configure the SCXI system, contact NI. Refer to the *Technical Support Information* document for contact information.

2

Connecting Signals

This chapter describes how to connect Wheatstone bridge sensors to the SCXI-1520 in quarter-, half-, and full-bridge configurations and for remote sensing. It also provides the front and rear signal pin assignments of the module.

Connecting Bridge Sensor Signals

This section discusses how to connect the signals of supported strain-gauge configuration types as well as full-bridge sensors such as load, force, torque, and pressure sensors. It also discusses connecting leads for remote sensing and shunt calibration. Refer to Chapter 4, *Theory of Operation*, for a discussion of strain-gauge concepts. Refer to the *SCXI-1314 Installation Guide* for more signal connection information.

Notes The circuits in this section illustrate circuits using the SCXI-1314 terminal block. If you are using the SCXI-1314T terminal block, refer to the *SCXI-1314T TEDS Bridge Sensor Terminal Block Installation Guide* for the permitted circuit configuration diagrams.

Refer to Figure 2-5 and use its wiring diagram for full-bridge sensors such as load, force, torque, and pressure sensors.

Quarter-Bridge Type I

This section provides information for connecting the quarter-bridge strain-gauge configuration type I. Figure 2-1 shows the quarter-bridge type I circuit wiring diagram.

Note S– is left unwired.

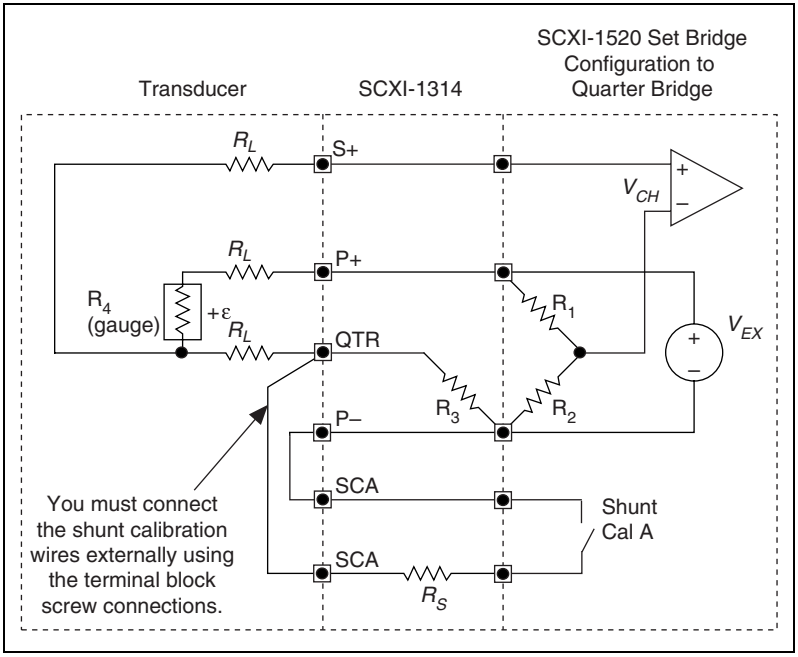


Figure 2-1. Quarter-Bridge I Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 and R_2 are half-bridge completion resistors.
- R_3 is the quarter-bridge completion resistor.
- R_4 is the active element measuring tensile strain (+ε).
- V_{EX} is the excitation voltage.
- R_L is the lead resistance.
- V_{CH} is the measured voltage.

Note The value of the quarter-bridge completion resistor, R_3, must equal the nominal resistance of the strain gauge. NI recommends using a 0.1% precision resistor.

Quarter-Bridge Type II

This section provides information for connecting the quarter-bridge strain-gauge configuration type II. Figure 2-2 shows the quarter-bridge type II circuit wiring diagram.

Note The quarter-bridge type II configuration is often confused with the more commonly used half-bridge type I configuration. In the half-bridge type I configuration, the R_3

element is active and bonded to the strain specimen to measure Poisson's ratio, while in the quarter-bridge type II configuration, the R_3 element does not actively measure strain, but is in close thermal contact with the strain specimen. In quarter-bridge type II configuration, the R_3 element is not bonded to the specimen. Typically it is either physically close to the specimen or mounted on the same type material at the same temperature, but is not under strain.

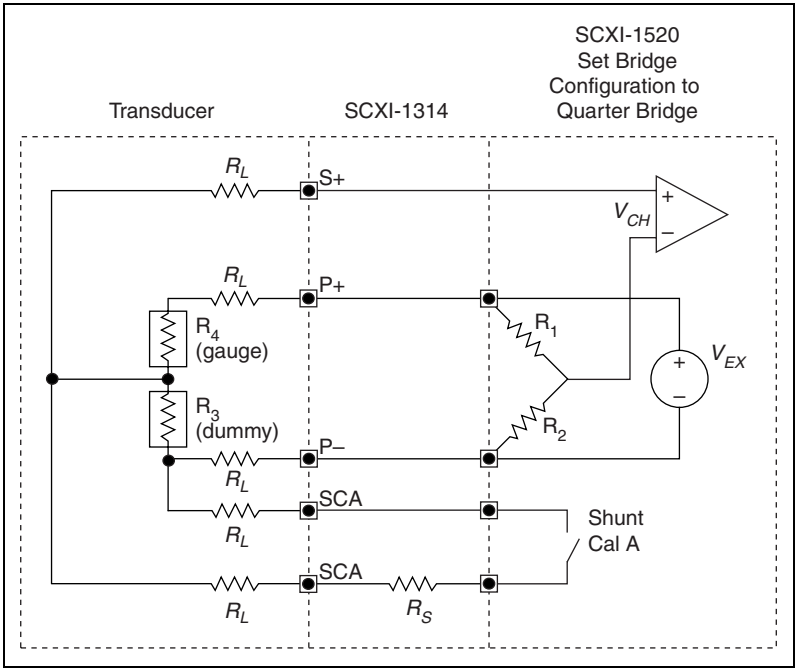


Figure 2-2. Quarter-Bridge II Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 and R_2 are half-bridge completion resistors.
- R_3 is the quarter-bridge temperature-sensing element (dummy gauge).
- R_4 is the active element measuring tensile strain (+ε).
- V_{EX} is the excitation voltage.
- R_L is the lead resistance.
- V_{CH} is the measured voltage.

Note S– and QTR are left unwired.

Half-Bridge Type I

This section provides information for connecting the half-bridge strain-gauge configuration type I. Figure 2-3 shows the half-bridge type I circuit wiring diagram.

Note S– is left unwired.

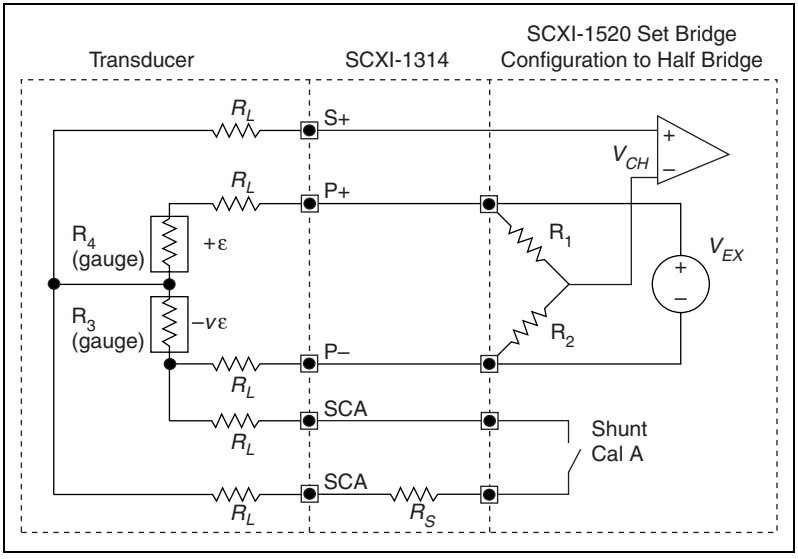


Figure 2-3. Half-Bridge Type I Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 and R_2 are half-bridge completion resistors.
- R_3 is the active element measuring compression from Poisson effect (–νε).
- R_4 is the active element measuring tensile strain (+ε).
- V_{EX} is the excitation voltage.
- R_L is the lead resistance.
- V_{CH} is the measured voltage.

Note As shown in Figure 2-4, for greatest calibration accuracy, use separate wires between the bridge and the SCA terminals. Do not directly connect S+ or P– to the SCA terminals inside the SCXI-1314 terminal block unless the strain-gauge cable length is very short.

Half-Bridge Type II

This section provides information for connecting the half-bridge strain-gauge configuration type II. Figure 2-4 shows the half-bridge type II circuit wiring diagram.

Note S– is left unwired.

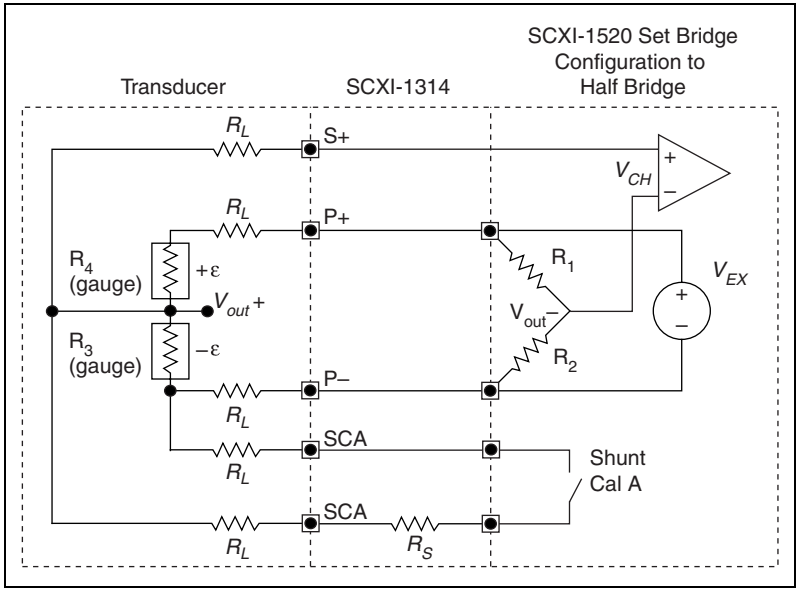


Figure 2-4. Half-Bridge Type II Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 and R_2 are half-bridge completion resistors.
- R_3 is the active element measuring compressive strain (–ε).
- R_4 is the active element measuring tensile strain (+ε).
- V_{EX} is the excitation voltage.
- R_L is the lead resistance.
- V_{CH} is the measured voltage.

Note As shown in Figure 2-3, for greatest calibration accuracy, use separate wires between the bridge and the SCA terminals. Do not directly connect S+ or P– to the SCA terminals inside the SCXI-1314 terminal block unless the strain-gauge cable length is very short.

Full-Bridge Type I

This section provides information for connecting the full-bridge strain-gauge configuration type I. Figure 2-5 shows the full-bridge type I circuit wiring diagram.

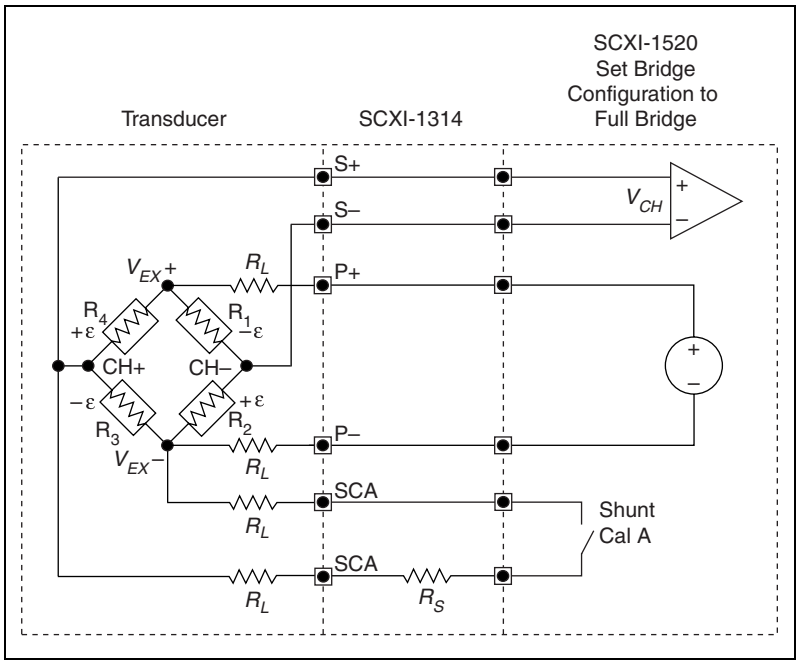


Figure 2-5. Full-Bridge Type I Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 is an active element measuring compressive strain (–ε).
- R_2 is an active element measuring tensile strain (+ε).
- R_3 is an active element measuring compressive strain (–ε).
- R_4 is an active element measuring tensile strain (+ε).
- V_{EX} is the excitation voltage.
- R_L is the lead resistance.
- V_{CH} is the measured voltage.

Note As shown in Figure 2-5, for greatest calibration accuracy, use separate wires between the bridge and the SCA terminals. Do not directly connect S+ or P– to the SCA terminals inside the SCXI-1314 terminal block unless the strain-gauge cable length is very short.

Full-Bridge Type II

This section provides information for connecting the full-bridge strain-gauge configuration type II. Figure 2-6 shows the full-bridge type II circuit wiring diagram.

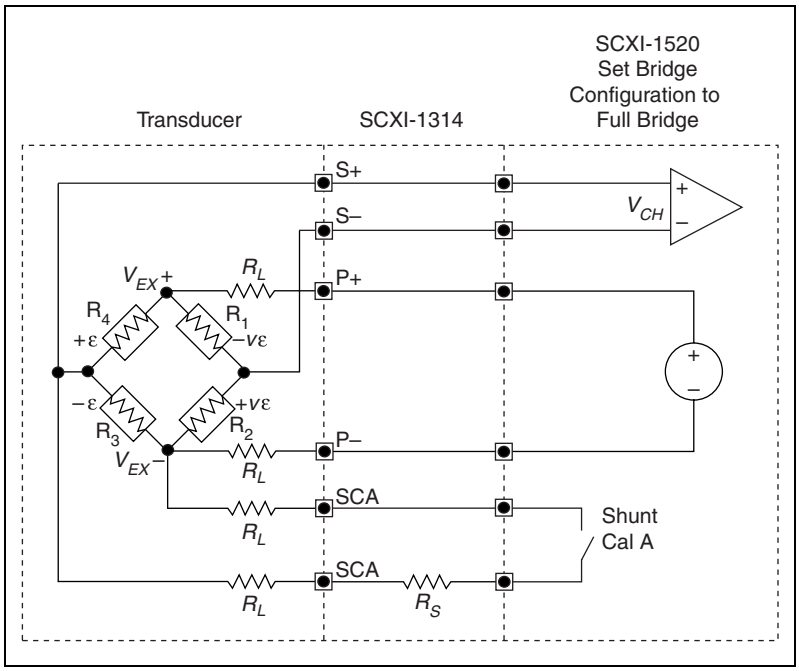


Figure 2-6. Full-Bridge Type II Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 is an active element measuring compressive Poisson effect ($-\nu\varepsilon$).
- R_2 is an active element measuring tensile Poisson effect ($+\nu\varepsilon$).
- R_3 is an active element measuring compressive strain ($-\varepsilon$).
- R_4 is an active element measuring tensile strain ($+\varepsilon$).
- V_{EX} is the excitation voltage.
- R_L is the lead resistance.
- V_{CH} is the measured voltage.

Note As shown in Figure 2-6, for greatest calibration accuracy, use separate wires between the bridge and the SCA terminals. Do not directly connect S+ or P– to the SCA terminals inside the SCXI-1314 terminal block unless the strain-gauge cable length is very short.

Full-Bridge Type III

This section provides information for connecting the full-bridge strain-gauge configuration type I. The full-bridge type III only measures axial strain. Figure 2-7 shows the full-bridge type III circuit wiring diagram.

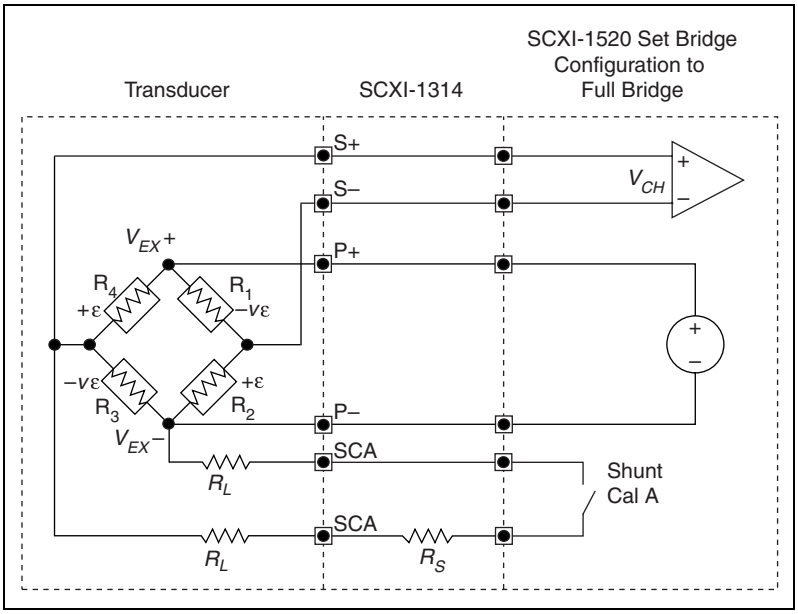


Figure 2-7. Full-Bridge Type III Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 is an active element measuring compressive Poisson effect (–νε).
- R_2 is an active element measuring tensile strain (+ε).
- R_3 is an active element measuring compressive Poisson effect (–νε).
- R_4 is an active element measuring the tensile strain (+ε).
- V_{EX} is the excitation voltage.
- R_L is the lead resistance.
- V_{CH} is the measured voltage.

Note As shown in Figure 2-7, for greatest calibration accuracy, use separate wires between the bridge and the SCA terminals. Do not directly connect S+ or P– to the SCA terminals inside the SCXI-1314 terminal block unless the strain-gauge cable length is very short.

Remote Sense

Note NI recommends using remote sense if your application requires the improved accuracy. Refer to Chapter 4, *Theory of Operation*, for more information about using remote sense.

Wire the SCXI-1520 for remote sense as shown in Figure 2-8.

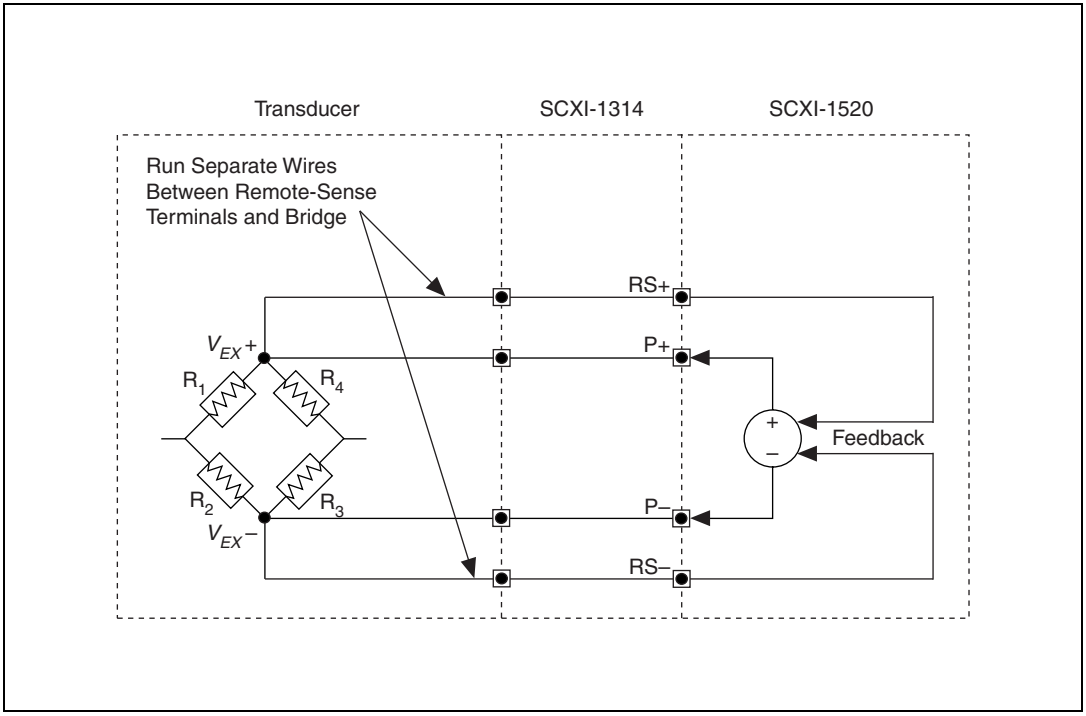


Figure 2-8. Remote-Sense Circuit Diagram

Note If you use remote sense, set R_L to zero in the equations for measured strain (ε).

Pin Assignments

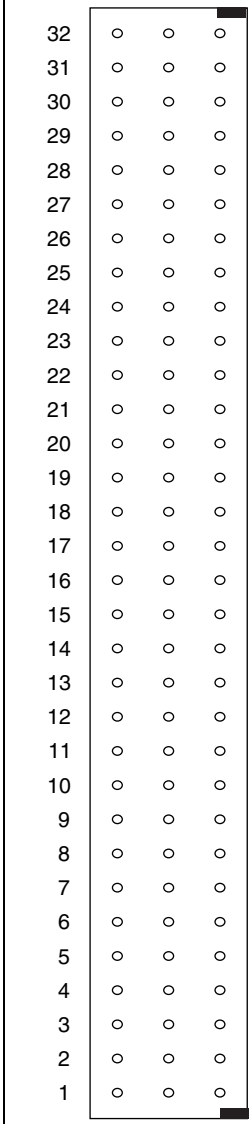
The pin assignments for the SCXI-1520 front signal connector are shown in Table 2-1. The front signal connector is a special 96-pin DIN C male connector through which you make all signal connections. The terminal assignments are as follows:

- S*X*+ and S*X*– are for analog input
- RS*X*+ and RS*X*– are for remote sense
- P*X*+ and P*X*– are for excitation output
- SCA*X* are for shunt calibration circuit A
- SCB*X* are for shunt calibration circuit B

where *X* is the channel number.

The negative terminals are listed in Column B and the positive terminals are listed in Column C. The pins labeled RSVD are reserved. Do *not* make any connections to the RSVD pins.

Table 2-1. Front Signal Pin Assignments

Front Connector Diagram	Pin Number	Column A	Column B	Column C
	32	SCB0	S0–	S0+
	31	SCB0	RS0–	RS0+
	30	SCB1	P0–	P0+
	29	SCB1	SCA0	SCA0
	28	RSVD	S1–	S1+
	27	RSVD	RS1–	RS1+
	26	RSVD	P1–	P1+
	25	RSVD	SCA1	SCA1
	24	SCB2	S2–	S2+
	23	SCB2	RS2–	RS2+
	22	SCB3	P2–	P2+
	21	SCB3	SCA2	SCA2
	20	RSVD	S3–	S3+
	19	RSVD	RS3–	RS3+
	18	RSVD	P3–	P3+
	17	RSVD	SCA3	SCA3
	16	SCB4	S4–	S4+
	15	SCB4	RS4–	RS4+
	14	SCB5	P4–	P4+
	13	SCB5	SCA4	SCA4
	12	RSVD	S5–	S5+
	11	RSVD	RS5–	RS5+
	10	RSVD	P5–	P5+
	9	RSVD	SCA5	SCA5
	8	SCB6	S6–	S6+
	7	SCB6	RS6–	RS6+
	6	SCB7	P6–	P6+
	5	SCB7	SCA6	SCA6
	4	RSVD	S7–	S7+
	3	RSVD	RS7–	RS7+
	2	RSVD	P7–	P7+
	1	RSVD	SCA7	SCA7

The rear signal connector is a 50-pin male cable connector used for analog signal connectivity and communication between the SCXI-1520 and the connected E/M Series DAQ device. The rear signal connector is shown in Table 2-2. The rear signal connector allows the DAQ device to access all eight differential analog output signals from the SCXI-1520. The positive terminal of each analog output is named CH*X*+ and the negative terminal CH*X*–.

Table 2-2. Rear Signal Pin Assignments

Rear Connector Diagram	Signal Name	Pin Number	Pin Number	Signal Name
	—	1	2	—
	CH 0 +	3	4	CH 0 –
	CH 1 +	5	6	CH 1 –
	CH 2 +	7	8	CH 2 –
	CH 3 +	9	10	CH 3 –
	CH 4 +	11	12	CH 4 –
	CH 5 +	13	14	CH 5 –
	CH 6 +	15	16	CH 6 –
	CH 7 +	17	18	CH 7 –
	—	19	20	—
	—	21	22	—
	—	23	24	DIG GND
	SER DAT IN	25	26	SER DAT OUT
	DAQ D*/A	27	28	—
	SLOT 0 SEL*	29	30	—
	—	31	32	—
	DIG GND	33	34	—
	—	35	36	AI HOLD COMP, AI HOLD
	SER CLK	37	38	—
	—	39	40	—
	—	41	42	—
	—	43	44	—
	—	45	46	SYNC
	—	47	48	—
	—	49	50	—

In parallel output mode, channel 0 is selected at the output multiplexer and is connected to CH 0. The seven other channels are directly connected to CH 1 through CH 7, respectively, on the rear connector.

In multiplexed mode, the CH 0 signal pair is used for sending all eight channels of the SCXI-1520, and analog signals from other modules, to the connected E/M Series DAQ device. If the module is cabled directly to the DAQ device, the other analog channels of the DAQ device are unavailable for general-purpose analog input because they are connected to the SCXI-1520 amplifier outputs. This means that connecting an SCXI-1180 module to the 50-pin breakout connector of the SCXI-1349, or other cable adapter assembly, may cause interference and incorrect measurements when the DAQ device is cabled to the SCXI-1520.

The communication signals between the DAQ device and the SCXI system are listed in Table 2-3. If the DAQ device is connected to the SCXI-1520, these digital lines are unavailable for general-purpose digital I/O.

Table 2-3. SCXI-1520 Communication Signals

Pin	SCXI Signal Name	NI-DAQmx Device Signal Name	Traditional NI-DAQ (Legacy) Device Signal Name	Direction	Description
24, 33	DIG GND	D GND	DGND	—	Digital ground—these pins supply the reference for E/M Series DAQ device digital signals and are connected to the module digital ground.
25	SER DAT IN	P0.0	DIO0	Input	Serial data in—this signal taps into the SCXIbus MOSI line to send serial input data to a module or Slot 0.
26	SER DAT OUT	P0.4	DIO4	Output	Serial data out—this signal taps into the SCXIbus MISO line to accept serial output data from a module.

Table 2-3. SCXI-1520 Communication Signals (Continued)

Pin	SCXI Signal Name	NI-DAQmx Device Signal Name	Traditional NI-DAQ (Legacy) Device Signal Name	Direction	Description
27	DAQ D*/A	P0.1	DIO1	Input	Board data/address line—this signal taps into the SCXIbus D*/A line to indicate to the module whether the incoming serial stream is data or address information.
29	SLOT0SEL*	P0.2	DIO2	Input	Slot 0 select—this signal taps into the SCXIbus INTR* line to indicate whether the information on MOSI is being sent to a module or Slot 0.
36	SCANCLK	AI HOLD COMP, AI HOLD	SCANCLK	Input	Scan clock—a rising edge indicates to the scanned SCXI module that the E/M Series DAQ device has taken a sample and causes the module to advance channels.
37	SER CLK	EXTSTROBE*	EXTSTROBE*	Input	Serial clock—this signal taps into the SCXIbus SPICLK line to clock the data on the MOSI and MISO lines.
46	HOLD TRIG	PFI 7/ AI SAMP CLK, AI SAMP	PFI7/ START SCAN	Input	Hold trigger—this signal is used by the MIO to set the track-and-hold state of the module.

3

Configuring and Testing

This chapter discusses configuring the SCXI-1520 in MAX for use with either NI-DAQmx or Traditional NI-DAQ (Legacy), creating and testing a virtual channel, global channel, and/or task.

SCXI-1520 Software-Configurable Settings

This section describes how to set the bridge configuration, voltage excitation level, filter bandwidth, and gain/input signal range, as well as how to use configuration utilities in MAX to programmatically perform offset null compensation and shunt calibration. It also describes how to perform configuration of these settings for the SCXI-1520 in NI-DAQmx and Traditional NI-DAQ (Legacy). For more information on the relationship between the settings and the measurements, and how to configure settings in your application, refer to Chapter 4, *Theory of Operation*.

Common Software-Configurable Settings

This section describes the most frequently used software-configurable settings for the SCXI-1520. Refer to Chapter 4, *Theory of Operation*, for a complete list of software-configurable settings.

Bridge Configuration

Bridge configuration is a software-configurable setting that allows you to connect quarter-, half-, or full-bridge configuration Wheatstone bridge sensors easily. When quarter- or half-bridge configuration is selected, Terminal S*X*– (where *X* is a particular channel) is disconnected from the front signal connector and internally connected to a half-bridge completion network. Implementing quarter-bridge completion also involves making field wiring connections to the quarter-bridge completion resistor (QTR) in the terminal block.

Excitation Level

Excitation level is a software-configurable setting that allows you to set the voltage excitation level available on P*X*+ and P*X*– (where *X* is a particular channel). You can choose voltage excitation settings between 0 and 10 V. To prevent the module from overheating, do not set the excitation voltage greater than

(*resistance connected between the excitation terminals*) × (29.0 mA)

Note You need not include the loading effect of the internal half-bridge completion resistors in the above calculation. When using internal quarter-bridge completion you must include the nominal gauge resistance as well as the quarter-bridge completion resistance ($R_3 + R_4$).

Table 3-1 shows the maximum allowable excitation voltages for standard bridge configurations and resistances.

Table 3-1. Excitation Voltage for Configuration and Gauge Resistances

Configuration/ Sensor	Resistance	NI-DAQmx Excitation Voltage Range	Traditional NI-DAQ (Legacy) Excitation Voltage Range
Quarter- or Half-Bridge	120 Ω	≤6.96 V	0 to 6.875 V
	350 Ω	0 to 10 V	0 to 10 V
	1000 Ω	0 to 10 V	0 to 10 V
Full-Bridge or Full-Bridge Sensor	120 Ω	≤3.48 V	0 to 3.125 V
	350 Ω	0 to 10 V	0 to 10 V
	1000 Ω	0 to 10 V	0 to 10 V

Filter Bandwidth

Filter bandwidth is a software-configurable setting that allows you to select a lowpass filter cutoff frequency. You can choose 10 Hz, 100 Hz, 1 kHz, 10 kHz, or filter-bypass mode. If your application requires other cutoff frequencies, refer to Chapter 4, *Theory of Operation*.

Gain/Input Range

Gain/input range is a software-configurable setting that allows you to choose the appropriate amplification to fully utilize the range of the E/M Series DAQ device. In most applications NI-DAQ chooses and sets the gain for you determined by the input range. This feature is described in Chapter 4, *Theory of Operation*. Otherwise, you should determine the appropriate gain using the input signal voltage range and the full-scale limits of the SCXI-1520 output signal. For common strain-gauge configurations where the Gauge Factor is 2.0, the maximum input signal (in microvolts) is:

$$\textit{quarter bridge} = \textit{(max strain)} \times \textit{(excitation voltage)} \times (0.5\ \mu V/V/\mu\varepsilon)$$

$$\textit{half bridge} = \textit{(max strain)} \times \textit{(excitation voltage)} \times (1.0\ \mu V/V/\mu\varepsilon)$$

$$\textit{full bridge} = \textit{(max strain)} \times \textit{(excitation voltage)} \times (2.0\ \mu V/V/\mu\varepsilon)$$

When you have determined the input signal voltage you can use the following equation to determine the appropriate gain:

$$\textit{gain} \leq \frac{\textit{(SCXI-1520 output voltage range)} \times (10\ V)}{\textit{(input signal voltage)}}$$

If you are using a bridge-based sensor, use the manufacturer-specified sensitivity (usually expressed in the units of millivolts per volt) to determine the maximum input signal. The maximum input signal is:

$$\textit{(max input signal voltage)} = \frac{\textit{(sensor sensitivity)} \times \textit{(excitation voltage)} \times \textit{(maximum input)}}{\textit{(sensor full-scale input)}}$$

For example, if you have a 0 to 500 psi pressure sensor with 3.0 mV/V sensitivity, an excitation voltage of 10 V, and a maximum pressure of 200 psi, the maximum signal is:

$$12\ mV = \frac{(3.0\ mV/V) \times (10\ V) \times (200\ psi)}{(500\ psi)}$$

If you are using a DAQ device that has a maximum analog input range of ±10 V and you have a maximum input to the SCXI-1520 of +12 mV, set the gain to the setting closest to

$$833 = \frac{10\ V}{12\ mV}$$

but *less* than 833. A larger gain setting saturates the DAQ device input for a 12 mV signal. In this example, the closest lesser gain setting for the SCXI-1520 is 750.

Null Potentiometers

Coarse and fine null potentiometers are software-configurable settings that allow you to remove unwanted offset voltage. In most cases, you do not explicitly set the null potentiometers, but instead allow driver software to automatically adjust them for you. However, if you want to explicitly set the null potentiometers, you can write an application program that adjusts the null potentiometers settings. Refer to Chapter 4, *Theory of Operation*, for more information.

Shunt Calibration Switches

Shunt calibration switches A and B are software control settings that allow you to engage or disengage the shunt calibration resistors in order to perform gain calibration. In most cases, you do not explicitly control the shunt calibration switches, but instead allow driver software to automatically adjust them for you during the automated shunt calibration procedure. However, if you want to explicitly control the calibration switches, you can write an application program that controls the shunt calibration switches. Refer to Chapter 4, *Theory of Operation*, for more information.



Note The gain adjustment is done for you automatically if you have performed shunt calibration using the NI-DAQ driver. Refer to the *Traditional NI-DAQ (Legacy)* section and the *NI-DAQmx* section for more information about how to perform shunt calibration using the driver.

Modes of Operation

The SCXI-1520 can operate in multiplexed mode or parallel mode. Using NI-DAQmx, you can operate the SCXI-1520 in either multiplexed or parallel mode. In Traditional NI-DAQ (Legacy), only multiplexed mode is supported. Refer to the *Strain-Gauge Theory* section of Chapter 4, *Theory of Operation*, for more information on multiplexed and parallel mode operation.

Simultaneous Sample and Hold

When it is critical to measure two or more signals at the same instant in time, simultaneous sample and hold (SS/H) is required. Typical applications that might require SS/H include vibration measurements and phase difference measurements. In NI-DAQmx, you can disable this setting through your application if you require scan rates beyond the maximum allowable with SS/H engaged. NI recommends leaving SS/H engaged.

Note You cannot change the simultaneous sampling mode in MAX. You must use an ADE such as LabVIEW or LabWindows/CVI to configure the setting using NI-DAQmx Channel Property Node. Refer to your ADE help file for more information.

Configurable Settings in MAX

Note If you are not using an NI ADE, using an NI ADE prior to version 7.0, or are using an unlicensed copy of an NI ADE, additional dialog boxes from the NI License Manager appear allowing you to create a task or global channel in unlicensed mode. These messages continue to appear until you install version 7.0 or later of an NI ADE.

This section describes where you can access each software-configurable setting for modification in MAX. The location of the settings varies depending on the version of NI-DAQ you use. Refer to either the *NI-DAQmx* section or the *Traditional NI-DAQ (Legacy)* section. You also can refer to the *DAQ Getting Started Guide* and the *SCXI Quick Start Guide* for more information on installing and configuring the hardware. You also can use the DAQ Assistant to graphically configure common measurement tasks, channels, or scales.

NI-DAQmx

In NI-DAQmx, you can configure software settings such as bridge configuration, voltage excitation level, filter bandwidth, gain/input signal range, and calibration settings in the following two ways:

- Task or global channel in MAX
- Functions in your application

Note All software-configurable settings are not configurable both ways. This section only discusses settings in MAX. Refer to Chapter 4, *Theory of Operation*, for information on using functions in your application.

These sections describe settings that you can change in MAX and where they are located. Strain and custom voltage with excitation are the most commonly used **NI-DAQmx Task** or **NI-DAQmx Global Channel** types with the SCXI-1520. Use the **Custom Voltage with Excitation NI-DAQmx** task or global channel when measuring load, force, torque, pressure, or other bridge-based sensors:

- Bridge configuration—configure using the settings tab of **NI-DAQmx Task** or **NI-DAQmx Global Channel** and functions in your application. Channel properties override module properties. The default bridge configuration for NI-DAQmx is full bridge.
- Voltage excitation—configure using either **NI-DAQmx Task** or **NI-DAQmx Global Channel**. You also can set the voltage excitation level through your application. In NI-DAQmx, you can choose from contiguous voltages between 0 and 10 V. The default voltage excitation in NI-DAQmx is 0 V.
- Filter bandwidth—configure the **Device** tab using either **NI-DAQmx Task** or **NI-DAQmx Global Channel**. You also can set the value through your application. The default filter cut-off frequency in NI-DAQmx is 10 kHz.
- Input signal range—configure the input signal range using either **NI-DAQmx Task** or **NI-DAQmx Global Channel**. When you set the minimum and maximum range of **NI-DAQmx Task** or **NI-DAQmx Global Channel**, the driver selects the best gain for the measurement. You also can set it through your application. The default gain setting in NI-DAQmx is 1.0. This setting corresponds to an input range of ±10 V.
- Calibration settings—null potentiometer settings and control shunt calibration switches only using **Strain NI-DAQmx Task**, **Strain NI-DAQmx Global Channel**, or your application. The **Custom Voltage with Excitation NI-DAQmx Task** or **NI-DAQmx Global Channel** cannot adjust calibration settings in MAX. Adjust calibration settings in your application. The default configuration settings set the null potentiometers at their midpoint, 62 for the coarse potentiometer and 2,047 for the fine potentiometer. The default state of the shunt calibration switches is open. This state leaves the shunt calibration resistor disconnected from the circuit.
- Modes of operation—configure only using chassis installation in software. Refer to Chapter 1, *About the SCXI-1520*, for more information on chassis installation. The default setting in NI-DAQmx is multiplexed.

- Simultaneous sample-and-hold settings—configure only using your application. The default setting in NI-DAQmx engages SS/H.

Note Refer to Chapter 4, *Theory of Operation*, for information on configuring the settings for your application using Traditional NI-DAQ (Legacy).

Creating a Strain Global Channel or Task

To create a new NI-DAQmx strain global task or channel, complete the following steps:

1. Double-click **Measurement & Automation** on the desktop.
2. Right-click **Data Neighborhood** and select **Create New**.
3. Select **NI-DAQmx Task** or **NI-DAQmx Global Channel**, and click **Next**.
4. Select **Analog Input**.
5. Select **Strain**.
6. If you are creating a task, you can select a range of channels by holding down the <Shift> key while selecting the channels. You can select multiple individual channels by holding down the <Ctrl> key while selecting channels. If you are creating a channel, you can only select one channel. Click **Next**.
7. Name the task or channel and click **Finish**.
8. In the **Channel List** box, select the channel(s) you want to configure. You can select a range of channels by holding down the <Shift> key while selecting the channels. You can select multiple individual channels by holding down the <Ctrl> key while selecting channels.
9. Enter the specific values for your application in the **Settings** tab. Context help information for each setting is provided on the right side of the screen.
10. Click the **Device** tab and select the autozero mode and lowpass filter cutoff frequency.
11. Ensure that you have selected the strain channel(s) you wish to calibrate in the **Channel List** box. Click **Calibration** to calibrate the strain channel(s).
12. On the screen that appears choose to enable offset nulling and/or shunt calibration. Enter the shunt calibration resistor information. Click **Next**.

13. **Measure and Calibrate** displays information specific to the strain channel(s). Click **Measure** to acquire a signal from the strain channel(s) and **Reset Data** to reset the values to default. Click **Calibrate** to calibrate the strain channel(s). When you have completed calibrating the strain channel(s), click **Finish**.
14. If you are creating a task and want to set timing or triggering controls, enter the values in the **Task Timing** and **Task Triggering** tabs.

Creating a Custom Voltage with Excitation Global Channel or Task

Use the **Custom Voltage with Excitation NI-DAQmx Task** or **Global Channel** when measuring load, force, torque, pressure, or other bridge-based sensors. To create an **NI-DAQmx Custom Voltage with Excitation Task** or **NI-DAQmx Global Channel**, complete the following steps:

1. Double-click **Measurement & Automation** on the desktop.
2. Right-click **Data Neighborhood** and select **Create New**.
3. Select **NI-DAQmx Global Channel** or **NI-DAQmx Task**, and click **Next**.
4. Select **Analog Input** then select **Custom Voltage with Excitation**.
5. If you are creating a channel, you can select only one channel. If you are creating a task, select the channels to add to the task. You can select a range of channels by holding down the <Shift> key while selecting the channels. You can select multiple individual channels by holding down the <Ctrl> key while selecting channels. Click **Next**.
6. Select the name of the task or channel, and click **Finish**.
7. In the **Channel List** box, select the channel(s) you want to configure. You can select a range of channels by holding down the <Shift> key while selecting the channels. You can select multiple individual channels by holding down the <Ctrl> key while selecting channels.
8. Enter the specific values for your application in the **Settings** tab. Context help information for each setting is provided on the right side of the screen.
9. Click the **Device** tab and select the autozero mode and lowpass filter cutoff frequency.
10. If you are applying custom scaling, select the **Create New** drop-down and follow the onscreen wizard.
11. If you are creating a task and want to set timing or triggering controls, enter the values in the **Task Timing** and **Task Triggering** tabs.

Traditional NI-DAQ (Legacy)

In Traditional NI-DAQ (Legacy), you can configure software settings, such as bridge configuration, voltage excitation level, filter bandwidth, gain/input signal range, and calibration settings, in the following three ways:

- module property pages in MAX
- virtual channels properties in MAX
- functions in your ADE



Note All software-configurable settings are not configurable in all three ways. This section only discusses settings in MAX. Refer to Chapter 4, *Theory of Operation*, for information on using functions in your application.

Most of these settings are available in module properties and/or using virtual channels:

- Bridge configuration—configure using module properties, virtual channels properties, and functions in your application. Virtual channel properties override module properties. The default bridge configuration for Traditional NI-DAQ (Legacy) is quarter bridge.
- Voltage excitation—configure using module properties or virtual channel properties. Virtual channel properties override module properties settings. You also can set excitation through your application. You can choose one of 17 voltage settings between 0 and 10 V. The default voltage excitation level for Traditional NI-DAQ (Legacy) is 2.5 V.
- Filter bandwidth—configure only using module properties. You also can set bandwidth through your application. The default filter bandwidth level for Traditional NI-DAQ (Legacy) is 10 Hz.
- Gain/input signal range—configure gain using module properties. When you set the minimum and maximum range of the virtual channel, the driver selects the best gain. The default gain setting for Traditional NI-DAQ (Legacy) is 100.
- Calibration settings—configure null potentiometer settings and control shunt calibration switches only using strain virtual channel or using your application. The default configuration settings set the null potentiometers at their midpoint, 62 for the coarse potentiometer and 2,047 for the fine potentiometer. The default state of the shunt calibration switches is open. This state leaves the shunt calibration resistor disconnected from the circuit.

- Modes of operation—configure only using module properties. The default setting in Traditional NI-DAQ (Legacy) is multiplexed mode. Parallel mode is not supported in Traditional NI-DAQ (Legacy).
- Simultaneous sample-and-hold settings—can modify this setting only using NI-DAQmx.

Note Refer to Chapter 4, *Theory of Operation*, for information on configuring the settings for your application using Traditional NI-DAQ (Legacy).

Configuring Module Property Pages in Traditional NI-DAQ (Legacy)

1. Right-click the SCXI-1520 module you want to configure and select **Properties**. Click **General**.
2. If the module you are configuring is connected to an E Series DAQ device, select that device by using **Connected to**. If you want this DAQ device to control the chassis, confirm there is a check in the **This device will control the chassis** checkbox. If the module you are configuring is not connected to an DAQ device, select **None**.
3. Click the **Channel** tab. Select the appropriate gain, filter, voltage excitation, and bridge configuration setting for each channel. If you want to configure all the channels at the same time, select the **Channel** drop-down menu, scroll to the bottom, and select **All Channels**. Refer to the *SCXI-1520 Software-Configurable Settings* section for a detailed description of each setting. Click **Apply**.
4. Click **Accessory**. Select the accessory you connected to the module. When configuration is complete, click **OK**.

The Traditional NI-DAQ (Legacy) chassis and SCXI-1520 should now be configured properly. If you need to change the module configuration, right-click the module and repeat steps 1 through 4. Test the system following the steps in the *Troubleshooting the Self-Test Verification* section of Chapter 1, *About the SCXI-1520*.

Creating a Strain Virtual Channel

To create a strain virtual channel, complete the following steps:

1. Right-click **Data Neighborhood** and select **Create New**.
2. Select **Traditional NI-DAQ Virtual Channel** and click **Finish**.
3. Click **Add Channel**.

4. Select **Analog Input** from the drop-down menu and click **Next**.
5. Enter the **Channel Name** and **Channel Description**, and click **Next**.
6. Select **Strain Gauge** from the drop-down menu and click **Next**.
7. Enter the following information:
   a. **Bridge type** from the drop-down menu
   b. **V init** in volts
   c. **Lead Resistance** in Ω
   d. **Nominal Gauge** in Ω
   e. **Gauge Factor**
   f. **Range min** in με
   g. **Range max** in με
8. Click **Next**.
9. Enter the following information:
   a. **What DAQ hardware will be used?** from the drop-down menu
   b. **What channel on your DAQ hardware?** from the drop-down menu
   c. **Which analog input mode will be used?** from the drop-down menu
   d. **What is the Excitation Voltage's source and value?** from the drop-down menu
   e. **Voltage** in volts
10. Click **Finish**.

Calibrating a Strain Virtual Channel

To calibrate a strain virtual channel, complete the following steps:

1. Right-click the virtual channel you want to calibrate and select **Properties**.
2. Click **Calibration**.
3. Select the **Engineering Units** from the drop-down menu.
4. Enter the **Calibration Data** and click **Update**.
5. Make the selections in **Shunt Cal Circuit A** and **Operation**, and click **Start**.
6. After the calibration is completed, click **Exit**.

Verifying the Signal

This section describes how to take measurements using test panels in order to verify signal, and configuring and installing a system in NI-DAQmx and Traditional NI-DAQ (Legacy).

Verifying the Signal in NI-DAQmx Using a Task or Global Channel

You can verify the signals on the SCXI-1520 using NI-DAQmx by completing the following steps:

1. Expand the list of tasks and virtual channels by clicking the **+** next to **Data Neighborhood**.
2. Click the **+** next to **NI-DAQmx Tasks** to expand the list of tasks.
3. Click the task.
4. Add or remove channels, if applicable, in the **Channel List**. Click the Add Channels button, shown at left, and select the type of channel you want to add.



   a. In the window that appears, expand the list of channels by clicking the **+** next to the module of interest.
   b. Select the channel(s) you want to verify. You can select a block of channels by holding down the <Shift> key or multiple channels by holding down the <Ctrl> key. Click **OK**.
5. Enter the appropriate information on the **Settings** tab.
6. Click the **Device** tab and enter the appropriate information on the **Device** tab.
7. Click the **Test** button to open the test panel.
8. Click the **Start** button, if necessary.
9. After you have completed verifying the channels, close the test panel window.

You have now verified the SCXI-1520 configuration and signal connection.



Note For more information on how to further configure the SCXI-1520, or how to use LabVIEW to configure the module and take measurements, refer to Chapter 4, *Theory of Operation*.

Verifying the Signal in Traditional NI-DAQ (Legacy)

This section discusses how to verify the signal in Traditional NI-DAQ (Legacy) using channel strings and virtual channels.

Verifying the Signal Using Channel Strings

The format of the channel string is as follows:

ob***x*** ! sc***y*** ! md***z*** ! *channel*

where

- ob***x*** is the onboard E Series DAQ device channel, with ***x*** representing a particular channel where the multiplexed channels are sent. This value is 0 for DAQ device channel 0 in a single-chassis system. In a multichassis or remote chassis system, the DAQ device channel *x* corresponds to chassis number *n* – 1, where DAQ device channel *x* is used for scanning the *n*th chassis in the system.
- sc***y*** is the SCXI chassis ID, where ***y*** is the number you chose when configuring the chassis.
- md***z*** is the slot position where the module is located, with ***z*** being the particular slot number. The slots in a chassis are numbered from left to right, starting with 1.
- ***channel*** is the channel that is sampled from module *z*.

Use the format `obx ! scy ! mdz !` ***n*** to verify the signal, where ***n*** is a single input channel.

Complete the following steps to use channel strings in verifying the signal:

1. Expand the list of tasks and virtual channels by clicking the **+** next to **Devices and Interfaces**.
2. Click the **+** next to **Traditional NI-DAQ Devices** to expand the device list.
3. Right-click the appropriate E Series DAQ device.
4. Click **Test Panels**.
5. Enter the channel string.
6. Enter the input limits.
7. Select the **Data Mode**.
8. Select the **Y Scale Mode**.

Refer to the *LabVIEW Measurements Manual* for more information and for proper formatting of channel strings for different uses.

Verifying the Signal Using Strain Virtual Channel

If you have already created a virtual channel, complete the following steps to verify the signal:

1. Right-click the strain virtual channel you want to verify and select **Test**.
2. In **Channel Names**, select the channel you want to verify.
3. When you have completed verifying the channel, click **Close**.

Using the Strain Calibration Wizard in NI-DAQmx

When using NI-DAQmx, you can perform an automated strain calibration on one or more channels in your task using the Strain Calibration Wizard in MAX.

Note All channels must be strain channels to use the Strain Calibration Wizard.

Complete the following steps to perform calibration using the Calibration Wizard:

1. Expand the list of devices by clicking the **+** next to **Data Neighborhood**.
2. Click the **+** next to **NI-DAQmx Tasks** to expand the list of tasks.
3. Select the strain task you previously created.
4. Click the **Device** tab.
5. Select the **Auto Zero Mode** and **Lowpass Filter Cutoff Frequency** from the dropdown lists.
6. Click the **Calibration** button and follow the onscreen instructions.

4

Theory of Operation

This chapter discusses strain-gauge concepts and the theory of operational measurement concepts.

Strain-Gauge Theory

This section discusses how to arrange, connect, and scale signals from bridge-based sensors, especially strain gauges.

Wheatstone Bridges

All strain-gauge configurations are based on the concept of a Wheatstone bridge. A Wheatstone bridge is a network of four resistive legs. One or more of these legs can be active sensing elements. Figure 4-1 shows a Wheatstone bridge circuit diagram.

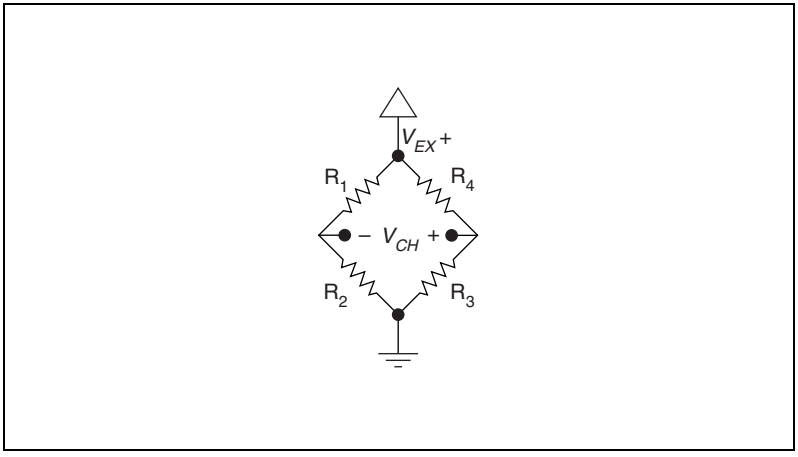


Figure 4-1. Basic Wheatstone Bridge Circuit Diagram

The Wheatstone bridge is the electrical equivalent of two parallel voltage divider circuits. R_1 and R_2 compose one voltage divider circuit, and R_4 and R_3 compose the second voltage divider circuit. The output of a Wheatstone bridge is measured between the middle nodes of the two voltage dividers.

A physical phenomena, such as a change in strain or temperature applied to a specimen, changes the resistance of the sensing elements in the Wheatstone bridge. The Wheatstone bridge configuration is used to help measure the small variations in resistance that the sensing elements produce corresponding to a physical changes in the specimen.

Strain Gauges

Strain-gauge configurations are arranged as Wheatstone bridges. The gauge is the collection of all of the active elements of the Wheatstone bridge. There are three types of strain-gauge configurations: quarter-, half-, and full-bridge. The number of active element legs in the Wheatstone bridge determines the kind of bridge configuration. Table 4-1 shows the number of active elements in each configuration.

Table 4-1. Strain-Gauge Configurations

Configuration	Number of Active Elements
Quarter-bridge	1
Half-bridge	2
Full-bridge	4

Each of these configurations is subdivided into multiple configuration types. The orientation of the active elements and the kind of strain measured determines the configuration type. NI supports seven configuration types in software. However, with custom software scaling you can use all Wheatstone bridge configuration types with any NI hardware product that supports the gauge configuration type.

The supported strain-gauge configuration types measure axial strain, bending strain, or both. While you can use some similar configuration types to measure torsional strain, NI software scaling does not support these configuration types. It is possible to use NI products to measure torsional strain, but to properly scale these configuration types you must create a custom scale in MAX or perform scaling in your software application.

This document discusses all of the mechanical, electrical, and scaling considerations of each strain-gauge configuration type supported by NI.

Acronyms, Formulas, and Variable Definitions

In the figures and equations in this document, the acronyms, formulas, and variables are defined as follows:

ε is the measured strain (+ε is tensile strain and –ε is compressive strain).

ε_S is the simulated strain.

GF is the Gauge Factor, which should be specified by the gauge manufacturer.

R_g is the nominal gauge resistance, which should be specified by the gauge manufacturer.

R_L is the lead resistance. If lead lengths are long, R_L can significantly impact measurement accuracy.

R_s is the shunt calibration resistor value.

U is the ratio of expected signal voltage to excitation voltage with the shunt calibration circuit engaged. Parameter *U* appears in the equations for simulated strain and is defined by the following equation:

$$U = \frac{-R_g}{4R_s + 2R_g}$$

ν is the Poisson's ratio, defined as the negative ratio of transverse strain to axial strain (longitudinal) strain. Poisson's ratio is a material property of the specimen you are measuring.

V_{CH} is the measured voltage of the signal.

V_{EX} is the excitation voltage.

V_r is the voltage ratio that is used in the voltage to strain conversion equations and is defined by the following equation:

$$V_r = \left(\frac{V_{CH}(\text{strained}) - V_{CH}(\text{unstrained})}{V_{EX}}\right)$$

Software Scaling and Equations

After you have acquired the voltage signal V_{CH}, you can scale this voltage to the appropriate strain units in software. This is done automatically for you in NI-DAQmx using a strain task or strain channel and in Traditional NI-DAQ (Legacy) using the strain virtual channel. You also can scale the voltages manually in your application using the voltage-to-strain conversion equations provided in this document for each configuration type.

Finally, there are voltage-to-strain conversion functions included in LabVIEW, NI-DAQmx, and Traditional NI-DAQ (Legacy). In LabVIEW, the conversion function, Convert Strain Gauge Reading VI, is in the **Data Acquisition»Signal Conditioning** subpalette. The prototypes for the NI-DAQ functions, `Strain_Convert` and `Strain_Buf_Convert`, are in the header file `convert.h` for C/C++, and `convert.bas` for Visual Basic. Refer to the *Traditional NI-DAQ User Manual* and the *LabVIEW Measurements Manual* for more information.

The names given the strain-gauge types in these sections directly correspond to bridge selections in MAX and the LabVIEW Convert Strain Gauge Reading VI.

Quarter-Bridge Type I

This section provides information for the quarter-bridge strain-gauge configuration type I. The quarter-bridge type I measures either axial or bending strain. Figure 4-2 shows how to position a strain-gauge resistor in an axial and bending configurations. Figure 4-3 shows the quarter-bridge type I circuit wiring diagram.

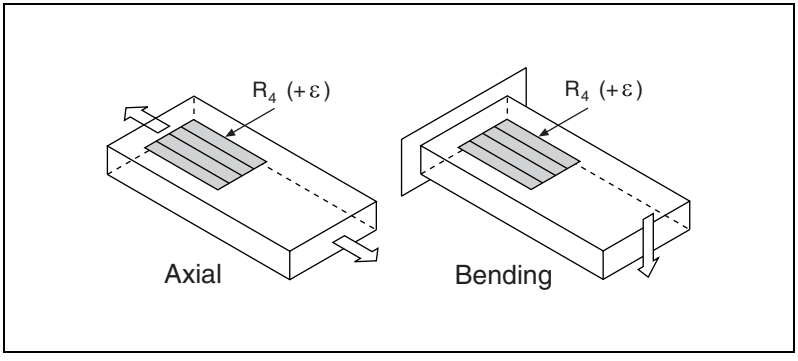


Figure 4-2. Quarter-Bridge Type I Measuring Axial and Bending Strain

A quarter-bridge type I has the following characteristics:

- A single active strain-gauge element is mounted in the principle direction of axial or bending strain.
- A passive quarter-bridge completion resistor (dummy resistor) is required in addition to half-bridge completion.
- Temperature variation in specimen decreases the accuracy of the measurements.
- Sensitivity at 1000 με is ~ 0.5 mV_{out} / V_{EX} input.

Note S– is left unwired.

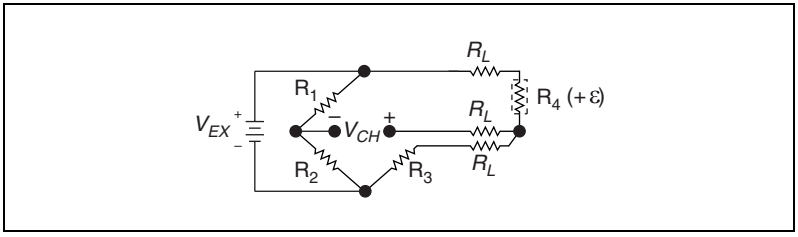


Figure 4-3. Quarter-Bridge I Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 and R_2 are half-bridge completion resistors.
- R_3 is the quarter-bridge completion resistor (dummy resistor).
- R_4 is the active strain-gauge element measuring tensile strain (+ε).
- V_{EX} is the excitation voltage.
- R_L is the lead resistance.
- V_{CH} is the measured voltage.

To convert voltage readings to strain units use the following equation:

$$strain\ (\varepsilon) = \frac{-4V_r}{GF(1+2V_r)} \times \left(1 + \frac{R_L}{Rg}\right)$$

where

- R_g is the nominal gauge resistance of the sensor.
- R_L is the lead resistance.
- GF is the Gauge Factor.

To simulate the effect on strain of applying a shunt resistor across R_3, use the following equation:

$$\varepsilon_s = \frac{-4U}{GF(1+4U)}$$

Notes The value of the quarter-bridge completion resistor (dummy resistor) must equal the nominal resistance of the strain gauge. NI recommends using a 0.1% precision resistor.

To minimize temperature drift errors, the strain gauge must have a self-temperature-compensation (STC) number that corresponds to the thermal expansion coefficient of the material under test. STC gauges have a temperature sensitivity that counteracts the thermal expansion coefficient of the test specimen. The STC number approximately equals the thermally induced change in strain with change in temperature and is expressed in units of microstrain per degree Fahrenheit. For example, if the test specimen is aluminum, use a gauge with an STC number of 13.0. If the test specimen is steel, use a gauge with an STC number of 6.0.

To minimize temperature drift errors in the wiring, use the three-wire connection shown in Figure 4-3. The wires connected to terminals S+ and QTR carry the same current and are on opposite sides of the same element of the bridge. Therefore, any temperature-related changes in voltage drop across R_L caused by temperature variation of the leads cancel out, leaving V_{CH} unchanged. The voltage drop across the lead resistance on a quarter-bridge type I configuration is uncompensated in hardware. It is important to accurately determine the gauge lead resistance and enter it in MAX or in the application software equation so the software can compensate for the voltage drop.

You can neglect lead resistance (R_L) of the wiring if shunt calibration is performed or if lead length is very short (~ <10 ft), depending on the wire gauge. For example 10 ft of 24-AWG copper wire has a lead resistance of 0.25 Ω.

Quarter-Bridge Type II

This section provides information for the quarter-bridge strain-gauge configuration type II. The quarter-bridge type II measures either axial or bending strain. Figure 4-4 shows how to position a strain-gauge resistor in an axial and bending configurations. Figure 4-5 shows the quarter-bridge type II circuit wiring diagram.

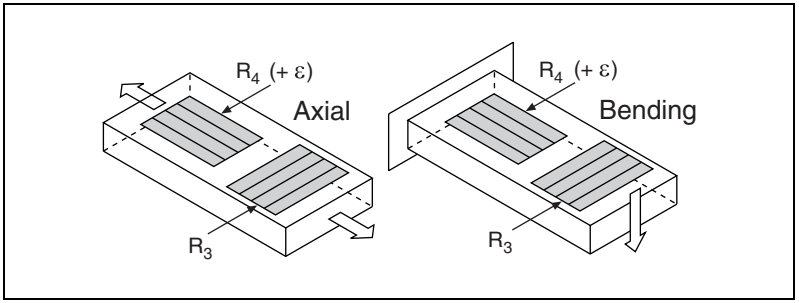


Figure 4-4. Quarter-Bridge Type II Measuring Axial and Bending Strain

A quarter-bridge type II has the following characteristics:

- One active strain-gauge element and one passive, temperature-sensing quarter-bridge element (dummy gauge). The active element is mounted in the direction of axial or bending strain. The dummy gauge is mounted in close thermal contact with the strain specimen but not bonded to the specimen, and is usually mounted transverse (perpendicular) to the principle axis of strain.
- This configuration is often confused with the half-bridge type I configuration, with the difference being that in the half-bridge type I configuration the R_3 element is active and bonded to the strain specimen to measure the effect of Poisson's ratio.
- Completion resistors provide half-bridge completion.
- Compensates for temperature.
- Sensitivity at 1000 με is ~ 0.5 mV_{out}/V_{EX} input.

Note S– and QTR are left unwired.

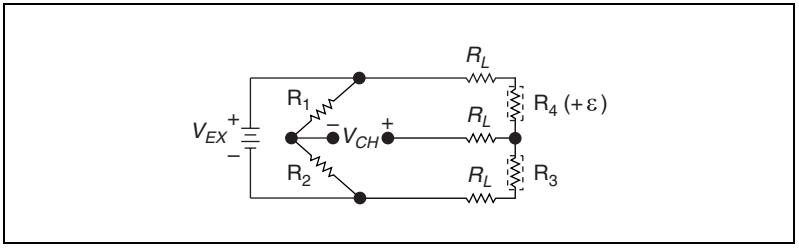


Figure 4-5. Quarter-Bridge II Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 and R_2 are half-bridge completion resistors.

- R_3 is the quarter-bridge temperature-sensing element (dummy gauge).
- R_4 is the active strain-gauge element measuring tensile strain (+ε).
- V_{EX} is the excitation voltage.
- R_L is the lead resistance.
- V_{CH} is the measured voltage.

To convert voltage readings to strain units use the following equation:

$$strain\ (\varepsilon) = \frac{-4V_r}{GF(1+2V_r)} \times \left(1 + \frac{R_L}{Rg}\right)$$

where

- R_g is the nominal gauge resistance.
- R_L is the lead resistance.
- GF is the Gauge Factor.

To simulate the effect on strain of applying a shunt resistor across R_3, use the following equation:

$$\varepsilon_s = \frac{-4U}{GF(1+4U)}$$

Notes The dummy gauge element must always be unstrained and mounted to the same type of material as the active gauge, but not strained. The dummy gauge temperature must closely track the temperature of the active gauge.

Gauges need not have a STC number corresponding to the material type of the test specimen.

As shown in Figure 4-5, for greatest calibration accuracy, use separate wires between the bridge and the SCA terminals. Do not directly connect S+ or P– to the SCA terminals inside the SCXI-1314 terminal block unless the strain-gauge cable length is very short.

You can neglect lead resistance (R_L) of the wiring if shunt calibration is performed or if lead length is very short (~ <10 ft), depending on the wire gauge. For example, 10 ft of 24-AWG copper wire has a lead resistance of 0.25 Ω.

The nominal value of R_3 is equal to R_g.

Half-Bridge Type I

This section provides information for the half-bridge strain-gauge configuration type I. The half-bridge type I measures either axial or bending strain. Figure 4-6 shows how to position strain-gauge resistors in an axial and bending configurations. Figure 4-7 shows the half-bridge type I circuit wiring diagram.

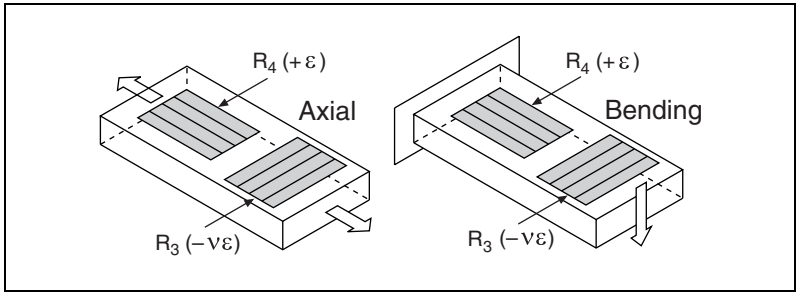


Figure 4-6. Half-Bridge Type I Measuring Axial and Bending Strain

A half-bridge type I has the following characteristics:

- Two active strain-gauge elements. One is mounted in the direction of axial strain, the other acts as a Poisson gauge and is mounted transverse (perpendicular) to the principal axis of strain.
- Completion resistors provide half-bridge completion.
- Sensitive to both axial and bending strain.
- Compensates for temperature.
- Compensates for the aggregate effect on the principle strain measurement due to the Poisson's ratio of the specimen material.
- Sensitivity at 1000 με is ~ 0.65 mV_{out}/V_{EX} input.

Note S– is left unwired.

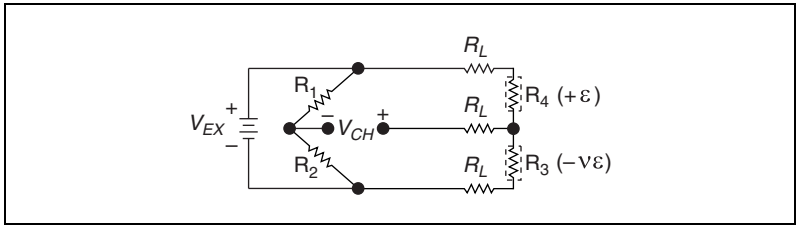


Figure 4-7. Half-Bridge Type I Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 and R_2 are half-bridge completion resistors.
- R_3 is the active strain-gauge element measuring compression from Poisson effect ($-\nu\varepsilon$).
- R_4 is the active strain-gauge element measuring tensile strain ($+\varepsilon$).
- V_{EX} is the excitation voltage.
- R_L is the lead resistance.
- V_{CH} is the measured voltage.

To convert voltage readings to strain units use the following equation:

$$strain\ (\varepsilon) = \frac{-4V_r}{GF[(1+\nu)-2V_r(\nu-1)]} \times \left(1+\frac{R_L}{R_g}\right)$$

where

- R_g is the nominal gauge resistance.
- R_L is the lead resistance.
- ν is the Poisson's ratio.
- GF is the Gauge Factor.

To simulate the effect on strain of applying a shunt resistor across R_3, use the following equation:

$$\varepsilon_s = \frac{-4U}{GF[(1+\nu)-2U(\nu-1)]}$$

Notes In half-bridge type I, R_4 is mounted along the principal axis of the stress field and R_3 is mounted transverse to the axis of the stress field. Use this configuration in applications where no stress exists along the axis of the transverse strain gauge.

Strain gauges need not have a particular STC number.

As shown in Figure 4-9, for greatest calibration accuracy, use separate wires between the bridge and the SCA terminals. Do not directly connect S+ or P– to the SCA terminals inside the SCXI-1314 terminal block unless the strain-gauge cable length is very short.

You can neglect lead resistance (R_L) of the wiring if shunt calibration is performed or if lead length is very short (~ <10 ft), depending on the wire gauge. For example 10 ft of 24-AWG copper wire has a lead resistance of 0.25 Ω.

The nominal values of R_3 and R_4 equal R_g.

Half-Bridge Type II

This section provides information for the half-bridge strain-gauge configuration type II. The half-bridge type II only measures bending strain. Figure 4-8 shows how to position strain-gauge resistors in an axial configuration. Figure 4-9 shows the half-bridge type II circuit wiring diagram.

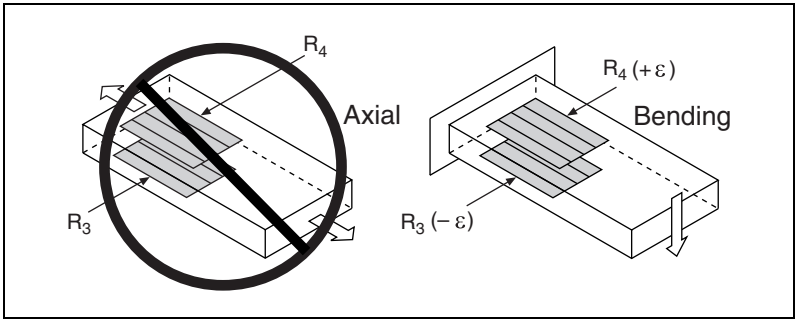


Figure 4-8. Half-Bridge Type II Rejecting Axial and Measuring Bending Strain

A half-bridge type II configuration has the following characteristics:

- Two active strain-gauge elements. One is mounted in the direction of bending strain on one side of the strain specimen (top), the other is mounted in the direction of bending strain on the opposite side (bottom).
- Completion resistors provide half-bridge completion.
- Sensitive to bending strain.
- Rejects axial strain.
- Compensates for temperature.
- Sensitivity at 1000 με is ~ 1 mV_{out}/V_{EX} input.

Note S– is left unwired.

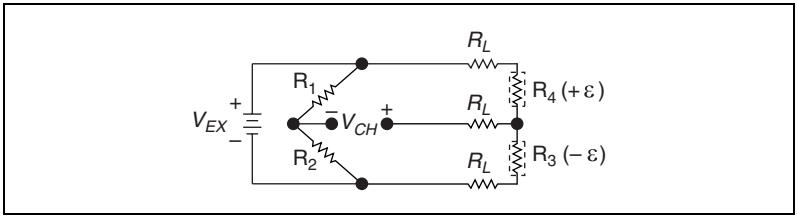


Figure 4-9. Half-Bridge Type II Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 and R_2 are half-bridge completion resistors.
- R_3 is the active strain-gauge element measuring compressive strain (–ε).
- R_4 is the active strain-gauge element measuring tensile strain (+ε).
- V_{EX} is the excitation voltage.
- R_L is the lead resistance.
- V_{CH} is the measured voltage.

To convert voltage readings to strain units use the following equation:

$$strain\ (\varepsilon) = \frac{-2V_r}{GF} \times \left(1 + \frac{R_L}{R_g}\right)$$

where

- R_g is the nominal gauge resistance.
- R_L is the lead resistance.
- GF is the Gauge Factor.

To simulate the effect on strain of applying a shunt resistor across R_3, use the following equation:

$$\varepsilon_s = \frac{-2U}{GF}$$

Notes Half-bridge type II requires one strain gauge to undergo tensile strain while the other strain gauge undergoes compressive strain of the same magnitude. This configuration is often used to measure bending strain where the strain gauges are mounted on opposite sides of a beam.

The strain gauges need not have a particular STC number.

As shown in Figure 4-7, for greatest calibration accuracy, use separate wires between the bridge and the SCA terminals. Do not directly connect S+ or P– to the SCA terminals inside the SCXI-1314 terminal block unless the strain-gauge cable length is very short.

You can neglect lead resistance (R_L) of the wiring if shunt calibration is performed or if lead length is very short (~ <10 ft), depending on the wire gauge. For example 10 ft of 24-AWG copper wire has a lead resistance of 0.25 Ω.

The nominal values of R_3 and R_4 equal R_g.

Full-Bridge Type I

This section provides information for the full-bridge strain-gauge configuration type I. The full-bridge type I only measures bending strain. Figure 4-10 shows how to position strain-gauge resistors in a bending configuration. Figure 4-11 shows the full-bridge type I circuit wiring diagram.

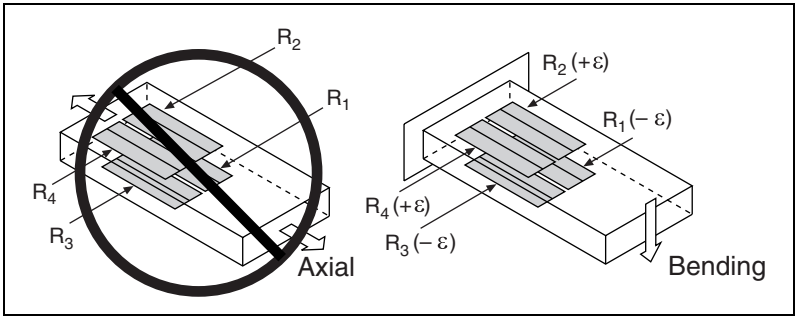


Figure 4-10. Full-Bridge Type I Rejecting Axial and Measuring Bending Strain

A full-bridge type I configuration has the following characteristics:

- Four active strain-gauge elements. Two are mounted in the direction of bending strain on one side of the strain specimen (top), the other two are mounted in the direction of bending strain on the opposite side (bottom).
- Highly sensitive to bending strain.
- Rejects axial strain.
- Compensates for temperature.
- Compensates for lead resistance.
- Sensitivity at 1000 με is ~ 2.0 mV_{out} / V_{EX} input.

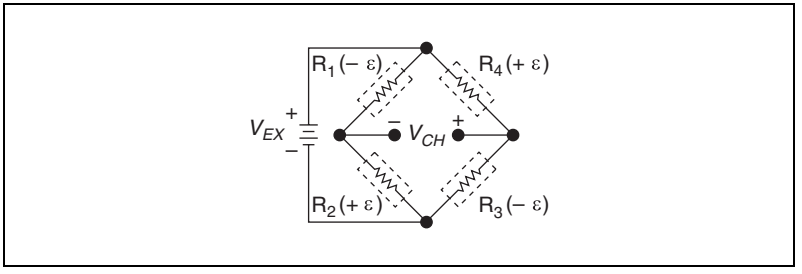


Figure 4-11. Full-Bridge Type I Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 is an active strain-gauge element measuring compressive strain (–ε).
- R_2 is an active strain-gauge element measuring tensile strain (+ε).
- R_3 is an active strain-gauge element measuring compressive strain (–ε).
- R_4 is an active strain-gauge element measuring tensile strain (+ε).
- V_{EX} is the excitation voltage.
- R_L is the lead resistance.
- V_{CH} is the measured voltage.

To convert voltage readings to strain units use the following equation:

$$strain\ (\varepsilon) = \frac{-V_r}{GF}$$

where

- GF is the Gauge Factor.

To simulate the effect on strain of applying a shunt resistor across R_3, use the following equation:

$$\varepsilon_s = \frac{-U}{GF}$$

Notes Strain gauges need not have a particular STC number.

As shown in Figure 4-11, for greatest calibration accuracy, use separate wires between the bridge and the SCA terminals. Do not directly connect S+ or P– to the SCA terminals inside the SCXI-1314 terminal block unless the strain-gauge cable length is very short.

The nominal values of R_1, R_2, R_3, and R_4 equal R_g.

Full-Bridge Type II

This section provides information for the full-bridge type II strain-gauge configuration. The full-bridge type II only measures bending strain. Figure 4-12 shows how to position strain-gauge resistors in a bending configuration. Figure 4-13 shows the full-bridge type II circuit wiring diagram.

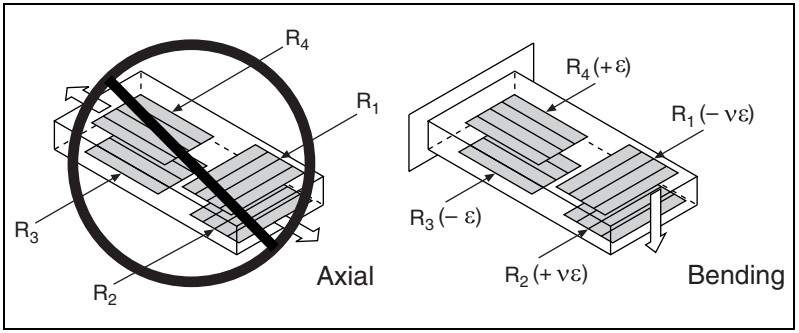


Figure 4-12. Full-Bridge Type II Rejecting Axial and Measuring Bending Strain

A full-bridge type II configuration has the following characteristics:

- Four active strain-gauge elements. Two are mounted in the direction of bending strain with one on one side of the strain specimen (top) and the other on the opposite side (bottom). The other two act together as a Poisson gauge and are mounted transverse (perpendicular) to the principal axis of strain with one on one side of the strain specimen (top) and the other on the opposite side (bottom).
- Rejects axial strain.
- Compensates for temperature.
- Compensates for the aggregate effect on the principle strain measurement due to the Poisson's ratio of the specimen material.
- Compensates for lead resistance.
- Sensitivity at 1000 με is ~ 1.3 mV_{out} / V_{EX} input.

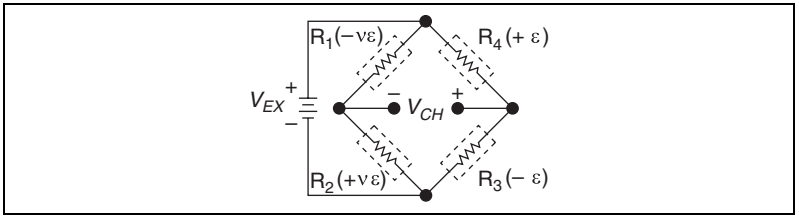


Figure 4-13. Full-Bridge Type II Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 is an active strain-gauge element measuring compressive Poisson effect ($-\nu\varepsilon$).
- R_2 is an active strain-gauge element measuring tensile Poisson effect ($+\nu\varepsilon$).
- R_3 is an active strain-gauge element measuring compressive strain ($-\varepsilon$).
- R_4 is an active strain-gauge element measuring tensile strain ($+\varepsilon$).
- V_{EX} is the excitation voltage.
- R_L is the lead resistance.
- V_{CH} is the measured voltage.

To convert voltage readings to strain units use the following equation:

$$strain\ (\varepsilon) = \frac{-2V_r}{GF(1+v)}$$

where

- GF is the Gauge Factor.
- ν is the Poisson's ratio.

To simulate the effect on strain of applying a shunt resistor across R_3, use the following equation:

$$\varepsilon_s = \frac{-2U}{GF(1+v)}$$

Notes Full-bridge type II is sometimes used for strain measurement of bending beams. R_3 and R_4 are positioned along the beam axis and on opposite sides of the beam, and R_1 and R_2 are positioned transverse to the beam axis and on opposite sides of the beam.

Strain gauges need not have a particular STC number.

As shown in Figure 4-13, for greatest calibration accuracy, use separate wires between the bridge and the SCA terminals. Do not directly connect S+ or P– to the SCA terminals inside the SCXI-1314 terminal block unless the strain-gauge cable length is very short.

The nominal values of R_1, R_2, R_3, and R_4 equal R_g.

Full-Bridge Type III

This section provides information for the full-bridge strain-gauge configuration type III. The full-bridge type III only measures axial strain. Figure 4-14 shows how to position strain-gauge resistors in an axial configuration. Figure 4-15 shows the full-bridge type III circuit wiring diagram.

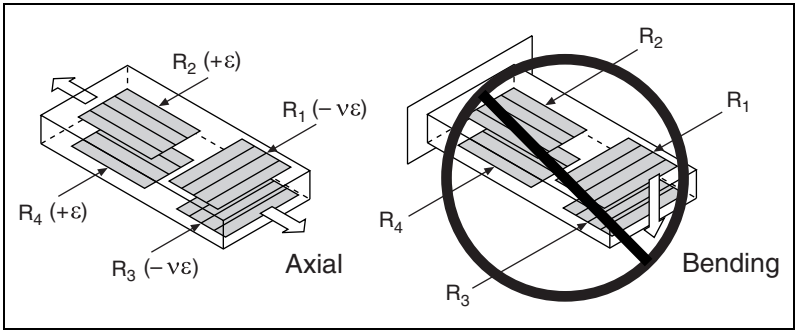


Figure 4-14. Full-Bridge Type III Measuring Axial and Rejecting Bending Strain

A full-bridge type III configuration has the following characteristics:

- Four active strain-gauge elements. Two are mounted in the direction of axial strain with one on one side of the strain specimen (top), the other on the opposite side (bottom). The other two act together as a Poisson gauge and are mounted transverse (perpendicular) to the principal axis of strain with one on one side of the strain specimen (top) and the other on the opposite side (bottom).
- Compensates for temperature.
- Rejects bending strain.
- Compensates for the aggregate effect on the principle strain measurement due to the Poisson's ratio of the specimen material.
- Compensates for lead resistance.
- Sensitivity at 1000 με is ~ 1.3 mV_{out} / V_{EX} input.

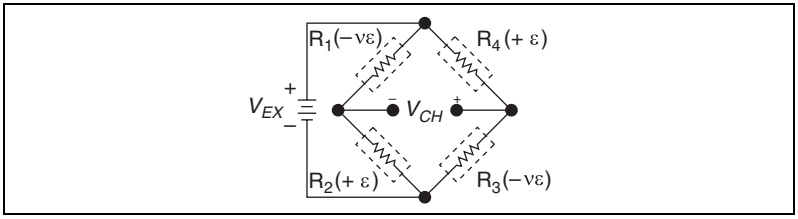


Figure 4-15. Full-Bridge Type III Circuit Diagram

The following symbols apply to the circuit diagram and equations:

- R_1 is an active strain-gauge element measuring compressive Poisson effect ($-\nu\varepsilon$).
- R_2 is an active strain-gauge element measuring tensile strain ($+\varepsilon$).
- R_3 is an active strain-gauge element measuring compressive Poisson effect ($-\nu\varepsilon$).
- R_4 is an active strain-gauge element measuring the tensile strain ($+\varepsilon$).
- V_{EX} is the excitation voltage.
- R_L is the lead resistance.
- V_{CH} is the measured voltage.

To convert voltage readings to strain units use the following equation:

$$strain\ (\varepsilon) = \frac{-2V_r}{GF[(v+1) - V_r(v-1)]}$$

where

- GF is the Gauge Factor.
- ν is the Poisson's ratio.

To simulate the effect on strain of applying a shunt resistor across R_3, use the following equation:

$$\varepsilon_s = \frac{-4U}{GF[(v+1) - U(v-1)]}$$

Notes Full-bridge type III is sometimes used for axial strain measurement. R_2 and R_4 are positioned along the beam axis and on opposite sides of the beam, and R_1 and R_3 are positioned transverse to the beam axis and on opposite sides of the beam.

Strain gauges need not have a particular STC number.

As shown in Figure 4-15, for greatest calibration accuracy, use separate wires between the bridge and the SCA terminals. Do not directly connect S+ or P– to the SCA terminals inside the SCXI-1314 terminal block unless the strain-gauge cable length is very short.

The nominal values of R_1, R_2, R_3, and R_4 equal R_g.

SCXI-1520 Theory of Operation

This section includes a brief overview and a detailed discussion of the circuit features of the module. Refer to Figure 4-16 while reading this section.

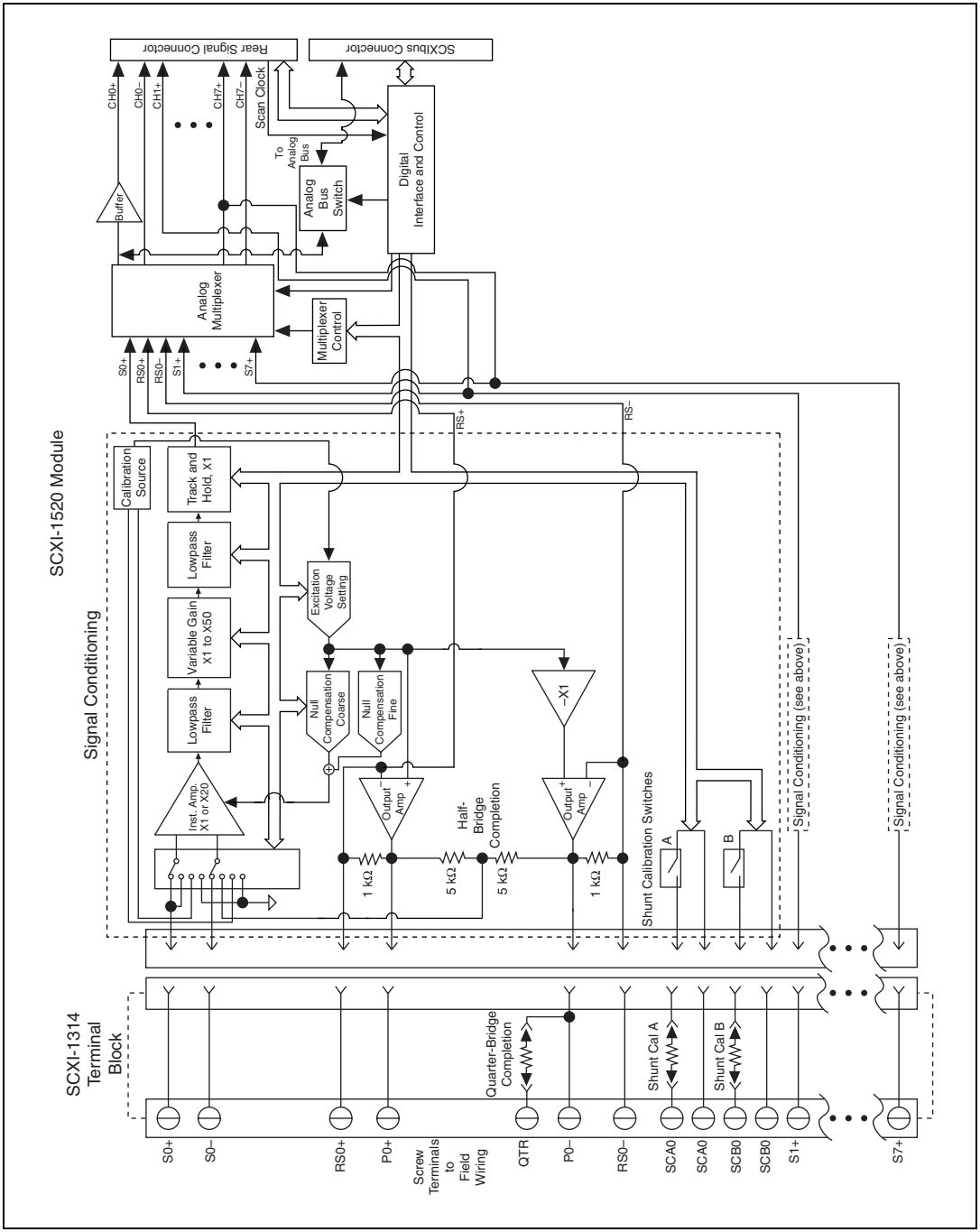


Figure 4-16. Block Diagram of SCXI-1314/SCXI-1520 Combination

The analog input signal from the strain gauge or bridge sensor connects to S*X*+ and S*X*– of the terminal block. The signal passes through the terminal block to an electronic four-position switch in the module. Figure 4-16 shows the switching stage that controls the input of to the signal conditioning circuitry and the E/M Series DAQ device.

In the switching stage there are four positions. In the first position where S*X*+ and S*X*– inputs connect directly to an instrumentation amplifier. This position is for full-bridge connections or general-purpose analog input. The second position connects the negative input to the internal voltage divider between the excitation terminals. The internal voltage divider functions as bridge completion for quarter- and half-bridge configurations. The third switch position connects the amplifier input to a calibration voltage source inside the module for gain calibration, and the fourth position grounds both inputs for offset calibration.

The instrumentation amplifier stage presents a very high input impedance to external signals and passes only the differential signal. The offset null compensation circuitry adjusts the signal voltage by a specified offset after an offset null calibration is performed.

The signal from the instrumentation amplifier stage passes through a lowpass filter stage, a variable gain stage, another lowpass filter stage, and finally a simultaneous sample-and-hold stage before reaching the output multiplexer for multiplex mode operation. The signals S1± through S7± are also directly routed to the rear signal connector for parallel mode operation.

You can set the cutoff frequencies of the lowpass filter stage to one of five settings.You also can bypass the filters for a maximum bandwidth of 20 kHz.

The variable gain stage allows you to set the gain at many discrete settings between 1 and 50. These settings, along with the 1 or 20 setting of the instrumentation amplifier, permit the SCXI-1520 to have 49 gain settings between 1 and 1000.

The simultaneous sample-and-hold stage uses track-and-hold circuitry to perform simultaneous sampling for all channels. When enabled, track-and-hold circuitry holds the signal at the beginning of a scan, and reverts back to track mode at the end of a scan.

The signal then passes from the simultaneous sample-and-hold stage to the multiplexer stage. The modes of operation are determined by the multiplexer stage. If configured for multiplexed mode operation, the multiplexer selects the conditioned analog signal from one of the

eight channels for routing. The signal is routed to the E/M Series DAQ device channel 0 if the SCXI-1520 is the cabled module and/or to the SCXI backplane through the SCXIbus connector. If configured for parallel mode operation, the signals are routed through the rear signal connector to the digitizing DAQ device.

The multiplexer stage is controlled by the digital interface and control circuitry. The digital interface and control circuitry stores the scan list, controls the multiplexer, and allows flexible scanning (random scanning).

Two other circuitry stages that are not directly in the signal path are excitation circuitry and shunt calibration switches. The excitation stage is stable output with a controlled feedback loop called remote sense. The remote sense signal is connected to the analog multiplexer. You can scan remote sense when configured in multiplexed mode operation.

The shunt calibration switches are controlled by the digital interface and control circuity. You must connect the SC*X* terminals to the bridge for shunt calibration to function correctly. When the switch is closed, a socketed shunt calibration resistor in the SCXI-1314 connects across a leg of a Wheatstone bridge.

For more detailed information about the operation of any of these circuitry stages, refer to the *Bridge Configuration and Completion* section, the *Excitation* section, the *Gain* section, the *Filter Bandwidth and Cutoff Frequency* section, the *Offset Null Compensation* section, the *Shunt Calibration* section, the *Simultaneous Sample and Hold* section, and the *Modes of Operation* section.

Bridge Configuration and Completion

You can configure the SCXI-1520 for use with Wheatstone bridge sensors that require bridge completion. Bridge completion is necessary for quarter- or half-bridge sensors. You can set the SCXI-1520 for quarter-, half-, or full-bridge configuration to match the configuration completion requirements of each sensor. When quarter- or half-bridge configuration is selected, Terminal S*X*– (where *X* is a particular channel) is disconnected from the front signal connector and internally connected to a half-bridge completion network. When quarter-bridge configuration is selected, a socketed quarter-bridge completion resistor in the terminal block is internally connected between P*X*– and the QTR terminal. You then field wire the quarter-bridge sensor between P*X*+ and QTR. Make sure that the value of the precision quarter-bridge completion resistor matches the nominal gauge resistance of the quarter-bridge sensor. The quarter-bridge completion resistor is socketed for easy replacement.

Note When using the SCXI-1520 and SCXI-1314 configured for quarter-bridge completion, do not wire the sensor or any signal to S*X*–.

Refer to the *Configurable Settings in MAX* section of Chapter 3, *Configuring and Testing*, for more information about programmatically setting bridge completion in MAX. For more information about programmatically setting bridge completion in NI-DAQmx and Traditional NI-DAQ (Legacy), refer to the *Developing Your Application in NI-DAQmx* section or the *Developing Your Application in Traditional NI-DAQ (Legacy)* section, respectively, of Chapter 5, *Using the SCXI-1520*.

Excitation

The SCXI-1520 provides DC excitation voltage for a Wheatstone bridge sensor. For half- and full-bridge applications, the excitation voltage is available at terminal block connections P*X*+ and P*X*–. For quarter-bridge applications, P*X*– is not used; instead, wire to terminals P*X*+ and QTR*X*. Terminal QTR*X* internally connects to P*X*–.

Excitation voltage originates from two output buffers dedicated to each channel. Since each channel is controlled independently, a short circuit across the excitation terminals of one channel has no effect on the excitation of another channel. The output buffers have negative feedback connections at the terminal block remote-sense terminals, RS*X*+ and RS*X*–. You can run separate wires from the bridge to these terminals so that the amplifiers obtain feedback directly from the bridge, thereby forcing bridge voltage to equal the desired setting.

Excitation voltage originates from two excitation output buffers per channel. One output buffer generates the positive excitation voltage, and the other output buffer generates the negative excitation voltage. Since each channel is controlled independently, a short circuit across the excitation terminals of one channel has no effect on the excitation of another channel.

P*X*+ is always positive with respect to ground, and P*X*– is always negative with respect to ground. The inverting amplifier –X1 forces the voltage at P*X*– to equal the negative of the voltage at P*X*+. For example, if you set the module output for +5 V, P*X*+ is at +2.5 V with respect to ground, and P*X*– is at –2.5 V with respect to ground. The excitation setting originates from an internal digital-to-analog converter (DAC). You can set the excitation voltage in a near-continuous range using NI-DAQmx and between 0 V and 10 V in 0.625 V increments using Traditional NI-DAQ (Legacy). You can power a 350 Ω full-bridge at 10 V without exceeding the maximum power rating of the excitation source. The excitation outputs are protected with

surge suppressors that prevent either excitation output terminal from exceeding 6 V with respect to chassis ground.

Note Chassis ground is at the same potential as earth ground when the chassis is plugged into a standard 3-prong AC outlet. If P*X*– is connected to earth ground, the excitation source does not function properly.

Refer to the *Configurable Settings in MAX* section of Chapter 3, *Configuring and Testing*, for more information about programmatically setting the excitation level in MAX. For more information about programmatically setting the excitation level in NI-DAQmx and Traditional NI-DAQ (Legacy), refer to the *Developing Your Application in NI-DAQmx* section or the *Developing Your Application in Traditional NI-DAQ (Legacy)* section, respectively, of Chapter 5, *Using the SCXI-1520*.

Remote Sense

The excitation output buffers have negative feedback connections at the terminal block remote-sense terminals, RS*X*+ and RS*X*–. You can run separate wires from the bridge to these terminals so that the amplifiers obtain feedback directly from the bridge, forcing bridge voltage to exactly equal the desired setting. This removes unwanted DC offset in the signal and compensates for changes in lead resistance caused by temperature variation in the lead wires.

The SCXI-1520 excitation output circuits set the output voltage by monitoring the remote-sense terminals. Therefore, the SCXI-1520 corrects for a voltage ($I \times R$) drop in the excitation leads between the module and the bridge, even if lead resistance changes with temperature.

You can scan the remote sense terminals. The output multiplexer has input connections to the RS*X*+ and RS*X*– terminals. You can scan these terminals for monitoring and scaling purposes, even if the remote-sense terminals are not connected. Refer to Chapter 5, *Using the SCXI-1520*, and Appendix B, *Using SCXI Channel Strings with Traditional NI-DAQ (Legacy) 7.0 or Later*, for more information.

Wire the SCXI-1520 for remote sense as shown in Figure 2-8, *Remote-Sense Circuit Diagram*. There are no configuration settings you need to change in the software.

Note If you use remote sense, set R_L to zero in the MAX configuration of the channel and in your application equations for measured strain (ε).

If you leave the remote-sense terminal unconnected, internal 1 kΩ resistors provide feedback to the buffers from the P*X*+ and P*X*– terminals. Therefore, you need not install a jumper wire between RS*X*+ and P*X*+, or RS*X*– and P*X*–. However, NI recommends performing a shunt calibration to compensate for the voltage drop across lead resistance.

Note NI recommends that you connect remote sense wires to the sensor directly for optimal performance.

If you are not connecting remote sense and not performing shunt calibration, you must scale the measurements to compensate for the excitation voltage drop across the lead resistance. You should use the following gain adjustment factor:

$$Gain\ Adjusting\ Factor\ =\ 1 + \frac{2R_L}{R_g}$$

This gain adjust factor is used in your application to compensate for the voltage drop across the leads as follows:

$$V_{meas} \times Gain\ Adjusting\ Factor$$

Gain

The SCXI-1520 has multiple gain stages to provide optimal overall signal gains appropriate for fully utilizing the range of the digitizing E/M Series DAQ device. The first gain stage (the instrumentation amplifier stage) provides gains of either 1 or 20. The second gain stage provides many discrete settings between 1 and 50. Together these two gain stages combine for 49 overall gain settings with overall gains between 1 and 1000.

For overall module gain settings equal to or greater than 20, the gain of the first stage is set to 20 so that the noise and offset drift of later stages is small in comparison to this stage. The instrumentation amplifier stage uses operational amplifiers with very low temperature drift and noise characteristics. If overall module gain is less than 20, the first stage is set to 1 and the appropriate second stage gain is applied.

In normal operation of the SCXI-1520, you need not set the gain since NI-DAQ sets the gain based on the range of your virtual channel, task, or global channel, or the input limits set in LabVIEW.

In NI-DAQmx the default setting is 1.0 and in Traditional NI-DAQ (Legacy) the default gain setting is 100.00.

Refer to the *Configurable Settings in MAX* section of Chapter 3, *Configuring and Testing*, for more information about programmatically setting gain using range settings in MAX. For more information about programmatically setting gain using range settings in NI-DAQmx and Traditional NI-DAQ (Legacy), refer to the *Developing Your Application in NI-DAQmx* section or the *Developing Your Application in Traditional NI-DAQ (Legacy)* section, respectively, of Chapter 5, *Using the SCXI-1520*.

Filter Bandwidth and Cutoff Frequency

The SCXI-1520 provides two filtering stages with an overall response of a four-pole Butterworth filter. You can control the cutoff frequency of the filter through software. You can choose 10 Hz, 100 Hz, 1 kHz, 10 kHz, or filter-bypass mode. For additional flexibility in cutoff frequency settings and for greater suppression, NI recommends combining the hardware filtering provided by the SCXI-1520 with digital filtering. NI recommends using the Advanced Analysis functions of LabVIEW, LabWindows/CVI, or Measurement Studio. By combining hardware anti-aliasing with digital filtering, you can choose any cutoff frequency.

The Advanced Analysis functions are only available in LabVIEW Full or Professional Development Systems, and LabWindows/CVI Base or Full Development Systems.

Refer to the *Configurable Settings in MAX* section of Chapter 3, *Configuring and Testing*, for more information about programmatically setting the cutoff frequency of the filter in MAX. For more information about programmatically setting the cutoff frequency of the filter in NI-DAQmx and Traditional NI-DAQ (Legacy), refer to the *Developing Your Application in NI-DAQmx* section or the *Developing Your Application in Traditional NI-DAQ (Legacy)* section, respectively, of Chapter 5, *Using the SCXI-1520*.

Offset Null Compensation

The SCXI-1520 provides offset null compensation to adjust signal voltages to proper levels when the strain gauge or bridge sensor is at rest (unstrained). For most sensors offset null compensation is used to remove an initial voltage offset from the Wheatstone bridge. Many strain-gauge signal conditioning devices use a manually adjusted multi-turn screw potentiometer for offset null compensation. In the SCXI-1520, offset null compensation is performed electronically using software-controlled electronic potentiometers.

Two offset null potentiometers are used, one for coarse adjustments and the other for fine adjustments. The sum of the two potentiometer signals is added to the analog input path to adjust the signal voltage to remove the offset, which nulls the strain-gauge channel. The voltage input to the potentiometers is a voltage proportional to the excitation voltage setting. Therefore, if the excitation voltage changes by a small amount due to changes such as temperature and sensor loading, the correction signal produced by the offset null potentiometers changes by the same amount and the offset null is maintained.

The offset null potentiometers are controlled digitally using control codes. The control codes of the offset null potentiometers are set in software using integer values. The coarse potentiometer ranges from 0 to 127 and the fine potentiometer from 0 to 4095. The span of correction (the voltage nulling range) for each potentiometer depends on the channel gain setting. Table 4-2 summarizes the nulling range and scale of the control codes.

Table 4-2. Control Codes for Coarse and Fine Offset Null Potentiometers

Offset Null Potentiometer	Range (Integer Values)	Mid-Scale	Module Channel Gain Settings	Approximate Correction Span at Analog Input
Coarse	0 to 127	62	≥20	$V_{EX}/10$
			<20	$2 \times V_{EX}$
Fine	0 to 4095	2047	≥20	$V_{EX}/364$
			<20	$V_{EX}/18$

In most cases, you do not explicitly set the offset null potentiometers, but instead allow the NI-DAQ driver software to automatically adjust them for you. You can do this either through MAX or in your application.

Refer to the *Configurable Settings in MAX* section of Chapter 3, *Configuring and Testing*, for more information about programmatically performing offset null compensation in MAX. For more information about programmatically performing offset null compensation in NI-DAQmx and Traditional NI-DAQ (Legacy), refer to the *Developing Your Application in NI-DAQmx* section or the *Developing Your Application in Traditional NI-DAQ (Legacy)* section, respectively, of Chapter 5, *Using the SCXI-1520*.

Shunt Calibration

Shunt calibration is a process used to obtain a gain adjust factor, which is used to correct for system gain error and discrepancies between nominal Gauge Factor and actual Gauge Factor of the strain gauge.

The gain adjust factor is derived using theoretical (simulated) signal levels that should result from engaging a shunt resistor across one leg of a bridge sensor and the measured signal levels with the shunt resistor actually engaged.

Use the following formula to calculate the gain adjust factor:

$$gain\ adjust\ factor = \frac{simulated\ signal\ level}{measured\ signal\ level\ with\ shunt\ resistor\ engaged}$$

The gain adjust factor is then multiplied by each future measurement to obtain highly accurate measurements that are adjusted for any gain errors or any discrepancies in the nominal Gauge Factor. Refer to the *Configurable Settings in MAX* section of Chapter 3, *Configuring and Testing*, for more information about performing shunt calibration automatically in global channels using NI-DAQmx in MAX or strain virtual channels using Traditional NI-DAQ (Legacy) and tasks. For more information about programmatically performing shunt calibration switches in NI-DAQmx and Traditional NI-DAQ (Legacy), refer to the *Developing Your Application in NI-DAQmx* section or the *Developing Your Application in Traditional NI-DAQ (Legacy)* section, respectively, of Chapter 5, *Using the SCXI-1520*.

The SCXI-1520 has two independent shunt calibration circuits available for each channel at terminal sets SCA*X* and SCB*X* on the terminal block. Each shunt calibration circuit consists of a resistor in series with a switch. The SCXI-1520 shunt calibration switch is a long-life solid-state switch. The electronic switch is galvanically isolated from ground; therefore, you can connect the switch across any external bridge element.

Notes You can control an individual shunt calibration switch or combination of multiple shunt calibration switches using NI-DAQ software. The shunt calibration resistors in series with each switch are housed in the SCXI-1314 terminal block. The shunt calibration resistors are socketed for easy replacement. The resistors are RN-55 style (standard 1/4 W)

precision resistors. For resistor replacement instructions, refer to the *SCXI-1314 Universal Strain Terminal Block Installation Guide*.

Perform an offset null compensation just before you perform a shunt calibration. Performing a shunt calibration before an offset null compensation causes improper gain adjustment because the offset signal voltage is compensated multiple times.

Simultaneous Sample and Hold

Simultaneous sample and hold (SS/H) signal conditioning allows multiplexing MIO DAQ devices to return synchronized samples of all channels with negligible skew time between channels. SS/H signal conditioning is performed on the SCXI-1520 with track-and-hold (T/H) circuitry. The outputs of the T/H amplifiers follow their inputs, also called *tracking* the inputs, until they receive a hold signal from the DAQ device. All channels with T/H circuitry hold their signal at the same time, even if they are on different SCXI modules. The DAQ device then digitizes the signal of each channel, giving you simultaneous sampling between channels since no time elapsed between the holding of each signal. All signals are then released and the T/H circuitry output returns to tracking the input signal. For accurate measurements, you can use the SS/H equations to calculate the maximum sample rate when scanning SCXI systems with at least one SS/H module in the scan list. Figure 4-17 shows and example of a signal during a SS/H sampling.

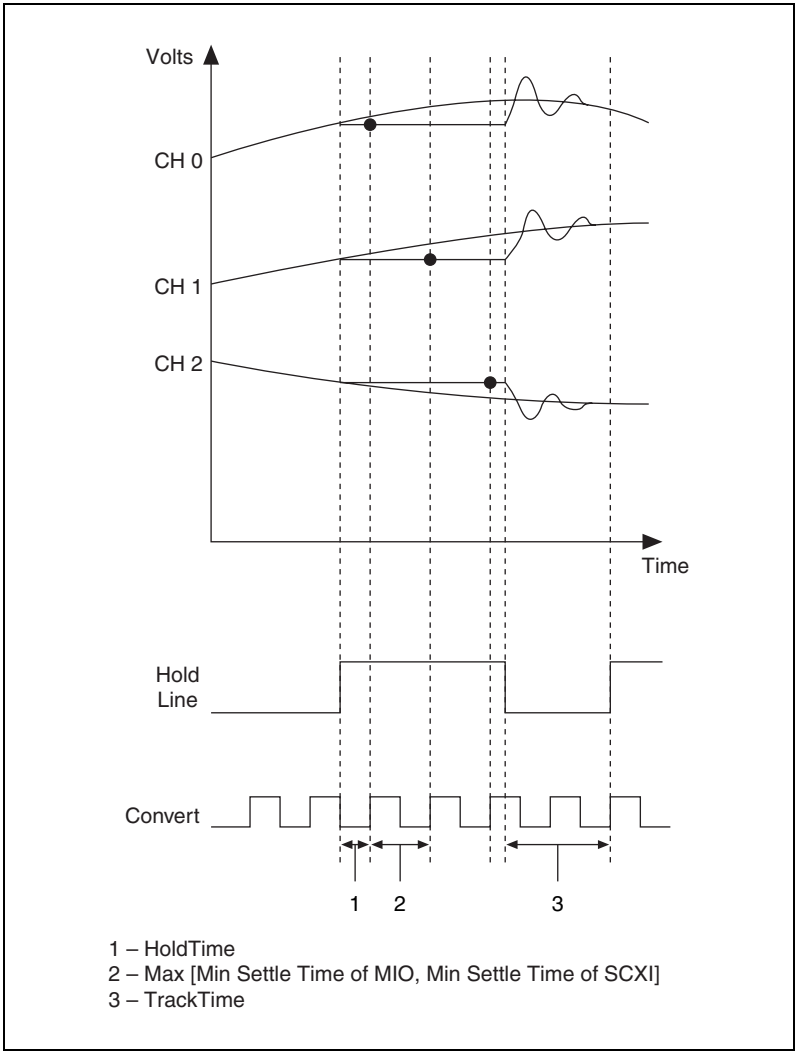


Figure 4-17. Signal During Simultaneous Sample-and-Hold Sampling

It is possible to enable and disable SS/H programmatically in NI-DAQmx, although NI recommends that you leave SS/H enabled for most applications. Disabling SS/H for one module disables this feature for all modules in all chassis that are controlled by the same DAQ device. You should only disable SS/H if your application does not require simultaneous sampling and requires higher acquisition rates than are possible with SS/H enabled. Refer to the *Developing Your Application in NI-DAQmx* section of Chapter 5, *Using the SCXI-1520*, for more information about

programmatically enabling and disabling SS/H using NI-DAQmx in your application.

Maximum Simultaneous Sample and Hold Sample Rate Using NI-DAQmx

When using NI-DAQmx you can use the SCXI-1520 in multiplexed or parallel mode.

Multiplexed Mode

Use the following formula to calculate the maximum SS/H sample rate in multiplexed mode:

$$SR = \frac{1}{(HT + (NoC - 1) \times [\text{Maximum of either } (MST_{MIO}) \text{ or } (MST_{SCXI})] + TT)}$$

where

SR is sample rate—frequency of acquisition of all channels

HT is hold time—the time between holding all the SS/H channels and the first A/D conversion

NoC is number of channels—the total number of channels being sampled in the scan list (SS/H or not)

MST_{MIO} is minimum settle time of MIO—inverse of maximum sample rate of the MIO (also minimum interchannel delay)

MST_{SCXI} is minimum settle time of SCXI—inverse of maximum multiplex rate of SCXI (1 ÷ 333 k = 3 µs for 12-bit MIO, 1 ÷ 1000 k = 10 µs for 16-bit MIO)

TT is track time—the minimum time between the last AD conversion of the current scan and engaging the hold signal of SS/H channels of next scan

Table 4-3 shows some example values used to determine the *SR* using the general equation.

Table 4-3. NI-DAQmx Values Used to Determine Maximum Sample Rate in Multiplexed Mode

MIO Device	Device Accuracy (Bits)	Device Max Sample Rate (S/s)	HT (µs)	NoC	MST_{MIO} (µs)	MST_{SCXI} (µs)†	TT (µs)†	Default NI-DAQmx SR (Multiplexed) (Hz)	DAQmx SR Required for Maximum Accuracy (Hz)‡
NI 6070E	12	1250000	3	8	0.8	3	7	32258	32258
				32	0.8	3	7	9709	9709
NI 6023E	12	200000	3	8	5	3	7	22222	22222
				32	5	3	7	6061	6061
NI 6221 (68-Pin)	16	250000	3	8	4	3	7	26316	5181
				32	4	3	7	7463	1486
NI 6289	18	625000	3	8	1.6	3	7	32258	5181
				32	1.6	3	7	9709	1486

† These are the default values used by DAQmx, but these might not be the desired values for your application.

‡ For DAQ boards with a 16 bit or higher ADC, 20 µs was used for MST_{SCXI} and 50 µs for TT.

Note: To use a MST_{SCXI} value that is different than the 3 µs default, you must explicitly set the AI Convert Clock Rate in DAQmx. Refer to your ADE help file for details on setting the AI Convert Clock Rate property.

Maximum SS/H Sample Rates in Parallel Mode

Use the following formula to calculate the maximum SS/H sample rate in parallel mode:

$$SR = \frac{1}{(HT + (NoC - 1) \times (MST_{MIO}) + TT)}$$

where

SR is sample rate—frequency of acquisition of all channels

HT is hold time—the time between holding all the SS/H channels and the first A/D conversion

NoC is number of channels—the total number of channels being sampled in the scan list (SS/H or not)

MST_{MIO} is minimum settle time of MIO—inverse of maximum sample rate of the MIO (also minimum interchannel delay)

TT is track time—the minimum time between the last AD conversion of the current scan and engaging the hold signal of SS/H channels of next scan

Table 4-4 shows some example values used to determine the *SR* using the general equation.

Table 4-4. NI-DAQmx Values Used to Determine Maximum Sample Rate in Parallel Mode

MIO Device	Device Accuracy (Bits)	Device Max Sample Rate (S/s)	HT (µs)	NoC	MST_{MIO} (µs)	TT (µs)†	Default NI-DAQmx SR (Parallel) (Hz)	DAQmx SR Required for Maximum Accuracy (Hz)‡
NI 6070E	12	1250000	3	8	0.8	7	64103	64103
NI 6023E	12	200000	3	8	5	7	22222	22222
NI 6221 (68-Pin)	16	250000	3	8	4	7	26316	12346
NI 6254	16	1000000	3	8	1	7	58824	16667
			3	16	1	7	40000	14706
NI 6289	18	625000	3	8	1.6	7	47170	15576
			3	16	1.6	7	29412	12987

† These are the default values used by DAQmx, but these might not be the desired values for your application.

‡ For DAQ boards with a 16 bit or higher ADC, 20 µs was used for MST_{SCXI} and 50 µs for TT.

Maximum Simultaneous Sample and Hold Using Traditional NI-DAQ (Legacy)

When using Traditional NI-DAQ (Legacy), you can only use the SCXI-1520 in multiplexed mode. To use parallel mode, you must use NI-DAQmx.

Multiplexed Mode

Use the following formula to calculate the maximum SS/H sample rate in multiplexed mode:

$$SR = \frac{1}{NoC \times (\text{Maximum of either } \sqrt{MST_{MIO}{}^2 + MST_{SCXI}{}^2} \text{ or } HT) + TT}$$

where

SR is sample rate—frequency of acquisition of all channels

HT is hold time—the time between holding all the SS/H channels and the first A/D conversion

NoC is number of channels—the total number of channels being sampled in the scan list (SS/H or not)

MST_{MIO} is minimum settle time of MIO—inverse of maximum sample rate of the MIO (also minimum interchannel delay)

MST_{SCXI} is minimum settle time of SCXI—inverse of maximum multiplex rate of SCXI (1 ÷ 333 k = 3 µs for 12-bit MIO, 1 ÷ 1000 k = 10 µs for 16-bit MIO)

TT is track time—the minimum time between the last AD conversion of the current scan and engaging the hold signal of SS/H channels of next scan

Table 4-5 shows some example values used to determine the *SR* using the general equation.

Table 4-5. Traditional NI-DAQ (Legacy) Values Used to Determine Maximum Sample Rate in Multiplexed Mode

MIO Device	Device Accuracy (Bits)	Device Maximum Sample Rate (S/s)	HT (µs)	NoC	MST_{MIO} (µs)	MST_{SCXI} (µs)	TT (µs)	Maximum SR Traditional NI-DAQ (Legacy) Multiplexed
NI 6070E	12	1250000	3	8	1	3	7	30961
NI 6070E	12	1250000	3	32	1	3	7	9243
NI 6023E	12	200000	3	8	5	3	7	18640
NI 6023E	12	200000	3	32	5	3	7	5166
NI 6052E	16	333333	3	8	3	10	7	11047
NI 6052E	16	333333	3	32	3	10	7	2932
NI 6032E	16	100000	3	8	10	10	7	8324
NI 6032E	16	100000	3	32	10	10	7	2176

Modes of Operation

The SCXI-1520 provides two modes of operation for passing the conditioned signals to the digitizing DAQ device—multiplexed mode and parallel mode.

Theory of Multiplexed Mode Operation

In multiplexed mode, all input channels of an SCXI module are multiplexed into a single analog input channel of the DAQ device. Multiplexed mode operation is ideal for high channel count systems. Multiplexed mode is typically used for performing scanning operations with the SCXI-1520. The power of SCXI multiplexed mode scanning is its ability to route many input channels to a single channel of the DAQ device.

The multiplexing operation of the analog input signals is performed entirely by multiplexers in the SCXI modules, not inside the DAQ device or SCXI chassis. In multiplexed mode, the SCXI-1520 scanned channels are kept by the NI-DAQ driver in a scan list. Immediately prior to a multiplexed scanning operation, the SCXI chassis is programmed with a module scan list that controls which module sends its output to the SCXIbus during a scan through the cabled SCXI module.

The list can contain channels in any physical order and the multiplexer can sequence the channel selection from the scan list in any order. The ordering of scanned channels need not be sequential. Channels can occur multiple times in a single scan list. The scan list can contain an arbitrary number of channels for each module entry in the scan list, limited to a total of 512 channels per DAQ device. This is referred to as flexible scanning (random scanning). Not all SCXI modules provide flexible scanning.

The module includes first-in first-out (FIFO) memory for storing the channel scan list defined in your application code. NI-DAQ drivers load the FIFO based on the channel assignments you make in your application. You need not explicitly program the module FIFO as this is done automatically for you by the NI-DAQ driver.

When you configure a module for multiplexed mode operation, the routing of multiplexed signals to the DAQ device depends on which module in the SCXI system is cabled to the DAQ device. There are several possible scenarios for routing signals from the multiplexed modules to the DAQ device.

If the scanned SCXI-1520 module is not directly cabled to the DAQ device, the module sends its signals through the SCXIbus to the cabled module. The cabled module, whose routing is controlled by the SCXI chassis, routes the SCXIbus signals to the DAQ device through the CH 0 pin on its rear signal connector.

If the DAQ device scans the cabled module, the module routes its input signals through the CH 0 pin on its rear signal connector to the DAQ device CH 0.

Multiplexed mode scanning acquisition rates have limitations that are determined based on the hardware in the system, the mode of operation, and SS/H. Refer to the *Simultaneous Sample and Hold* section for equations that can help you determine maximum acquisition rates with SS/H enabled. If SS/H is disabled and the system is configured for multiplexed mode operation, the maximum sampling rate is determined by the slower of the maximum sample rate of the DAQ device and the maximum multiplexing rate of SCXI. The maximum multiplexing rate of SCXI is 333 kHz. If the DAQ device can sample more quickly than 333 kHz, then the maximum multiplexing rate of SCXI is the limiting factor. If the DAQ device can sample at 333 kS/s, then the DAQ device's sample rate is the limiting factor on the maximum acquisition rate of the system in multiplexed mode operation.

Theory of Parallel Mode Operation

Parallel mode is ideal for high speed acquisitions. In parallel mode, the eight conditioned analog output signals at the rear signal connector of the SCXI-1520, shown in Figure 4-16, are connected directly to the eight analog input channels on the DAQ device. When the SCXI-1520 operates in parallel mode, the DAQ device performs multiplexed scans of the SCXI-1520 parallel outputs. The SCXI-1520 module does not multiplex the channels.

Traditional NI-DAQ (Legacy) driver software can only control the SCXI-1520 module in multiplexed mode. NI-DAQmx can operate the SCXI-1520 in both multiplexed and parallel mode.

In parallel mode, SCXI-1520 channels 0 through 7 conditioned outputs are passed directly to DAQ device channels 0 through 7. The DAQ device channels should be configured for differential input mode.

Scanning remote-sense channels is not possible when operating the SCXI-1520 in parallel mode operation. This is because RS*X*+ and RS*X*– terminals are not connected to the 50-pin rear signal connector of the SCXI-1520 as shown in Figure 4-16, but instead are only connected internally to the analog multiplexer. The NI-DAQmx driver can still scan the remote sense channel to utilize for strain task and channel calibration and scaling in MAX. However, during operation in your application you cannot monitor the remote-sense channels if the SCXI-1520 is operating in parallel mode.

Note The remote-sense hardware control loop still functions regardless of the mode of operation correcting the excitation voltage level at all times, even though you cannot always scan the remote-sense channels.

When SS/H is enabled, the parallel output signals are held while the channels are scanned by the DAQ device. The T/H circuit of each channel is in hold mode during this time. This appears as glitches on the parallel outputs as the SCXI-1520 is sampled by the digitizing DAQ device. Due to these signal events, NI recommends that you not scan the SCXI-1520 channels with a DAQ device while simultaneously measuring their parallel outputs with any other analog input device, such as an oscilloscope, unless you disable SS\H.

It is possible to enable and disable SS/H programmatically in NI-DAQmx, although NI recommends that you leave SS/H enabled for most applications. Disabling SS/H for one module disables this feature for all modules in all chassis that are controlled by the same DAQ device. SS/H should only be disabled if your application does not require simultaneous sampling and requires higher acquisition rates than are possible with SS/H enabled. Refer to the *Developing Your Application in NI-DAQmx* section of Chapter 5, *Using the SCXI-1520*, for more information about programmatically enabling and disabling SS/H using NI-DAQmx in your application.

For more information about programmatically performing offset null compensation in NI-DAQmx and Traditional NI-DAQ (Legacy), refer to the *Developing Your Application in NI-DAQmx* section or the *Developing Your Application in Traditional NI-DAQ (Legacy)* section, respectively, of Chapter 5, *Using the SCXI-1520*.

Parallel mode operation acquisition rates have limitations that are determined based on the DAQ device you are using and SS/H. Refer to the *Simultaneous Sample and Hold* section for equations that can help you determine maximum acquisition rates with SS/H enabled. If SS/H is disabled and the system is configured for parallel mode operation, the maximum sampling rate is determined by the maximum sample rate of the DAQ device. The 333 kHz maximum SCXI multiplexing rate is not a limitation in parallel mode operation. Therefore, if the DAQ device can sample more quickly than 333 kHz, the SCXI-1520 configured for parallel mode operation is not the limiting factor.

5

Using the SCXI-1520

This chapter makes suggestions for developing your application and provides basic information regarding calibration.

Developing Your Application in NI-DAQmx

Note If you are not using an NI ADE, using an NI ADE prior to version 7.0, or are using an unlicensed copy of an NI ADE, additional dialog boxes from the NI License Manager appear allowing you to create a task or global channel in unlicensed mode. These messages continue to appear until you install version 7.0 or later of an NI ADE.

This section describes how to configure and use NI-DAQmx to control the SCXI-1520 in LabVIEW, LabWindows/CVI, and Measurement Studio. These ADEs provide greater flexibility and access to more settings than MAX, but you can use ADEs in conjunction with MAX to quickly create a customized application.

Typical Program Flowchart

Figure 5-1 shows a typical program flowchart for creating a task to configure channels, take a measurement, analyze the data, present the data, stop the measurement, and clear the task.

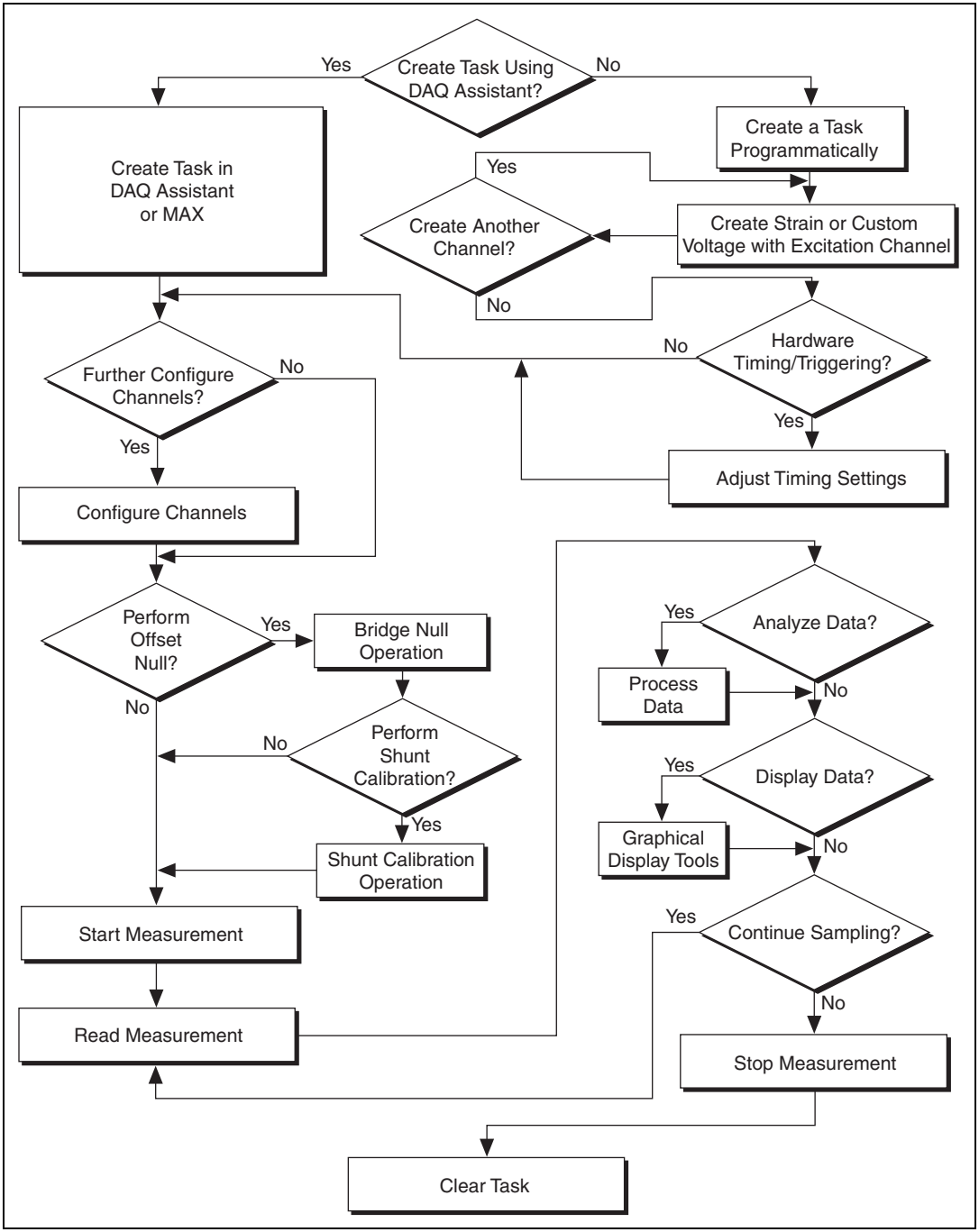


Figure 5-1. Typical Program Flowchart

General Discussion of Typical Flowchart

The following sections briefly discuss some considerations for a few of the steps in Figure 5-1. These sections are meant to give an overview of some of the options and features available when programming with NI-DAQmx.

Creating a Task Using DAQ Assistant or Programmatically

When creating an application, you must first decide whether to create the appropriate task using the DAQ Assistant or programmatically in the ADE.

Developing your application using DAQ Assistant gives you the ability to configure most settings such as measurement type, selection of channels, bridge configuration, excitation voltage, signal input limits, task timing, and task triggering. You can access the DAQ Assistant through MAX or your NI ADE. Choosing to use the DAQ Assistant can simplify the development of your application. NI recommends creating tasks using the DAQ Assistant for ease of use, when using a sensor that requires complex scaling, or when many properties differ between channels in the same task.

If you are using an ADE other than an NI ADE, or if you want to explicitly create and configure a task for a certain type of acquisition, you can programmatically create the task from your ADE using functions or VIs. If you create a task using the DAQ Assistant, you can still further configure the individual properties of the task programmatically with functions or property nodes in your ADE. NI recommends creating a task programmatically if you need explicit control of programmatically adjustable properties of the DAQ system.

Programmatically adjusting properties for a task created in the DAQ Assistant overrides the original, or default, settings only for that session. The changes are not automatically saved to the task configuration. The next time you load the task, the task uses the settings originally configured in the DAQ Assistant. Refer to the *NI-DAQmx Help* for information on programmatically saving tasks.

Adjusting Timing and Triggering

There are several timing properties that you can configure through the DAQ Assistant or programmatically using function calls or property nodes. If you create a task in the DAQ Assistant, you can still modify the timing properties of the task programmatically in your application.

When programmatically adjusting timing settings, you can set the task to acquire continuously, acquire a buffer of samples, or acquire one point at a time. For continuous acquisition, you must use a While Loop around the acquisition components even if you configured the task for continuous acquisition using MAX or the DAQ Assistant. For continuous and buffered acquisitions, you can set the acquisition rate and the number of samples to read in the DAQ Assistant or programmatically in your application. By default, the clock settings are automatically set by an internal clock based on the requested sample rate. You also can select advanced features such as clock settings that specify an external clock source, internal routing of the clock source, or select the active edge of the clock signal.

Configuring Channel Properties

All ADEs used to configure the SCXI-1520 access an underlying set of NI-DAQmx properties. Table 5-1 shows some of these properties. You can use Table 5-1 to determine what kind of properties you need to set to configure the module for your application. For a complete list of NI-DAQmx properties, refer to your ADE help file.

Note You cannot adjust some properties while a task is running. For these properties, you must stop the task, make the adjustment, and re-start the application. Figure 5-1 assumes all properties are configured before the task is started.

Table 5-1. NI-DAQmx Properties

Property	Short Name	Description
Analog Input»General Properties» Advanced»Range»High	AI.Rng.High	Specifies the upper limit of the input range.
Analog Input»General Properties» Advanced»Range»Low	AI.Rng.Low	Specifies the lower limit of the input range.
Analog Input»General Properties» Filter»Analog Lowpass»Enable	AI.Lowpass.Enable	Enables the lowpass filter of the channel.

Table 5-1. NI-DAQmx Properties (Continued)

Property	Short Name	Description
Analog Input»General Properties» Filter»Analog Lowpass»Cutoff Frequency	AI.Lowpass.CutoffFreq	Specifies in hertz the frequency corresponding to the –3 dB cutoff of the filter. You can specify 10, 100, 1000, or 10000.
Analog Input»General Properties» Signal Conditioning»Bridge» Configuration	AI.Bridge.Cfg	Specifies the sensor Wheatstone bridge type.
Analog Input»General Properties» Signal Conditioning»Bridge» Shunt Cal»Shunt Cal Enable	AI.Bridge.ShuntCal.Enable	Specifies whether to place the shunt calibration resistor across one arm of the bridge.
Analog Input»General Properties» Signal Conditioning»Bridge» Shunt Cal»Shunt Cal Select	AI.Bridge.ShuntCal.Select	Specifies which calibration switch(es) to enable.
Analog Input»General Properties» Signal Conditioning»Excitation» Value	AI.Excit.Val	Specifies the amount of excitation in volts.
Analog Input»Strain»Strain Gage» Configuration	AI.StrainGage.Cfg	Specifies the strain-gauge configuration type.
Analog Input»General Properties» Signal Conditioning»Bridge» Nominal Resistance	AI.Bridge.NomResistance	Specifies in ohms the resistance of the bridge in an unloaded condition.
Analog Input»Strain»Strain Gage» Gage Factor	AI.StrainGage.GageFactor	Specifies the sensitivity of the strain gauge.
Analog Input»Strain»Strain Gage» Poisson Ratio	AI.StrainGage.PoissonRatio	Specifies the ratio of lateral strain to axial strain in the specimen material.

Table 5-1. NI-DAQmx Properties (Continued)

Property	Short Name	Description
Analog Input»General Properties» Signal Conditioning»Bridge» Initial Bridge Voltage	AI.Bridge.InitialVoltage	Specifies in volts the output voltage of the bridge in the unloaded condition.
Analog Input»General Properties» Signal Conditioning»Bridge» Balance»Coarse Potentiometer Property	AI.Bridge.Balance.CoarsePot	Specifies by how much to compensate for offset in the signal. This value can be between 0 and 127.
Analog Input»General Properties» Signal Conditioning»Bridge» Balance»Fine Potentiometer Property	AI.Bridge.Balance.FinePot	Specifies by how much to compensate for offset in the signal. This value can be between 0 and 4095.
Analog Input»General Properties» Signal Conditioning»Excitation» Source	AI.Excit.Src	Specifies the source of excitation.
Analog Input»General Properties» Advanced»Sample and Hold Enable	AI.SampAndHold.Enable	Specifies whether to enable the sample-and-hold circuitry of the device.

Note This is *not* a complete list of NI-DAQmx properties and does not include every property you may need to configure your application. It is a representative sample of important properties to configure for strain and Wheatstone bridge measurements. For a complete list of NI-DAQmx properties and more information about NI-DAQmx properties, refer to your ADE help file.

Performing Offset Null Compensation

The SCXI-1520 provides offset null compensation circuitry to adjust signal voltages to proper levels when the strain gauge or bridge sensor is at rest (unstrained). For most sensors, offset null compensation removes an initial voltage offset from the Wheatstone bridge. If you are measuring strain, you can use a strain task or global channel to perform offset null compensation. The offset null compensation can be performed during the configuration of the global channel(s) or programmatically using the DAQmx Offset Null function (in LabVIEW, use `Daqmx Perform Bridge Offset Nulling`

`Calibration.vi`; in CVI, use the `DAQmxPerformBridgeOffsetNullingCal` function). Refer to the *Creating a Strain Global Channel or Task* section of Chapter 3, *Configuring and Testing*, for information about offset null compensation when in MAX. If you are not measuring strain or would like to adjust the offset to an arbitrary voltage, you can manually adjust the coarse and fine potentiometer settings using properties.

For more information about offset null compensation, refer to the *Offset Null Compensation* section of Chapter 4, *Theory of Operation*.

Performing Shunt Calibration

Shunt calibration is a process used to obtain a gain adjust factor, which corrects for system gain error and discrepancies between the nominal gauge factor and actual gauge factor of the strain gauge. If you are measuring strain, you can use a strain task or global channel to perform shunt calibration. The shunt calibration is performed during the configuration of the global channel(s). Refer to the *Creating a Strain Global Channel or Task* section of Chapter 3, *Configuring and Testing*, for information about shunt calibration in MAX.

To manually perform shunt calibration, refer to the *Shunt Calibration* section of Chapter 4, *Theory of Operation*.

Acquiring, Analyzing, and Presenting

After configuring the task and channels, you can start the acquisition, read measurements, analyze the data returned, and display it according to the needs of your application. Typical methods of analysis include digital filtering, averaging data, performing harmonic analysis, applying a custom scale, or adjusting measurements mathematically.

Some custom scaling applications require the actual excitation voltage applied to the bridge instead of the nominal excitation voltage output by the SCXI-1520. You can scan the remote sense pins RS*X*+ and RS*X*– with the DAQmx physical channels `Dev`*X*`/_pPos`*X* and `Dev`*X*`/_pNeg`*X* to find the actual excitation voltage. Take the difference of the two physical channels to determine the actual excitation applied to the bridge and use this value in the scaling equation.

Note If RS*X*+ and RS*X*– are not wired to the bridge where P*X*+ and P*X*– connect, `_pPos`*X* and `_pNeg`*X* only measure the internal excitation. Measuring this voltage does not correct for the voltage drop in the excitation leads.

NI provides powerful analysis toolsets for each NI ADE to help you perform advanced analysis on the data without requiring you to have a programming background. After you acquire the data and perform any required analysis, it is useful to display the data in a graphical form or log it to a file. NI ADEs provide easy-to-use tools for graphical display, such as charts, graphs, slide controls, and gauge indicators. NI ADEs have tools that allow you to easily save the data to files such as spread sheets for easy viewing, ASCII files for universality, or binary files for smaller file sizes.

Completing the Application

After you have completed the measurement, analysis, and presentation of the data, it is important to stop and clear the task. This releases any memory used by the task and frees up the DAQ hardware for use in another task.

Note In LabVIEW, tasks are automatically cleared.

Developing an Application Using LabVIEW

This section describes in more detail the steps shown in the typical program flowchart in Figure 5-1, such as how to create a task in LabVIEW and configure the channels of the SCXI-1520. If you need more information or for further instructions, select **Help»VI, Function, & How-To Help** from the LabVIEW menu bar.

Note Except where otherwise stated, the VIs in Table 5-2 are located on the **Functions» All Functions»NI Measurements»DAQmx - Data Acquisition** subpalette and accompanying subpalettes in LabVIEW.

Table 5-2. Programming a Task in LabVIEW

Flowchart Step	VI or Program Step
Create Task in DAQ Assistant	Create a `DAQmx Task Name Constant` located on the **Controls»All Controls»I/O»DAQmx Name Controls** subpalette, right-click it, and select `New Task (DAQ Assistant)`.
Create a Task Programmatically (optional)	`DAQmx Create Task.vi`—This VI is optional if you created and configured your task using the DAQ Assistant. However, if you use it in LabVIEW, any changes you make to the task will not be saved to a task in MAX.

Table 5-2. Programming a Task in LabVIEW (Continued)

Flowchart Step	VI or Program Step
Create AI Strain Channel (optional) or Create AI Custom Voltage with Excitation Channel (optional)	`DAQmx Create Virtual Channel.vi` (AI Voltage by default, to change to a strain gauge channel, click **AI Voltage** and select **Analog Input»Strain»Strain Gage**.)—This VI is optional if you created and configured your task and channels using the DAQ Assistant. Any channels created with this VI are not saved in the DAQ Assistant. They are only available for the present session of the task in LabVIEW.
Adjust Timing Settings (optional)	`DAQmx Timing.vi` (Sample Clock by default)—This VI is optional if you created and configured your task using the DAQ Assistant. Any timing settings modified with this VI are not saved in the DAQ Assistant. They are only available for the present session.
Configure Channels (optional)	DAQmx Channel Property Node, refer to the *Using a DAQmx Channel Property Node in LabVIEW* section for more information. This step is optional if you created and fully configured the channels using the DAQ Assistant. Any channel modifications made with a channel property node are not saved in the task in the DAQ Assistant. They are only available for the present session.
Perform Offset Null Compensation	`Daqmx Perform Bridge Offset Nulling Calibration.vi` or you can perform offset null compensation when you create and configure your channels using the DAQ Assistant. Refer to the *Creating a Strain Global Channel or Task* section of Chapter 3, *Configuring and Testing*, for information about offset null compensation in MAX.
Perform Shunt Calibration	You can perform shunt calibration when you create and configure your channels using the DAQ Assistant. Refer to the *Creating a Strain Global Channel or Task* section of Chapter 3, *Configuring and Testing*, for information about shunt calibration in MAX.
Start Measurement	`DAQmx Start Task.vi`
Read Measurement	`DAQmx Read.vi`
Analyze Data	Some examples of data analysis include filtering, scaling, harmonic analysis, or level checking. Some data analysis tools are located on the **Functions»Signal Analysis** subpalette and on the **Functions»All Functions»Analyze** subpalette.

Table 5-2. Programming a Task in LabVIEW (Continued)

Flowchart Step	VI or Program Step
Display Data	You can use graphical tools such as charts, gauges, and graphs to display your data. Some display tools are located on the **Controls»Numeric Indicators** subpalette and **Controls» All Controls»Graph** subpalette.
Continue Sampling	For continuous sampling, use a While Loop. If you are using hardware timing, you also need to set the `DAQmx Timing.vi` sample mode to Continuous Samples. To do this, right-click the terminal of the `DAQmx Timing.vi` labeled **sample mode** and click **Create»Constant**. Click the box that appears and select **Continuous Samples**.
Stop Measurement	`DAQmx Stop Task.vi` (This VI is optional, clearing the task automatically stops the task.)
Clear Task	`DAQmx Clear Task.vi`

Using a DAQmx Channel Property Node in LabVIEW

Note With the SCXI-1520, you must use property nodes to disable SS/H.

You can use property nodes in LabVIEW to manually configure the channels. To create a LabVIEW property node, complete the following steps:

1. Launch LabVIEW.
2. Create the property node in a new VI or in an existing VI.
3. Open the block diagram view.
4. From the **Functions** toolbox, select **All Functions» NI Measurements»DAQmx - Data Acquisition**, and select `DAQmx Channel Property Node`.
5. Configure your channels. The initial **ActiveChan** item allows you to specify exactly what channel(s) you want to configure. If you want to configure several channels with different properties, separate the lists of properties with another **Active Channels** box and assign the appropriate channel to each list of properties.

Note If you do not use Active Channels, the properties are set on all of the channels in the task.

6. Right-click **ActiveChan**, select **Add Element**, and left-click in the new **ActiveChan** box. Navigate through the menus, and select the property you wish to define.
7. Change the property to read or write to either get the property or write a new value. Right-click the property, go to **Change To**, and select **Write**, **Read**, or **Default Value**.
8. After you have added the property to the property node, right-click the terminal to change the attributes of the property, add a control, constant, or indicator.

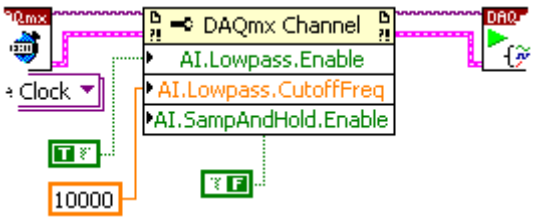


Figure 5-2. LabVIEW Channel Property Node with Filtering Enabled at 10 kHz and SS/H Disabled

9. To add another property to the property node, right-click an existing property and left-click **Add Element**. To change the new property, left-click it and select the property you wish to define.

Note Refer to the *LabVIEW Help* for information about property nodes and specific NI-DAQmx properties.

Specifying Channel Strings in NI-DAQmx

Use the channel input of **DAQmx Create Channel** to specify the SCXI-1520 channels. The input control/constant has a pull-down menu showing all available external channels. You can right-click the physical channel input, select **I/O Name Filtering**, and check **Internal Channels**. This allows you to select the SCXI-1520 excitation channels. The strings take one of the following forms:

- single device identifier/channel number—for example `SC1Mod1/ch0`
- multiple, noncontinuous channels—for example `SC1Mod1/ch0, SC1Mod1/ch4`

- multiple continuous channels—for example `SC1Mod1/ch0:4` (channels 0 through 4)
- positive or negative excitation on a particular SCXI-1520 channel—for example `SC1Mod1/_pPos0`, `SC1Mod1/_pNeg0`

When you have a task containing SCXI-1520 channels, you can set the properties of the channels programmatically using the **DAQmx Channel Property Node**.

Follow the general programming flowchart or open an example to build a basic strain virtual channel. You can use property nodes in LabVIEW to control, configure, and customize the NI-DAQmx task and SCXI-1520. To create a LabVIEW property node, complete the following steps:

1. Launch LabVIEW.
2. Create the property node in a new Virtual Instrument (VI) or in an existing VI.
3. Open the block diagram view.
4. From the **Functions** tool bar, select **NI Measurements**, **DAQmx - Data Acquisition**, and select the type of property node you wish to configure.
5. The **ActiveChan** item allows you to specify what channel(s) you want to configure. If you want to configure several channels with different properties, separate the lists of properties with another **Active Channels** box, and assign the appropriate channel to each list of properties.
6. Right-click **ActiveChan** and select **Add Element**. Left-click the new **ActiveChan** box. Navigate through the menus and select the property you wish to define.
7. You must change the property to read or write to either get the property or write a new value. Right-click the property, go to **Change To**, and select **Write**, **Read**, or **Default Value**.
8. After you have added the property to the property node, right-click the terminal to change the attributes of the property, add a control, constant, or indicator.
9. To add another property to the property node, right-click an existing property and left-click **Add Element**. To change the new property, left-click it and select the property you wish to define.



Note Refer to the *LabVIEW Help* for information about property nodes and specific NI-DAQmx properties.

Text Based ADEs

You can use text based ADEs such as LabWindows/CVI, Measurement Studio, Visual Basic, .NET, and C# to create code for using the SCXI-1520.

LabWindows/CVI

LabWindows/CVI works with the **DAQ Assistant** in MAX to generate code for a strain task. You can then use the appropriate function call to modify the task. To create a configurable channel or task in LabWindows/CVI, complete the following steps:

1. Launch LabWindows/CVI.
2. Open a new or existing project.
3. From the menu bar, select **Tools»Create/Edit DAQmx Tasks**.
4. Choose **Create New Task In MAX** or **Create New Task In Project** to load the DAQ Assistant.
5. Configure the NI-DAQmx strain task following the instructions in the *Creating a Strain Global Channel or Task* section of Chapter 3, *Configuring and Testing*.
6. The DAQ Assistant creates the code for the task based on the parameters you define in MAX and the device defaults. To change a property of the channel programmatically, use the `DAQmxSetChanAttribute` function.

Note Refer to the *NI LabWindows/CVI Help* for more information on creating NI-DAQmx tasks in LabWindows/CVI and NI-DAQmx property information.

Measurement Studio (Visual Basic, .NET, and C#)

When creating a strain task in Visual Basic .NET and C#, follow the general programming flow in Figure 5-1. You can then use the appropriate function calls to modify the task. This example creates a new task and configures an NI-DAQmx strain channel on the SCXI-1520. You can use the same functions for Visual Basic .NET and C#.

In this example, an analog input channel object is used since reading the voltage from a Wheatstone bridge configuration is an analog input operation. The following text is a function prototype example:

```
void AIChannelCollection.CreateStrainGageChannel(
    System.String physicalChannelName,
    System.String nameToAssignChannel,
    System.Double minVal,
```

```
    System.Double maxVal,
    AIStrainGageConfiguration strainGageConfiguration,
    AIExcitationSource excitationSource,
    System.Double excitationValue,
    System.Double gageFactor,
    System.Double initialBridgeVoltage,
    System.Double normalGageResist,
    System.Double poissonRatio,
    System.Double leadWireResist,
    AIStrainUnits units);
```

To actually create and configure the channel, you would enter something resembling the following example code:

```
Task myTask = new
NationalInstruments.DAQmx.Task("myTaskName");
MyTask.CreateStrainGageChannel (
    "SC1Mod1/ai0", // System.String physicalChannelName
    "strain0", // System.String nameToAssignChannel
    -0.001, // System.Double minVal
    0.001, // System.Double maxVal
    AIStrainGageConfiguration.FullBridgeIII, //
    AIStrainGageConfiguration strainGageConfiguration
    AIExcitationSource.Internal, // AIExcitationSource
    excitationSource
    3.3, // System.Double excitationValue
    2.0, // System.Double gageFactor
    0.0, // System.Double initialBridgeVoltage
    120.0, // System.Double normalGageResist
    0.3, // System.Double poissonRatio
    0.0, // System.Double leadWireResist
    AIStrainUnits.Strain); // AIStrainUnits units
// setting attributes after the channel is created
AIChannel myChannel = myTask.AIChannels["strain0"];
myChannel.LowpassCutoffFrequency = 10.0;
myChannel.LowpassEnable = true;
myChannel.AutoZeroMode = AIAutoZeroMode.Once;
```

You can change any of the properties at a later time. For example, to change the filter settings of `myChannel`, enter the following lines:

```
AIChannel myChannel = myTask.AIChannels["strain 0"];
myChannel.LowpassCutoffFrequency = 10.0;
myChannel.LowpassEnable = true;
```

Modify the example code above or the code from one of the shipping examples as needed to suit your application. Refer to the *Other Application Documentation and Material* section for the location of program examples.

Notes You can create and configure the strain task in MAX and load it into your application with the function call `NationalInstruments.DAQmx.DaqSystem.Local.LoadTask`

Refer to the *NI Measurement Studio Help* for more information on creating NI-DAQmx tasks in LabWindows/CVI and NI-DAQmx property information.

Programmable NI-DAQmx Properties

All of the different ADEs that configure the SCXI-1520 access an underlying set of NI-DAQmx properties. Table 5-3 provides a list of some of the properties that configure the SCXI-1520. You can use this list to determine what kind of properties you need to set to configure the device for your application. For a complete list of NI-DAQmx properties, refer to your ADE help file.

Table 5-3. NI-DAQmx Properties

Property	Short Name	Description
Analog Input»General Properties» Advanced»Range»High	AI.Rng.High	Specifies the upper limit of the input range on the digitizer device.
Analog Input»General Properties» Advanced»Range»Low	AI.Rng.Low	Specifies the lower limit of the input range on the digitizer device.
Analog Input»General Properties» Advanced»Sample and Hold Enable	AI.SampAndHold.Enable	Specifies whether to enable the sample-and-hold circuitry of the device.
Analog Input»General Properties» Signal Conditioning»Bridge» Configuration	AI.Bridge.Cfg	Specifies whether the sensor is a type of Wheatstone bridge.
Analog Input»General Properties» Signal Conditioning»Bridge» Shunt Cal»Shunt Cal Enable	AI.Bridge.ShuntCal.Enable	Specifies whether to place the shunt calibration resistor across one arm of the bridge.

Table 5-3. NI-DAQmx Properties (Continued)

Property	Short Name	Description
Analog Input»General Properties» Signal Conditioning»Bridge» Shunt Cal»Shunt Cal Select	AI.Bridge.ShuntCal.Select	Specifies which calibration switch(es) to enable.
Analog Input»General Properties» Signal Conditioning»Excitation» Source	AI.Excit.Src	Specifies the source of excitation.
Analog Input»General Properties» Signal Conditioning»Excitation» Value	AI.Excit.Val	Specifies the amount of excitation in volts.
Analog Input»Strain»Strain Gage» Configuration	AI.StrainGage.Cfg	Specifies the strain-gauge configuration type.
Analog Input»General Properties» Signal Conditioning»Bridge» Nominal Resistance	AI.Bridge.NomResistance	Specifies in ohms the resistance of the bridge in an unloaded condition.
Analog Input»Strain»Strain Gage» Gage Factor	AI.StrainGage.GageFactor	Specifies the sensitivity of the strain gauge.
Analog Input»Strain»Strain Gage» Poisson Ratio	AI.StrainGage.PoissonRatio	Specifies the ratio of lateral strain to axial strain in the specimen material.
Analog Input»General Properties» Signal Conditioning»Bridge» Initial Bridge Voltage	AI.Bridge.InitialVoltage	Specifies in volts the output voltage of the bridge in the unloaded condition.
Analog Input»Strain»Units	AI.Strain.Units	Specifies the units to use to return strain measurements from the channel.
Analog Input»General Properties» Advanced»Gain and Offset» Gain Value	AI.Gain	Specifies a gain factor to apply to the signal conditioning portion of the channel.

Table 5-3. NI-DAQmx Properties (Continued)

Property	Short Name	Description
Analog Input»General Properties» Advanced»High Accuracy Settings» Auto Zero Mode	AI.AutoZeroMode	Specifies when to measure ground. NI-DAQmx then subtracts the voltage either on every sample or only once, depending on the setting.
Analog Input»Measurement Type	AI.MeasType	Indicates the measurement to take with the analog input channel.

Note This is *not* a complete list of NI-DAQmx properties and does not include every property you may need to configure your application. It is a representative sample of important properties to configure for strain and Wheatstone bridge measurements. For a complete list of NI-DAQmx properties and more information on NI-DAQmx properties, refer to your ADE help file.

Developing Your Application in Traditional NI-DAQ (Legacy)

Note If you are not using an NI ADE, using an NI ADE prior to version 7.0, or are using an unlicensed copy of an NI ADE, additional dialog boxes from the NI License Manager appear allowing you to create a task or global channel in unlicensed mode. These messages continue to appear until you install version 7.0 or later of an NI ADE.

This section describes how to configure and use Traditional NI-DAQ (Legacy) to control the SCXI-1520 in LabVIEW, LabWindows/CVI, Measurement Studio, and other text-based ADEs. These NI ADEs provide greater flexibility and access to more settings than MAX, but you can use ADEs in conjunction with MAX to quickly create a customized application.

Traditional NI-DAQ (Legacy) in LabVIEW

LabVIEW is a graphical programming environment for test and measurement application development with built-in easy to use tools for data acquisition, analysis, and display. You can use functional graphical blocks called subVIs to easily create a custom application that fully utilizes the SCXI-1520 programmable functionality. Traditional NI-DAQ (Legacy) provides several standard data acquisition subVIs as well as subVIs specifically for use with the SCXI-1520.

For applications using Traditional NI-DAQ (Legacy) in LabVIEW, there are two typical methods of addressing SCXI-1520 channels—virtual channels (specifically strain virtual channels) and SCXI channel strings. Depending on the needs of your application, you choose one of these channel-addressing methods to use in your LabVIEW application.

The strain virtual channel provides scaling for strain gauges, provides an easy interface for offset null compensation and shunt calibration, and allows you to select any name for the SCXI-1520 strain channel that you choose without additional code. When you use virtual channels, the maximum number of channels per E Series DAQ device is 512 in multichassis systems. NI recommends using the strain virtual channel for ease of use. Refer to Appendix B, *Using SCXI Channel Strings with Traditional NI-DAQ (Legacy) 7.0 or Later*, for more information on how to create a strain virtual channel.

The SCXI channel string allows you to combine large numbers of channels into fewer scan list entries, to measure the signal voltage level directly for custom scaling, and to dynamically perform an offset null compensation in your application. NI recommends using SCXI channel strings for more advanced applications. In LabVIEW, an array of these channel strings configures multiple modules for scanning. When using SCXI channel strings, you can scan up to 3,072 channels in a multichassis system using a single DAQ device. Refer to Appendix B, *Using SCXI Channel Strings with Traditional NI-DAQ (Legacy) 7.0 or Later*, for more information about using SCXI channel strings.



Note You cannot mix virtual channels with the SCXI channel strings within the same channel string array.

To use virtual channels, enter the name of a virtual channel into the analog input channel string. If using multiple virtual channels, enter them in a different index in the channel string array, or separate them using a comma.

Since you can randomly scan analog input virtual channels, you can enter the virtual channels you want to scan in any order or repeatedly in a channel string array.

Typical Program Flow

After you have determined how you want to address the channels and whether you want to configure the SCXI-1520 in MAX or LabVIEW, you can design your application using a typical program flow such as the one shown in Figure 5-3.

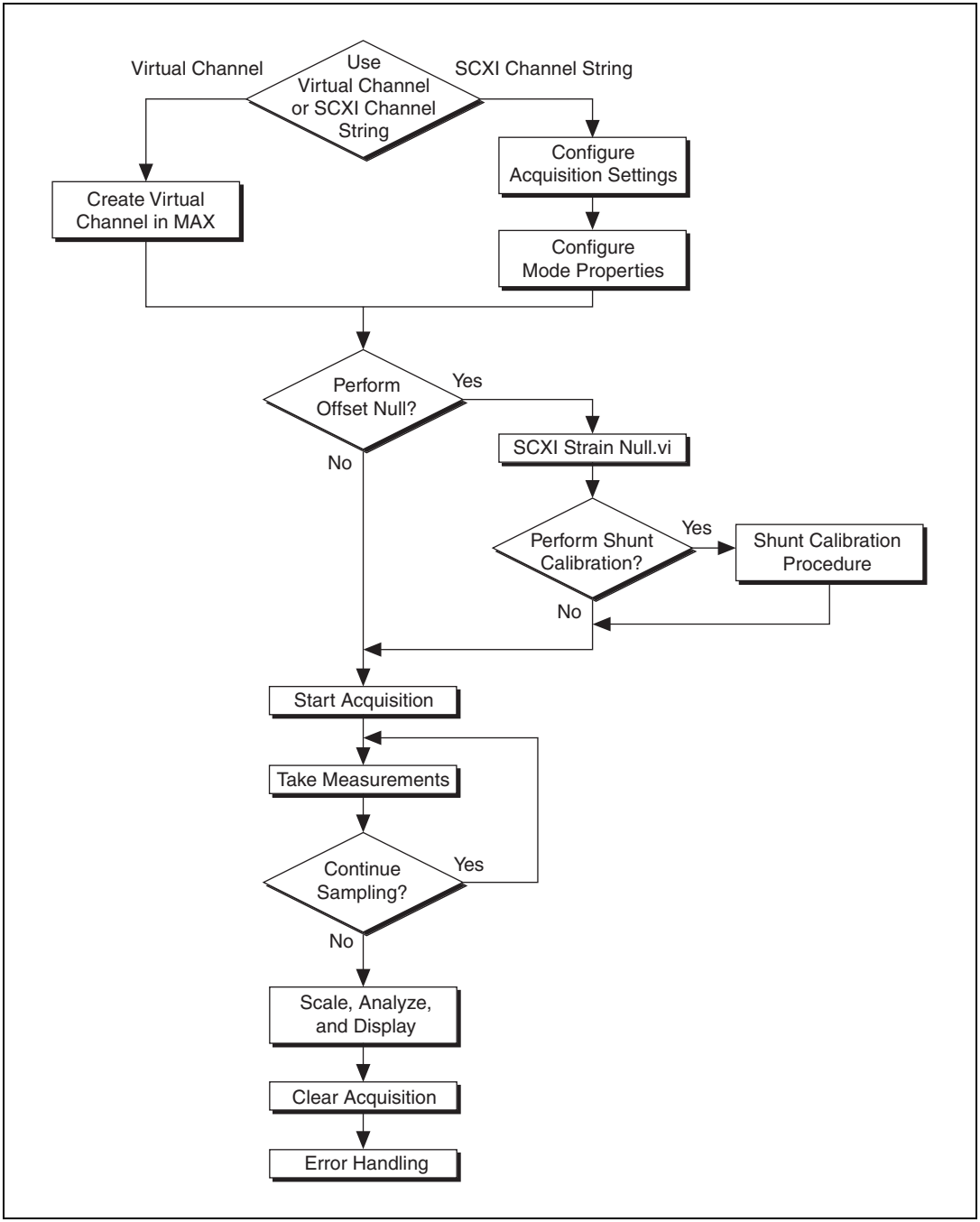


Figure 5-3. Typical SCXI-1520 Program Flow with Traditional NI-DAQ (Legacy)

Configuring the SCXI-1520 Settings Using Traditional NI-DAQ (Legacy) in LabVIEW

You can configure SCXI-1520 settings, perform offset null compensation, and perform shunt calibration in MAX using the strain virtual channel. To configure and control the SCXI-1520 from LabVIEW, use the AI Parameter VI. You can find AI Parameter VI in the function subpalette **Data Acquisition»Analog Input»Advanced Analog Input**.

A parameter changed by the AI Parameter VI takes effect in hardware when AI Start VI is called, not when AI Parameter VI is called. The AI parameter VI merely changes the configuration in the driver memory. When called, the AI Start VI reads the configuration settings in the driver memory and then sends the actual control information to the SCXI-1520 module. A setting established through AI Parameter VI is only valid for the LabVIEW session and does not change the setting in MAX.

You can use the AI Parameter VI to configure the SCXI-1520 settings shown in Table 5-4.

Table 5-4. Settings for Configuring the SCXI-1520 Through the AI Parameter

Software-Configurable Setting	AI Parameter VI		Allowable Settings (Float In, Boolean In, or Value In)	
	Parameter Name	Value	Data Type	Values
Excitation Level	SCXI DC Voltage Excitation	17	Float In (dbl)	0.000, 0.625, 1.125, 1.875, 2.500, 3.125, 3.750, 5.375, 5.000, 5.625, 6.125, 6.875, 7.500, 8.125, 8.750, 9.375, 10.00
Filter Bandwidth	Filter Setting	14	Float In (dbl)	0.0 (disable filter), 10.0, 100.0, 1000.0, 10000.0
Bridge Type	SCXI Connection Type	19	Value In (u16)	9 = Quarter Bridge 10 = Half Bridge 11 = Full Bridge
Coarse Potentiometer	SCXI Coarse Potentiometer	24	Float In (dbl)	Any integer between 0 and 127, with 62 at *mid-scale*
Fine Potentiometer	SCXI Fine Potentiometer	23	Float In (dbl)	Any integer between 0 and 4095, with 2048 at *mid-scale*

Table 5-4. Settings for Configuring the SCXI-1520 Through the AI Parameter (Continued)

Software-Configurable Setting	AI Parameter VI		Allowable Settings (Float In, Boolean In, or Value In)	
	Parameter Name	Value	Data Type	Values
Shunt A Enable	SCXI Shunt A Enabled	25	Boolean In (T/F)	TRUE turns switch ON FALSE turns switch OFF
Shunt B Enable	SCXI Shunt B Enabled	26	Boolean In (T/F)	TRUE turns switch ON FALSE turns switch OFF

An example of using the AI Parameter VI to control an SCXI-1520 is shown in Figure 5-4.

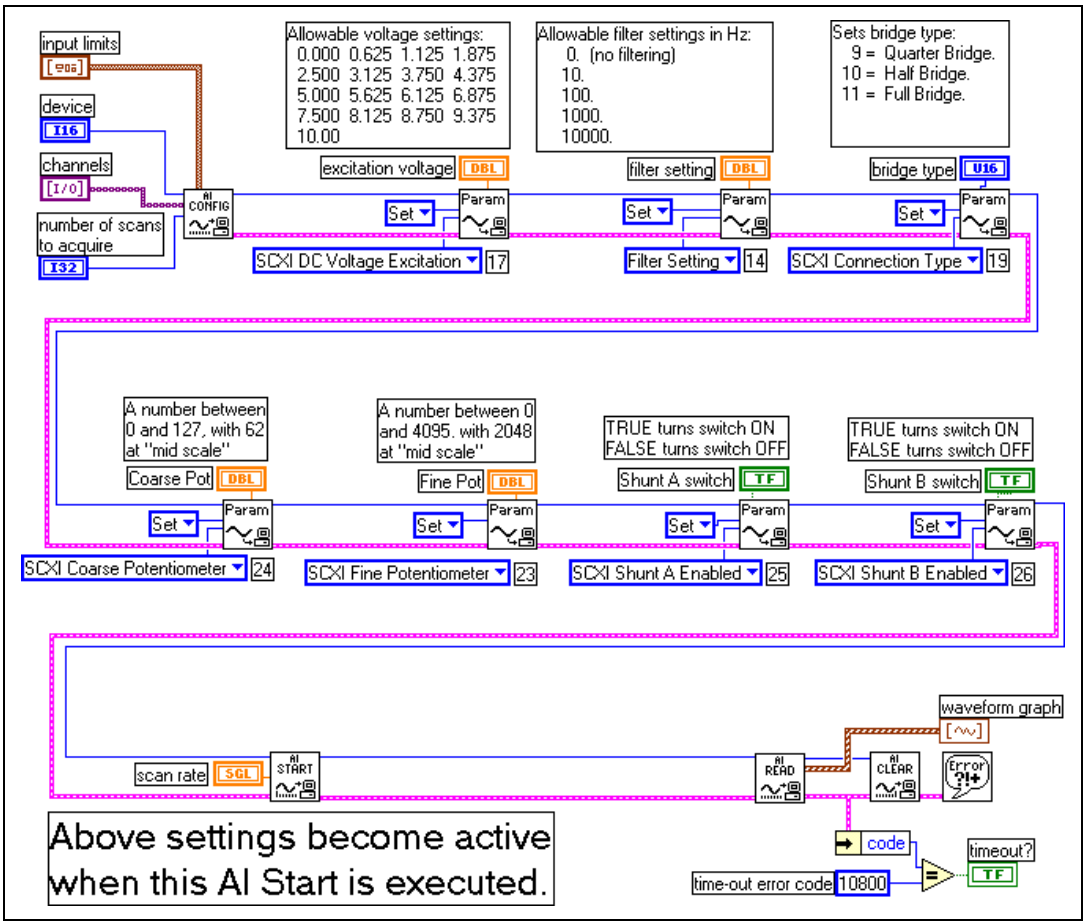


Figure 5-4. Using the AI Parameter VI to Set Up the SCXI-1520

Performing Offset Null Compensation Using Traditional NI-DAQ (Legacy) in LabVIEW

The SCXI-1520 provides offset null compensation to adjust signal voltages to remove an initial signal voltage offset from the Wheatstone bridge sensor. If you are measuring strain, you can use the strain virtual channel in Traditional NI-DAQ (Legacy) to perform offset null compensation, shunt calibration, and to properly scale strain measurements. The offset null compensation and shunt calibration are performed during configuration of the strain virtual channel. Refer to Appendix B, *Using SCXI Channel Strings with Traditional NI-DAQ (Legacy) 7.0 or Later*, for more information about creating a strain virtual channel in MAX.

After you have created a strain virtual channel, simply use a DAQ channel control or constant to select the strain virtual channel from a list of all the virtual channels you have configured in MAX. You can find the DAQ channel constant in the function subpalette **Data Acquisition»Analog Input**. You can find the DAQ channel control in the control subpalette **I/O**.

If you are using a strain virtual channel, you cannot perform offset null compensation dynamically in your application. If you need to dynamically perform an offset null compensation in your application, you must use SCXI channel strings. For more information about using SCXI channel strings with the SCXI-1520, refer to Appendix B, *Using SCXI Channel Strings with Traditional NI-DAQ (Legacy) 7.0 or Later*. If you are measuring any other kind of bridge sensor such as a load cell, pressure sensor, or torque sensor and require the measurement to be displayed in units of interest for the sensor, you cannot use the strain virtual channel. This is because the scaling provided by the strain virtual channel returns measurements in units of microstrain (με) rather than the units of interest for the sensor. If you require alternative scaling, you can either use an analog input voltage virtual channel with a custom scale configured in MAX, or SCXI channel strings and provide scaling in your LabVIEW application.

To perform an offset null compensation for bridge sensors such as strain gauges, load cells, pressure sensors, or torque sensors dynamically in your LabVIEW application, use the SCXI Strain Null VI. You can find the SCXI Strain Null VI in the function subpalette **Data Acquisition»Analog Input»Calibration and Configuration**. The SCXI Strain Null VI only performs offset null compensation for SCXI channel strings, not virtual channels.

If you want to explicitly set the potentiometers, you can write an application program that adjusts the settings of many channels simultaneously or restores a particular null setting between sessions without performing a nulling operation each time. To explicitly set or get the control codes of the potentiometers in Traditional NI-DAQ (Legacy), use the LabVIEW AI Parameter VI. An example of using the AI Parameter VI to control an SCXI-1520 is shown in Figure 5-4.

For more information and example programs for setting the offset null potentiometers, go to `ni.com/info` and use these info codes: `rd1520`, `rdnull`, and `rdxi15`.

Performing Shunt Calibration Using Traditional NI-DAQ (Legacy) in LabVIEW

Shunt calibration is a process used to obtain a gain adjust factor, which corrects system gain error and discrepancies between nominal Gauge Factor and actual Gauge Factor of the strain gauge. If you are measuring strain, you can use the strain virtual channel in Traditional NI-DAQ (Legacy) to perform offset null compensation, shunt calibration, and to properly scale strain measurements. The offset null compensation and shunt calibration are performed during configuration of the strain virtual channel. Refer to Appendix B, *Using SCXI Channel Strings with Traditional NI-DAQ (Legacy) 7.0 or Later*, for more information about creating a strain virtual channel in MAX.

Refer to the *Shunt Calibration* section of Chapter 4, *Theory of Operation*, for more information on the process and calculations required for shunt calibration in your application. To perform shunt calibration for bridge sensors such as strain gauges, load cells, pressure sensors, or torque sensors dynamically in your LabVIEW application, use the AI Parameter VI to programmatically engage and disengage the shunt calibration. As with all settings that are controlled by the AI Parameter VI, the switch settings take effect when the next AI Start VI is encountered in your software, not at the time the AI Parameter VI is called. Either insert a 500 ms delay in your code or discard the first 500 ms of data after the switches are closed since the filters in the SCXI-1520 are not fully stabilized until 500 ms have elapsed. You can find the AI Parameter VI in the function subpalette **Data Acquisition»Analog Input»Advanced Analog Input**. An example of using the AI Parameter VI to control an SCXI-1520 is shown in Figure 5-4.

NI recommends acquiring a buffer of 1000 samples of a channel with the shunt resistors engaged, then using the average of this buffer in the shunt calibration calculations. After you have measured a buffer of data with the shunt resistors engaged, you can calculate the gain adjust factor to use to adjust measurements on that channel. If you are performing shunt calibration on a strain gauge, you can use the equations for simulated strain found in the *Strain-Gauge Theory* section of Chapter 4, *Theory of Operation*, for the shunt calibration calculations. After you have determined the correct gain adjust factor, multiply each measurement in your application by the gain adjust factor for maximum absolute accuracy.

Configure, Start Acquisition, and Take Readings Using Traditional NI-DAQ (Legacy) in LabVIEW

After you have performed an offset null compensation, shunt calibration, and configured the SCXI-1520 settings for your application, you can use the intermediate analog input functions AI Config VI, AI Start VI, AI Read VI, and AI Clear VI to create your data acquisition application. You can find the intermediate data acquisition Traditional NI-DAQ (Legacy) functions in the function subpalettes **Data Acquisition»Analog Input**. NI recommends using the intermediate analog input functions for most SCXI-1520 applications. For more information about using the intermediate data acquisition Traditional NI-DAQ (Legacy) functions, refer to the *LabVIEW Measurements Manual*. You also can use the *LabVIEW Help* for more detailed information about the various inputs and outputs of these functions.

Converting Scaling Using Traditional NI-DAQ (Legacy) in LabVIEW

The names given the strain-gauge types in Chapter 4, *Theory of Operation*, in Figure 4-3, *Quarter-Bridge I Circuit Diagram*, Figure 4-5, *Quarter-Bridge II Circuit Diagram*, Figure 4-7, *Half-Bridge Type I Circuit Diagram*, Figure 4-9, *Half-Bridge Type II Circuit Diagram*, Figure 4-11, *Full-Bridge Type I Circuit Diagram*, Figure 4-13, *Full-Bridge Type II Circuit Diagram*, and Figure 4-15, *Full-Bridge Type III Circuit Diagram*, directly correspond to bridge selections in MAX and the LabVIEW Convert Strain Gauge Reading VI. You find this VI on the function subpalette **Data Acquisition»Signal Conditioning**. Using this VI, you wire the SCXI-1520 analog input reading to $\mathbf{V_{SG}}$, the initial analog input reading with the system unstrained to $\mathbf{V_{init}}$, and the excitation voltage to $\mathbf{V_{EX}}$.

If you are measuring strain, you can use the strain virtual channel in Traditional NI-DAQ (Legacy) to perform offset null compensation, shunt calibration, and to properly scale strain measurements. If you are measuring any other kind of bridge sensor such as load cell, pressure sensor, or torque sensor, and the measurement must be displayed in units of interest for the sensor, you cannot use the strain virtual channel. This is because the scaling provided by the strain virtual channel returns measurements in units of microstrain (με) rather than the units of interest for the sensor. If you require alternative scaling, you can either use an analog input voltage virtual channel with a custom scale configured in MAX or SCXI channel strings, and provide scaling in your LabVIEW application.

If you are using SCXI channel strings, you can easily convert the SCXI-1520 voltage signal measurements in your application into scaled units of interest such as strain, pounds, or newtons. LabVIEW has some common conversion scaling functions such as the Convert Strain Gauge Reading VI in the function subpalette **Data Acquisition»Analog Input» Signal Conditioning**.

You also can use an Expression Node or Formula Node to convert voltage signal measurements into whatever units your application requires. You can find an Expression Node in the function subpalette **Numeric**. You can find Formula Nodes in the **Function** subpalettes **Analyze»Mathematics» Formula**. For more information about using the Expression Node or Formula Node, refer to the *LabVIEW User Manual*. You also can use the *LabVIEW Help* for more detailed information about how to use these nodes to perform mathematical calculations such as scaling conversions.

Analyze and Display Using Traditional NI-DAQ (Legacy) in LabVIEW

In LabVIEW, you can easily analyze SCXI-1520 measurements with a variety of powerful analysis functions that you can find in the function subpalettes **Analyze»Waveform Conditioning** and **Analyze»Signal Processing**. You can perform post acquisition processing such as waveform comparisons, harmonic analysis, and digital filtering. For more information about these VIs, refer to the *LabVIEW Analysis Concepts* manual. You also can use the *LabVIEW Help* for more detailed information about how to use the analysis VIs.

In LabVIEW, you also can easily display SCXI-1520 measurements with a variety of graphical waveform graphs, numeric slides, gauges, and other indicators. You can find useful graphical controls and indicators for user interaction with your application in the controls subpalettes. For more information about these VIs, refer to the *LabVIEW User Manual*. You also can use the *LabVIEW Help* for more detailed information about how to use graphical controls and indicators in your application.

Traditional NI-DAQ (Legacy) in Text-Based ADEs

NI text-based ADEs, such as LabWindows/CVI, Measurement Studio for Microsoft Visual Basic, and Measurement Studio for Microsoft Visual C++, offer help in the development of test and measurement applications. These ADEs provide easy data acquisition, data analysis, graphical display, and data logging tools. Refer to the ADE user manual for more information about how to use these features.

The high-level data acquisition tools provided in LabWindows/CVI and Measurement Studio allow you to easily use virtual channels configured in MAX, providing easy configuration and programming of the data acquisition systems. However, some of the more advanced features of the SCXI-1520 are not accessible through this easy-to-use API. For more advanced features or for more explicit control of the programmatic attributes, use the low-level DAQ functions provided in the Traditional NI-DAQ (Legacy) C API. Refer to the ADE user documentation for more information about how to use the high-level data acquisition tools that are provided in your NI ADE.

For more advanced SCXI-1520 applications, or if you are using an ADE other than an NI ADE, you can use the Traditional NI-DAQ (Legacy) C API to call functions from the DAQ driver dynamically linked library (dll). The *Low-Level DAQ Functions* section outlines the steps for programming with the low-level DAQ function calls. If you are using LabWindows/CVI or Measurement Studio, you also can write advanced applications using the same low-level DAQ functions guidelines.

Low-Level DAQ Functions

Notes If you are a new SCXI-1520 user, NI recommends that you use the NI-DAQmx API rather than the Traditional NI-DAQ (Legacy) C API. NI-DAQmx is the second generation data acquisition driver optimized for ease of use and improved performance.

You can find a complete example using Traditional NI-DAQ (Legacy) C API functions to perform an offset null compensation and shunt calibration with the SCXI-1520 at `ni.com/info` using the code `rdscaq`. Use this example program as a guide when developing your Traditional NI-DAQ (Legacy) C API application.

You can design your SCXI-1520 application using a typical offset null compensation and offset null program flow shown in Figure 5-5, which has the following basic steps:

1. Configure the system settings for the offset null compensation operation.
2. Perform offset null compensation.
3. Configure settings for the shunt calibration operation.
4. Perform shunt calibration.
5. Configure the settings for acquisition.
6. Perform the acquisition.
7. Convert the scaling.

8. Analyze and display the data.
9. Clear the acquisition.

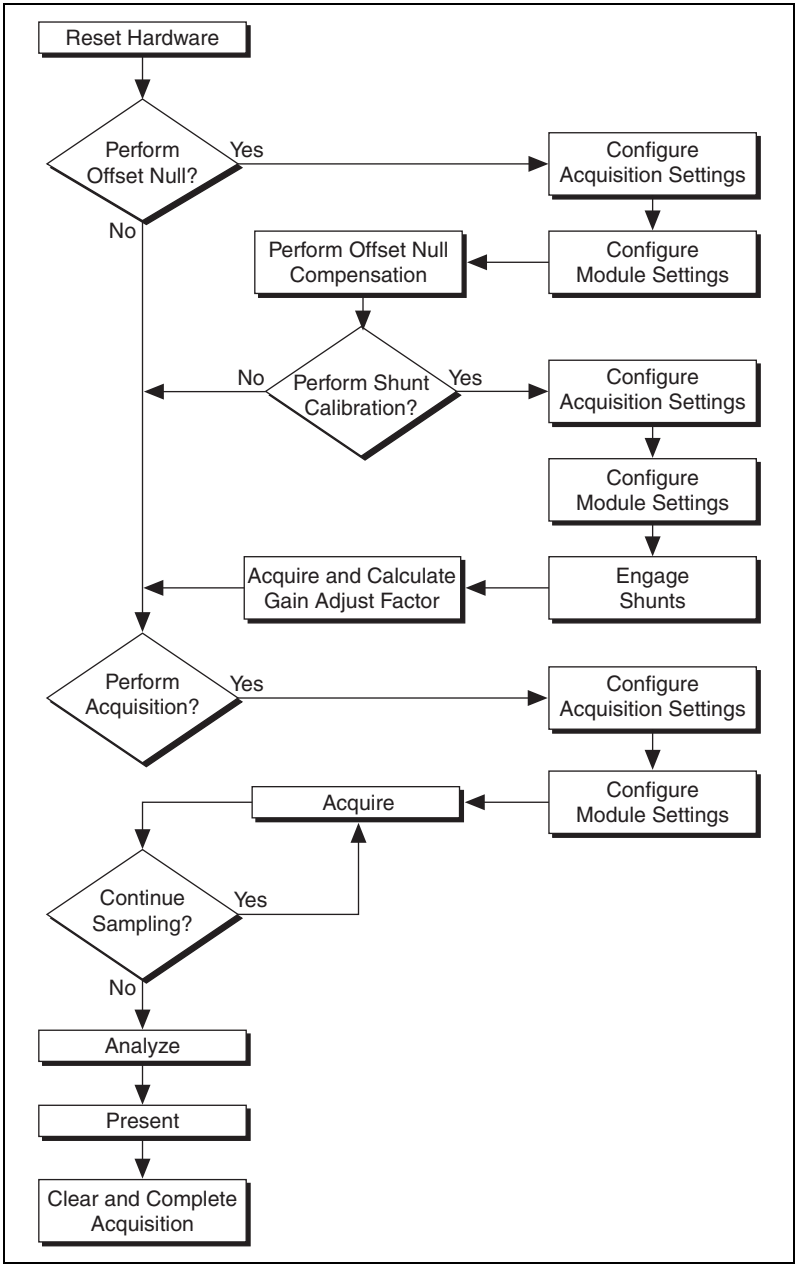


Figure 5-5. Offset Null and Shunt Calibration Flowchart

Configuring System Settings Using Traditional NI-DAQ (Legacy) C API

Start the configuration of the acquisition by ensuring that the SCXI-1520 module and SCXI chassis are in their default states, and that the driver software configuration matches the states the actual physical hardware configuration. After setting the hardware and software to the defaults of the module(s), you can configure any module settings that vary from the default configuration settings. You also should configure the acquisition parameters using the functions in Table 5-5. For additional information such as the function prototypes, parameters, and usage instructions for each function, refer to the *Traditional NI-DAQ Function Reference Help* installed by default in **Start»Programs»National Instruments»NI-DAQ**.

Table 5-5. Configuration Functions

Function	Description
`SCXI_Reset`	Resets the hardware such as the specified module to its default state. You also can use `SCXI_Reset` to reset the SCXI chassis Slot 0 scanning circuitry or reset the entire chassis. The SCXI-1520 default conditions are: • Channels configured for full-bridge connection • Gain set at 1.0 • 10 Hz lowpass filter • Excitation set at 0 volts • Shunt switches disabled • Potentiometers mid-ranged
`SCXI_Load_Config`	Loads the SCXI chassis configuration information you established in MAX. Sets the software states of the chassis and the modules present to their default states. This function makes no changes to the hardware state of the SCXI chassis or modules. It is possible to programmatically change the configuration you established in MAX using the `SCXI_Set_Config` function.
`SCXI_Track_Hold_Setup`	Establishes the T/H behavior of an SS/H module and sets up the module for either a single-channel operation or an interval-scanning operation.

Table 5-5. Configuration Functions (Continued)

Function	Description
SCXI_SCAN_Setup	Initializes multiplexing circuitry for a scanned data acquisition operation. Initialization includes storing a table of the channel sequence and gain setting for each channel to be digitized (MIO and AI devices only). You *cannot* repeat channels or use nonsequential channels when using the SCXI_SCAN_Setup function.
SCXI_MuxCtr_Setup	Programs the E Series DAQ device with the correct number of channels multiplexed per scan. This number must match the total number of channels programmed in SCXI_SCAN_Setup.

Note NI strongly recommends monitoring the built-in error status of each NI-DAQ function. The NI-DAQ C API provides the NIDAQErrorHandler function, which ensures that a specified NI-DAQ function executed properly, and assists in handling error messages and reporting.

Configuring Module Settings Using Traditional NI-DAQ (Legacy) C API

After configuring the hardware for acquisition, you must load the various channel attributes such as filter, gain, bridge configuration, and excitation appropriate for your application explicitly using the NI-DAQ function calls shown in Table 5-6. For more information regarding each setting, refer to the *Traditional NI-DAQ Function Reference Help* installed by default in **Start»Programs»National Instruments»NI-DAQ**.

Table 5-6. NI-DAQ Functions Used to Configure SCXI-1520

Channel Setting	NI-DAQ Function to Use	Significant Parameters	Possible Parameters Values
Gain	`SCXI_Set_Gain`	f64 `gain` (gain setting)	1, 1.15, 1.3, 1.5, 1.8, 2, 2.2, 2.4, 2.7, 3.1, 3.6, 4.2, 5.6, 6.5, 7.5, 8.7, 10, 11.5, 13, 15, 18, 20, 22, 24, 27, 31, 36, 42, 56, 65, 75, 87, 100, 115, 130, 150, 180, 200, 220, 240, 270, 310, 360, 420, 560, 650, 750, 870, 1000
Bandwidth	`SCXI_Configure_Filter`	i16 `filterMode` (filter configuration mode) f64 `freq` (filter cutoff frequency if filterMode = 1)	0—Bypass the filter 1—Set filter cutoff frequency to freq 10.0, 100.0, 1000.0, 10,000.0 Hz
Excitation Voltage	`SCXI_Set_Excitation`	i16 `excitationType` (type of excitation to set) f32 `excitationValue` (new value for the specified excitation parameter)	2—DC voltage specified in units of volts 0, 0.625, 1.25, 1.875, 2.5, 3.125, 3.75, 4.375, 5.0, 5.625, 6.25, 6.875, 7.5, 8.125, 8.75, 9.375, 10.0

Table 5-6. NI-DAQ Functions Used to Configure SCXI-1520 (Continued)

Channel Setting	NI-DAQ Function to Use	Significant Parameters	Possible Parameters Values
Bridge Configuration	`SCXI_Configure_Connection`	i16 `connectionType` (type of sensor connected to the specified channel)	4—Quarter bridge 5—Half bridge 6—Full bridge
Shunt Calibration	`SCXI_Calibrate_Setup`	i16 `CalOp` (calibration operation to be performed)	0—turn off shunts 4—turn on shunt A on all channels 5—turn on shunt B on all channels

Performing Offset Null Compensation Using Traditional NI-DAQ (Legacy) C API

After configuring the system settings and module properties, you can perform an offset null compensation programmatically using `SCXI_Strain_Null`. This function takes measurements and adjusts the coarse and fine offset null potentiometers to minimize or eliminate any electrical offset for a channel. You can repeat this process for each channel by calling the `SCXI_Strain_Null` function in a loop. You can use the resulting imbalance in your application as a software correction factor by determining the residual voltage from the imbalance, and subtracting this residual offset from each future measurement. For more information regarding the operation of `SCXI_Strain_Null`, refer to the *Traditional NI-DAQ Function Reference Help* installed by default in **Start» Programs»National Instruments»NI-DAQ**.

Performing Shunt Calibration Using Traditional NI-DAQ (Legacy) C API

After performing an offset null compensation, you can perform a shunt calibration programmatically. This process is described in the *Shunt Calibration* section of Chapter 4, *Theory of Operation*. You can use `SCXI_Calibrate_Setup` with the parameter `CalOp` set to `4` to engage SCA, set to `5` to engage SCB, and set to `0` to disengage the shunt resistor of both switches. After you engage a shunt resistor across an element of the bridge sensor, wait until the voltage settles, then take a buffer of samples and average them. Determine what the resultant voltage offset should be. Calculate a gain adjust factor by dividing the ideal or simulated output by the measured output and then use the gain adjust factor by multiplying each

future measurement by the gain adjust factor. Remember to disengage the shunt switches before continuing your application. For more information regarding the operation of SCXI_Calibrate_Setup, refer to the *Traditional NI-DAQ Function Reference Help* installed by default in **Start»Programs»National Instruments»NI-DAQ**.

Performing Acquisition Using Traditional NI-DAQ (Legacy) C API

There are several NI-DAQ functions you can use to take measurements. Usually in SCXI the preference is to take multiple samples from multiple channels using the SCAN_Op function. SCAN_Op performs a synchronous, multiple-channel scanned data acquisition operation. SCAN_Op does not return until Traditional NI-DAQ (Legacy) acquires all the data or an acquisition error occurs (MIO, AI, and DSA devices only). For this reason, it is sometimes useful to use SCAN_Op in conjunction with the function Timeout_Config, which establishes a timeout limit synchronous functions to ensure that these functions eventually return control to your application. After acquiring data using SCAN_Op, the resultant data is not organized by channel, so you should demultiplex the data using SCAN_Demux. SCAN_Demux rearranges, or demultiplexes, data acquired by a SCAN_Op into row-major order, meaning each row of the array holding the data corresponds to a scanned channel for easier access by C applications. BASIC applications need not call SCAN_Demux to rearrange two-dimensional arrays since these arrays are accessed in column-major order. For more information regarding each acquisition function, refer to the *Traditional NI-DAQ Function Reference Help* installed by default in **Start»Programs»National Instruments»NI-DAQ**.

Performing Scaling, Analysis, and Display

After acquiring raw voltage data from the acquisition functions, most applications require adjustment by device calibration constants for accuracy, scaling measured voltage, analysis, and graphical display.

The SCXI-1520 has stored software calibration constants loaded on the module EEPROM that are used to achieve the absolute accuracy specifications. SCXI_Scale scales an array of binary data acquired from an SCXI channel to voltage using the stored software calibration constants when it scales the data. You must call SCAN_Demux before SCXI_Scale if you have multiple channels in the scan. For more information regarding SCXI_Scale, refer to the *Traditional NI-DAQ Function Reference Help* installed by default in **Start»Programs»National Instruments»NI-DAQ**.

After you have adjusted the measurement by the appropriate calibration constants using `SCXI_Scale`, you can use a function from the NI conversion library `convert.h` to convert a voltage or voltage buffer from a strain gauge to units of strain. NI-ADEs also provide many powerful analysis functions to perform digital filtering, harmonic analysis, averaging, and complex mathematics on measurements.

After performing scaling and analysis on the acquired data, you can display the measurements in several ways. You can use any built-in GUI tools in your ADE. NI ADEs provide many graphical controls and indicators such as charts, graphs, gauges, slides, and plots that you can use to display the data. There is also a built-in function, found in `nidaqex.h`, called `NIDAQPlotWaveform`, that you can use to generate a simple plot of the data.

Other Application Documentation and Material

Refer to the ADE manual and the DAQ analog input examples that come with your application software for more detailed information on programming the SCXI modules for scanning in multiplexed mode.

Traditional NI-DAQ (Legacy) CVI Examples

Many example programs ship with NI-DAQ. For more example information on how to create tasks and channels, refer to the example programs. By default, the example programs are installed in `C:\Program Files\NationalInstruments\CVI 7.0\Samples`. More examples are installed by default in `C:\Program Files\National Instruments\NI-DAQ\Examples`.

Traditional NI-DAQ (Legacy) Measurement Studio Examples

Many example programs ship with NI-DAQ. For more example information on how to create tasks and channels, refer to the example programs. By default, the example programs are installed in `C:\Program Files\NationalInstruments\Measurement Studio 7.0`. More examples are installed by default in `C:\Program Files\National Instruments\NI-DAQ\Examples`.

Calibrating the Strain System

There are two types of calibration important to verifying the accuracy of a strain measurement system. Device calibration ensures the accuracy of the SCXI-1520. System calibration involves removing potential error-causing variables such as offset and verifying the accuracy of the strain element through shunt calibration.

Calibrating the SCXI-1520

The SCXI-1520 is shipped with a calibration certificate and is calibrated at the factory to the specifications described in Appendix A, *Specifications*. Calibration constants are stored inside the calibration EEPROM and provide software correction values your application development software uses to correct the measurements for offset errors in the module.

To obtain the highest level of accuracy, you should periodically perform an internal calibration. You can initiate an internal calibration using NI software.

For more information on calibrating the SCXI-1520, download the *SCXI-1520 Calibration Procedure* from `ni.com/calibration`.

Internal Calibration Procedure

The SCXI-1520 incorporates internal calibration paths that allow routing channel inputs to ground or to an onboard reference voltage. NI software disconnects the channel inputs from the front signal connector and reconnects the inputs to ground or to an onboard reference when performing an internal calibration. You need not change any input connections for an internal calibration.

Internal Calibration Using LabVIEW

Note NI recommends that you internally calibrate the DAQ device before you internally calibrate the SCXI-1520.

For internal calibration using LabVIEW, complete the following steps using the LabVIEW SCXI Calibrate VI found in LabVIEW at **NI Measurements»Data Acquisition»Calibration and Configuration**:

1. Enter the DAQ device and the SCXI channel string for the channel you want to calibrate.
2. Select **internal calibration** as the calibration operation you are going to perform.

The driver software takes a few seconds to perform the calibration. After completion, the module has new calibration constants stored for all gain settings. You must repeat the procedure to calibrate other channels in the module.

Internal Calibration Using a C-Based ADE

For internal calibration using a C-based ADE, complete the following steps using the NI-DAQ function, `SCXI_Calibrate`:

1. Enter the DAQ device, DAQ channel, module slot, and module channel.
2. Select **internal calibration (0)** as the operation you are going to perform.

The SCXI-1520 takes a few seconds to perform the calibration. After completion, the module has new calibration constants stored for all gain settings. You must repeat the procedure to calibrate other channels in the module.

External Calibration

For instructions on how to perform an external calibration on the SCXI-1520, refer to the *SCXI-1520 Calibration Procedure* available by going to `ni.com/calibration` and clicking **Manual Calibration Procedures**. NI recommends you perform an external calibration once a year.

Calibrating the System

You should perform offset null compensation or shunt calibration on transducers in the system to improve accuracy. This is considered system, or end-to-end, calibration.

Offset Null Compensation

Performing an offset null compensation removes offset in the measurement system. Factors such as imperfections in the strain gauge, electrical offset in the measurement system, signal leads with significant lead resistance, as well as other system variables can create offset. Refer to the *Offset Null Compensation* section of Chapter 4, *Theory of Operation*, for information about how to perform offset null compensation.

Shunt Calibration

Performing shunt calibration removes gain or amplitude errors in the measurement system. Factors such as non-ideal gauges, incorrect strain gauge factor, temperature fluctuations, as well as other system variables can create these errors. Refer to the *Shunt Calibration* section of Chapter 4, *Theory of Operation*, for information about how to perform shunt calibration.

A

Specifications

This appendix lists the specifications for the SCXI-1520 modules. These specifications are typical at 25 °C unless otherwise noted.

Analog Input

Number of channels 8

Voltage gain settings ..... X1 to X1000 with the following gain settings: 1; 1.15; 1.3; 1.5; 1.8; 2; 2.2; 2.4; 2.7; 3.1; 3.6; 4.2; 5.6; 6.5; 7.5; 8.7; 10; 11.5; 13; 15; 18; 20; 22; 24; 27; 31; 36; 42; 56; 65; 75; 87; 100; 115; 130; 150; 180; 200; 220; 240; 270; 310; 360; 420; 560; 650; 750; 870; 1000

Input coupling ..... DC

Overvoltage protection ..... ±35 V powered on, ±25 V powered off

Inputs protected ..... <0..7>

Transfer

Nonlinearity ..... Better than 0.02% of FSR

Gain error ..... ±0.35% of setting at RSC, ±0.1% of the value returned by driver software

Offset error

- Gain ≥20 ..... 150 μV max
- Gain <20 ..... 3 mV max

Complete Accuracy Table, Voltage

Nominal Range†	Overall Gain†	Percent of Reading†	Offset†	System Noise (Peak, 3 Sigma)†		Temperature Drift	
				Single Point	100-Point Average	Gain Drift (%/°C)	Offset (µV/°C)
±10.0 V	1.0	±0.1	±3.0 mV	10.0 mV	1.0 mV	±0.03	±25
±5.0 V	2.0	±0.1	±1.5 mV	5.0 mV	0.5 mV	±0.03	±25
±1.8 V	4.2	±0.1	±0.5 mV	2.0 mV	0.2 mV	±0.03	±25
±1.0 V	10.0	±0.1	±0.3 mV	1.0 mV	0.1 mV	±0.03	±25
±500.0 mV	20.0	±0.1	±150.0 µV	0.5 mV	50.0 µV	±0.03	±5
±180.0 mV	42.0	±0.1	±75.0 µV	0.2 mV	20.0 µV	±0.03	±5
±100.0 mV	100.0	±0.1	±50.0 µV	100.0 µV	10.0 µV	±0.03	±5
±50.0 mV	200.0	±0.1	±50.0 µV	50.0 µV	5.0 µV	±0.03	±5
±18.0 mV	420.0	±0.1	±50.0 µV	20.0 µV	2.0 µV	±0.03	±5
±10.0 mV	1000.0	±0.1	±50.0 µV	20.0 µV	2.0 µV	±0.03	±5

† Absolute accuracy (15 to 35 °C). Absolute accuracy is (*Voltage Reading*) × (*% of Reading*) + (*Offset Error*) + (*System Noise*).
To include the effects of temperature drift outside the range 15 to 35 °C, add the term, $T \times$ (*Gain Drift*) × (*Range*) × $T \times$ (*Offset Drift*),
where T is temperature difference between the module temperature and 15 or 35 °C, whichever is smaller. Bandwidth setting is 10 Hz and scan rate for 100-point averages is 200 scans/s. Excitation is set to 0 V. To calculate the absolute accuracy for the SCXI-1520, visit `ni.com/accuracy`.

Complete Accuracy Table, Strain, GF = 2.0, Excitation = 5 V

Bridge	Range	Gain	Percent of Reading†	Hardware Nulling Range	System Noise (Peak, 3 Sigma)†		Temperature Drift	
					Single Point	100-Point Average	Gain Drift (%/°C)	Offset (με/°C)
Quarter-Bridge	±40000 με	100	±0.1	±80000 με	±40 με	±4 με	±0.03	±80
	±7000 με	560	±0.1	±80000 με	±7 με	±2 με	±0.03	±16
	±4000 με	1000	±0.1	±80000 με	±4 με	±1 με	±0.03	±8
Half-Bridge	±2500 με	1000	±0.1	±40000 με	±2 με	±0.5 με	±0.03	±4
Full-Bridge	±1250 με	1000	±0.1	±20000 με	±1 με	±0.2 με	±0.03	±2

† Absolute accuracy (15 to 35 °C). Absolute accuracy is (*Voltage Reading*) × (*% of Reading*) + (*Offset Error*) + (*System Noise*).
To include the effects of temperature drift outside the range 15 to 35 °C, add the term, $T \times$ (*Gain Drift*) × (*Range*) + $T \times$ (*Offset Drift*),
where T is temperature difference between the module temperature and 15 or 35 °C, whichever is smaller. Bandwidth setting is 10 Hz and scan rate for 100-point averages is 200 scans/s. To calculate the absolute accuracy for the SCXI-1520, visit `ni.com/accuracy`.

Amplifier

Input impedance (DC) ..... >1 GΩ

Input impedance (DC) powered off.....5.8 kΩ min

Input bias current .....±20 nA max

Input offset current .....±20 nA max

CMRR (DC to 60 Hz, full-bridge setting)

Gain ≥20 .....>85 dB

Gain <20 .....>60 dB

Dynamic

Minimum scan interval (per channel, any gain in multiplexed mode)

±0.0125% accuracy .....3 µs

±0.006% accuracy .....10 µs

±0.0015% accuracy .....20 µs

Noise RTI, gain = 200, 0.1 to 10 Hz.....2.0 μV_{pp}

Spot noise RTI, gain = 200, 1000 Hz .....16 nV/$\sqrt{Hz}$

Filter

Lowpass filter type .....4-pole Butterworth (24 dB/octave rolloff)

Lowpass filter settings .....10 Hz, 100 Hz, 1 kHz, 10 kHz, or bypass

Bandwidth, filter bypassed .....–3 dB at 20 kHz

Simultaneous Sample and Hold

Acquisition time

Settle to 0.012%.....7 µs

Settle to 0.003%.....10 µs

Settle to 0.0015%.....50 µs

Hold mode settling time .....1 µs typ

Interchannel skew .....200 ns typ

Intermodule skew ..... 200 ns typ

Droop rate ..... 30 mV/s typ, 100 mV/s max

Stability

Recommended warm-up time ..... 15 minutes

Gain drift ..... ±40 ppm of reading/°C max

Offset drift

- Gain ≥20 ..... ±2 µV/°C typ, ±5 µV/°C max
- Gain <20 ..... ±10 µV/°C typ, ±25 µV/°C max

Offset Null Compensation

Range ..... ±4% of excitation voltage, 20,000 counts of resolution (±80,000 µε offset null compensation range, 4 µε resolution for quarter-bridge, GF = 2.0)

Excitation

Type ..... Constant voltage

Settings ..... 0.0 to 10.0 V in 0.625 V increments

Error ..... ±20 mV ±0.3% of nominal setting ±0.1% of value returned by driver software

Maximum operating current in all ranges ..... 29 mA

Short-circuit protection ..... Yes

Regulation ..... No load to 120 Ω load

- With remote sense ..... ±0.003%
- Without remote sense ..... ±0.08%

Temperature drift ..... ±0.005%/°C, ±30 µV/°C max

Noise, DC to 10 kHz.....200 μV_{pp}

Remote sense .....Error less than ±0.02% per ohm of lead resistance, both leads

Protection.....Surge arrestors in parallel with excitation terminals, shunt to ground

Bridge Completion

Half-bridge.....Two precision resistors, 5 kΩ each, 0.1% ratio matching

Quarter-bridge .....Socketed resistor inside the SCXI-1314 terminal block[1]

Shunt Calibration

Type .....Two independent points

Resistor .....Socketed inside the SCXI-1314 terminal block[2]

Switch resistance .....32 Ω typ
50 Ω max

Switch off leakage .....<1 nA

Switch break-down voltage .....±60 VDC

Power Consumption

V+ .....18.5 to 25 VDC, +170 mA max

V– .....–18.5 to –25 VDC, –170 mA max

+5 V .....+4.75 to 5.25 VDC, 50 mA max

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[1] Half-bridge completion is performed inside the module and configured under software control. The quarter-bridge completion resistor is in the SCXI-1314 terminal block and is socketed. Resistors shipped with the SCXI-1314 are 120 Ω and 350 Ω (default value) RN-55 style (standard 1/4 W size). The tolerance is ±0.1% and the temperature coefficient is 10 ppm/°C max.

[2] Shunt calibration resistors are in the SCXI-1314 terminal block and are socketed. Resistors shipped with the SCXI-1314 are 100 kΩ RN-55 style (standard 1/8 W size). The tolerance is ±0.1% and the temperature coefficient is 10 ppm/°C max.

Physical

Dimensions..... 3.0 × 17.2 × 20.3 cm (1.2 × 6.9 × 8.0 in.)

Weight..... 750 g (1 lb 10.4 oz)

Maximum Working Voltage

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

Channel-to-earth..... Either the S*X*+ or S*X*– input should remain within ±10 V of ground. Both inputs should be within ±10 V of one another, Measurement Category I

Channel-to-channel..... Either the S*X*+ or S*X*– input should remain within ±10 V of ground. Both inputs should be within ±10 V of one another, Measurement Category I

Caution Do *not* use for measurements within Categories II, III, or IV.

Environmental

Operating temperature..... 0 to 50 °C

Storage temperature..... –20 to 70 °C

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

Maximum altitude..... 2,000 m

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

Safety

The SCXI-1520 is designed to meet the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1
- CAN/CSA-C22.2 No. 61010-1

Note For UL and other safety certifications, refer to the product label or visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

Electromagnetic Compatibility

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

Immunity .....EN 61326:1997 + A2:2001, Table 1

EMC/EMI .....CE, C-Tick, and FCC Part 15 (Class A) Compliant

Note For EMC compliance, operate this device with shielded cabling.

CE Compliance

The SCXI-1520 meets the essential requirements of applicable European Directives, as amended for CE marking, as follows:

Low-Voltage Directive (safety).....73/23/EEC

Electromagnetic Compatibility
Directive (EMC).....89/336/EEC

Note Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain the DoC for this product, visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

B

Using SCXI Channel Strings with Traditional NI-DAQ (Legacy) 7.0 or Later

Note This appendix is not applicable if you use the virtual channels to configure and measure the SCXI channels. Virtual channels are configured using MAX. If you use virtual channels, you address the SCXI channels by specifying the channel name(s) in the channel string input.

When using LabVIEW, Measure, and Visual Basic, the SCXI channel string determines which SCXI channels are scanned and the scanning sequence. The SCXI channel string allows you to take measurements from several channels on one module with only one channel string entry. An array of these channel string entries configures multiple modules for scanning. When the application program runs, the channel string is used for programming the channel information into the SCXI system.

The format of the channel string is as follows:

ob*x* ! sc*y* ! md*z* ! *channels*

where

ob*x* is the onboard E Series DAQ device channel, with *x* representing a particular channel where the multiplexed channels are sent. This value is 0 for DAQ device channel 0 in a single-chassis system. In a multichassis or remote chassis system, the DAQ device channel *x* corresponds to chassis number $n - 1$, where DAQ device channel *x* is used for scanning the *n*th chassis in the system.

sc*y* is the SCXI chassis ID, where *y* is the number you chose when configuring the chassis.

md*z* is the slot position where the module is located, with *z* being the particular slot number. The slots in a chassis are numbered from left to right starting with 1.

channels is the list of channels that are scanned for module *z*. It can have several formats:

- obx ! scy ! mdz ! *nx*, where *nx* is a single input channel.
- obx ! scy ! mdz ! (*n0, n2*), where *n0, n2* are individual input channels that are not necessarily sequential.
- obx ! scy ! mdz ! *n0*:*n3*, where *n0* and *n3* represent an ascending sequential list of input channels, inclusive.
- obx ! scy ! mdz ! (*n0, n2, n3*:*n4, n1, n5, n2*), where *n0*, *n2*, and *n5* represent single channels, not necessarily sequential, and *n3* and *n4* represent the endpoints of an ascending sequential list of channels, inclusive. In this case, channels *n1* and *n2* are explicitly repeated in the channel list.

Notes Using parentheses surrounding multiple channels in a channel string is important for correct scanning operation of the SCXI channels.

In a single-chassis system, the obx ! specifier is optional and causes the gains on the module and E Series DAQ device to be automatically set to fit the input limits parameter. When this specifier is omitted, the default gain on the DAQ device, usually the lowest gain, is used, but the SCXI-1520 gain is adjusted to fit the input limits. NI recommends using the obx ! specifier.

Repeating channels or having channels out of sequence in a scan list is not supported on all SCXI modules. Refer to the manual of each module for information on this feature, which is referred to as flexible scanning or random scanning.

For more information about using SCXI channel string, refer to the *LabVIEW Measurements Manual* and SCXI-1520 shipping examples.

Special SCXI-1520 Channel Strings

There are two special channel strings you can use with the SCXI-1520 to acquire signals from alternative locations rather than the signal inputs on the channels: the remote-sense and calibration ground channel strings. This section describes the use of these channels.

Remote-Sense Channel String

You can scan the remote-sense terminals to monitor the excitation voltage while simultaneously acquiring data from analog input channels. This is useful for scaling the measurements by exactly the excitation voltage that

is applied to the bridge sensor. To scan the positive remote-sense terminal of the *n*th channel, use the channel string `obx ! scy ! mdz ! p_pos(n)`

To scan the negative remote-sense terminal of the *n*th channel, use the channel string `obx ! scy ! mdz ! p_neg(n)`

Note To measure the total excitation voltage across the bridge, you must take the difference between `p_pos(n)` and `p_neg(n)`.

(*nth channel bridge excitation voltage*) = (*reading from* `p_pos(n)`) – (*reading from* `p_neg(n)`)

Note If no wires are connected to the remote-sense terminals RS+ and RS–, the voltages measured are the voltages on excitation output terminals P+ and P–. Internal 1 kΩ resistors connect RS+ to P+ and RS– to P–.

Calibration Ground Channel String

The SCXI-1520 has a special calibration feature that enables LabVIEW to ground the module amplifier inputs so that you can read the amplifier offset. For the other SCXI analog input modules, you must physically wire the terminals to ground. The measured amplifier offset is for the entire signal path including the SCXI module and the E Series DAQ device.

To read the grounded amplifier on the SCXI-1520 use the standard SCXI string syntax in the channels array with `calgndz` substituted for the channel number, where `z` is the appropriate SCXI channel needing grounding.

For example, use the SCXI channel string `ob0 ! sc1 ! md1 ! calgnd0` to read the grounded channel 0 signal of the module in Slot 1 of SCXI chassis 1. The resulting measurement should be very close to 0 V. The AI Start VI grounds the amplifier before starting the acquisition. The AI Clear VI removes the grounds from the amplifier after the acquisition completes.

You can specify a range of channels also. The string `calgnd0:7` grounds the amplifier inputs for channels 0 through 7 and reads the offset for each amplifier.

Use the SCXI Calibrate VI, available on the **Functions»Data Acquisition» Calibration and Configuration** palette, to automatically perform a self calibration and modify the scaling constants on the module to adjust for any amplifier offset. Refer to the *Calibrating the Strain System* section of Chapter 5, *Using the SCXI-1520*, for more information about how to use SCXI Calibrate VI with the SCXI-1520.

C

Removing the SCXI-1520

This appendix explains how to remove the SCXI-1520 from MAX and an SCXI chassis.

Removing the SCXI-1520 from MAX

To remove a module from MAX, complete the following steps after launching MAX:

1. Expand **Devices and Interfaces**.
2. Expand the list of installed chassis by clicking the **+** next to **NI-DAQmx** and/or **Traditional NI-DAQ Devices**.
3. Expand the list of installed modules by clicking the **+** next to the appropriate chassis.
4. Right-click the module or chassis you want to delete and click **Delete**.
5. A confirmation window opens. Click **Yes** to continue deleting the module or chassis or **No** to cancel this action.

Note Deleting the SCXI chassis deletes all modules in the chassis. All configuration information for these modules is also lost.

The SCXI chassis and/or SCXI module(s) should now be removed from the list of installed devices in MAX.

Removing the SCXI-1520 from a Chassis

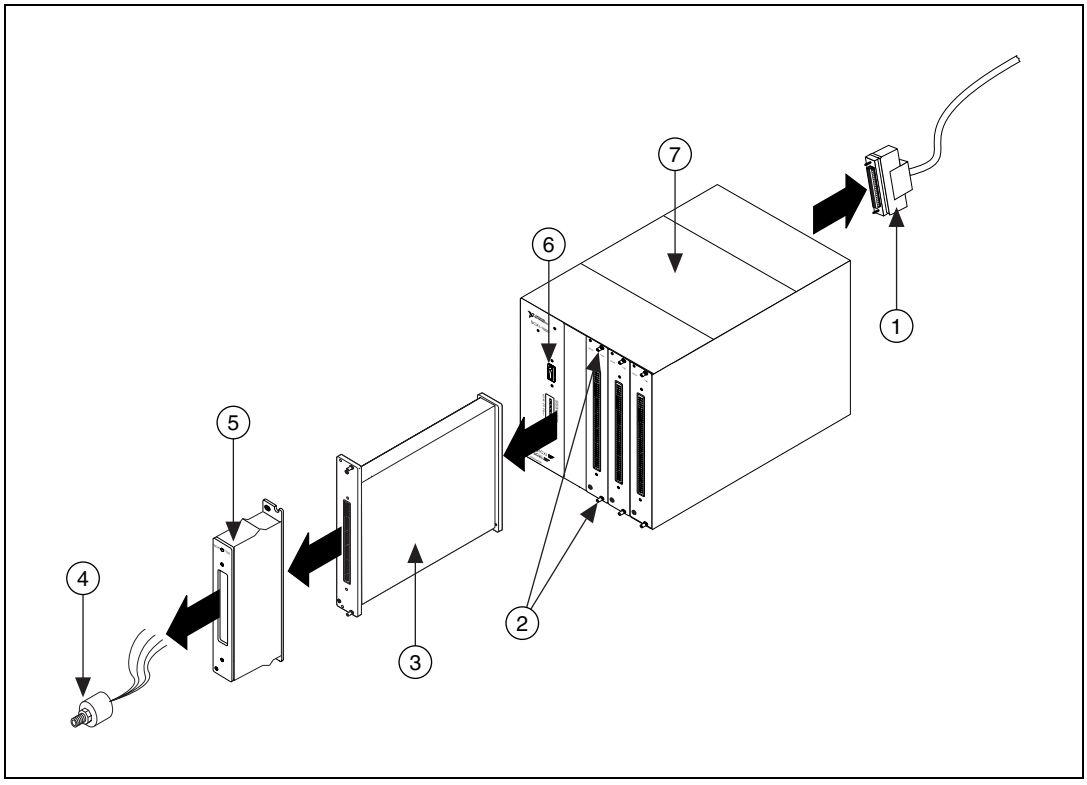
Consult the documentation for the chassis and accessories for additional instructions and precautions. To remove the SCXI-1520 module from a chassis, complete the following steps while referring to Figure C-1:

Note Figure C-1 shows an SCXI chassis, but the same steps are applicable to a PXI/SCXI combination chassis.

1. Power off the chassis. Do *not* remove the SCXI-1520 module from a chassis that is powered on.

2. If the SCXI-1520 is the module cabled to the E/M Series DAQ device, disconnect the cable.
3. Remove any terminal block that connects to the SCXI-1520.
4. Rotate the thumbscrews that secure the SCXI-1520 to the chassis counterclockwise until they are loose, but do not completely remove the thumbscrews.

Remove the SCXI-1520 by pulling steadily on both thumbscrews until the module slides completely out.



1 Cable	5 Terminal Block
2 SCXI Module Thumbscrews	6 SCXI Chassis Power Switch
3 SCXI-1520	7 SCXI Chassis
4 Strain-Gauge or Wheatstone-Bridge Based Transducer	

Figure C-1. Removing the SCXI-1520

D

Common Questions

This appendix lists common questions related to the use of the SCXI-1520.

Which version of NI-DAQ works with the SCXI-1520, and how do I get the most current version of NI-DAQ?

You must have NI-DAQ 7.0 or later. Visit the NI Web site at `ni.com` and select **Download Software»Drivers and Updates»Search Drivers and Updates**. Enter the keyword `NI-DAQ` to find the latest version of NI-DAQ for your operating system.

I have gone over the *Verifying and Self-Testing the Installation* section of Chapter 1, *About the SCXI-1520*, yet I still cannot correctly test and verify that my SCXI-1520 is working. What should I do now?

Unfortunately, there is always the chance that one or more components in the system are not operating correctly. You may have to call or email a technical support representative. The technical support representative often suggests additional troubleshooting measures. If requesting technical support by phone, have the system nearby so you can try these measures immediately. NI contact information is listed in the *Technical Support Information* document.

In NI-DAQmx, can I use channels of different measurement types in the same task?

Yes, you can set up your channels programmatically or through the DAQ Assistant.

Will MAX allow me to configure two SCXI-1520 modules that are in the same chassis, in multiplexed mode, with two different E/M Series DAQ devices?

No.

If the SCXI-1520 module is not cabled directly to a E/M Series DAQ device, can I measure conditioned signals for channels 0 through 7 at the rear connector, for example using a scope, DMM, or custom acquisition system?

NI does not support or recommend this usage. In multiplexed mode simultaneous sample and hold would cause glitches in the scope and would likely average glitches in the DMM, giving inaccurate measurements.

Can I use the unused analog input channels of the E/M Series DAQ device if I am directly cabled to the SCXI-1520, for example with the SCXI-1180 feedthrough?

No. E/M Series DAQ device channels 1 through 7 connect to the conditioned analog outputs of SCXI-1520 channels 1 through 7.

Can I configure the SCXI-1520 for use in parallel mode?

You can configure the SCXI-1520 for parallel mode using NI-DAQmx. Refer to Chapter 4, *Theory of Operation*, for more information.

You cannot configure the SCXI-1520 for parallel mode using Traditional NI-DAQ (Legacy).

Which digital lines are unavailable on the E/M Series DAQ device if it is cabled to an SCXI-1520 module?

Table D-1 shows the digital lines that are used by the SCXI-1520 for communication and scanning. These lines are unavailable for general-purpose digital I/O if the SCXI-1520 is connected to the E/M Series DAQ device.

Table D-1. Digital Signals on the SCXI-1520

E/M Series DAQ Device Signal Name	NI-DAQmx SCXI Signal Name	Traditional NI-DAQ (Legacy) SCXI Signal Name	50-Pin Connector	68-Pin Connector	Direction†
DIO0	P0.0	SER DAT IN	25	52	Output
DIO4	P0.4	SER DAT OUT	26	19	Input
DIO1	P0.1	DAQ D*/A	27	17	Output
DIO2	P0.2	SLOT0SEL*	29	49	Output
SCANCLK	AI HOLD COMP, AI HOLD	SCAN CLK	36	46	Output

Table D-1. Digital Signals on the SCXI-1520 (Continued)

E/M Series DAQ Device Signal Name	NI-DAQmx SCXI Signal Name	Traditional NI-DAQ (Legacy) SCXI Signal Name	50-Pin Connector	68-Pin Connector	Direction†
PFI 7/ AI SAMP CLK	PFI 7/ AI SAMP CLK, AI SAMP	HOLD TRIG	46	38	Input
EXTSTROBE*	EXTSTROBE*	SER CLK	37	45	Input

† With respect to the E/M Series DAQ device.

In LabVIEW, can I use different input limits for the same SCXI-1520 channel if I repeat the channel in the SCXI channel string array?

No. The SCXI-1520 cannot dynamically change the gain settings during scanning. Therefore, group channels with similar input ranges together in the channel string array. Make sure that repeated channels in different indices of the channel string array have the same input limits in the corresponding input limits array.

In LabVIEW, can I use a VI to change my SCXI-1520 configuration settings?

Yes. You can use the AI Parameter VI to change all the SCXI-1520 configuration settings. You also can change the configuration settings in NI-DAQmx using **NI-DAQmx Tasks**. Refer to Chapter 5, *Using the SCXI-1520*, for more information.

Some SCXI modules permit flexible scanning. Does the SCXI-1520 module permit flexible scanning?

Yes. Flexible scanning is described in Chapter 3, *Configuring and Testing*, but you cannot use flexible scanning when you are using C and Traditional NI-DAQ (Legacy). When using C, you can scan only consecutive channels using traditional SCXI channel programming. Refer to the *NI-DAQ Function Reference Help* for more details on SCXI scanning.

Are there any cabling restrictions when using an SCXI-1520 module with a plug-in E/M Series DAQ device?

Yes. If a chassis contains an SCXI-1520, SCXI-1530/1531, or SCXI-1140 module, at least one of these modules must be the cabled module. A cabled module is the module connected directly to the E/M Series DAQ device. This ensures that a timing signal is available for use by all simultaneous-sampling SCXI modules in the chassis.

Can I use the SCXI-1520 with a version of NI-DAQ that works under the Macintosh Operating System (Mac OS)?

No, as of NI-DAQ 6.6.1. Check the release notes of later versions of NI-DAQ at `ni.com` for updates.

Is a register-level programming manual available for the SCXI-1520?

NI does not support register-level programming for the SCXI-1520.

What is the power-on state of the SCXI-1520 multiplexer, analog bus switches, and configuration settings?

The multiplexer, analog bus switches, and configuration settings are not in a known state immediately after power on. All hardware settings are programmed automatically when beginning an acquisition in LabVIEW or a test panel in MAX.

Which accessories can I use to connect signals to the front of the SCXI-1520 module?

Refer to Chapter 1, *About the SCXI-1520*, for more information.

How do I control the gain, excitation voltage, filter setting, bridge configuration, potentiometer settings, and shunt calibration switches from LabVIEW?

The gain of each SCXI-1520 channel is automatically set based on the channel limits used in setting up the acquisition. You usually use the LabVIEW AI Config VI to set the channel limits. If the channel limits are not explicitly set, the SCXI-1520 defaults to the gain setting entered when the module was configured using MAX. Refer to Chapter 3, *Configuring and Testing*, for more information.

Although excitation voltage, filter setting, and bridge configuration are usually set using MAX, you also can control or change these settings programmatically using AI Parameter VI in LabVIEW.

Although you usually use the SCXI Strain Null VI to adjust the electronic potentiometers for offset nulling the analog inputs to zero, you also can manually set or retrieve the potentiometer settings using the AI Parameter VI.

The shunt calibration switches are exclusively controlled using the AI Parameter VI.

How do I control the gain, excitation voltage, filter setting, bridge configuration, potentiometer settings, and shunt calibration switches in C-based application environments?

You must use the NI-DAQ functions listed in Table 5-6, *NI-DAQ Functions Used to Configure SCXI-1520*.

For an SCXI-1520 channel to take a voltage measurement from a sensor that is not in a bridge configuration, are there any special considerations?

You should set the excitation voltage to zero and the bridge configuration to full bridge. This is because the SCXI-1520 input offset correction constants stored in the EEPROM are obtained with the excitation voltage set to zero. With the excitation voltage not at zero, error voltages from the auto-nulling circuits can increase offset error beyond the limits given in the specifications.

What should I take into consideration when I take measurements from sensors with external excitation?

Set the SCXI-1520 internal excitation to the closest value to match the external excitation level. If you want to perform offset null compensation, you must set the excitation level to a value other than zero.

If I am powering my bridge-based transducers with an external voltage source, what voltage setting should I set on the SCXI-1520?

Use the closest corresponding value allowed by the SCXI-1520.

Do the SCXI-1314 or SCXI-1314T terminal blocks contain a CJC temperature sensor?

No.

Are there any user-serviceable parts inside the SCXI-1520?

No. There are no fuses, multiturn potentiometers, DIP switches, slide switches, socketed resistors, or jumpers inside the module. Disassembly of the module for any reason can void its warranty and nullify its calibration.

Can I use remote sense when powering a Wheatstone-bridge based transducer with an external source?

No. Remote sense uses a feedback loop and this feedback loop would be erratic since the SCXI-1520 cannot control the level of the external source.

How do I perform external triggering using the SCXI-1520?

For analog triggering, use your data acquisition device analog triggering functionality through pin PFI 0. Verify that your E/M Series DAQ device supports analog triggering. For more information about analog triggering with the SCXI-1520, refer to the *Analog Hardware Triggering using SCXI* KnowledgeBase by going to `ni.com/info` and using the info code `rdahtu`.

For digital triggering, use your data acquisition device digital triggering functionality through pin PFI 0. All E/M Series DAQ devices support digital triggering. For more information about digital triggering with the SCXI-1520, refer to the DAQ device help file for more information.

Can I measure TEDS load cells with the SCXI-1520?

You can use the SCXI-1314T terminal block to read TEDS load cells. Refer to `ni.com` for more information about TEDS sensors and accessories.

Glossary

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

Numbers/Symbols

%	percent
+	positive of, or plus
–	negative of, or minus
±	plus or minus
<	less than
>	greater than
/	per
°	degree
ε	strain
ε_s	simulated strain
υ	Poisson's ratio

Ω	ohms
+5V (signal)	+5 VDC source signal

A

A	Amperes
A/D	Analog-to-Digital
absolute accuracy	The maximum difference between the measured value from a data acquisition device and the true voltage applied to the input, typically specified as ± voltage.
AC	Alternating Current
acquisition time	The time required by a sample-and-hold system to switch from hold mode back to tracking a signal.
ADC	Analog-to-Digital Converter—An electronic device, often an integrated circuit, that converts an analog voltage to a digital number.
ADE	Application Development Environment, such as LabVIEW, LabWindows/CVI, Visual Basic, C, and C++.
AI	analog input
AI HOLD	Scan clock signal used to increment to the next channel after each E/M Series DAQ device analog-to-digital conversion.
AI HOLD COMP	*See* AI HOLD.
AI SAMP	*See* HOLD TRIG.
AI SAMP CLK	*See* HOLD TRIG.
amp	amplifier
amplification	A type of signal conditioning that improves accuracy in the resulting digitized signal by increasing signal amplitude relative to noise.
ANSI	American National Standards Institute

B

bandwidth	The range of frequencies present in a signal, or the range of frequencies to which a measuring device can respond.
bias current	The small input current flowing into or out of the input terminals of an amplifier.
bipolar	A voltage range spanning both negative and positive voltages.
bit	one binary digit, either 0 or 1
bridge completion resistors	Fixed-valued resistors used to complete a Wheatstone bridge when fewer than four of the bridge elements are working strain gauges.
Butterworth filter	A lowpass filter whose characteristics are optimized for maximum flatness in the passband.

C

C	Celsius
CE	European emissions control standard
CFR	Code of Federal Regulations
CH	channel
channel	Pin or wire lead to which you apply, or from which you read, an analog or digital signal. Analog signals can be single-ended or differential. For digital signals, channels are grouped to form ports.
chassis	The enclosure that houses, powers, and controls SCXI modules.
CLK	clock input signal
CMRR	Common-Mode Rejection Ratio—A measure of the ability of a differential amplifier to reject interference from a common-mode signal, usually expressed in decibels (dB).
CMV	*See* common-mode voltage.
common-mode noise	Noise that appears on both inputs of a differential amplifier.

common-mode voltage	Voltage that appears on both inputs of a differential amplifier.
compressive strain	Strain that results from an object being compressed; has a negative value.
current excitation	A source that supplies the current needed by a sensor for its proper operation.
cutoff frequency	The frequency that defines the upper end of the passband of a lowpass filter.

D

D/A	Digital-to-Analog
D*/A	Data/Address
D GND	*See* DGND.
DAC	D/A converter—An electronic device, often an integrated circuit, that converts a digital number into a corresponding analog voltage or current.
DAQ	data acquisition—(1) Collecting and measuring electrical signals from sensors, transducers, and test probes or fixtures and processing the measurement data using a computer; (2) Collecting and measuring the same kinds of electrical signals with A/D and/or DIO boards plugged into a computer, and possibly generating control signals with D/A and/or DIO boards in the same computer.
DAQ D*/A	The data acquisition board data/address line signal used to indicate whether the SER DAT IN pulse train transmitted to the SCXI chassis contains data or address information.
DAQ device	A data acquisition device.
dB	decibel—The unit for expressing a logarithmic measure of the ratio of two signal levels: $dB = 20\log_{10} V1/V2$, for signals in volts.
DC	Direct Current
device	A plug-in data acquisition board, module, card, or pad that can contain multiple channels and conversion devices.

DIFF	differential input configuration
differential amplifier	An amplifier with two input terminals, neither of which are connected to a ground reference, whose voltage difference is amplified.
differential input	The two-terminal input to a differential amplifier.
DGND	digital ground signal
DIG GND	*See* DGND.
DIN	Deutsche Industrie Norme (German Industrial Standard)
DIO	Digital Input/Output
drivers/driver software	Software that controls a specific hardware device, such as an E/M Series DAQ device.
droop rate	The rate that a sample-and-hold circuit in hold mode deviates from the true hold value, expressed in millivolts per second.

E

EEPROM	Electrically Erasable Programmable Read-Only Memory—ROM that can be erased with an electrical signal and reprogrammed. Some SCXI modules contain an EEPROM to store measurement-correction coefficients.
EMC	ElectroMagnetic Compliance
EMI	ElectroMagnetic Interference
excitation	Supplying a voltage or current source to energize an active sensor or circuit.
EXTCLK	external clock signal
external trigger	A voltage pulse from an external source that causes a DAQ operation to begin.
EXTSTROBE*	*See* SER CLK.

F

F	(1) Fahrenheit—a temperature measurement scale; (2) farad—a measurement unit of capacitance.
FIFO	First-In First-Out memory buffer
filtering	A type of signal conditioning that allows you to remove unwanted frequency components from the signal you are trying to measure.
flexible scanning	The hardware capability to sequence through channels in a scan list in any order.
FSR	Full-Scale Range
full bridge	A Wheatstone bridge in which all four elements are active strain gauges.

G

gain	The factor by which a signal is amplified, sometimes expressed in decibels.
gain accuracy	A measure of deviation of the gain of an amplifier from the ideal gain.
gain error	*See* gain accuracy.
Gauge Factor	For a given strain gauge, is the fractional resistance change relative to the strain that caused the resistance change. Thus, Gauge Factor is a measure of strain-gauge sensitivity.
GF	*See* Gauge Factor.

H

half bridge	A Wheatstone bridge consisting of two active strain gauges and two passive fixed-valued resistors.
hold mode settling time	The time it takes for a sample-and-hold circuit to switch from sampling mode to hold mode and settle within a given percentage at the true hold value.
hold step	The difference in the true hold value and the measured hold value in a sample-and-hold circuit.

HOLD TRIG	hold trigger
Hz	Hertz—Cycles per second of a periodic signal.

I

I/O	Input/Output—The transfer of data to/from a computer system involving communications channels, operator interface devices, and/or data acquisition and control interfaces.
ICD	*See* interchannel delay.
ID	identifier
in.	inch or inches
indirect scanning	The measurement that occurs when a signal passes on the SCXIbus from the scanned SCXI module to the cabled SCXI module.
input bias current	The current that flows into the inputs of a circuit.
input damage level	The highest voltage level that you can apply to the module without damaging it.
input impedance	The measured resistance and capacitance between the input terminals of a circuit.
input offset current	The difference between the bias current flowing out of the input terminals S*X*+ and S*X*–; ideally, is zero so that no error voltage is generated across the input due to differences in bias current.
instrumentation amplifier	A very accurate differential amplifier with a high input impedance.
interchannel delay	Amount of time that passes between sampling consecutive channels. The interchannel delay must be short enough to allow sampling of all the channels in the channel list, within the scan interval.
interchannel skew	The largest difference in hold mode settling time between two sample-and-hold circuits on the same module.
intermodule skew	The largest difference in hold mode settling time between two sample-and-hold circuits on different modules.

L

line resistance	The small, but nonzero, resistance of a lead wire that varies with the lead length and ambient temperature; can cause measurement error if the lead wire carries excitation current.
lowpass filter	A filter that passes signals below a cutoff frequency while blocking signals above that frequency.

M

m	meters
M	(1) Mega, The standard metric prefix for 1 million or 10^6, when used with units of measure such as volts and hertz; (2) mega, The prefix for 1,048,576, or 2^{20}, when used with B to quantify data or computer memory.
max	maximum
microstrain	The unit of strain measurement usually denoted by με; one με represents a deformation of 10^{-6}, or 0.0001%.
min	(1) minutes (2) minimum
MIO	Multifunction I/O
MIO device	Refers to the multifunction I/O E/M Series DAQ devices that have *MIO* or 60*XX* in their names.
MISO	Master-In-Slave-Out signal
MOSI	Master-Out-Slave-In signal
multiplex	To route one of many input signals to a single output.

multiplexed mode	An SCXI operating mode in which analog input channels are multiplexed into one module output so that the cabled E/M Series DAQ device has access to the module's multiplexed output as well as the outputs of all other multiplexed modules in the chassis.
mux	multiplexer—A switching device with multiple inputs that sequentially connects each of its inputs to its single output, typically at high speeds, in order to measure several signals with a single analog-to-digital converter.

N

NC	Not Connected (signal)
NI-DAQ	The driver software needed in order to use NI E/M Series DAQ devices and SCXI components.
noise	An undesirable electrical signal—Noise comes from external sources such as AC power lines, motors, generators, transformers, fluorescent lights, soldering irons, CRT displays, computers, electrical storms, welders, radio transmitters, and internal sources such as semiconductors, resistors, and capacitors. Noise corrupts signals you are trying to measure.
nonlinearity	For an amplifier, a measure of the maximum output deviation from an ideal linear response in units of percent relative to full scale. The ideal linear response is taken to be a straight line on a plot of measured output voltage to measured input voltage with the ends of the line connecting the extremes of the plot at the full-scale limits.

O

offset error	The output of a system with a zero-volt input.
offset null compensation	The provision in strain-gauge signal conditioning hardware to remove the unwanted offset voltage present at the output of a strain-gauge bridge when no strain is applied.
overvoltage protection	Maximum voltage that does not cause hardware damage.

P

parallel mode	A type of SCXI operating mode in which the module sends each of its output channels directly to a separate analog input channel of the E/M Series DAQ device connected to the module.
passband	The range of input frequencies that are passed to the filter output without attenuation.
PFI	*See* HOLD TRIG.
Poisson's ratio	The negative ratio of transverse strain to longitudinal (axial) strain.
pole	A term used to describe the quality of a lowpass filter. In general, the more poles a lowpass filter has, the better it attenuates frequencies beyond the cutoff frequency.
port	(1) A digital port consisting of multiple I/O lines on a E/M Series DAQ device; (2) a serial or parallel interface connector on a PC.
pp	peak to peak
ppm	parts per million
psi	pounds per square inch
PX–	a negative excitation output terminal
PX+	a positive excitation output terminal
PXI	PCI eXtensions for Instrumentation—An open specification that builds on the CompactPCI specification by adding instrumentation-specific features.

Q

QTR	Terminal for connection to a quarter-bridge completion resistor.
quarter bridge	A Wheatstone bridge consisting of one active strain gauge and three passive fixed-valued resistors.
quarter-bridge completion resistor	The bridge completion resistor in series with the active strain gauge in a quarter-bridge configuration; the quarter-bridge completion resistor must have the same nominal resistance value as the strain gauge.

R

remote sense	The method of compensating for voltage drops in bridge excitation leads by remotely measuring the voltage applied to the bridge.
R_g	gauge resistance
R_L	line resistance
RMA	Return Material Authorization
rms	root mean square—The square root of the average value of the square of the instantaneous signal amplitude; a measure of signal amplitude.
rolloff	The ratio that a system attenuates signals in the stopband with respect to the passband, usually defined in decibels per octave.
R_S	shunt-calibration resistance
RS–	remote-sense terminal, negative input
RS+	remote-sense terminal, positive input
RSC	Rear Signal Connector
RSVD	reserved bit, pin, or signal
RTI	Referred To Input—Calculates a specification relative to the input range.
RTO	Referred To Output
RTSI	Real-Time System Integration
RTSI bus	Real-Time System Integration bus—The NI timing bus that connects an E/M Series DAQ device directly, by means of connectors on top of the devices, for precise synchronization of functions.

S

s	seconds
S	samples

S/s	Samples per second—Used to express the rate at which an E/M Series DAQ device samples an analog signal.
sample	An instantaneous measurement of a signal, normally using an analog-to-digital converter in an E/M Series DAQ device.
sample and hold	A circuit with a sample mode where the output tracks the input and a hold mode where the output remains at the last known input before switching modes.
sample rate	The number of samples a system takes over a given time period, usually expressed in samples per second.
SCA	Shunt Calibration terminal, circuit A
scan	One or more analog samples taken at the same time, or nearly the same time. Typically, the number of input samples in a scan is equal to the number of channels in the input group. For example, one scan acquires one new sample from every analog input channel in the group.
scan interval accuracy	The minimum interchannel delay needed to achieve a given accuracy.
scan rate	The number of scans a system takes during a given time period, usually expressed in scans per second.
SCB	Shunt Calibration terminal, circuit B
SCXI	Signal Conditioning eXtensions for Instrumentation
SCXIbus	Located in the rear of an SCXI chassis, the SCXIbus is the backplane that connects modules in the same chassis to each other.
sensor	A device that converts a physical phenomenon into an electrical signal.
SER CLK	Serial clock signal used to synchronize digital data transfers over the SER DAT IN and SER DAT OUT lines.
SER DAT IN	serial data input signal
SER DAT OUT	serial data output signal
settling time	The amount of time required for a voltage to reach its final value within specified accuracy limits.

shunt calibration	The method of calibrating the gain of a strain-gauge data acquisition channel by placing a resistor of known value in parallel with a bridge element.
signal conditioning	The manipulation of signals to prepare them for digitizing.
simulated strain	A strain measurement where the change in bridge output voltage is not caused by deformation of the specimen being measured; rather, it is caused by temporarily connecting a known resistance in parallel with one of the bridge elements while all the strain gauges in the bridge remain unstrained.
simultaneous sample and hold	A series of sample-and-hold circuits that are connected in a matter so as to switch modes in unison.
Slot 0	Refers to the power supply and control circuitry in the SCXI chassis.
SLOT0SEL	Slot 0 select signal
SPICLK	serial peripheral interface clock signal
spot noise	The rms noise voltage or rms noise current in a frequency band 1 Hz wide at the specified frequency.
STC strain gauge	self-temperature compensating strain gauge—Has a resistive temperature coefficient that counteracts the thermal expansion coefficient of the material to which the gauge is bonded; thus, makes the system insensitive to changes in temperature.
strain	The fractional deformation of a body under an applied force; is usually given in the units of microstrain, where one microstrain represents a deformation of 10^{-6}, or 0.0001%.
S*X*–	negative signal input terminal for channel *X*
S*X*+	positive signal input terminal for channel *X*
SYNC	Synchronization pulse for scanning (only used with modules featuring simultaneous sample and hold).
system noise	A measure of the amount of noise seen by an analog circuit or an ADC when the analog inputs are grounded.

T

TEDS	Transducer Electronic Data Sheets
tensile strain	Strain that results from an object being stretched; has a positive value.
track-and-hold	*See* simultaneous sample and hold.
TRIG0	trigger 0
TTL	Transistor-Transistor Logic
typ	typical

U

UL	Underwriters Laboratory
unipolar	A voltage range that only spans positive voltages.

V

V	volts
VDC	volts, direct current
VI	Virtual Instrument—(1) A combination of hardware and/or software elements, typically used with a PC, that has the functionality of a classic stand-alone instrument; (2) A LabVIEW software module (VI), which consists of a front panel user interface and a block diagram program.
virtual channels	Channel names that can be defined outside the application and used without having to perform scaling operations.
voltage excitation	A source that supplies the voltage needed by a sensor for its proper operation.
V_r	$\left(\frac{V_{CH}}{V_{EX}}\right)_{\text{STRAINED}} - \left(\frac{V_{CH}}{V_{EX}}\right)_{\text{UNSTRAINED}}$
V_{rms}	volts, root mean square

W

W	watts
Wheatstone bridge	A circuit arrangement consisting of four resistive elements in a diamond pattern; with excitation voltage applied across two opposing terminals, small resistance changes in the elements are easily detected by measuring voltage changes across the remaining two terminals.
working voltage	The highest voltage with respect to ground that should be applied to an input terminal during normal use, normally well under the breakdown voltage for safety margin. Includes both the signal and common-mode voltages.

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