

# CALIBRATION PROCEDURE

# SCXI™-1600

This document contains information about calibrating the SCXI-1600 module. This document does not discuss programming techniques or compiler configuration.

NI-DAQmx contains online help files that have compiler-specific instructions and detailed function explanations. You can add these help files when you install NI-DAQmx on the calibration computer.

You should calibrate the SCXI-1600 at a regular interval as defined by the measurement accuracy requirements of your application. National Instruments recommends that you perform a complete calibration at least once every year. You can shorten this interval to 90 days or six months.

## Conventions

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The following conventions appear in this manual:

- » 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.
- 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 and hardware labels.
- italic* Italic text denotes variables, emphasis, a cross reference, or an introduction to a key concept. This font also denotes text that is a placeholder for a word or value that you must supply.
- monospace Monospace text 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.

# Software

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Calibration requires the latest version of NI-DAQmx, which includes high-level function calls to simplify the task of writing software to calibrate devices. NI-DAQmx supports many programming languages, including LabVIEW, LabWindows™/CVI™, Microsoft Visual C++, Microsoft Visual Basic, and Borland C++.

# Documentation

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The following documents are your primary references for writing your calibration utility.

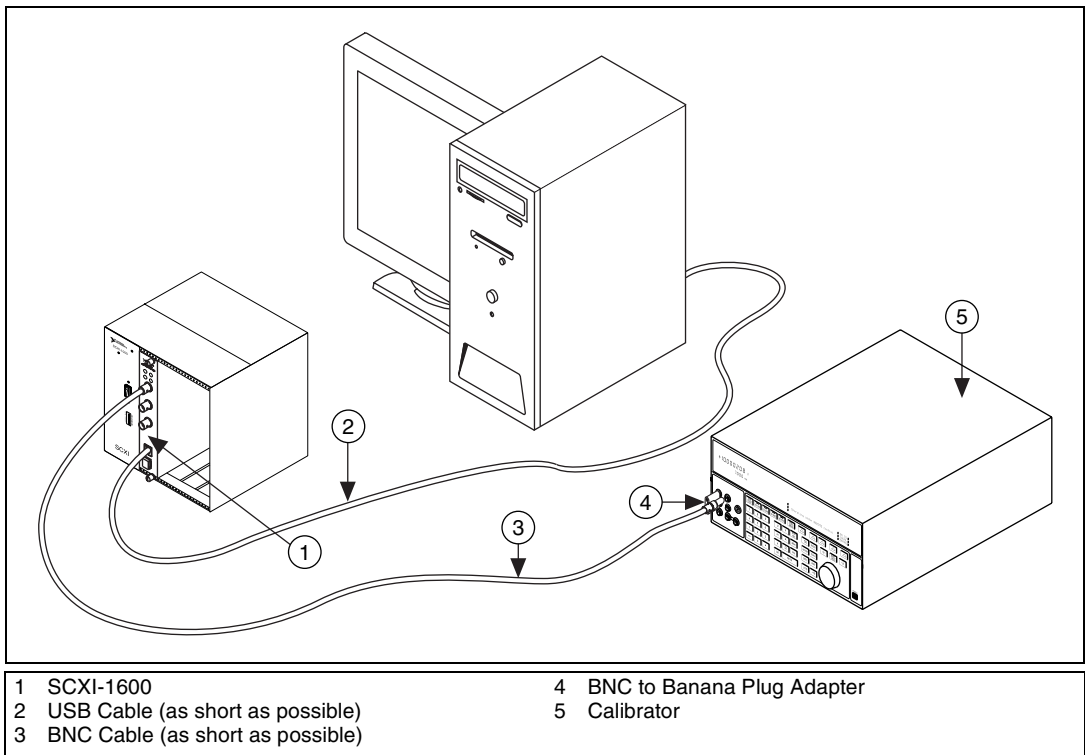
- The *NI-DAQmx C Reference Help* includes information about the functions in NI-DAQmx.
- The *DAQ Getting Started Guide* provides instructions for installing and configuring NI-DAQ devices.
- The *SCXI Quick Start Guide* includes information for installing and configuring the SCXI-1600.
- The *NI-DAQmx Help* includes information about creating applications that use NI-DAQmx.

For more information about the SCXI-1600, refer to the *SCXI-1600 User Manual*.

# Test Equipment

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Figure 1 shows the test equipment you need to calibrate the SCXI-1600. The specific connections are described in the [Calibration Process](#) section.



**Figure 1.** Calibration Connections

When calibrating the SCXI-1600, NI recommends that you use the following:

- Calibrator—Fluke 5700A. If that instrument is unavailable, use a high-precision voltage source that is at least 10 ppm.
- BNC cable—Use shielded BNC cables for the most accurate calibration.

## Test Considerations

Connection and environmental considerations:

- Keep connections to the SCXI-1600 as short as possible. Long cables and wires can act as antennae, which could pick up extra noise that affect measurements.
- Use shielded copper wire for all cable connections to the SCXI-1600. Use twisted-pair wire to eliminate noise and thermal offsets.
- Maintain an ambient temperature of 18 to 28 °C. (The SCXI-1600 temperature will be greater than the ambient temperature.)

- Keep relative humidity below 80%.
- Allow a warm-up time of at least 30 minutes to ensure that the measurement circuitry is at a stable operating temperature.

## Calibration Process

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This section provides instructions for verifying and calibrating the SCXI-1600.

### Calibration Process Overview

The calibration process has the following steps:

1. **Initial Setup**—Configure the SCXI-1600 in NI-DAQmx.
2. **Self-Calibration**—Perform an internal calibration.
3. **Verification Procedure**—Verify the existing operation of the SCXI-1600. This step allows you to confirm that the SCXI-1600 was operating within its specified range prior to calibration.
4. **Adjustment Procedure**—Perform an external calibration that adjusts the SCXI-1600 calibration constants with respect to a known voltage source.
5. Perform another verification to ensure that the SCXI-1600 is operating within its specifications after adjustment.

These steps are described in detail in the *Initial Setup*, *Verification Procedure*, and *Adjustment Procedure* sections.

### Initial Setup

NI-DAQmx automatically detects the SCXI-1600 and configures the chassis. However, for NI-DAQmx to communicate with the SCXI-1600, it must be configured in NI-DAQmx.

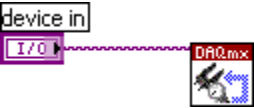
Complete the following steps to configure the SCXI-1600 in NI-DAQmx.

1. Install the NI-DAQmx software.
2. Connect the USB cable from the computer port to the USB port on the SCXI-1600.
3. (Optional) Attach the cable to the strain relief using a cable tie.
4. Launch Measurement & Automation Explorer (MAX).
5. Expand **Devices and Interfaces**.
6. Expand **NI-DAQmx Devices**.

7. Expand the chassis where the SCXI-1600 module is located.
8. Right-click the chassis containing the SCXI-1600, and select **Test** to ensure that the SCXI-1600 is working properly.

## Self-Calibration

Call self-calibration before doing the first verification. This function measures the onboard reference voltage of the device and adjusts the self-calibration constants to account for any errors caused by short-term fluctuations in the operating environment. When you self-calibrate a device, no external signal connections are necessary.

NI-DAQ Function Call	LabVIEW Block Diagram
Call <code>DAQmxSelfCal</code> with the following parameters:  <b>Device_Name[]</b> : dev1	

## Verification Procedure

Verification determines how well the SCXI-1600 meets its specifications. By completing this procedure, you can see how the SCXI-1600 performed since its last calibration. You can use this information to help determine the appropriate calibration interval for your application.

The verification procedure is divided into the major functions of the SCXI-1600. Throughout the verification process, use Table 1 to determine if the SCXI-1600 needs adjustment.

### Analog Input Verification

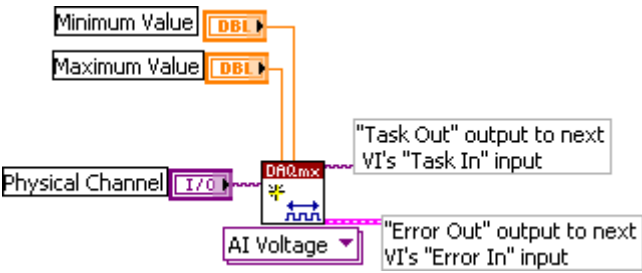
Since the SCXI-1600 has many different ranges, you must check measurements for each available range.

Complete the following steps to check the performance of the analog input.

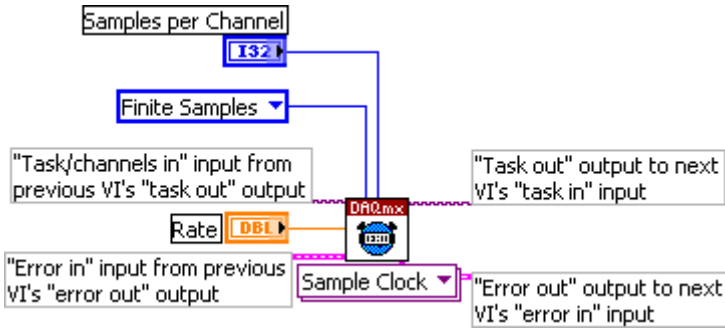
1. Connect a BNC cable between the EXT CAL BNC connector on the SCXI-1600 front panel and the calibrator.
2. If your calibrator has a guard connection, leave it unconnected.
3. Table 1 shows all acceptable settings for the SCXI-1600. Although NI recommends that you verify all ranges, you can save time by checking only the ranges used in your application.
4. Set the calibrator voltage to the test value indicated on Table 1.
5. Create a task using `DAQmxCreateTask`.

NI-DAQ Function Call	LabVIEW Block Diagram
Call DAQmxCreateTask with the following parameters:  <b>taskName:</b> AIVerificationTask <b>taskHandle:</b> &taskHandle	LabVIEW does not require this step.

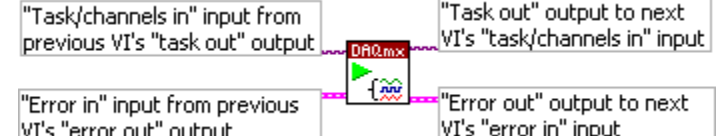
6. Add a channel to the task using DAQmxCreateAIVoltageChan (DAQmx Create Virtual Channel VI) and configure the channel. Use Table 1 to determine the minimum and maximum values for the SCXI-1600.

NI-DAQ Function Call	LabVIEW Block Diagram
Call DAQmxCreateAIVoltageChan with the following parameters:  <b>taskHandle:</b> taskHandle <b>physicalChannel:</b> dev1/_extcal <b>nameToAssignToChannel:</b> myVoltageChannel <b>terminalConfig:</b> DAQmx_Val_Cfg_Default <b>minVal:</b> -10.0 <b>maxVal:</b> 10.0 <b>units:</b> DAQmx_Val_Volts <b>customScaleName:</b> NULL	
If you have not previously enabled internal channels in LabVIEW, double-click the AI Voltage VI, right-click the Physical Channel Control and select I/O Name Filtering, and then check Internal Channels to make _extcal show up in the Physical Channel Control drop-down list.	

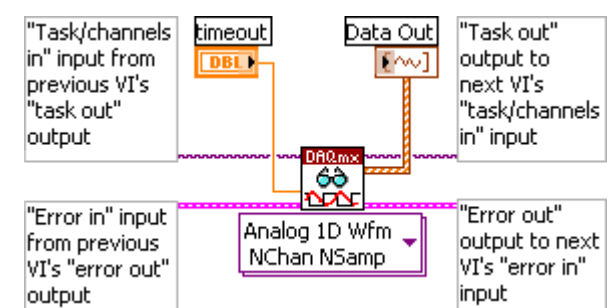
7. Configure timing for the voltage acquisition using DAQmxCfgSampClkTiming (DAQmx Timing VI).

NI-DAQ Function Call	LabVIEW Block Diagram
<p>Call DAQmxCfgSampClkTiming with the following parameters:</p> <p><b>taskHandle:</b> taskHandle  <b>source:</b> NULL  <b>rate:</b> 100000.0  <b>activeEdge:</b> DAQmx_Val_Rising  <b>sampleMode:</b> DAQmx_Val_FiniteSamps  <b>sampsPerChan:</b> 10000</p>	

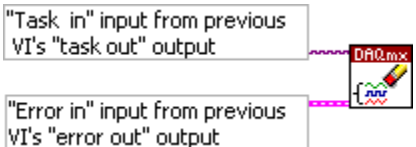
8. Start the acquisition using DAQmxStartTask (DAQmx Start Task VI).

NI-DAQ Function Call	LabVIEW Block Diagram
<p>Call DAQmxStartTask with the following parameter:</p> <p><b>taskHandle:</b> taskHandle</p>	

9. Acquire 10,000 points of voltage data using DAQmxReadAnalogF64 (DAQmx Read VI).

NI-DAQ Function Call	LabVIEW Block Diagram
<p>Call DAQmxReadAnalogF64 with the following parameters:</p> <p><b>taskHandle:</b> taskHandle  <b>numSampsPerChan:</b> -1  <b>timeout:</b> 10.0  <b>fillMode:</b> DAQmx_Val_GroupByChannel  <b>readArray:</b> data  <b>arraySizeInSamples:</b> 10000  <b>sampsPerChanRead:</b> &amp;read  <b>reserved:</b> NULL</p>	

10. Average the 10,000 voltage values. Compare the resulting average to the upper and lower limits listed in Table 1. If the result is between these values, the analog input is verified.
11. Clear the acquisition using `DAQmxClearTask` (**DAQmx Clear Task VI**).

NI-DAQ Function Call	LabVIEW Block Diagram
Call <code>DAQmxClearTask</code> with the following parameter:  <b>taskHandle:</b> <code>taskHandle</code>	

12. Repeat steps 4 through 10 until all values are verified.
13. Disconnect the calibrator from the SCXI-1600.

You have finished verifying the analog input levels on the SCXI-1600.

## Adjustment Procedure

Use this adjustment procedure to adjust the analog input calibration constants. At the end of each calibration procedure, these new constants are stored in the external calibration area of the EEPROM. The values in the EEPROM are password-protected, which prevents the accidental access or modification of any calibration constants adjusted by the metrology laboratory. The default password is NI.

Perform adjustment of the SCXI-1600 with a calibrator by completing the following steps:

1. Connect a BNC cable between the EXT CAL BNC connector on the SCXI-1600 and the output of the calibrator.
2. Set your calibrator to output a voltage of 7.50 V.
3. Open a calibration session on the SCXI-1600 using `DAQmxInitExtCal` (**DAQmx Initialize External Calibration VI**). The default password is NI.



NI-DAQ Function Call	LabVIEW Block Diagram
<p>Call DAQmxInitExtCal with the following parameters:</p> <p><b>deviceName:</b> dev1  <b>password:</b> NI  <b>calHandle:</b> &amp;calHandle</p>	

- Perform an external calibration adjustment using DAQmxESeriesCalAdjust (**DAQmx Adjust E-Series Calibration VI**).

NI-DAQ Function Call	LabVIEW Block Diagram
<p>Call DAQmxESeriesCalAdjust with the following parameters:</p> <p><b>calHandle:</b> calHandle  <b>referenceVoltage:</b> 7.5</p>	

- Save the adjustment to the EEPROM, or onboard memory, using DAQmxCloseExtCal (**DAQmx Close External Calibration**). This function also saves the date, time, and temperature of the adjustment to the onboard memory.

NI-DAQ Function Call	LabVIEW Block Diagram
<p>Call DAQmxCloseExtCal with the following parameters:</p> <p><b>calHandle:</b> calHandle  <b>action:</b> DAQmx_Val_Action_Commit</p>	

- Disconnect the calibrator from the SCXI-1600.

The SCXI-1600 is now calibrated with respect to your external source.

After calibrating the SCXI-1600, NI recommends reverifying the analog input operation. To do this, repeat the *Verification Procedure* section using the 24-hour test limits values from the *SCXI-1600 Test Limits* section.

## SCXI-1600 Test Limits

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Table 1 lists the specifications for the SCXI-1600, and displays the specifications for both 1-year and 24-hour calibration intervals. The 1-year ranges display the specifications that the SCXI-1600 should meet if it has been one year between calibrations. When an SCXI-1600 has been calibrated with an external source, the 24-hours ranges are the valid specifications.

### Using the Table

The following definitions describe how to use the information from Table 1.

#### Range

*Range* refers to the maximum allowable voltage range of an input or output signal.

#### Test Point

The *Test Point* is the voltage value that is input or output for verification purposes. This value is broken down into two columns: *Location* and *Value*. *Location* refers to where the test value fits within the test range. *Pos FS* stands for positive full-scale and *Neg FS* stands for negative full-scale. *Value* refers to the voltage value to be verified and is in volts.

#### 24-Hour Ranges

The *24-Hour Ranges* column contains the *Upper Limits* and *Lower Limits* for the test point value. That is, when the SCXI-1600 is within its 24-hour calibration interval, the test point value should fall between the upper and lower limit values. Upper and lower limits are expressed in volts.

#### 1-Year Ranges

The *1-Year Ranges* column contains the *Upper Limits* and *Lower Limits* for the test point value. That is, when the SCXI-1600 is within its 1-year calibration interval, the test point value should fall between the upper and lower limit values. Upper and lower limits are expressed in volts.

# SCXI-1600—16-Bit Resolution

Table 1 includes values for the SCXI-1600 analog input.

**Table 1.** SCXI-1600 Analog Input Values

Range (V)		Test Point		24-Hour Ranges		1-Year Ranges	
Minimum	Maximum	Location	Value (V)	Lower Limit (V)	Upper Limit (V)	Lower Limit (V)	Upper Limit (V)
-10	10	Pos FS	9.900	9.8929	9.9071	9.8925	9.9075
-10	10	0	0.000	-0.0017	0.0017	-0.0017	0.0017
-10	10	Neg FS	-9.900	-9.9071	-9.8929	-9.9075	-9.8925
-5	5	Pos FS	4.950	4.9484	4.9516	4.9482	4.9518
-5	5	0	0.000	-0.0009	0.0009	-0.0009	0.0009
-5	5	Neg FS	-4.950	-4.9516	-4.9484	-4.9518	-4.9482
-0.5	0.5	Pos FS	0.495	0.49462	0.49538	0.49460	0.49540
-0.5	0.5	0	0.000	-0.00011	0.00011	-0.00011	0.00011
-0.5	0.5	Neg FS	-0.495	-0.49538	-0.49462	-0.49540	-0.49460
-0.05	0.05	Pos FS	0.0495	0.049441	0.049559	0.049439	0.049561
-0.05	0.05	0	0.000	-0.000032	0.000032	-0.000032	0.000032
-0.05	0.05	Neg FS	-0.0495	-0.049559	-0.049441	-0.049561	-0.049439

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