

SCXI™-1141/1142/1143

Introduction

This document contains information and step-by-step instructions for verifying and calibrating the National Instruments SCXI-1141/1142/1143 signal conditioning module.

What Is Calibration?

Calibration is a procedure of reading offset and gain errors from a device and updating special analog calibration circuitry that corrects these errors. National Instruments calibrates every SCXI-1141/1142/1143 module at the factory. During the factory calibration process, the calibration constants are stored in the non-volatile memory of the device. These values are loaded from memory and used as needed by the device.

Why Should You Calibrate?

Offset and gain errors drift with time and temperature changes, which could invalidate the factory-set calibration of a device. Calibration restores the device to its specified accuracy.

How Often Should You Calibrate?

The measurement accuracy requirements of your application determine how often you should calibrate your SCXI-1141/1142/1143 module. National Instruments recommends you perform a complete calibration at least once every year. You can shorten this interval to six months or 90 days, based on the demands of your application.

Equipment and Other Test Requirements

This section describes the equipment, software, documentation, and other test conditions required for calibrating the SCXI-1141/1142/1143.

Test Equipment

Calibration requires a high-precision voltage source with at least 50 ppm accuracy, a multiranging 5 1/2 digit digital multimeter (DMM) with 15 ppm accuracy, and a National Instruments E Series DAQ device.

National Instruments recommends the following instruments for calibration of an SCXI-1141/1142/1143:

- Calibrator—Fluke 5700A
- DMM—NI 4060 or HP 34401A
- National Instruments E Series DAQ device

If these instruments are not available, use the accuracy requirements listed above to select a substitute calibration standard.



Note If you do not have custom connection hardware, you need a connector block, such as the National Instruments SCXI-1300, a shielded 68-pin connector cable, a 50-pin ribbon cable, a 50-pin breakout box, and an SCXI adapter. These components provide easy access to the individual pins on the SCXI-1141/1142/1143 front and rear connectors.

Software and Documentation

You will need the following software and documentation to calibrate the SCXI- 1141/1142/1143 signal conditioning modules. You can find these on the National Instruments Web site at ni.com/calibration:

- The latest version of the National Instruments NI-DAQ driver
- *NI-DAQ Function Reference Online Help* file
- *NI-DAQ User Manual for PC Compatibles*

Software

The SCXI- 1141/1142/1143 calibration procedure requires the latest version of the National Instruments NI-DAQ driver on the calibration system. The driver supports a number of programming languages, including LabVIEW, LabWindows/CVI, Microsoft Visual C++, Microsoft Visual Basic, and Borland C++. When you install the driver, you only need to install support for the programming language you will use.

Documentation

The *NI-DAQ Function Reference Online Help* file and *NI-DAQ User Manual for PC Compatibles* contain detailed information on using the NI-DAQ driver. The function reference online help file includes detailed information on the driver functions. You can access the online help by clicking **Start»Programs»National Instruments DAQ»NI-DAQ Help**. The user manual provides instructions on installing and configuring National Instruments DAQ devices. This manual also includes detailed information on creating applications that use the NI-DAQ driver. These are your primary references for writing your calibration utility. For further information on the products you are calibrating, refer to your device user manuals.

Test Conditions

Follow these guidelines to optimize the connections and the environment during calibration:

- Keep connections to the SCXI module short. Long cables and wires act as antennae, picking up extra noise and thermal offsets that can affect measurements.
- Use shielded copper wire for all cable connections to the device. Use twisted-pair wire to eliminate noise and thermal offsets.
- Maintain the temperature between 18 and 28 °C.
- Keep relative humidity below 80%.
- Allow a warm-up time of at least 15 minutes for the SCXI module and 30 minutes for the E Series device to ensure the measurement circuitry is at a stable operating temperature.

Calibration

The calibration process consists of the following steps:

1. Setting up the module for testing.
2. Verifying the existing operation of the module to determine whether your module is operating within its specifications.
3. Adjusting the module with respect to a known voltage source.
4. Verifying that the module is operating within its specifications after adjustments.

Setting Up Your Module

Complete the following steps to set up your module for verification:

1. Install your SCXI-1141/1142/1143 in slot 1 of your SCXI chassis.
2. Connect a 68-to-68-pin cable between your SCXI module and E Series DAQ device.
3. Configure the hardware with Measurement & Automation Explorer. If you need more information on configuring the system, refer to the E Series device and SCXI module documentation.

Verifying the Operation of Your Module

The verification procedure determines how well the SCXI-1141/1142/1143 module is meeting its specifications. You can use this information to select the appropriate calibration interval for your application.

Verifying Analog Input Offsets

Complete the following steps to verify the analog input offsets of your SCXI-1141/1142/1143:

1. Read the *Test Conditions* section earlier in this document.
2. Refer to Table 1 for the specification limits to test. This table shows all acceptable settings for the module. National Instruments recommends you verify all ranges and gains. However, you can save time by checking only those ranges that are used in your application.
3. Ensure that the E Series device is connected to the SCXI module.
4. Call `Calibrate_E_Series` to minimize the uncertainty associated with the E Series device. Set the following parameters:
 - **device**—The device number assigned by Measurement & Automation Explorer
 - **calOp**—`ND_SELF_CALIBRATE`
 - **setOfCalConst**—`ND_USER_EEPROM_AREA`
 - **calRefVolts**—0.0
5. Call `MIO_Config` to enable dithering on the E Series devices measurements. Set the following parameters:
 - **deviceNumber**—The device number assigned by Measurement & Automation Explorer
 - **dither**—1
 - **useAMUX**—0

6. Call `SCXI_Single_Chan_Setup` to configure the module for single channel measurements. Set the following parameters:
 - **SCXIchassisID**—The value obtained from Measurement & Automation Explorer
 - **moduleSlot**—1
 - **moduleChan**—0
 - **DAQdeviceNumber**—The device number assigned by Measurement & Automation Explorer for the E Series DAQ device
7. Call `SCXI_Set_Gain` to configure the module to the gain value you want to test. Set the following parameters:
 - **SCXIchassisID**—The value obtained from Measurement & Automation Explorer
 - **moduleSlot**—1
 - **moduleChan**—0
 - **gain**—The gain value from Table 1 that you want to test
8. Input the test voltage listed in Table 1 to channel 0 of the SCXI module.
9. Call `DAQ_Op`. Set the following parameters:
 - **deviceNumber**—The device number of the DAQ device
 - **channel**—0
 - **gain**—1 for a 16-bit E Series device or -1 for a 12-bit E Series device
 - **count**—100
 - **sampleRate**—100
10. Call `SCXI_Scale` to convert the reading from binary to voltage. Set the following parameters:
 - **SCXIChassisID**—The device number obtained from Measurement & Automation Explorer
 - **moduleSlot**—1
 - **channel**—0
 - **SCXIgain**—The gain you are testing
 - **TBgain**—1
 - **DAQboard**—The device number for the data acquisition device
 - **DAQChannel**—0
 - **DAQgain**—1

- **numPoints**—100
- **binArray**—The array returned from DAQ_Op

The result is a set of scaled voltages read from the SCXI module.

11. Average the results returned from `SCXI_Scale`. The averaged result is the final reading that you will compare to the upper and lower limits listed in Table 1.
12. Repeat steps 6 through 11 for each remaining test point.
13. Repeat steps 6 through 12 for each remaining channel, changing the **moduleChan** variable to the channel number you are testing.

You have now completed verifying the operation of your SCXI-1141/1142/1143.

Adjusting Your Module

This section contains three adjustment procedures: one for adjusting gain and offset errors, one for adjusting calibration constants, and one for adjusting filter AC gain.

Adjusting Gain and Offset Errors

Complete the following steps to adjust the gain and offset errors in the SCXI-1141/1142/1143 module:

1. Read the *Test Conditions* section earlier in this document.
2. Refer to Table 1 for the specification limits to be tested. This table shows all acceptable settings for the module.
3. Ensure that the E Series device is connected to the SCXI-1141/1142/1143.
4. Call `SCXI_Single_Chan_Setup` to configure the module for single channel measurements. Set the following parameters:
 - **SCXIchassisID**—The value obtained from Measurement & Automation Explorer
 - **moduleSlot**—1
 - **moduleChan**—0
 - **DAQdeviceNumber**—The device number assigned by Measurement & Automation Explorer for the E Series DAQ device
5. Call `SCXI_Set_Gain` to configure the module to the gain value you want to adjust. Set the following parameters:
 - **SCXIchassisID**—The value obtained from Measurement & Automation Explorer
 - **moduleSlot**—1

- **moduleChan**—0
 - **gain**—The gain value from Table 1.
6. Connect the calibrator to the appropriate analog input channel, starting with channel 0. Refer to Figure 1 to determine the pins on the 96-pin front connector that correspond to the positive and negative inputs of the specified channel. If you are using an SCXI-1300 breakout module connected to the SCXI-1141/1142/1143, connect your calibrator to the CH0+ and CH0– inputs.
 7. Connect your DMM to the positive output on pin 3 (MCHO+) and negative output on pin 4 (MCHO–) on the rear panel connector, illustrated in Figure 2.



Tip For easy access to individual pins, use a screw terminal adapter connected to a 50-pin terminal block.

8. Set the calibrator voltage to the positive test point value in Table 1.
9. Read the voltage from the DMM. Record the actual DMM reading, which is *output1*, and the calibrator output voltage, which is *volt1*, for later use.
10. Set the calibrator to the negative test point value for the same gain. Skip any input limits that are specified as 0.0 V. You need only upper and lower limits for adjustment.
11. Read the voltage from the DMM. Record the actual DMM reading, *output2*, and the calibrator output voltage, *voltage2*.
You now have two pairs of data points, (*volt1*, *output1*) and (*volt2*, *output2*), where *volt* is the calibrator reading and *output* is the DMM reading.
12. Convert the DMM voltage readings (*output1* and *output2*) to binary readings (*binary1* and *binary2*) by using one of the following equations:

$$\text{binary reading for 12-bit E Series products (binary)} = \left(\frac{\text{output}}{20} \right) \times 2^{12}$$

$$\text{binary reading for 16-bit E Series products (binary)} = \left(\frac{\text{output}}{20} \right) \times 2^{16}$$

For example, using a 12-bit product such as a PCI-MIO-16E-1 and obtaining a DMM reading of –9.9 V, you would have the following results:

$$\text{binary reading} = (-9.9/20) \times 2^{12} = -2027.52$$

13. Record *binary1* with *volt1* and *binary2* with *volt2* for later use.

14. Repeat steps 5 through 13 for the remaining gain values you want to adjust on this channel.
15. Repeat step 4 through 14 for the remaining channels you want to adjust.

You have now finished adjusting for the gain and offset errors on your SCXI-1141/1142/1143.

Adjusting Calibration Constants

Complete the following steps to adjust the calibration constants on your SCXI-1141/1142/1143 module:

1. Reconnect the E Series DAQ device to the SCXI-1141/1142/1143.
2. Call `SCXI_Cal_Constants` to create and store the new calibration constants in the SCXI-1141/1142/1143 memory. Use the following parameters:
 - **SCXIchassisID**—The ID assigned by Measurement & Automation Explorer
 - **ModuleSlot**—1, unless you have installed the module in a different slot
 - **channel**—The channel you want to adjust
 - **OpCode**—2
 - **calibrationArea**—0
 - **rangeCode**—0 (not used for the SCXI-1141/1142/1143)
 - **SCXIgain**—100
 - **DAQboard**—The device number assigned by Measurement & Automation Explorer
 - **DAQChan**—0
 - **DAQGain**—1 for 16-bit devices, -1 for 12-bit devices
 - **Tbgain**—1.0
 - **volt1** and **volt2**—The first and second voltage readings for the gain values that you are about to save on the SCXI-1141/1142/1143
 - **binary1** and **binary2**—The first and second binary readings for the gain values that you are about to save on the SCXI-1141/1142/1143
 - **calConst1** and **calConst2**—These are return values.
3. Repeat step 1, changing, **calibrationArea** to 1.
4. Repeat step 1, changing **calibrationArea** to 3
5. Repeat steps 1 through 3 for the next channel.

You have now finished adjusting the calibration constants on your SCXI-1141/1142/1143.

Adjusting Filter AC Gain

The AC gain of the filter is independent of the gain of the amplifier, so you can do this procedure with any amplifier gain. Ideally, the amplifier gain (G_s) and the amplitude of the sine wave (V_s) should be set so $V_s = 3.4 \text{ Vrms}/G_s$. V_s may be set to a lower amplitude, but not a higher one. To prevent errors due to ripple in the passband, the frequency of the sine wave must be lower than 1/50th of the cutoff frequency. You must also set the filters to a cutoff frequency of 25 kHz and use a sine wave of less than 500 Hz.

Complete the following steps to adjust the AC gain of the filter on your SCXI-1141/1142/1143:

1. Read the *Test Conditions* section earlier in this document.
2. Ensure that the E Series device is connected to the SCXI-1141/1142/1143.
3. Call `SCXI_Set_Gain` to configure the module to a gain value of 1. Set the following parameters:
 - **SCXIChassisID**—The value obtained from Measurement & Automation Explorer
 - **moduleSlot**—1
 - **moduleChan**—0
 - **gain**—1
4. Call `SCXI_Configure_Filter` to enable the filter bypass. Set the following parameters:
 - **ChassisID**—The value obtained from Measurement & Automation Explorer
 - **moduleSlot**—1
 - **channel**—0
 - **filterMode**—0
 - **freq**—0
 - **cutoffDivDown**—0
 - **outClkDivDown**—0
5. Connect the calibrator to analog input channel 0. Refer to Figure 1 to determine the pins on the 96-pin front connector that correspond to the positive and negative inputs of the specified channel. If you are using an SCXI-1300 breakout module connected to the SCXI-1141/1142/1143, connect the calibrator to the CH0+ and CH0– inputs.

6. Connect the DMM to the output of channel 0. Refer to Figure 2 to determine the pins on the 50-pin rear connector that correspond to the positive and negative outputs for the specified channel. For example, the positive output for channel 0 is pin 3, which is labeled MCH0+. The negative input for channel 0 is pin 4, which is labeled MCH0-.
7. Set the calibrator voltage to 3.4 V, 400 Hz.
8. Measure and record the amplitude of the sine wave with the DMM.
9. Call `SCXI_Configure_Filter` to disable the filter bypass. Set the following parameters:
 - **ChassisID**—The value obtained from Measurement & Automation Explorer
 - **moduleSlot**—1
 - **channel**—0
 - **filterMode**—1
 - **freq**—25 kHz
 - **cutoffDivDown**—0
 - **outClkDivDown**—2
10. Measure the amplitude of the sine wave at the output and adjust the potentiometer until the amplitude is at the same level as it was with the filter in bypass mode.
11. Repeat steps 4 through 10 for the remaining channels.

You have now finished adjusting the filter AC gain of your SCXI-1141/1142/1143.

Verifying Adjusted Values

After you complete the adjustment procedure, it is important that you verify the accuracy of the adjusted values by repeating the procedure in the section [Verifying the Operation of Your Module](#). Verifying the adjusted values ensures your module is now operating within its specifications.

Front and Rear Panel Diagrams

Figure 1 shows the pin assignments for the SCXI-1141 module front panel connector. Figure 2 shows the pin assignments for the SCXI-1141 rear panel connector.

Pin Number	Signal Name	Column			Signal Name
		A	B	C	
32	IN0+	○	○	○	IN0-
31		○	○	○	
30	IN1+	○	○	○	IN1-
29		○	○	○	
28	AGND	○	○	○	AGND
27		○	○	○	
26	IN2+	○	○	○	IN2-
25		○	○	○	
24	IN3+	○	○	○	IN3-
23		○	○	○	
22	AGND	○	○	○	AGND
21		○	○	○	
20	IN4+	○	○	○	IN4-
19		○	○	○	
18	IN5+	○	○	○	IN5-
17		○	○	○	
16	AGND	○	○	○	AGND
15		○	○	○	
14	IN6+	○	○	○	IN6+
13		○	○	○	
12	IN7+	○	○	○	IN7-
11		○	○	○	
10		○	○	○	
9		○	○	○	
8	DGND	○	○	○	DGND
7		○	○	○	
6	RSVD	○	○	○	DGND
5		○	○	○	
4	RSVD	○	○	○	EXTCLK
3		○	○	○	
2	DGND	○	○	○	OUTCLK
1		○	○	○	

Figure 1. SCXI-1141 Front Connector Pin Assignments

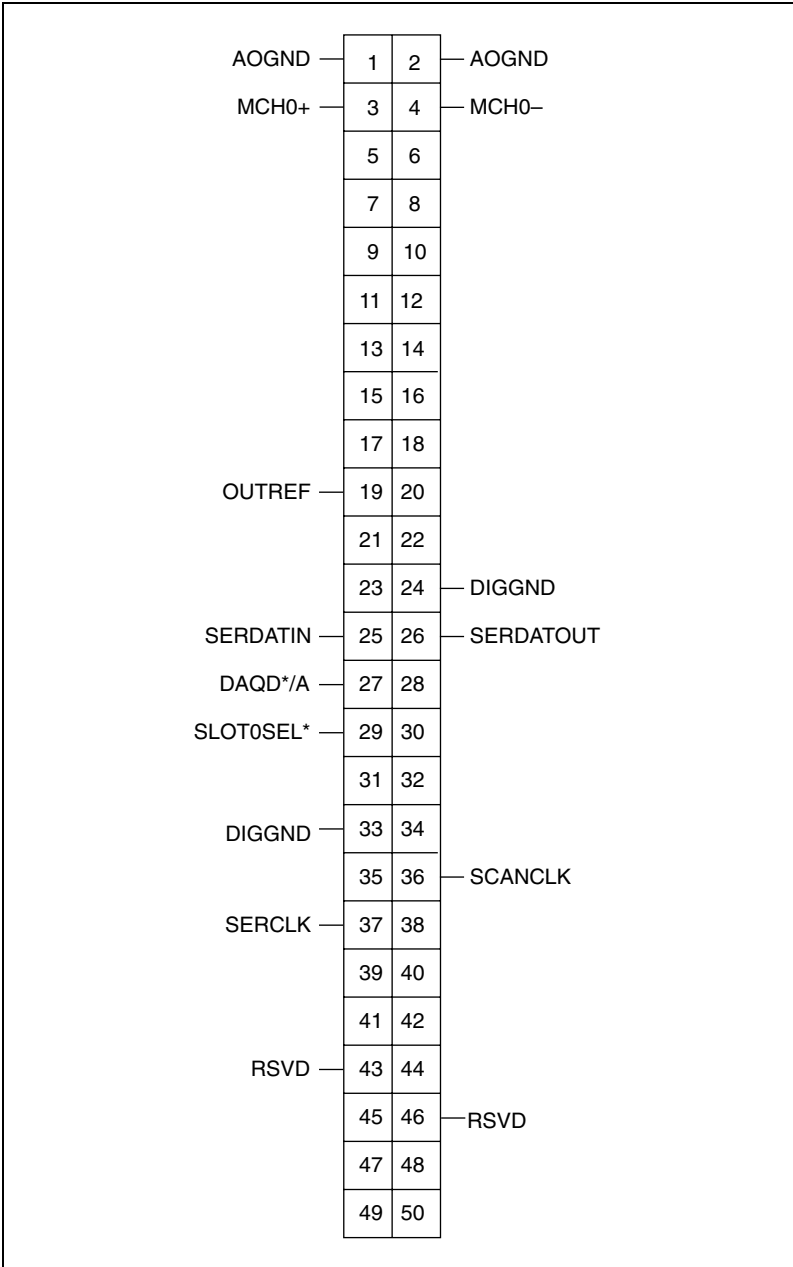


Figure 2. SCXI-1141 Rear Connector Pin Assignments

Specifications

The following table contains test specifications for the SCXI-1141 signal conditioning module. If the device has been calibrated within the last year, the *Test Point* value should fall between the *Upper Limit* and *Lower Limit* values.

Table 1. SCXI-1141/1142/1143 Specifications

Test Point (V)	Gain	Upper Limit (V)	Lower Limit (V)
4.9	1	4.930235	4.869765
0	1	0.000835	-0.000835
-4.9	1	-4.869765	-4.930235
2.45	2	2.465417	2.434583
0	2	0.000717	-0.000717
-2.45	2	-2.434583	-2.465417
0.98	5	0.986527	0.973473
0	5	0.000647	-0.000647
-0.98	5	-0.973473	-0.986527
0.49	10	0.493564	0.486437
0	10	0.000624	-0.000624
-0.49	10	-0.486437	-0.493564