CALIBRATION PROCEDURE

SCXI™-1102/B/C

This document contains information and step-by-step instructions for verifying and calibrating the National Instruments SCXI-1102/B/C signal conditioning module.

Equipment and Other Test Requirements

This section describes the equipment, software, documentation, and test conditions required for calibrating the SCXI-1102/B/C.

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 an E Series data acquisition (DAQ) device.

NI recommends the following instruments for calibration of an SCXI-1102/B/C:

- Calibrator—Fluke 5700A
- DMM—NI 4070 or Agilent 34401A
- 16-bit 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 may need a connector block such as the NI SCXI-1300, a shielded 68-pin connector cable, a 50-pin ribbon cable, a 50-pin breakout box, and an SCXI adapter. These components give easy access to the individual pins on the SCXI-1102/B/C front and rear connectors.

NATIONAL INSTRUMENTS™

Software and Documentation

You need the following software and documentation to calibrate the SCXI-1102/B/C:

- The latest version of the National Instruments NI-DAQ driver

- *NI-DAQ Function Reference Online Help*

- *NI-DAQ User Manual for PC Compatibles*

You can download documentation from `ni.com/manuals`.

Software

The SCXI-1102/B/C calibration procedure requires the latest version of NI-DAQ 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 use.

Documentation

The *NI-DAQ Function Reference Online Help* and the *NI-DAQ User Manual for PC Compatibles* contain detailed information on using NI-DAQ. Help includes detailed information on the NI-DAQ functions. You can access the help by selecting **Start»Programs»National Instruments»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 NI-DAQ. These are the primary references for writing your calibration utility. For further information on the products you are calibrating, refer to the device user manuals.

Test Conditions

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

- Keep connections to the SCXI module as short as possible. Long cables and wires can act as antennae, which pick up extra noise 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 the 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 DAQ device to ensure the measurement circuitry is at a stable operating temperature.

Calibration

✏️ **Note** The verification and adjustment procedures in this document are for use in manually calibrating the SCXI-1102/B/C. To automate verification and calibration, use Calibration Executive.

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 the 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

This section explains how to set up your module in an SCXI chassis and a PXI-1010 chassis.

SCXI Chassis

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

1. Install the SCXI-1102/B/C into the SCXI chassis.
2. Connect a 68-to-68-pin cable between the SCXI-1102/B/C and E Series DAQ device.
3. Configure the hardware with Measurement & Automation Explorer (MAX). If you need more information on configuring the system, refer to the E Series DAQ device and SCXI-1102/B/C documentation.

PXI-1010 Chassis

In normal operation, the PXI-1010 chassis automatically handles the SCXI communication through internal connections when the E Series DAQ module is installed in the right-most slot. To calibrate an SCXI-1102/B/C in a PXI-1010 chassis, complete the following steps:

1. Install the SCXI-1349 cable adapter to the rear signal connector of the SCXI module you are calibrating.

2. Install the E Series DAQ module in any slot other than the right-most slot.

3. Connect the cable from the SCXI-1349 cable adapter to the E Series DAQ module.

Note You must connect the SCXI-1102/B/C to the E Series DAQ module through an SCXI-1349 cable adapter to calibrate the module. You cannot calibrate an SCXI-1102/B/C in a PXI-1011 chassis because you cannot install an SCXI-1349 cable adapter in the PXI-1011 chassis.

Verifying the Operation of Your Module

The verification procedure determines how well the SCXI-1102/B/C is meeting its specifications. You can use this information to select the appropriate calibration interval for your application. Refer to Table 2 or Table 3 for the module specifications.

Complete the following steps to verify the operation of your SCXI-1102/B/C:

1. Read the *Test Conditions* section.

2. Refer to the *Specifications* section:
   - For SCXI-1102/1102B modules, refer to Table 2.
   - For SCXI-1102C modules, refer to Table 3.

Note Although you should verify all ranges and gains, you can save time by checking only those ranges that you use in your application.

3. Connect the E Series DAQ device to the SCXI-1102/B/C.

4. Call Calibrate_E_Series to minimize the uncertainty associated with the E Series DAQ device. Set the following parameters:
   - **deviceNumber**—The value obtained from MAX
   - **calOp**—ND_SELF_CALIBRATE
   - **setOfCalConstants**—ND_USER_EEPROM_AREA
   - **calRefVolts**—0.0

5. Call `AI_Configure` to put the E Series DAQ device in bipolar mode. Set the following parameters:

   - **deviceNumber**—The value obtained from MAX

   - **chan**—`0`

   - **inputMode**—`0`

   - **inputRange**—`0`

   - **polarity**—`0`

   - **driveAIS**—`0`

6. Call `MIO_Config` to enable dithering on the E Series DAQ device. Set the following parameters:

   - **deviceNumber**—The value obtained from MAX

   - **dither**—`1`

   - **useAMUX**—`0`

7. Connect the calibrator to the appropriate analog input, starting with channel 0. Refer to Table 1 to determine the pins on the 96-pin front connector that correspond to the positive and negative inputs of the specified channel. For example, the positive input for channel 0 (CH0+) is pin C32. The negative input for channel 0 (CH0–) is pin B32. If you are using an SCXI-1300 breakout module connected to the SCXI-1102/B/C, connect the calibrator to the CH0+ and CH0– inputs.

8. Call `SCXI_Single_Chan_Setup` to configure the module for single-channel measurements. Set the following parameters:

   - **SCXIchassisID**—The value obtained from MAX

   - **moduleSlot**—The number of the slot where you installed the module

   - **moduleChan**—The same channel number from step 7

   - **DAQdeviceNumber**—The device number assigned by MAX for the E Series DAQ device

9. Call `SCXI_Set_Gain` to set the selected gain on the module. Set the following parameters:

   - **SCXIchassisID**—The ID of the SCXI chassis. The ID is obtained when the chassis is configured with MAX

   - **moduleSlot**—The number of the slot where you installed the module

   - **channel**—The same channel number from step 7

   - **gain**—The first gain value you want to test—you can find this gain value in either Table 2 for SCXI-1102/1102B modules or Table 3 for SCXI-1102C modules

10. Set the calibrator to output the test point voltage from Table 2 or Table 3. Use the 1-year values for verification.

11. Call DAQ_Op. Set the following parameters:

    - **deviceNumber**—The device number of the E Series DAQ device
    - **channel**—0
    - **gain**—1 for 16-bit E Series DAQ devices (except for the 6034E, 6035E, 6036E, and 6052E devices) or –1 for 12-bit E Series DAQ devices or the 6034E, 6035E, 6036E, and 6052E devices
    - **count**—100
    - **sampleRate**—100

12. Call SCXI_Scale. Set the following parameters:

    - **SCXIChassisID**—The value obtained from MAX
    - **moduleSlot**—The number of the slot where you installed the module
    - **channel**—The same channel number from step 7
    - **SCXIgain**—The same gain value from step 9
    - **TBgain**—1
    - **DAQboard**—The device number for the E Series DAQ device
    - **DAQChannel**—0
    - **DAQgain**—1 for 16-bit devices, –1 for 12-bit devices
    - **numPoints**—100
    - **binArray**—The array returned from the DAQ_Op function

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

13. Average the results returned from the SCXI_Scale function. Compare the averaged result to the 1-year upper and lower limits in Table 2 or Table 3. If the result falls within these limits, the module passed this portion of the test. If it does not, adjust the module using the instructions in the *Adjusting Gain and Offset Errors and Calibration Constants* section.

14. Repeat steps 8 through 13 for the remaining gains.

15. Repeat steps 7 through 14 for the remaining channels.

You have now completed verifying the operation of the SCXI-1102/B/C.

✎ **Note** If all channels fall within the 1-year upper and lower limits, the module does not require calibration.

Adjusting Gain and Offset Errors and Calibration Constants

This section includes an adjustment procedure for adjusting gain and offset errors, and for adjusting calibration constants.

Adjusting Gain and Offset Errors

Complete the following steps to adjust the gain and offset errors in the SCXI-1102/B/C module:

1. Read the *Test Conditions* section.

2. Connect the E Series DAQ device to the SCXI-1102/B/C.

3. Call `Calibrate_E_Series` to minimize the uncertainty associated with the E Series DAQ device. Set the following parameters:

   - **deviceNumber**—The value obtained from MAX
   - **calOp**—`ND_SELF_CALIBRATE`
   - **setOfCalConstants**—`ND_USER_EEPROM_AREA`
   - **calRefVolts**—`0.0`

4. Call `AI_Configure` to put the E Series DAQ device in bipolar mode. Set the following parameters:

   - **deviceNumber**—The value obtained from MAX
   - **chan**—`0`
   - **inputMode**—`0`
   - **inputRange**—`0`
   - **polarity**—`0`
   - **driveAIS**—`0`

5. Call `MIO_Config` to enable dithering on the E Series DAQ device. Set the following parameters:

   - **deviceNumber**—The value obtained from MAX
   - **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 MAX
   - **moduleSlot**—The number of the slot where you installed the module
   - **moduleChan**—The channel you want to calibrate
   - **DAQdeviceNumber**—The device number assigned by MAX for the E Series DAQ device

7. Call `SCXI_Set_Gain` to set the selected gain on the module. Set the following parameters:

   - **SCXIchassisID**—The ID of the SCXI chassis obtained when you configured the chassis with MAX

   - **moduleSlot**—The number of the slot where you installed the module

   - **channel**—The same channel number from step 6

   - **gain**—The gain value you want to test; refer to Table 2 for acceptable gain values

8. Connect the calibrator to the channel you selected in step 6. Refer to Table 1 to determine the pins on the 96-pin front connector that correspond to the positive and negative inputs of the specified channel. For example, the positive input for channel 0 is pin C32, which is labeled CH0+. The negative input for channel 0 is pin B32, which is labeled CH0–. If you are using an SCXI-1300 breakout module connected to the SCXI-1102/B/C, connect the calibrator to the CH0+ and CH0– inputs.

9. Connect the DMM to the positive output on pin 3 (CH0+) and negative output on pin 4 (CH0–) on the rear panel connector. Figure 1 shows the 50-pin rear signal connector pin assignments.

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

10. Set the calibrator voltage to the positive test point value in Table 2 or Table 3.

11. Read the voltage from the DMM. Record the actual DMM reading, *output1*, and the calibrator output voltage, *volt1*, for later use.

12. 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.

13. Read the voltage from the DMM. Record the actual DMM reading, *output2*, and the calibrator output voltage, *volt2*. 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.

14. Convert the DMM voltage readings (*output1* and *output2*) to binary readings (*binary1* and *binary2*) by using one of the following equations:

$$\text{\textit{binary reading for 12-bit E Series DAQ}} \atop \text{\textit{(or 6034E, 6035E, 6036E, 6052E) devices}} = \left(\frac{output}{20}\right) \times 2^{12}$$

$$\text{binary reading for 12-bit E Series DAQ} \atop \text{(except 6034E, 6035E, 6036E, 6052E) devices} = \left(\frac{output}{20}\right) \times 2^{16}$$

For example, using a 12-bit E Series DAQ device such as an NI PCI-6070E and obtaining a DMM reading of –9.9 V, you have the following results:

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

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

16. Repeat steps 5 through 15 for the remaining gain values you want to adjust on this channel.

17. Repeat steps 4 through 16 for the remaining channels you want to adjust.

You have now completed adjusting the gain and offset errors.

Adjusting Calibration Constants

Complete the following steps to adjust the calibration constants on the SCXI-1102/B/C:

1. Call SCXI_Cal_Constants to create and store the new calibration constants in the SCXI-1102/B/C memory. Use the following parameters:

    - **SCXIchassisID**—The ID assigned by MAX
    - **moduleSlot**—The number of the slot where you installed the module
    - **channel**—The channel you want to adjust
    - **OpCode**—2
    - **calibrationArea**—0
    - **rangeCode**—0
    - **SCXIgain**—The gain you are adjusting
    - **DAQboard**—The device number assigned by MAX
    - **DAQChan**—0

- **DAQGain**—1 for 16-bit E Series DAQ devices (except for the 6034E, 6035E, 6036E, and 6052E devices) or –1 for 12-bit E Series DAQ devices or the 6034E, 6035E, 6036E, and 6052E 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-1102

- **binary1** and **binary2**—The first and second binary readings for the gain values that you are about to save on the SCXI-1102

- **calConst1** and **calConst2**—These are return values

2. Repeat step 1, changing **calibrationArea** to 1.

3. Repeat step 1, changing **calibrationArea** to 3.

4. Repeat steps 1 through 3 for the next channel.

You have now completed adjusting the calibration constants.

Verifying Adjusted Values

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

Front and Rear Panel Diagrams

Table 1 shows the pin assignments for the SCXI-1102/B/C module front panel connector. Figure 1 shows the pin assignments for the SCXI-1102/B/C rear signal connector.

Table 1. SCXI-1102/B/C Front Signal Pin Assignments

Front Connector Diagram	Pin Number	Column A	Column B	Column C
Column A B C (pin grid diagram, pins 1–32, three columns of circles)	32	CGDN	CH0–	CH0+
	31	NC	CH1–	CH1+
	30	NC	CH2–	CH2+
	29	NC	CH3–	CH3+
	28	NC	CH4–	CH4+
	27	NC	CH5–	CH5+
	26	NC	CH6–	CH6+
	25	NC	CH7–	CH7+
	24	CGND	CH8–	CH8+
	23	NC	CH9–	CH9+
	22	NC	CH10–	CH10+
	21	NC	CH11–	CH11+
	20	NC	CH12–	CH12+
	19	NC	CH13–	CH13+
	18	NC	CH14–	CH14+
	17	NC	CH15–	CH15+
	16	CGND	CH16–	CH16+
	15	NC	CH17–	CH17+
	14	NC	CH18–	CH18+
	13	NC	CH19–	CH19+
	12	NC	CH20–	CH20+
	11	NC	CH21–	CH21+
	10	NC	CH22–	CH22+
	9	NC	CH23–	CH23+
	8	NC	CH24–	CH24+
	7	NC	CH25–	CH25+
	6	NC	CH26–	CH26+
	5	CGND	CH27–	CH27+
	4	CJSENSOR	CH28–	CH28+
	3	CJSENSOR	CH29–	CH29+
	2	CGND	CH30–	CH30+
	1	+5V	CH31–	CH31+

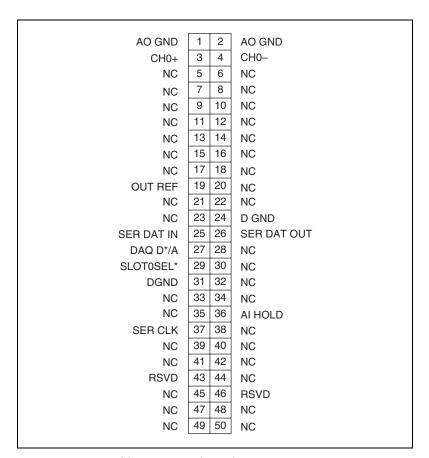|			
AO GND	1	2	AO GND
CH0+	3	4	CH0–
NC	5	6	NC
NC	7	8	NC
NC	9	10	NC
NC	11	12	NC
NC	13	14	NC
NC	15	16	NC
NC	17	18	NC
OUT REF	19	20	NC
NC	21	22	NC
NC	23	24	D GND
SER DAT IN	25	26	SER DAT OUT
DAQ D*/A	27	28	NC
SLOT0SEL*	29	30	NC
DGND	31	32	NC
NC	33	34	NC
NC	35	36	AI HOLD
SER CLK	37	38	NC
NC	39	40	NC
NC	41	42	NC
RSVD	43	44	NC
NC	45	46	RSVD
NC	47	48	NC
NC	49	50	NC

Figure 1. SCXI-1102 Rear Signal Connector Pin Assignments

Specifications

Tables 2 and 3 contain test specifications for the SCXI-1102/B and SCXI-1102C, respectively. If the device was calibrated within the last year, the *Test Point* value should fall between the *Upper Limit* and *Lower Limit* values.

Table 2. SCXI-1102/B Specifications

Gain	Test Point (V)	1-Year Ranges	
		Upper Limit (V)	Lower Limit (V)
100.0000	0.098000	0.098050	0.097950
	0.000000	0.000030	−0.000030
	−0.098000	−0.097950	−0.098050
1.0000	9.800000	9.803980	9.796020
	0.000000	0.000550	−0.000550
	−9.800000	−9.796020	−9.803980

Table 3. SCXI-1102C Specifications

Gain	Test Point (V)	1-Year Values	
		Upper Limit (V)	Lower Limit (V)
100.0000	0.098000	0.098055	0.097945
	0.000000	0.000035	−0.000035
	−0.098000	−0.097945	−0.098055
1.0000	9.800000	9.804000	9.796000
	0.000000	0.000570	−0.000570
	−9.800000	−9.796000	−9.804000