SCXI™-1104

Introduction

This document contains information and step-by-step instructions for verifying and calibrating the National Instruments SCXI-1104 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-1104 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, 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-1104 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 test conditions required for calibrating the SCXI-1104.

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-1104:

- 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 will 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 give easy access to the individual pins on the SCXI-1104 front and rear connectors.

Software and Documentation

You will need the following software and documentation to calibrate the SCXI-1104. 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-1104 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 the *NI-DAQ User Manual for PC Compatibles* contain detailed information on using the NI-DAQ driver. The online help file includes detailed information on the driver functions. You can access the online help file 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 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 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 your 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-1104 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 your 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-1104 module is meeting its specifications. You can use this information to select the appropriate calibration interval for your application.

Complete the following steps to verify the operation of your SCXI-1104:

1. Read the *Test Conditions* section earlier in this document.

2. Refer to Table 1 at the end of this document to see the test specifications.

    National Instruments recommends you verify all ranges and gains. However, you can save time by checking only those ranges that you use in your application.

3. Connect the E Series device to the SCXI-1104.

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

    *   **deviceNumber**—The value obtained from Measurement & Automation Explorer
    *   **calOp**—`ND_SELF_CALIBRATE`
    *   **setOfCalConstants**—`ND_USER_EEPROM_AREA`
    *   **calRefVolts**—0.0

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

    *   **deviceNumber**—The value obtained from Measurement & Automation Explorer
    *   **chan**—0
    *   **inputMode**—0
    *   **inputRange**—0
    *   **polarity**—0
    *   **driveAIS**—0

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

  - **deviceNumber**—The value obtained from Measurement & Automation Explorer

  - **dither**—1

  - **useAMUX**—0

7. Connect the calibrator to the appropriate analog input, 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. 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-1104, connect your 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 Measurement & Automation Explorer

  - **moduleSlot**—1

  - **moduleChan**—The channel you are verifying

  - **DAQdeviceNumber**—The device number assigned by Measurement & Automation Explorer for the E Series DAQ device

9. Set your calibrator to output the test point voltage from Table 1.

10. Call `DAQ_Op`. Set the following parameters:

  - **deviceNumber**—The device number of the DAQ device

  - **channel**—0

  - **gain**—1 for 16-bit E Series devices or –1 for 12-bit E Series devices

  - **count**—100

  - **sampleRate**—100

11. Call `SCXI_Scale`. Set the following parameters:

  - **SCXIChassisID**—The value obtained from Measurement & Automation Explorer

  - **moduleSlot—1**

  - **channel**—The channel you are verifying

  - **SCXIgain**—0.1

  - **TBgain—1**

  - **DAQboard**—The device number for the DAQ device

- **DAQChannel**—**0**
- **DAQgain**—0 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.

12. Average the results returned from the SCXI_Scale function. Compare the averaged result to the upper and lower limits in Table 1. If the result falls within these limits, your module has passed this portion of the test. If it does not, use the steps in the next section, *Adjusting Gain and Offset Errors and Calibration Constants*, to adjust your module.

13. Repeat steps 7 through 12 for the remaining channels.

You have now completed verifying the operation of your SCXI-1104.

Note If all channels fall within the upper and lower limits, your module does not need to be adjusted.

Adjusting Gain and Offset Errors and Calibration Constants

This section contains step-by-step instructions on adjusting gain and offset errors and calibration constants.

Adjusting Gain and Offset Errors

Complete the following steps to adjust gain and offset errors in your SCXI-1104:

1. Read the *Test Conditions* section.

2. Connect the E Series device to the SCXI-1104.

3. Call Calibrate_E_Series to minimize the uncertainty associated with the E series device. Set the following parameters:
   - **deviceNumber**—The value obtained from Measurement & Automation Explorer
   - **calOp**—ND_SELF_CALIBRATE
   - **setOfCalConstants**—ND_USER_EEPROM_AREA
   - **calRefVolts**—0.0

4. Call AI_Configure to put the E Series device in bipolar mode. Set the following parameters:
   - **deviceNumber**—The value obtained from Measurement & Automation Explorer
   - **chan**—0

- **inputMode**—0
- **inputRange**—0
- **polarity**—0
- **driveAIS**—0

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

    - **deviceNumber**—The value obtained from 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**—The channel you want to calibrate
    - **DAQdeviceNumber**—The device number assigned by Measurement & Automation Explorer for the E Series DAQ device

7. Connect the calibrator to the channel you want to adjust. 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. 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-1104, connect your calibrator to the CH0+ and CH0– inputs.

8. Connect your DMM to the positive output on pin 3 (MCHO+) and negative output on pin 4 (MCHO–) on the rear panel connector. Figure 2 shows the 50-pin rear panel connector pin assignments.

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

9. Set the calibrator voltage to the positive test point value in Table 1.

10. 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.

11. Set the calibrator to the negative test point value for the same gain. Skip any input limits that are specified as 0 V. You need only upper and lower limits for adjustment.

12. 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.

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

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

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

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:

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

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

15. Repeat step 4 through 14 for the remaining channels you want to adjust.

Adjusting Calibration Constants

Complete the following steps to adjust the calibration constants on your SCXI-1104:

1. Call `SCXI_Cal_Constants` to create and store the new calibration constants in the SCXI-1104 memory. Set 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-1104)
   - **SCXIgain**—0.1
   - **DAQboard**—The device number assigned by the 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-1104
- **binary1** and **binary2**—The first and second binary readings for the gain values that you are about to save on the SCXI-1104
- **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 adjusted the calibration constants.

Verifying Adjusted Values

After completing the adjustments, it is important to verify the adjusted values by repeating the steps listed in the *Verifying the Operation of Your Module* section of this document. 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-1104 module front panel connector. Figure 2 shows the pin assignments for the SCXI-1104 rear panel connector.

	A			B			C	
CGND	32		CH0–	32		CH0+	32	
NC	31		CH1–	31		CH1+	31	
NC	30		CH2–	30		CH2+	30	
NC	29		CH3–	29		CH3+	29	
NC	28		CH4–	28		CH4+	28	
NC	27		CH5–	27		CH5+	27	
NC	26		CH6–	26		CH6+	26	
NC	25		CH7–	25		CH7+	25	
CGND	24		CH8–	24		CH8+	24	
NC	23		CH9–	23		CH9+	23	
NC	22		CH10–	22		CH10+	22	
NC	21		CH11–	21		CH11+	21	
NC	20		CH12–	20		CH12+	20	
NC	19		CH13–	19		CH13+	19	
NC	18		CH14–	18		CH14+	18	
NC	17		CH15–	17		CH15+	17	
CGND	16		CH16–	16		CH16+	16	
NC	15		CH17–	15		CH17+	15	
NC	14		CH18–	14		CH18+	14	
NC	13		CH19–	13		CH19+	13	
NC	12		CH20–	12		CH20+	12	
NC	11		CH21–	11		CH21+	11	
NC	10		CH22–	10		CH22+	10	
NC	9		CH23–	9		CH23+	9	
NC	8		CH24–	8		CH24+	8	
NC	7		CH25–	7		CH25+	7	
NC	6		CH26–	6		CH26+	6	
CGND	5		CH27–	5		CH27+	5	
RSVD	4		CH28–	4		CH28+	4	
RSVD	3		CH29–	3		CH29+	3	
CGND	2		CH30–	2		CH30+	2	
+5 V	1		CH31–	1		CH31+	1	

Figure 1. SCXI-1104 Front Connector Pin Assignments

```
AOGND    1  2   AOGND
MCH0+    3  4   MCH0–
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
OUTREF  19  20  NC
NC      21  22  NC
NC      23  24  DGND
SERDATIN 25 26  SERDATOUT
DAQD*/A 27  28  NC
SLOT0SEL* 29 30 NC
NC      31  32  NC
DGND    33  34  NC
NC      35  36  SCANCLK
SERCLK  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
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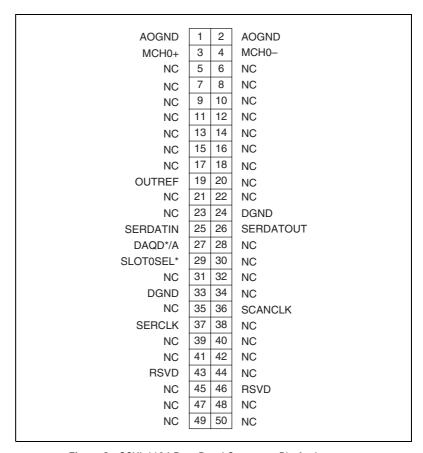
Figure 2. SCXI-1104 Rear Panel Connector Pin Assignments

Specifications

The following table contains test specifications for the SCXI-1104 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-1104 Specifications

Gain	Test Point (V)	Ranges	
		Upper Limit (V)	Lower Limit (V)
0.100	41.8000	41.8219	41.7781
	0.0000	0.0010	–0.0010
	–41.8000	–41.7781	–41.8219