SCXI™-1122

Introduction

This document contains information and step-by-step instructions for verifying and calibrating the National Instruments SCXI-1122 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-1122 device 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 requirements of your application determine how often you should calibrate your SCXI-1122 to maintain its accuracy. 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-1122.

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 calibrating your SCXI-1122:

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

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-1122 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 *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 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-1122 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

These verification procedures determine how well your SCXI-1122 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:

1. Read the *Test Conditions* section earlier in this document.
2. Refer to Table 1 in the *Specifications* section for the limits to verify. Although you should verify all ranges and gains, you can save time by checking only those ranges used in your application.
3. Ensure that the E Series device is connected to the SCXI-1122.
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 the E Series device. Set the following parameters:
   - **deviceNumber**—the value obtained from Measurement & Automation Explorer
   - **dither—**1
   - **useAmux**—0
7. Call `SCXI_Configure_Filter` to configure the filter mode of the SCXI-1122. Set the following parameters:
   - **SCXIchassisId**—The value obtained from Measurement & Automation Explorer.
   - **moduleSlot**—1
   - **channel**— –1
   - **filterMode**—1
   - **freq**—4.0
   - **cutoffDivDown**—0
   - **and outClkDivDown**—2
   - **ActualFreq**—This is a return value
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**—0
   - **DAQdeviceNumber**—The device number assigned by Measurement & Automation Explorer for the E Series DAQ device
9. Call `SCXI_Calibrate_Setup` to auto-zero the device. Set the following parameters:
   - **SCXIchassisID**—The value obtained from Measurement & Automation Explorer
   - **moduleSlot**—1
   - **calOp**—2
10. Call `SCXI_Set_Gain` to set the selected gain on the module. Set the following parameters:
    - **SCXIchassisID**—The value obtained from Measurement & Automation Explorer
    - **moduleSlot**—1

- **channel**— –1
- **gain**—the gain value you want to test

  Acceptable gain values are listed in Table 1.

11. If an SCXI-1300, SCXI-1303, or SCXI-1308 connection module was supplied with your SCXI-1122, connect the calibrator to the CH0+ and CH0– inputs of the connection module. If you are not using a connection module, connect the calibrator to analog input channel 0. Refer to Figure 1to 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 A32, which is labeled CH0+. The negative input for channel 0 is pin C31, which is labeled CH0–.
12. Set the calibrator voltage to the *Test Point* value in Table 1that corresponds to the gain from step 10.
13. Call `DAQ_Op` to retrieve measurement data from the SCXI module. Set the following parameters:
    - **deviceNumber**—The value obtained from Measurement & Automation Explorer
    - **chan**—0
    - **gain**—1
    - **count**—100
    - **sampleRate**—100

    The data will be returned to the buffer variable.
14. Call `SCXI_Scale` to convert the acquired readings into scaled voltage values. Set the following parameters:
    - **SCXIChassisID**—The value obtained from Measurement & Automation Explore
    - **moduleSlot**—0
    - **channel**—0
    - **SCXIgain**—The gain from step 10
    - **TBgain**—1
    - **DAQBoard**—The value obtained from Measurement & Automation Explorer
    - **DAQchannel**—0
    - **DAQgain**—1
    - **numPoints**—100

    Average the resulting scaled data to obtain the final voltage measurement.

15. Compare the measurement result to the upper and lower limits shown in Table 1. If the measurement value falls between the *Upper Limit* and *Lower Limit* values, the module has passed the test.
16. Repeat steps 5 through 15 for each of the remaining gain values. You only need to check channel 0 because all inputs are multiplexed back through a single analog-to-digital converter.

    After you have checked all gains for Table 1, continue with step 17.
17. Repeat steps 4 through 16 using Table 1, but set the **freq** input to 4000.0 in step 7.

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

You have completed verifying the analog input offsets of your SCXI-1122 module.

Verifying Excitation Limits

Complete the following steps to verify the excitation limits of your SCXI-1122 module:

1. Connect a 15 Ω resistor between VEX+ and VEX– on the front of your SCXI module.
2. Set your DMM to voltage mode and connect it across the resistor.
3. Compare the DMM reading to the upper and lower limits for voltage excitation shown in Table 2. If the reading falls between the *Upper Limit* and *Lower Limit* values, the module has passed the test.
4. Set your DMM to current mode and connect it between the IEX+ and IEX– pins of you SCXI module.
5. Compare the DMM reading to the upper and lower limits for the current excitation shown in Table 2. If the reading falls between the *Upper Limit* and *Lower Limit* values, the module has passed the test.

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 excitation.

Adjusting Gain and Offset Errors

Complete the following steps to adjust gain and offset errors on your SCXI-1122 module:

1. Connect the E Series device to the SCXI-1122.
2. Call `SCXI_Configure_Filter` to configure the filter mode of the SCXI-1122. Set the following parameters:
   - **SCXIchassisId**—The value obtained from Measurement & Automation Explorer
   - **moduleSlot**—1
   - **channel**— –1
   - **filterMode**—1
   - **freq**—4.0
   - **cutoffDivDown**—0
   - **outClkDivDown**—2
   - **ActualFreq**—This is a return value
3. 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.
4. Call `SCXI_Calibrate_Setup` to autozero the device. Set the following parameters:
   - **SCXIchassisID**—The value obtained from Measurement & Automation Explorer
   - **moduleSlot**—1
   - **calOp**—2

5. Call `SCXI_Set_Gain` to set the selected gain on the module. Set the following parameters:
   - **SCXIchassisID**—The value obtained from Measurement & Automation Explorer
   - **moduleSlot**—0
   - **channelSet**— –1
   - **gainSet**—The first gain value you want to test

     Acceptable gain values are listed in Table 1.
6. 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. For example, the positive input for channel 0 is pin A32, which is labeled CH0+. The negative input for channel 0 is pin C31, which is labeled CH0–. If you are using an SCXI-1322 breakout module connected to the SCXI-1122, connect your calibrator to the CH0+ and CH0– inputs.
7. 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–.
8. Set the calibrator voltage to the test point value specified by the *Test Point* entry on 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 V. You need only upper and lower limits for adjustment.
11. Read the voltage from the DMM. Record the actual DMM reading, which is *output2*, and the calibrator output voltage, which is *volt2*, for later use.
12. Convert the DMM voltage reading to a binary reading by using one of the following equations:

$$\textit{binary reading for 12-bit products} = \left(\frac{\text{DMM voltage}}{20}\right) \times 2^{12}$$

$$\textit{binary reading for 16-bit products} = \left(\frac{\text{DMM voltage}}{20}\right) \times 2^{16}$$

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:

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

13. Repeat steps 5 through 12 for the remaining input ranges.
14. Repeat steps 2 through 13 with **freq** in step 2 set to 4000.0.
15. When you are finished, you will have a table of calibrator voltages and corresponding binary readings.

You have now finished adjusting the offset and gain errors on your SCXI-1122 module.

Adjusting Calibration Constants

Complete the following steps to adjust the calibration constants on your SCXI-1122 module:

1. Call `SCXI_Cal_Constants` to create and store the new calibration constants in the memory of the SCXI-1122 module. Call this function for each gain setting. Set the following parameters for the `SCXI_Cal_Constants` function:
   - **SCXIchassisID**—the ID assigned by Measurement & Automation Explorer configuration utility
   - **ModuleSlot**—1, unless you have installed the module in a different slot
   - **channel**— –1
   - **opCode**—2
   - **calibrationArea**—0
   - **rangeCode**—0 (not used for the SCXI-1122)
   - **SCXIgain**—the appropriate gain for the pair of constants you are about to save on the SCXI-1122
   - **DAQboard**—Device number assigned by Measurement & Automation Explorer
   - **DAQChan**—0
   - **DAQGain**—1 for 16-bit devices, –1 for 12-bit devices
   - **Tbgain**—1
   - **volt1** and **volt2**—The first and second calibrator voltage readings for the gain values you are about to save on the SCXI-1122
   - **binary1** and **binary2**—The first and second binary readings for the gain values you are about to save on the SCXI-1122
   - **calConst1** and **calConst2**—These are return values

Repeat this step with **calibrationArea** set to 1, and then again with **calibrationArea** set to 3.

2. Repeat step 1 for all remaining gain values.

You have now finished adjusting the calibration constants of your SCXI-1122 module.

Adjusting Excitation Limits

Complete the following steps to adjust the excitation limits on your SCXI-1122 module:

1. Refer to Table 1for the specific limits to test.
2. Connect a National Instrument E Series device to the SCXI-1122.
3. Connect a 15 Ω resistor to the VEX+ and IEX– pins, which make up the voltage excitation channel.
4. Set the DMM to voltage mode and connect it across the 15 Ω load.
5. Measure the voltage and use the measurement as **calConst2**.
6. Set the digital multimeter to DC current mode and connect it across the current excitation channel (pin IEX+ and IEX–).
7. Measure the DC current and use the measurement as **calConst1**.
8. `SCXI_Cal_Constants` creates and stores the new calibration constants in the SCXI-1122. Call `SCXI_Cal_Constants` for each gain. Set the following parameters:
   - **SCXIchassisID**—The ID assigned by Measurement & Automation Explorer
   - **ModuleSlot**—1, unless the module is in a different slot
   - **channel**— –2
   - **opCode**—3
   - **calibrationArea**—0
   - **rangeCode**—0 (not used for the SCXI-1122)
   - **SCXIgain**—0
   - **DAQboard**—Device number assigned by Measurement & Automation Explorer.
   - **DAQChan**—0
   - **DAQGain**—1
   - **Tbgain**—1
   - **volt1**—0
   - **binary1**—0
   - **volt2**—0

- **binary2**—0
- **calConst1**—This is the value obtained in step 7
- **calConst2**—This is the value obtained in step 5

Repeat this step with **calibrationArea** set to 1, and again with **calibrationArea** set to 3.

You have now finished adjusting the excitation channels of your SCXI-1122 module.

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-1122 module front panel connector. Figure 2 shows the pin assignments for the SCXI-1122 rear panel connector.

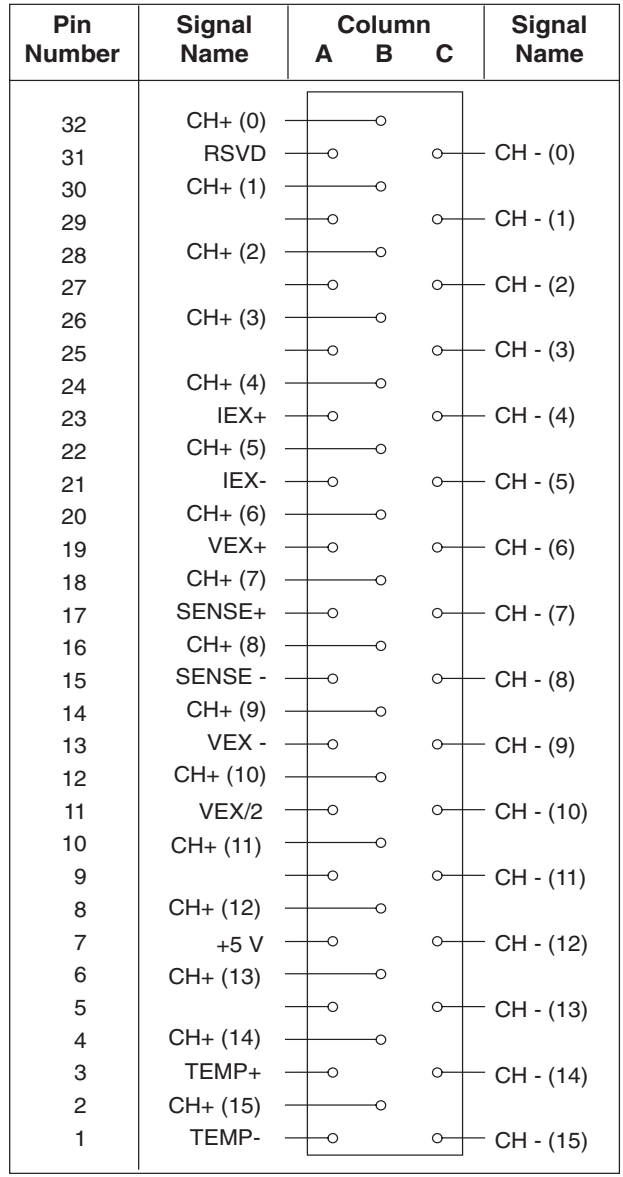

Figure 1. SCXI-1122 Front Connector Pin Assignments

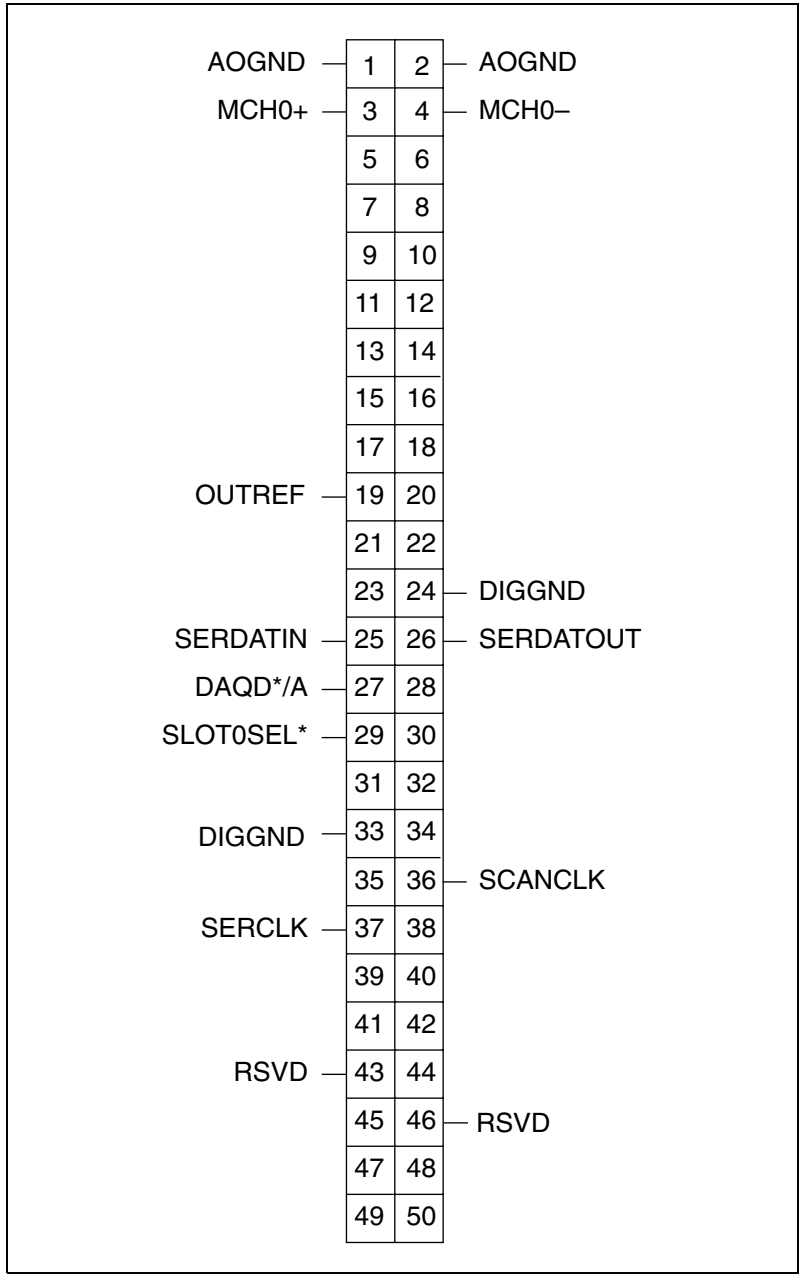

Figure 2. SCXI-1122 Rear Connector Pin Assignments

Specifications

The following tables contain test specifications and excitation test limits for the SCXI-1122 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-1122 Specifications

Gain	Test Point (V)[1]	4 Hz Ranges		4 kHz Ranges	
		Upper Limit (V)	Lower Limit (V)	Upper Limit (V)	Lower Limit (V)
0.0100	245.0000	245.6546212	244.3453788	245.6645421	244.3354579
	0.0000	0.280261209	–0.280261209	0.290182066	–0.290182066
	–245.0000	–244.3453788	–245.6546212	–244.3354579	–245.6645421
0.0200	245.0000	245.5146676	244.4853324	245.519628	244.480372
	0.0000	0.140307605	–0.140307605	0.145268033	–0.145268033
	–245.0000	–244.4853324	–245.5146676	–244.480372	–245.519628
0.0500	98.0000	98.20607944	97.79392056	98.20806361	97.79193639
	0.0000	0.056335442	–0.056335442	0.058319613	–0.058319613
	–98.0000	–97.79392056	–98.20607944	–97.79193639	–98.20806361
0.1000	49.0000	49.10321672	48.89678328	49.10420881	48.89579119
	0.0000	0.028344721	–0.028344721	0.029336807	–0.029336807
	–49.0000	–48.89678328	–49.10321672	–48.89579119	–49.10420881
0.2000	24.5000	24.55178536	24.44821464	24.5522814	24.4477186
	0.0000	0.01434936	–0.01434936	0.014845403	–0.014845403
	–24.5000	–24.44821464	–24.55178536	–24.4477186	–24.5522814
0.5000	9.8000	9.820926544	9.779073456	9.821124961	9.778875039
	0.0000	0.005952144	–0.00592144	0.006150561	–0.006150561
	–9.8000	–9.779073456	–9.820926544	–9.778875039	–9.821124961
1.0000	4.9000	4.905639272	4.894360728	4.905738481	4.894261519
	0.0000	0.002807072	–0.002807072	0.002906281	–0.002906281
	–4.9000	–4.894360728	–4.905639272	–4.894261519	–4.905738481

Table 1. SCXI-1122 Specifications

Gain	Test Point (V)[1]	4 Hz Ranges		4 kHz Ranges	
		Upper Limit (V)	Lower Limit (V)	Upper Limit (V)	Lower Limit (V)
2.0000	2.4500	2.452823636	2.447176364	2.45287324	2.44712676
	0.0000	0.001407536	–0.001407536	0.00145714	–0.00145714
	–2.4500	–2.447176364	–2.452823636	–2.44712676	–2.45287324
5.0000	0.9800	0.981134254	0.978865746	0.981154096	0.978845904
	0.0000	0.000567814	–0.00567814	0.000587656	–0.000587656
	–0.9800	–0.978865746	–0.1981134254	–0.978845904	–0.981154096
10.0000	0.49	0.490571127	0.489428873	0.490581048	0.489418952
	0.0000	0.000287907	–0.000287907	0.000297828	–0.000297828
	–.49	–0.489428873	–0.490571127	–0.489418952	–0.490581048
20.0000	0.2450	0.245289564	0.244710436	0.245300686	0.244699314
	0.0000	0.000147954	–0.000147954	0.000159076	–0.000159076
	–0.245	–0.244710436	–0.245289564	–0.244699314	–0.245300686
50.0000	0.0980	0.098121183	0.097878817	0.098131902	0.097868098
	0.0000	6.45391E–05	–6.45391E-05	7.52582E-05	–7.52582E-05
	–0.098	–0.097878817	–0.098121183	–0.097868098	–0.098131902
100.0000	0.0490	0.049065034	0.048934966	0.049069951	0.048930049
	0.0000	3.6712E-05	–3.6712E-05	4.16291E-05	–4.16291E-05
	–0.0490	–0.048934966	–0.049065034	–0.048930049	–0.049069951
200.0000	0.0245	0.024536751	0.024463249	0.024538976	0.024461024
	0.0000	2.25901E-05	–2.25901E-05	2.48145E-05	–2.48145E-05
	–0.0245	–0.024463249	–0.024536751	–0.024461024	–0.024538976
500.0000	0.0098	0.009819644	0.009780356	0.00982039	0.00977961
	0.0000	1.39798E-05	–1.39798E-05	1.47258E-05	–1.47258E-05
	–0.0098	–0.009780356	–0.009819644	–0.00977961	–0.00982039

Table 1. SCXI-1122 Specifications

Gain	Test Point (V)[1]	4 Hz Ranges		4 kHz Ranges	
		Upper Limit (V)	Lower Limit (V)	Upper Limit (V)	Lower Limit (V)
1000.0000	0.0049	0.004913822	0.004886178	0.004914195	0.004885805
	0.0000	1.09899E-05	–1.09899E-05	1.13629E-05	–1.13629E-05
	–0.0049	–0.004886178	–0.004913822	–0.004885805	–0.004914195
2000.000	0.00245	0.002460984	0.002439016	0.002461098	0.002438902
	0.0000	9.56784E-06	–9.56784E-06	9.68145E-06	–9.68145E-06
	–0.00245	–0.002439016	–0.002460984	–0.002438902	–0.002461098

[1]The *test point* is the voltage value that you input for verification purposes.

Table 2. Excitation Test Limits

Excitation Type	Test Point	Upper Limit	Lower Limit
Voltage	3.333 V	3.3343 V	3.3317 V
Current	1.00 mA	1.0004 mA	0.9996 mA