SCXI Isolated Universal Input Modules

NI SCXI-1121, NI SCXI-1122

- Isolated analog inputs
- Isolated voltage and current excitation
- Signal inputs from millivolts to ±250 V
- Lowpass filtering
- Shunt calibration
- NI-DAQ driver software simplifies configuration, measurements, and scaling

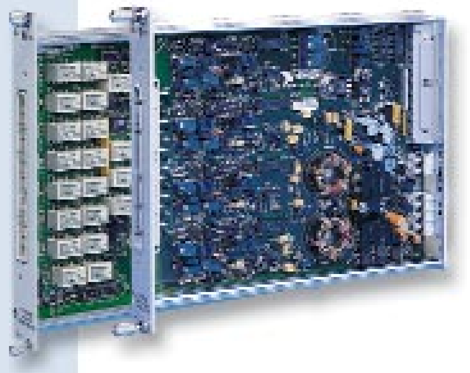
SCXI-1121
- 4 isolated input channels
- 4 isolated excitation channels
- 250 V_{rms} working isolation per channel
- Offset nulling and shunt calibration with SCXI-1321

SCXI-1122
- 16 channels
- 100 S/s (4 kHz filter), 1 S/s (4 Hz filter)
- 2 excitation sources
- 480 V_{rms} working isolation per channel

Operating Systems
- Windows 2000/NT/XP

Recommended Software
- LabVIEW
- LabWindows/CVI
- Measurement Studio
- VI Logger

Driver Software
- NI-DAQ 7



Overview
The National Instruments SCXI-1121 and SCXI-1122 modules are designed for a wide variety of sensor and signal inputs requiring isolation. The NI SCXI-1121 offers independent jumper-configurable isolation amplifiers, filters, and excitation sources for each channel. The SCXI-1122 offers an isolation amplifier, filter, and excitation source for all channels. Both SCXI-1121 and SCXI-1122 modules offer at least 250 V_{rms} working isolation and can acquire strain, RTD, thermocouple, millivolt, volt, 250 V, 0 to 20 mA, and 4 to 20 mA current input signals. Both modules can multiplex their channels into a single channel of the controlling DAQ device. The SCXI-1121 also offers parallel-mode operation. If you are specifically interested in strain measurements, consider using the NI SCXI-1520 Universal Strain Gauge Input Module. For thermocouple measurements, consider using the NI SCXI-1102 Thermocouple Input Module. For RTD measurements, consider using the SCXI-1102 in combination with the SCXI-1581 Current Excitation Module or the PXI-4070 DMM with SCXI-1127 switch.

Analog Input
SCXI-1121
The analog inputs of the SCXI-1121 consist of four isolated instrumentation amplifiers. You can configure each channel independently using jumpers for input ranges of ±2.5 mV to ±5 V. You can extend the input range for each channel to ±250 VDC/±250 VAC with the SCXI-1327 terminal block. Each channel also includes a lowpass filter that you can configure using jumpers for 4 Hz or 10 kHz. You can sample channels at a rate up to 333 kS/s (3 µs per channel in multiplexed mode). Each channel offers transducer-specific features such as bridge completion, configurable voltage and current excitation, bridge balancing, and shunt calibration depending on the configured terminal block. Each channel is individually isolated with a working voltage limit of 250 V_{rms} between channels or channel to earth. Finally, the SCXI-1121 is CE certified as double insulated, Category II, for 250 V_{rms} of operational isolation.

SCXI-1122
The SCXI-1122 consists of 16 relay multiplexers that route the input channels to a single isolated instrumentation amplifier and lowpass filter. You can program all inputs together for a range of ±5 mV to ±250 V. You can program the lowpass filter setting for all input channels for either 4 Hz or 4 kHz. With this relay multiplexer architecture, you are limited to a maximum sampling rate of 100 S/s for the 4 kHz filter setting, and 1 S/s for the 4 Hz filter setting on all channels in your scan list. Thus, the SCXI-1122 is not intended to be used for the scanning of multiple channels. It should be used to acquire multiple samples from a single channel before acquiring from the next channel. This module also offers cold-junction compensation, bridge completion, and a single voltage and current excitation source with remote sensing. You can configure the SCXI-1122 for 4-wire scanning mode, accepting up to eight 5 k devices. You can also connect up to 16 devices in series. Each channel is individually isolated with a working common-mode voltage of 250 V_{rms} between channels or 480 V_{rms} channel to earth. Finally, the SCXI-1122 is CE certified as double insulated, Category II, for 250 V_{rms} of operational isolation.

SCXI Module	Bridge	RTD	Thermocouple	±2.5 mV	±5 mV to ± 250 V	0 to 20 mA 4 to 20 mA
SCXI-1121	✓	✓	✓	✓	✓	✓
SCXI-1122	✓	✓	✓	–	✓	✓

Table 1. Signal Compatibility

SCXI Isolated Universal Input Modules

Cold-Junction Compensation

Both the SCXI-1121 and SCXI-1122 can read the cold-junction sensor from a compatible terminal block that offers a cold-junction sensor. In multiplexed mode, both modules must read the sensor as a separate analog input operation. This is usually done before the start of a continuous acquisition. For thermocouple measurements, the SCXI-1102, 1112, and 1125 an sample the cold-junction sensor in the same scan as the thermocouples, to provide better accuracy.

Transducer Conditioning

SCXI-1121

The SCXI-1121 offers a jumper-configurable, isolated excitation source for each analog input channel. You can independently configure each excitation source for 3.33 V, 10 V, 0.15 mA, or 0.45 mA with jumpers for each setting. With this architecture, you can select from 120 or 350 bridge-based transducers, 100 RTDs, or up to 10 k thermistors on a per-channel basis. Each channel also includes a jumper-configurable internal half-bridge completion circuitry for half and quarter-bridge measurements.

With the SCXI-1321, you can manually null the offset of bridges with potentiometers and perform shunt calibration of strain gauges. The SCXI-1321 includes four software programmable switches that connect a socketed 301 k shunt resistor across the transducer elements.

SCXI-1122

The SCXI-1122 offers only one voltage and one current excitation channel for transducers such as RTDs, thermistors, and bridge-based transducers. The isolated voltage excitation channel is a 3.333 V source with internal half-bridge completion and a single remote sensing terminal to help reduce lead resistance effects. The SCXI-1122 also includes software-controlled shunt calibration capabilities for bridge transducers. When activated, the module switches a 301 k shunt resistor, R_{SHUNT}, across one arm of the bridge, from the positive input to V_{EX+}. The shunt resistor is socketed for easy replacement.

The isolated current excitation channel is a 1.0 mA source. This source can drive fifteen 100 devices, such as RTDs, connected in series. You can also configure the SCXI-1122 for 4-wire scanning mode. When configured for 4-wire scanning mode, the current source can drive up to eight 5 k devices, such as thermistors, and still maintain electrical isolation between transducers. The SCXI-1122 is intended for use in low-speed, static (DC) measurements, not dynamic measurements.

Calibration

Each channel of the SCXI-1121 has offset potentiometers so you can calibrate each channel manually. The SCXI-1122 contains calibration hardware to null-out error sources. With automatic input zeroing, software programmable analog switches ground the inputs of the instrumentation amplifier for offset error calibration. An onboard EEPROM stores the calibration constants for each channel for each input range in a user-defined area. The EEPROM also stores a set of factory calibration constants in permanent memory, and cannot be modified. NI-DAQ driver software transparently uses the calibration constants to correct for gain, offset, and excitation source errors.

	120 Ω (3.33 V) *			350 Ω (10 V) *			350 Ω (3.33 V) *			RTDs	Thermistors	
SCXI Module	¼	½	Full	¼	½	Full	¼	½	Full	100 Ω	< 5 kΩ	< 10 kΩ
SCXI-1121		4	4	4	4	–	4	4	4	4	4	4
SCXI-1122	16	16	8	–	–	–	16	16	16	16 (series), 8 (4-wire)	8 (4-wire)	–

*Bridge Transducer

Table 2. Channel Densities for Various Transducer Configurations

SCXI Isolated Universal Input Modules

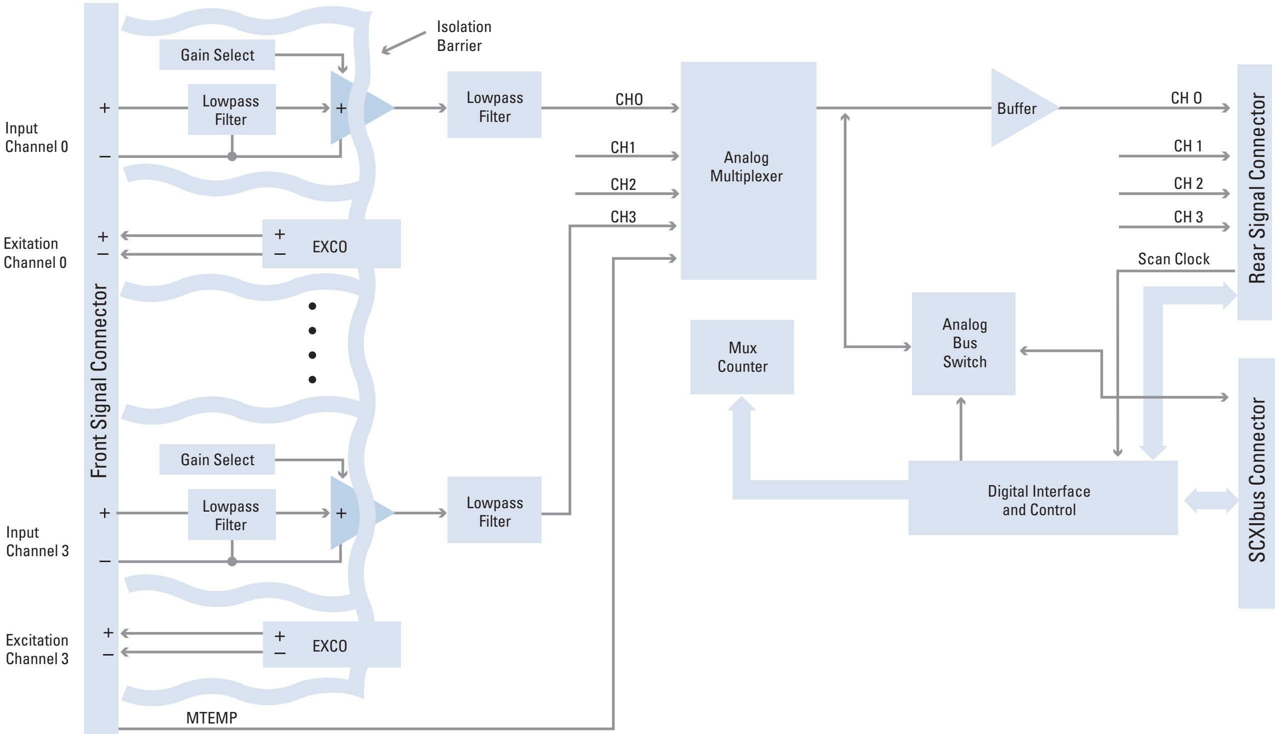


Figure 1. SCXI-1121 Block Diagram

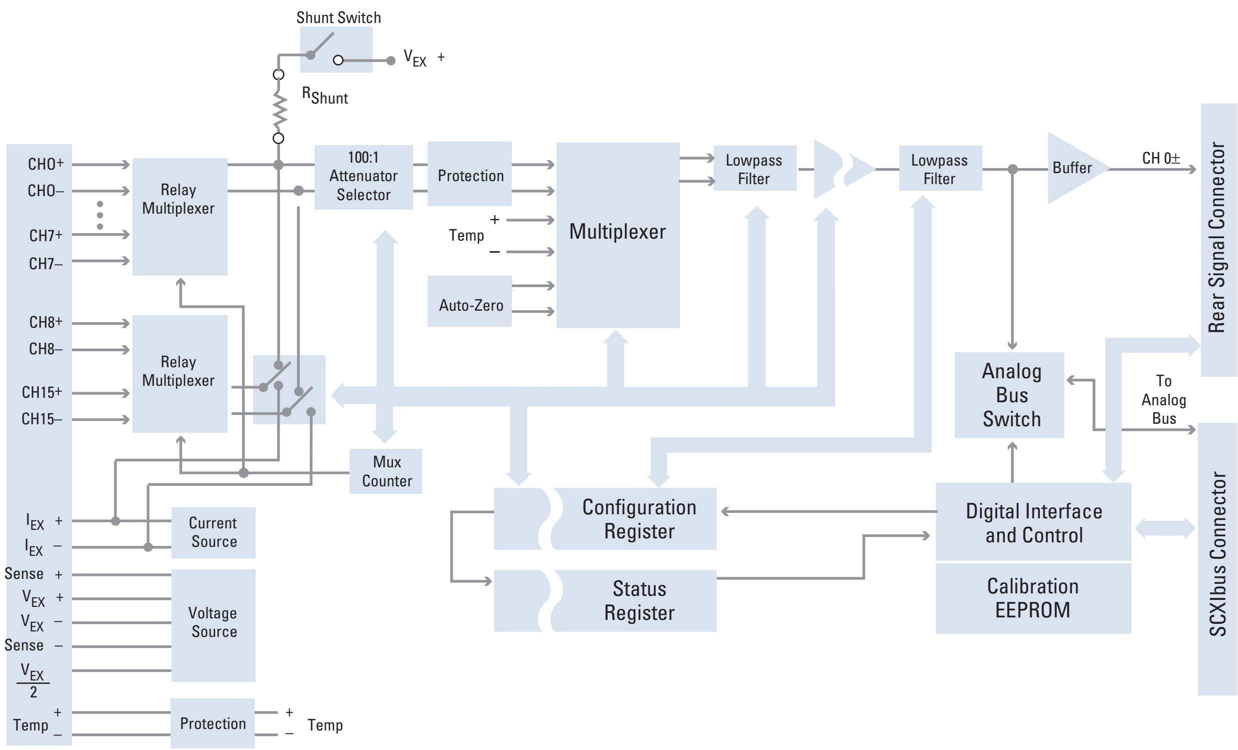


Figure 1. SCXI-1122 Block Diagram

SCXI Isolated Universal Input Modules

Terminal Block	Part Number	Type	CJ Sensor	Compatible Modules	Cabling	Special Functions	Page
SCXI-1320	777687-20	Screw terminals Front-mounting	✔	SCXI-1121	–	–	329
SCXI-1321	777687-21	Screw terminals Front-mounting	✔	SCXI-1121	–	Offset nulling and shunt calibration for strain gauges	329
SCXI-1327	777687-27	Screw terminals Front-mounting	✔	SCXI-1121	–	Extended voltage input range (to 250 V_{rms})	329
SCXI-1328	777687-28	Screw terminals Front-mounting	✔	SCXI-1121	–	Isothermal construction	329
SCXI-1322	777687-22	Screw terminals Front-mounting	✔	SCXI-1121	–	–	329
SCXI-1305	777687-05	BNC connectors Front-mounting	–	SCXI-1122	–	BNC connectors AC coupling (configurable per channel)	328
TBX-1328	777207-28	Screw terminals DIN-rail mount	–	SCXI-1121	SH32-32A (183230-01)	DIN rail mount Isothermal construction	331
TBX-1329	777207-29	Screw terminals DIN-rail mount	–	SCXI-1121	SH32-32A (183230-01)	DIN rail mount AC/DC coupling Removable screw terminals	331
SCXI-1330	777687-30	Solder pins Front-mounting	–	SCXI-1121	–	Low-cost connector and shell assembly	330

Table 3. Terminal Block Options for SCXI-1121 and SCXI-1122

Ordering Information

NI SCXI-1121 776572-21
NI SCXI-1122 776572-22

Accessories

SCXI current resistors (4-pack) 776582-01

For information on extended warranty and value-added services, see page 20.

BUY ONLINE!

*Visit **ni.com/info** and enter scxi1121 and/or scxi1122.*

See page 276 to configure your complete SCXI system.

SCXI Isolated Universal Input Modules

Specifications

Maximum for 25 °C unless otherwise noted

Complete Accuracy Table

						System Noise (Peak, 3 Sigma)*				Temperature Drift	
			Percent of Reading*			Single Point		Average		Percent of	
Module	**Nominal Range*** [2]	**Overall Gain***	**Typical**	**Max**	**Offsett**	**4 Hz**	**10 kHz**	**4 Hz**	**10 kHz**	**Reading/°C**	**Offset (°C)**
SCXI-1121	±250 V_{rms} [3]	0.012	0.2548	0.6498	0.5 V	74.4 mV	709 mV	14.4 mV	151 mV	0.0029	22.0 mV
	±250 V[3]	0.022	0.2548	0.6498	250 mV	33.6 mV	336 mV	7.28 mV	77.0 mV	0.0029	11.0 mV
	±100 V[3]	0.052	0.2548	0.6498	100 mV	13.0 mV	146 mV	2.91 mV	32.4 mV	0.0029	4.4 mV
	±50 V[3]	0.12	0.2548	0.6498	50 mV	6.48 mV	71.1 mV	1.46 mV	17.2 mV	0.0029	2.2 mV
	±25 V[3]	0.22	0.2548	0.6498	25 mV	3.75 mV	43.3 mV	728 µV	11.5 mV	0.0029	1.12 mV
	±10 V[3]	0.52	0.2548	0.6498	10 mV	1.3 mV	15.2 mV	293 µV	3.39 mV	0.0029	460 µV
	±5 V	1	0.2478	0.6478	5.0 mV	625 µV	6.34 mV	144 µV	1.52 mV	0.0027	240 µV
	±2.5 V	2	0.2478	0.6478	2.5 mV	352 µV	3.40 mV	70.3 µV	771 µV	0.0027	130 µV
	±1 V	5	0.2478	0.6478	1.0 mV	138 µV	1.32 mV	28.4 µV	311 µV	0.0027	64 µV
	±500 mV	10	0.2478	0.6478	508 µV	67.3 µV	609 µV	15.6 µV	154 µV	0.0027	42 µV
	±250 mV	20	0.2478	0.6478	258 µV	35.1 µV	371 µV	7.23 µV	83.4 µV	0.0027	31 µV
	±100 mV	50	0.2478	0.6478	108 µV	13.3 µV	129 µV	2.86 µV	31.9 µV	0.0027	24.4 µV
	±50 mV	100	0.2478	0.6478	58 µV	6.65 µV	70.0 µV	1.44 µV	16.0 µV	0.0027	22.2 µV
	±25 mV	200	0.2478	0.6478	33 µV	3.04 µV	36.2 µV	0.704 µV	9.44 µV	0.0027	21.1 µV
	±20 mV	250	0.2478	0.6478	28 µV	2.60 µV	37.8 µV	0.573 µV	9.85 µV	0.0027	20.7 µV
	±10 mV	500	0.2478	0.6478	18 µV	1.43 µV	20.6 µV	0.303 µV	5.60 µV	0.0027	20.4 µV
	±5 mV	1,000	0.2478	0.6478	13 µV	0.681 µV	17.3 µV	0.170 µV	4.35 µV	0.0027	20.2 µV
	±2.5 mV	2,000	0.2478	0.6478	11 µV	0.488 µV	16.3 µV	0.119 µV	3.74 µV	0.0027	20.1 µV

*Absolute Accuracy (15 to 35 °C). Absolute accuracy is (voltage reading) x (% of Reading) + (offset error) + (system noise). To include the effects of temperature drift outside the range 15 to 25 °C, add the term ΔT x (Gain drift) x (Range) + ΔT x (Offset Drift), where ΔT is temperature difference between the module temperature and 15 or 35 °C, whichever is smaller. Bandwidth setting is 10 Hz and Scan rate for 100-point averages is 200 scans/s. [1]V_{rms} refers to sinusoidal waveform; V refers to DC or AC peak.
[2] With SCXI-1327 high-voltage terminal block. [3]Voltage is limited to 42 V_{rms} if using the SCXI-1305 terminal block. To calculate absolute accuracy for the SCXI-1121 refer to page 194 or visit ***ni.com/accuracy***

						System Noise (Peak, 3 Sigma)*				Temperature Drift	
			Percent of Reading*			Single Point		Average		Percent of	
Module	**Nominal Range***	**Overall Gain***	**Typical**	**Max**	**Offsett**	**4 Hz**	**10 kHz**	**4 Hz**	**10 kHz**	**Reading/°C**	**Offset (°C)**
SCXI-1122	±250 V_{rms}	0.01	0.1528	0.1528	270 mV	29.8 mV	142 mV	5.9 mV	15.8 mV	0.0032	15.0 mV
	±250 V	0.02	0.1528	0.1528	137 mV	14.9 mV	71.2 mV	2.95 mV	7.91 mV	0.0032	7.5 mV
	±200 V	0.05	0.1528	0.1528	55.1 mV	5.96 mV	28.5 mV	1.18 mV	3.17 mV	0.0032	3.0 mV
	±100 V	0.1	0.1528	0.1528	27.7 mV	2.98 mV	14.2 mV	591 µV	1.58 µV	0.0032	1.5 mV
	±50 V	0.2	0.1528	0.1528	14.0 mV	1.49 mV	7.12mV	295 µV	791 µV	0.0032	750 µV
	±20 V	0.5	0.1528	0.1528	5.83 mV	596 µV	2.85 mV	118 µV	317 µV	0.0032	300 µV
	±10 V	1	0.0578	0.0578	2.75 mV	298 µV	1.43 mV	59.1 µV	158 µV	0.0017	150 µV
	±5 V	2	0.0578	0.0578	1.48 mV	149 µV	712 µV	29.5 µV	79.1 µV	0.0017	75.2 µV
	±2 V	5	0.0578	0.0578	556 µV	59.6 µV	285 µV	11.8 µV	31.7 µV	0.0017	30.2 µV
	±1 V	10	0.0578	0.0578	282 µV	29.8 µV	142 µV	5.96 µV	15.8 µV	0.0017	15.2 µV
	±500 mV	20	0.0578	0.0578	145 µV	14.9 µV	127 µV	2.95 µV	14.1 µV	0.0017	7.7 µV
	±200 mV	50	0.0578	0.0578	62.8 µV	5.96 µV	112 µV	1.74 µV	12.5 µV	0.0017	3.2 µV
	±100 mV	100	0.0578	0.0578	35.4 µV	2.98 µV	56.1 µV	1.31 µV	6.23 µV	0.0017	1.7 µV
	±50 mV	200	0.0578	0.0578	21.7 µV	1.49 µV	28 µV	0.89 µV	3.11 µV	0.0017	0.95 µV
	±20 mV	500	0.0578	0.0578	13.5 µV	0.596 µV	11.2 µV	0.50 µV	1.25 µV	0.0017	0.50 µV
	±10 mV	1,000	0.0578	0.0578	10.7 µV	0.298 µV	5.61 µV	0.25 µV	0.62 µV	0.0017	0.35 µV
	±5 mV	2,000	0.0578	0.0578	9.37 µV	0.149 µV	2.8 µV	0.20 µV	0.31 µV	0.0017	0.27 µV

*Absolute Accuracy (15 to 35 °C). Absolute accuracy is (voltage reading) x (% of Reading) + (offset error) + (system noise). To include the effects of temperature drift outside the range 15 to 25 °C, add the term ΔT x (Gain drift) x (Range) + ΔT x (Offset Drift), where ΔT is temperature difference between the module temperature and 15 or 35 °C, whichever is smaller. Bandwidth setting is 10 Hz and Scan rate for 100-point averages is 200 scans/s. To calculate absolute accuracy for the SCXI-112s refer to page 194 or visit ***ni.com/accuracy***

Input Characteristics

SCXI-1121	4 differential
SCXI-1122	16 differential

Number of channels

Input signal ranges... See accuracy table

Input Coupling

SCXI-1121	DC (or AC with SCXI-1305)
SCXI-1122	DC

Maximum working voltage

Module	Signal + Common-mode
SCXI-1121	Each input should remain within 250 V_{rms} of ground and any other channel
SCXI-1122	Each input should remain within 480 V_{rms} of ground and 250 V_{rms} of any other channel

Overvoltage protection

Module	Powered On	Powered Off
SCXI-1121	250 V_{rms}	250 V_{rms}
SCXI-1122	250 V_{rms}	250 V_{rms}

Inputs Protected

SCXI-1121	CH <0..3>
SCXI-1122	CH <0..15>

Transfer Characteristics

Nonlinearity

Module	Percent of Full Scale Range
SCXI-1121	± 0.04
SCXI-1122	± 0.01

Offset error.. See accuracy table
Gain error .... See accuracy table

For a definition of specific terms, please visit *ni.com/glossary*.

SCXI Isolated Universal Input Modules

Specifications

Amplifier Characteristics

Input impedance

Module	Normal Powered On	Powered Off / Overload
SCXI-1121	1 GΩ	50 kΩ
SCXI-1122 (gain>1)	1 GΩ	100 kΩ
SCXI-1122 (gain<1)	1 MΩ	100 kΩ

Input bias current .... ±80 pA
Input offset current
SCXI-1121 .... ±80 pA
SCXI-1122 .... ±80 pA
NMR (Normal Mode Rejection)
SCXI-1121 .... 60 dB (with 4 Hz filter enabled)
SCXI-1122 .... 60 dB (with 4 Hz filter enabled)
CMRR (Common Mode Rejection Ratio) (DC to 60 Hz)

Module	Filter	CMRR 50 or 60 Hz
SCXI-1121	4 Hz	160 dB
	10 kHz	100 dB
SCXI-1122	4 Hz	160 dB
	4 kHz	100 dB

Output range
SCXI-1121 .... ± 5 V
SCXI-1122 .... ± 10 V
Output impedance

Module	Multiplexed Mode	Parallel Mode
SCXI-1121	100 Ω	330 Ω
SCXI-1122	75 Ω	–

Dynamic Characteristics

Multiplexer performance

		Scan Interval (per channel, any gain setting)		
Module	Filter Setting	Settle to ±0.012%[1]	Settle to ±0.006%[2]	Settle to ±0.0015%[2]
SCXI-1121	All settings	5.2 µs	10 µs	20 µs
SCXI-1122	4 Hz	1 s	–	–
	4 kHz	10 ms	–	–

System noise .... See sccuracy table
Filter type .... 3-pole RC
Cutoff frequency (-3dB)
SCXI-1121 .... 4 Hz, 10 kHz (jumper selectable)
SCXI-1122 .... 4 Hz, 4 kHz (jumper selectable)
Stability

Module	Gain Temperature Coefficient	Offset Temperature Coefficient
SCXI-1121	20 ppm/°C	(± 0.2 ± 200/gain) µV/°C
SCXI-1122 (gain≥1)	10 ppm/°C	(± 0.2 ± 150/gain) µV/°C
SCXI-1122 (gain<1)	25 ppm/°C	(± 0.2 ± 150/gain) µV/°C

Excitation

Output Characteristics

Channels
SCXI-1121 .... 4 (voltage or current)
SCXI-1122 .... 2 (1 voltage and 1 current)
Bridge type .... Quarter, half, or full
Bridge completion
SCXI-1121 .... 4 (voltage or current)
SCXI-1122 .... 2 (1 voltage and 1 current)

Voltage Mode

Level

Module	Excitation Level	Accuracy
SCXI-1121 (jumper selectable)	3.333 V	± 0.04%
	10 V	± 0.2%
SCXI-1122	3.333 V	± 0.04%

Drift............ ±40 ppm/°C
Current drive
SCXI-1121 .... 28 mA per channel, (@ 3.333 V)
SCXI-1121 .... 14 mA per channel, (@ 10 V)
SCXI-1122 .... 225 mA

Current Mode

Level

Module	Excitation Level	Accuracy
SCXI-1121 (jumper selectable)	0.15 mA	± 0.04%
	0.45 mA	± 0.2%
SCXI-1122	1.0 mA	± 0.04%

Drift............ ±40 ppm/°C
Maximum load resistance
SCXI-1121 .... 10 kΩ
SCXI-1122 .... 5 kΩ

Physical

Dimensions .... 3.0 by 17.3 by 20.3 cm
(1.2 by 6.8 by 8.0 in.)
I/O connectors
Rear .... 50-pin male ribbon cable rear connector
Front .... 32-pin male DIN C connector

Environment

Operating temperature .... 0 to 50 °C
Storage temperature .... -20 to 70 °C
Relative humidity .... 5 to 90% noncondensing

Certification and Compliance

SCXI-1121/1122 .... 250 V, Cat II working voltage

European Compliance CE

EMC .... EN 61326 Group I Class A, 10m,
Table 1 Immunity
Safety .... EN 61010-1

North American Compliance

EMC ....FCC Part 15 Class A using CISPR
Safety .... UL Listed to UL 3111-1
CAN/CSA C22.2 No. 1010.1

Australia & New Zealand Compliance

EMC .... AS/NZS 2064.1/2 (CISPR-11)

[1] Includes effects of AT-MIO-16E-2 with 1 or 2 m SCXI cable assembly.
[2] Includes effects of AT-MIO-16X with 1 or 2 m SCXI cable assembly.

For a definition of specific terms, please visit *ni.com/glossary*

Multifunction DAQ and SCXI Signal Conditioning Accuracy Specifications Overview

Every Measurement Counts

There is no room for error in your measurements. From sensor to software, your system must deliver accurate results. NI provides detailed specifications for our products so you do not have to guess how they will perform. Along with traditional data acquisition specifications, our E Series multifunction data acquisition (DAQ) devices and SCXI signal conditioning modules include accuracy tables to assist you in selecting the appropriate hardware for your application.

To calculate the accuracy of NI measurement products, visit ni.com/accuracy

Absolute Accuracy

Absolute accuracy is the specification you use to determine the overall maximum tolerance of your measurement. Absolute accuracy specifications apply only to successfully calibrated DAQ devices and SCXI modules. There are four components of an absolute accuracy specification:

- **Percent of Reading** – is a gain uncertainty factor that is multiplied by the actual input voltage for the measurement.
- **Offset** – is a constant value applied to all measurements.
- **System Noise** – is based on random noise and depends on the number of points averaged for each measurement (includes quantization error for DAQ devices).
- **Temperature Drift** – is based on variations in your ambient temperature.
- **Input Voltage** – the absolute magnitude of the voltage input for this calculation. The fullscale voltage is most commonly used.

Based on these components, the formula for calculating absolute accuracy is:

$$\text{Absolute Accuracy} = \pm[(\text{Input Voltage X \% of Reading}) + (\text{Offset} + \text{System Noise} + \text{Temperature Drift})]$$

$$\text{Absolute Accuracy RTI}^{1} = (\text{Absolute Accuracy Input Voltage})$$

[1]RTI = relative to input

Temperature drift is already accounted for unless your ambient temperature is outside 15 to 35 °C. For instance, if your ambient temperature is at 45 °C, you must account for 10 °C of drift. This is calculated by:

$$\text{Temperature Drift} = \text{Temperature Difference x \% Drift per °C x Input Voltage}$$

Absolute Accuracy for DAQ Devices

Absolute Device Accuracy at Full Scale is a calculation of absolute accuracy for DAQ devices for a specific voltage range using the maximum voltage within that range taken one year after calibration, the Accuracy Drift Reading, and the System Noise averaged value.

Below is the Absolute Accuracy at Full Scale calculation for the NI PCI-6052E DAQ device after one year using the ±10 V input range while averaging 100 samples of a 10 V input signal. In all the Absolute Accuracy at Full Scale calculations, we assume that the ambient temperature is between 15 and 35 °C. Using the Absolute Accuracy table on the next page, we see that that the calculation for the ±10 V input range for Absolute Accuracy at Full Scale yields 4.747 mV. This calculation is done using the parameters in the same row for one year Absolute Accuracy Reading, Offset and Noise + Quantization, as well as a value of 10 V for the input voltage value. You can then see that the calculation is as follows:

$$\text{Absolute Accuracy} = \pm[(10 \text{ X } 0.00037) + 947.0\ \mu V + 87\ \mu V] = \pm 4.747 \text{ mV}$$

In many cases, it is helpful to calculate this value relative to the input (RTI). Therefore, you do not have to account for different input ranges at different stages of your system.

$$\text{Absolute Acuracy RTI} = (\pm 0.004747/10) = \pm 0.0475\%$$

The following example assumes the same conditions except that the ambient temperature is 40 °C. You can begin with the calculation above and add in the Drift calculation using the % Drift per °C from Table 2 on page 196.

$$\text{Absolute Accuracy} = 4.747 \text{ mV} + ((40 - 35\ °C) \text{ x } 0.000006\ /°C \text{ X } 10 \text{ V}) = \pm 5.047 \text{ mV}$$

$$\text{Absolute Acuracy RTI} = (\pm 0.005047/10) = \pm 0.0505\%$$

Absolute Accuracy for SCXI Modules

Below is an example for calculating the absolute accuracy for the NI SCXI-1102 using the ±100 mV input range while averaging 100 samples of a 14 mV input signal. In this calculation, we assume the ambient temperature is between 15 and 35 °C, so Temperature Drift = 0. Using the accuracy table on page 313, you find the following numbers for the calculation:

Input Voltage = 0.014
% of Reading Max = 0.02% = 0.0002
Offset = 0.000025 V
System Noise = 0.000005 V

$$\text{Absolute Accuracy} = \pm[(0.014 \text{ x } 0.0002) + 0.000025 + 0.000005] \text{ V} = \pm 32.8\ \mu V$$

$$\text{Absolute Accuracy RTI} = \pm(0.0000328 / 0.014) = \pm 0.234\ \%$$

The following example assumes the same conditions, except the ambient temperature is 40 °C. You can begin with the Absolute Accuracy calculation above and add in the Temperature Drift.

$$\text{Absolute Accuracy} = 32.8\ \mu V + (0.014 \text{ x } 0.000005 + 0.000001) \text{ x } 5 = \pm 38.15\ \mu V$$

$$\text{Absolute Accuracy RTI} = \pm(0.00003815 / 0.014) = \pm 0.273\ \%$$

Multifunction DAQ and SCXI Signal Conditioning Accuracy Specifications Overview

For both DAQ devices and SCXI modules, you should use the Single-Point System Noise specification from the accuracy tables when you are making single-point measurements. If you are averaging multiple points for each measurement, the value for System Noise changes. The Averaged System Noise in the accuracy tables assumes that you average 100 points per measurement. If you are averaging a different number of points, use the following equation to determine your Noise + Quantization:

$$\text{System Noise} = \text{Average System Noise from table} \times \sqrt{(100/\text{number of points})}$$

For example, if you are averaging 1,000 points per measurement with the PCI-6052E in the ±10 V (±100 mV for the SCXI-1102) input range, System Noise is determined by:

NI PCI-6052E**
System Noise= 87.0 0 µV x $\sqrt{(100/1000)}$ = 27.5 0 µV

NI SCXI-1102
System Noise= 5 µV x SQRT $\sqrt{(100/1000)}$ = 1.58 µV

**The System Noise specifications assume that dithering is disabled for single-point measurements and enabled for averaged measurements.

See page 21 or visit ni.com/calibration for more information on the importance of calibration on DAQ device accuracy.

Absolute System Accuracy

Absolute System Accuracy represents the end-to-end accuracy including the signal conditioning and DAQ device. Because absolute system accuracy includes components set for different input ranges, it is important to use Absolute Accuracy RTI numbers for each component.

Total System Accuracy RTI = ±SQRT [(Module Absolute Accuracy RTI)2
+ (DAQ Device Absolute Accuracy RTI)2]

The following example calculates the Absolute System Accuracy for the SCXI-1102 module and PCI-6052E DAQ board described in the first examples:

Total System Accuracy RTI = ± $\sqrt{[(0.00273)2 + (0.000505)2]}$ = ±0.278%

Units of Measure

In many applications, you are measuring some physical phenomenon, such as temperature. To determine the absolute accuracy in terms of your unit of measure, you must perform three steps:

1. Convert a typical expected value from the unit of measure to voltage
2. Calculate absolute accuracy for that voltage
3. Convert absolute accuracy from voltage to the unit of measure

Note: it is important to use a typical measurement value in this process, because many conversion algorithms are not linearized. You may want to perform conversions for several different values in your probable range of inputs, rather than just the maximum and minimum values.

For an example calculation, we want to determine the absolute system accuracy of an NI SCXI-1102 system with a NI PCI-6052E, measuring a J-type thermocouple at 100 °C.

1. A J-type thermocouple at 100 °C generates 5.268 mV (from a standard conversion table or formula)
2. The absolute accuracy for the system at 5.268 mV is ±0.82%. This means the possible voltage reading is anywhere from 5.225 to 5.311 mV.
3. Using the same thermocouple conversion table, these values represent a temperature spread of 99.3 to 100.7 °C.

Therefore, the absolute system accuracy is ±0.7 °C at 100 °C.

Benchmarks

The calculations described above represent the maximum error you should receive from any given component in your system, and a method for determining the overall system error. However, you typically have much better accuracy values than what you obtain from these tables.

If you need an extremely accurate system, you can perform an end-to-end calibration of your system to reduce all system errors. However, you must calibrate this system with your particular input type over the full range of expected use. Accuracy depends on the quality and precision of your source.

We have performed some end-to-end calibrations for some typical configurations and achieved the results in Table 1:

To maintain your measurement accuracy, you must calibrate your measurement system at set intervals over time.

For a current list of SCXI signal conditioning products with calibration services, please visit ni.com/calibration

Multifunction DAQ and SCXI Signal Conditioning Accuracy Specifications Overview

Module	Empirical Accuracy
SCXI-1102	±0.25 °C at 250 °C ±24 mV at 9.5 V
SCXI-1112	±0.21 °C at 300 °C
SCXI-1125	±2.2 mV at 2 V

Table 1. Possible Empirical Accuracy with System Calibration

		Absolute Accuracy							Relative Accuracy	
Nominal Range (V)		% of Reading			System Noise (mV)		Temp Drift	Absolute Accuracy	Resolution (µV)	
Positive FS	Negative FS	24 Hours	1 Year	Offset (µV)	Single Point	Averaged	(%/°C)	at Full Scale (mV)	Single Point	Averaged
10.0	-10.0	0.0354	0.0371	947.0	981.0	87.0	0.0006	4.747	1145.0	115.0
5.0	-5.0	0.0054	0.0071	476.0	491.0	43.5	0.0001	0.876	573.0	57.3
2.5	-2.5	0.0354	0.0371	241.0	245.0	21.7	0.0006	1.190	286.0	28.6
1.0	-1.0	0.0354	0.0371	99.2	98.1	8.7	0.0006	0.479	115.0	11.5
0.5	-0.5	0.0354	0.0371	52.1	56.2	5.0	0.0006	0.243	66.3	6.6
0.25	-0.25	0.0404	0.0421	28.6	32.8	3.0	0.0006	0.137	39.2	3.9
0.1	-0.1	0.0454	0.0471	14.4	22.4	2.1	0.0006	0.064	27.7	2.8
0.05	-0.05	0.0454	0.0471	9.7	19.9	1.9	0.0006	0.035	25.3	2.5
10.0	0.0	0.0054	0.0071	476.0	491.0	43.5	0.0001	1.232	573.0	57.3
5.0	0.0	0.0354	0.0371	241.0	245.0	21.7	0.0006	2.119	286.0	28.6
2.0	0.0	0.0354	0.0371	99.2	98.1	8.7	0.0006	0.850	115.0	11.5
1.0	0.0	0.0354	0.0371	52.1	56.2	5.0	0.0006	0.428	66.3	6.6
0.5	0.0	0.0404	0.0421	28.6	39.8	3.0	0.0006	0.242	48.2	3.9
0.2	0.0	0.0454	0.0471	14.4	22.4	2.1	0.0006	0.111	27.7	2.8
0.1	0.0	0.0454	0.0471	9.7	19.9	1.9	0.0006	0.059	25.3	2.5

Table 2. NI PCI-6052E Analog Input Accuracy Specifications

Note: Accuracies are valid for measurements following an internal (self) E Series calibration. Averaged numbers assume averaging of 100 single-channel readings. Measurement accuracies are listed for operational temperatures within ±1 °C of internal calibration temperature and ±10 °C of external or factory-calibration temperature. One-year calibration interval recommended. The absolute accuracy at full scale calculations were performed for a maximum range input voltage (for example, 10 V for the ±10 V range) after one year, assuming 100 point averaging of data.