SC Series – DAQ with Integrated Signal Conditioning

SC Series

SC Series Technologies
- Tightly integrated measurement-specific signal conditioning on a single data acquisition device
- Direct sensor/signal connectivity
- 200 kS/s, 16-bit resolution
- Self-calibration for accuracy over time
- NI-PGIA custom instrumentation amplifier for accurate measurements

Models
- NI PXI-4204
- NI PXI-4220

Operating Systems
- Windows 2000/NT/XP

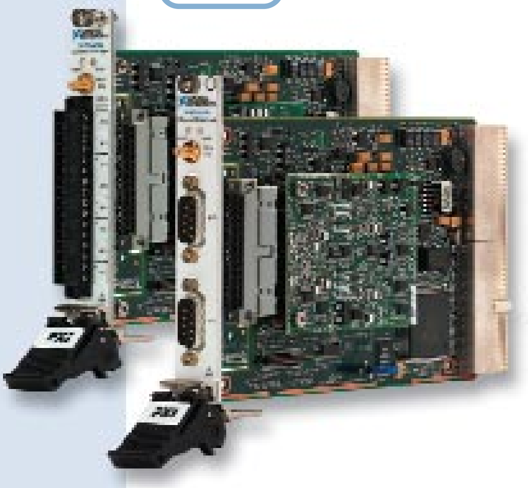
Recommended Software
- LabVIEW
- LabWindows/CVI
- Measurement Studio

Other Compatible Software
- Visual Basic, C/C++, and C#

Driver Software (included)
- NI-DAQ 7

Calibration Certificate Included
See page 21.

NEW



Family	Bus	Analog Inputs	Resolution (bits)	Sampling Rate	Input Range	Simultaneous Sampling	Triggers	Filter Settings per Channel	Page
NI 4204	PXI	8 DI ±100 V	16	200 kS/s	±0.5 to ±100 V	✓	2 Digital	2-pole Butterworth (6 Hz or 10 kHz)	224
NI 4220	PXI	2 Quarter, half, or full-bridge	16	200 kS/s	±0.01 to ±10 V	✓	2 Digital	4-pole Butterworth (10 Hz, 100 Hz, 1 kHz, 10 kHz, bypass)	226

Table 1. SC Series Devices – NI 4204, NI 4220

Family	Bus	Analog Inputs	Resolution (bits)	Sampling Rate	Input Range	Simultaneous Sampling	Triggers	Filter Settings per Channel	Page
NI 4472	PXI, PCI	8 IEPE[1]	24	102.4 kS/s	±10 V	✓	Analog and digital	Tracking filter (.5465 fs)	402
NI 435x	PXI, PCI, USB	16 DI thermocouple, RTD, or resistance	24	60 S/s	±15 V	–	–	20 Hz Bandwidth	357

[1]Integrated Electronics Piezoelectric Accelerometers and Microphones

Table 2. Other NI Data Acquisition Devices with Built-In Signal Conditioning

Overview
National Instruments SC Series data acquisition (DAQ) devices expand the measurement capability of PXI by integrating measurement-specific signal conditioning onto a 16-bit PXI data acquisition device. With this tight integration of signal conditioning and data acquisition functionality, the SC Series delivers high-performance sensor-specific measurements at a lower cost per channel than leading solutions, such as SCXI DAQ systems, for low-to-medium channel counts.

Features
SC Series devices feature an integrated architecture that combines the high-performance functionality of NI 16-bit E Series devices with the accuracy improvements of signal conditioning. With this integrated architecture, SC Series PXI modules deliver higher performance measurements, taking advantage of the many inherent benefits of the rugged PXI platform. In particular, with the PXI trigger bus you can synchronize SC Series modules with one another and with other PXI measurement modules to provide tight integration between measurement types in a single data acquisition system. In addition, SC-Series devices feature temperature-drift-protection circuitry that minimizes the effect of ambient temperature changes to ensure accuracy in all environments. SC Series devices also feature the NI-PGIA, an instrument-class amplifier that guarantees settling times at all gains, ensuring that you take advantage of the full 16-bit resolution of the amplifier. Each SC Series device also features an onboard precision voltage source for self-calibration, and digital triggering for precise acquisition control.

Related Products
For high-channel-count or portable applications requiring signal conditioning, please refer to:

SCC Signal Conditioning...see page 251
SCXI Signal Conditioning..see page 270

High-Voltage Data Acquisition
16-Bit, 200 kS/s, 8 Analog Inputs

NEW

NI PXI-4204

- 8 analog inputs at 200 kS/s, 16-bit resolution
- ±100 V input range
- Programmable gain (0.5, 1, 10, 100) per channel
- Programmable 2-pole Butterworth filter (6 Hz or 10 kHz) per channel
- Differential simultaneous sampling inputs
- Combicon screw terminal direct connectivity
- NI-DAQ driver simplifies configuration and measurements

Operating Systems
- Windows 2000/NT/XP

Recommended Software
- LabVIEW
- LabWindows/CVI
- Measurement Studio

Other Compatible Software
- Visual Basic, C/C++, and C#

Driver Software (included)
- NI-DAQ 7

Calibration Certificate Included
See page 21.

Device	Bus	Analog Inputs	Resolution	Sampling Rate	Input Range	Triggers	Filter Settings
PXI-4204	PXI	8 Differential inputs	16 bits	200 kS/s	±0.5 to ±100 V	Digital (2)	2-pole Butterworth (6 Hz or 10 kHz)

Table 1. NI PXI-4204 Specifications Summary (See page 246 for detailed specifications.)

Overview and Applications

The National Instruments PXI-4204 module delivers accurate data acquisition for input ranges up to 100 V. With this module you can handle a broad variety of applications including:

- 42 V automotive applications
- High-voltage, multichannel data logging applications
- Fuel cell and battery test applications

Features

The NI PXI-4204 is a full-featured data acquisition module with a ±100 V input range, 16-bit accuracy, and software-selectable filter and gain settings per channel. Programmable filter and gain settings ensure that the PXI-4204 achieves maximum accuracy over the entire ±100 V input range. NI LabVIEW, LabWindows/CVI, and Measurement Studio for Visual Studio can configure the PXI-4204 and acquire data through a menu-based window, eliminating the need to manually program the device.

For high-channel-count, high-voltage applications, explore NI signal conditioning hardware. Visit ni.com/sigcon

High-Performance, Easy-to-Use Driver Software

NI-DAQ is the robust driver software that makes it easy to access the functionality of your data acquisition hardware, whether you are a beginning or advanced user. Helpful features include:

Automatic Code Generation – The DAQ Assistant is an interactive guide that steps you through configuring, testing, and programming measurement tasks and generates the necessary code automatically for LabVIEW, LabWindows/CVI, or Measurement Studio.

Cleaner Code Development – basic and advanced software functions have been combined into one easy-to-use yet powerful set to help you build cleaner code and move from basic to advanced applications without replacing functions.

DAQ for High-Voltage Measurements
16-Bit, 200 kS/s, 8 Analog Inputs

High-Performance Driver Engine – software-timed single point input (typically used in control loops) with NI-DAQ achieves rates of up to 50 kHz. NI-DAQ also delivers maximum system throughput I/O with a multithreaded driver.

Test Panels – with NI-DAQ you can test all device functions before you begin development.

Scaled Channels – easily scale your voltage data into the proper engineering units using the NI-DAQ measurement ready virtual channels by choosing from a list of common sensors and signals or creating your own custom scale.

LabVIEW Integration – all NI-DAQ functions create the waveform data type, which carries acquired data and timing information directly into more than 400 LabVIEW built-in analysis routines for display of results in engineering units on a graph.

Worldwide Support and Services

NI provides you with a wealth of resources to help you get your application up and running more quickly, including:

Technical Support – purchase of NI hardware or software gives you access to application engineers all over the world as well as Web resources with more than 3,000 measurement examples and more than 9,000 KnowledgeBase entries. – ***ni.com/support***

NI Factory Installation Services (FIS) – software and hardware installed in PXI and PXI/SCXI systems, tested and ready to use – ***ni.com/advisor***

Calibration – includes NIST-traceable basic calibration certificates, services for ANSI/NCSL-Z540 and periodic calibration – ***ni.com/calibration***

Extended Warranty – meet project life-cycle requirements and maintain optimal performance in a cost-effective way – ***ni.com/services***

Data Acquisition Training – instructor-led courses – ***ni.com/training***

Professional Services – feasibility, consulting, and integration through our Alliance Partners – ***ni.com/alliance***

For more information on NI services and support, please visit ni.com/services

Ordering Information

NI PXI-4204 778745-4204

Includes NI-DAQ driver software and calibration certificate.

For more information on extended warranty and value-added services, visit ***ni.com/services***

BUY ONLINE!

*Visit **ni.com/info** and enter pxi4204.*

SC Series Specifications

Specifications – PXI-4204

Input Characteristics

SSH Disabled

Nominal Range (V)		Absolute Accuracy: % of Reading			Noise + Quantization (mV)				
Positive FS	Negative FS	24 Hrs	1 Year	Offset (mV)	Single Pt.	Averaged	Temperature Drift (%/°C)	Absolute Accuracy at Full Scale (mV)	Percent Error at Full Scale (%)
100	-100	0.063	0.070	± 16.8	± 9.34	± 0.92	0.0027	88	0.088
50	-50	0.031	0.038	± 10.4	± 4.68	± 0.57	0.0025	30	0.060
5	-5	0.061	0.068	± 4.7	± 0.69	± 0.40	0.0027	8.5	0.17
0.5	-0.5	0.061	0.068	± 4.1	± 0.49	± 0.40	0.0027	4.8	0.97

Note: Accuracies are valid for measurements following an internal calibration. Averaged numbers assume dithering and 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.

SSH Enabled

Nominal Range (V)		Absolute Accuracy: % of Reading			Noise + Quantization (mV)				
Positive FS	Negative FS	24 Hrs	1 Year	Offset (mV)	Single Pt.	Averaged	Temperature Drift (%/°C)	Absolute Accuracy at Full Scale (mV)	Percent Error at Full Scale (%)
100	-100	0.085	0.090	± 19.0	± 9.35	± 1.02	0.0027	110	0.110
50	-50	0.035	0.042	± 12.6	± 4.70	± 0.73	0.0025	34	0.069
5	-5	0.063	0.070	± 6.8	± 0.82	± 0.60	0.0027	11	0.22
0.5	-0.5	0.063	0.070	± 6.3	± 0.66	± 0.60	0.0027	7.2	1.4

	Number of Channels
PXI-4204	8 differential

Input signal ranges........ see accuracy tables
Resolution........ 16 bits, 1 in 65,536

Sampling Rate

Maximum sampling rate........ 200 kS/s aggregate multi-channel
Max per channel (scanning all channels)

Module	Single Channel	Scan Rate w/SSH*	Scan Rate w/o SSH*
PXI-4204	333 kS/s	20 kS/s/ch	25 kS/s/ch

*SSH = Simultaneous Sample and Hold

Overvoltage protection

Connector	Powered On	Powered Off
Screw terminals	±110 VDC	±110 VDC
SMB connector	±15 V	±15 V

Inputs with overvoltage protection........ CH<0..7>
Input coupling........ DC
Data transfers........ DMA, interrupts, programmed I/O

Transfer Characteristics

Nonlinearity

Range	Percent of Full Scale (Typical)
± 100 V	0.02%
Other ranges	0.01%
± 100 V, SSH enabled	0.06%
Other ranges, SSH enabled	0.02%

DNL

Module	Typical	Maximum
PXI-4204	± 0.5 LSB	± 1 LSB

Gain error........ See Accuracy Table
Offset error........ See Accuracy Table**

Amplifier Characteristics

Input Impedance

Module	Input Configuration	Normal Powered On	Powered Off
PXI-4204	Differential input Single-ended	2 MΩ 1 MΩ	2 MΩ 1 MΩ

NMR (60 Hz)	
PXI-4204	40 dB @ 6 Hz filter setting

CMRR

Module	Input Frequency Ranges	CMRR
PXI-4204	DC to 60 Hz 100 Hz to 10 kHz	>60 dB >40 dB

**Gain Error = Actual Input Voltage * % of Reading

Track and Hold Characteristics

Acquisition time........ 7 us typical
Hold mode settling time........ 3 us typical
Droop rate........ < 400 mV/s typical

Filter Characteristics

Filter type........ 6 Hz or 10 kHz, 2-pole, Butterworth

Triggers

Digital Triggers
Number of triggers........ 2
Purpose........ Start and stop trigger, gate, clock
Source........ PFI0/TRIG1 (front SMB connector), PXI_TRIG_0…PXI_TRIG_6 (PXI trigger bus)
Slope........ Positive or negative; software selectable
Compatibility........ 5 V/TTL
Response........ Rising or falling edge
Pulse width........ 10 ns minimum
Impedance........ 10 kΩ
Coupling........ DC

PXI trigger bus
Trigger lines........ 6
Star trigger........ 1

Bus Interface

PXI........ Master, slave

Power Requirements

Module	5 VDC (±5%)
PXI-4204	1 A

Calibration

Recommended warm-up time........ 15 minutes
External calibration interval........ 1 year
Onboard calibration reference
Level........ 5.000 V ±1 mV
Temperature coefficient........ + 0.6 ppm/°C
Long-term stability........ 6 ppm/$\sqrt{1000 \text{ h}}$

Physical

Dimensions (not including connectors)........ 10 by 16 cm (3.9 by 6.3 in.)
Analog input signal connector........ 16 x 1 minicombicon, 3.81 mm pitch
Analog input signal mating connector........ 16 x 1 minicombicon, 3.81 mm pitch, 28-16 AWG signal wire

I/O Connectors

Module	Front
PXI-4204	16 screw terminals, 1 SMB

SC Series Specifications

Specifications – PXI-4220

Input Characteristics

SSH Enabled

Nominal Range (V)		Absolute Accuracy: Percent of Reading			Absolute Accuracy: Noise + Quantization (mV)		Temperature Drift		
Positive FS	Negative FS	24 Hrs	1 Year (Max)	Max Offset (μV)	Single Pt.	Averaged	Gain Drift (%/°C)	Offset Drift (μV/°C)	Absolute Accuracy at Full Scale
+ 10.0 V	- 10.0 V	1	0.1	3000	5000	500	0.0300	25.00	± 13.5 mV
+ 5.0 V	- 5.0 V	2	0.1	1500	2500	250	0.0300	25.00	± 6.8 mV
+ 1.8 V	- 1.8 V	4.2	0.1	500	1000	100	0.0300	25.00	± 2.4 mV
+ 1.0 V	- 1.0 V	10	0.1	300	500	50	0.0300	25.00	± 1.4 mV
+ 500.0 mV	- 500.0 mV	20	0.1	150	250	25	0.0300	5.00	± 675 μV
+ 180.0 mV	- 180.0 mV	42	0.1	75	100	10	0.0300	5.00	± 265 μV
+ 100.0 mV	- 100.0 mV	100	0.1	50	50	5.0	0.0300	5.00	± 155 μV
+ 50.0 mV	- 50.0 mV	200	0.1	50	25	2.5	0.0300	5.00	± 103 μV
+ 18.0 mV	- 18.0 mV	420	0.1	50	10	1.0	0.0300	5.00	± 69 μV
+ 10.0 mV	- 10.0 mV	1000	0.1	50	10	1.0	0.0300	5.00	± 61 μV

Note: Accuracies are valid for measurements following an internal calibration. Averaged numbers assume dithering and 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.

Number of Channels	
PXI-4220	2 differential

Input signal ranges .... See accuracy tables
Resolution .... 16 bits, 1 in 65,536

Sampling Rate

Maximum sampling rate .... 200 kS/s aggregate multi-channel
Max per channel (scanning all channels)

Module	Single Channel	Scan Rate w/SSH*	Scan Rate w/o SSH*
PXI-4220	333 kS/s	66 kS/s/ch	100 kS/s/ch

*SSH = Simultaneous Sample and Hold

Input coupling .... DC
Bandwidth .... 20 kHz, filter bypassed
Maximum working voltage
(signal + common mode) .... Each input should remain within ±10 V of ground
Overvoltage protection
D-Sub connectors: .... Powered on ±35 V
Powered off ±25 V
SMB connector: .... Powered on and off ±15 V
Bus interface: Master, slave

Transfer Characteristics

Offset error .... 150 μV (gain ≥ 20); 3 mV (gain < 20)
Gain error .... ±0.1%
Non-Linearity .... Better than 0.02% of full-scale range
DNL .... ±0.5 LSB (typical) ±1 LSB (maximum)
No missing codes .... 16 bits, guaranteed

Amplifier Characteristics

Input impedance (DC) .... >1 GΩ
Input bias current .... ±20 nA maximum
Input offset current .... ±20 nA maximum

CMRR

Gain	CMRR DC to 60 Hz
< 20	> 60 dB
≥ 20	> 85 dB

Dynamic Characteristics

Minimum scan interval
(±0.0015% relative accuracy (16-bit)) .... 5 μs
Noise RTI, gain = 200, 0.1 to 10 Hz .... 1.5 μV_{p-p}
Spot noise RTI, gain = 200, 1000 Hz .... 16 $nV/\sqrt{Hz}$

Filter Characteristics

Lowpass filter type .... 4-pole Butterworth (24 dB/octave rolloff)
Lowpass filter settings .... 10 Hz, 100 Hz, 1 kHz, 10 kHz, or bypass
Bandwidth, filter bypassed .... -3 dB at 20 kHz

Track and Hold Characteristics

Acquisition time .... 7 μs typical
Hold mode settling time .... 3 μs typical
Droop rate .... 30 mV/s typical, 100 mV/s maximum
Interchannel skew .... 200 ns typical
Intermodule skew .... 250 ns typical

Stability

Recommended warm-up time .... 15 min
Gain drift .... ±40 ppm/°C maximum
Offset drift
Gain ≥20 .... ±2 μV/°C typical, ±5 μV/°C maximum
Gain <20 .... ±15 μV/°C typical, ±25 μV/°C maximum

Null Compensation Characteristics

Range .... ±4% of excitation voltage, 20,000 counts of resolution (±80,000 με null compensation range, 4 με resolution for quarter bridge, GF = 2.0)

Excitation Characteristics

Type .... Constant voltage
Settings .... 0.0 to 10.0 V in 9.76 mV increments
Error .... ±20 mV ±0.3% of nominal setting
Maximum operating current .... 29 mA, all ranges
Short-circuit protection .... Yes
Regulation, no load to 120 Ω load
With remote sense .... ±0.003%
Without remote sense .... ±0.30%
Temperature drift .... ±0.005%/°C, ±30 μV/°C max
Noise, DC to 10 kHz .... 200 μV_{p-p}
Remote sense .... Error less than ±0.02%/Ω of lead resistance
Protection .... Surge arrestors in parallel with excitation terminals, shunt to ground

Bridge Completion*

Half-bridge .... Two precision resistors, 5 kΩ each
Quarter-bridge .... 350 Ω resistor socketed on PXI-4220
120 Ω resistor included in kit

*Note: Half-bridge completion is peformed inside the module and configured under software control. The quarter-bridge completion resistor is located near the front of the PXI-4220 and is socketed. Resistors shipped with the PXI-4220 are 350 Ω (installed) and 120 Ω (in bag with kit) RN-55 style (standard 1/4 W size). The tolerance is +0.1% and the temperature coefficient is 10 ppm/ °C maximum.

Shunt Calibration**

Type .... Two independent points
Resistor .... 100 kΩ resistors socketed on PXI-4220
Switch resistance .... 32 Ω typical, 50 Ω maximum
Switch off leakage .... <1 nA
Switch break-down voltage .... +60 V

**Note: Shunt calibration resistors are located near the front of the PXI-4220 and are socketed. Resistors shipped with the PXI-4220 are 100 kΩ RN-55 style (standard 1/4 W size). The tolerance is +0.1% and the temperature coefficient is 10 ppm/ °C maximum.

SC Series Specifications

Specifications – PXI-4220 (continued)

Calibration

Recommended warm-up time .... 15 minutes
External calibration interval .... 1 year
Onboard calibration reference
- Level .... 5.000 V ±1 mV
- Temperature coefficient .... ±0.6 ppm/°C
- Long-term stability .... 6 ppm/$\sqrt{1000\ h}$

Digital, Timing, Power

Digital triggers
- Number of triggers 2
- Purpose .... Start and stop trigger, gate, clock
- Source .... PFI0/TRIG1 (front SMB connector),

PXI trigger bus
- Slope .... Positive or negative; software selectable
- Compatibility .... 5 V/TTL
- Response .... Rising or falling edge
- Pulse width .... 10 ns minimum
- Impedance .... 10 kΩ
- Coupling .... DC

PXI trigger bus
- Trigger lines 6
- Star trigger 1

Power Requirements

Module	5 VDC (±5%)
PXI-4220	1 A

Physical

Dimensions (not including connectors) .... 10 by 16 cm (3.9 by 6.3 in.)
Analog input signal connector .... 9-Pin D-Sub

Common Specifications – PXI-4204, PXI-4220

Input Characteristics

FIFO buffer size .... 512 samples
Data transfers .... DMA, interrupts, programmed I/O
DMA modes .... Scatter-gather (single transfer, demand transfer)
Configuration memory size .... 512 words

Environment

Operating temperature .... 0 to 55 °C
Storage temperature .... -20 to 70 °C
Relative humidity .... 10 to 90%, noncondensing
Maximum altitude .... 2,000 m
Pollution degree (indoor use only) 2

Certification and Compliance (PXI-4204, PXI-4220)

European Compliance CE

Low-Voltage Directive (safety) 73/23/EEC
Electromagnetic Compatibility
- Directive (EMC) 89/336/EEC

Emissions .... EN 55011 Class A 10 m
Immunity .... EN 61326:1997 + A2:2001, Table 1
EMC .... CE, C-Tick and FCC Part 15 (Class A) Compliant
Safety .... IEC 61010-1, EN 61010-1

North American Compliance CE

Emissions .... EN 55011 Class A at 10 m
FCC Part 15A above 1 GHz
Immunity .... EN 61326:1997 + A2:2001, Table 1
EMC .... CE, C-Tick and FCC Part 15 (Class A) Compliant
Safety .... IEC 61010-1, EN 61010-1, UL 3111-1,
UL 61010B-1, CAN/SA C22.2 No. 1010

	Maximum Working Voltage (Signal + Common mode)
Channel-to-earth (inputs)	100 VDC, 70 VRMS, Installation Category I*
Channel-to-channel (inputs	100 VDC, 70 VRMS, Installation Category I*

*Caution: This device is rated for Installation Category I and intended to carry signal voltages no greater than 100V. This device can withstand up to 500V impulse voltage without creating a safety hazard. Do not use this device for connection to signals or for measurements within Categories II, III, or IV. Do not connect to MAINs supply circuits, such as wall outlets, of 115 or 230 VAC.

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:

Absolute Accuracy = ±[(Input Voltage X % of Reading) + (Offset + System Noise + Temperature Drift)]

Absolute Accuracy RTI[1] = (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:

Temperature Drift = 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:

Absolute Accuracy = ±[(10 X 0.00037) + 947.0 µV + 87 µV] = ±4.747 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.

Absolute Acuracy RTI = (±0.004747/10) = ±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.

Absolute Accuracy = 4.747 mV + ((40 – 35 °C) x 0.000006 /°C X 10 V) = ±5.047 mV

Absolute Acuracy RTI = (±0.005047/10) = ±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

Absolute Accuracy = ±[(0.014 x 0.0002) + 0.000025 + 0.000005] V = ±32.8 µV

Absolute Accuracy RTI = ±(0.0000328 / 0.014) = ±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.

Absolute Accuracy = 32.8 µV + (0.014 x 0.000005 + 0.000001) x 5 = ±38.15 µV

Absolute Accuracy RTI = ±(0.00003815 / 0.014) = ±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:

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

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.