SCXI Universal Strain Gauge Input Module

NI SCXI-1520

- 8 simultaneously sampled analog input channels
- Programmable excitation (0-10 V) per channel
- Programmable gain (1 to 1000) per channel
- Programmable 4-pole Butterworth filter (10 Hz, 100 Hz, 1 kHz, 10 kHz) per channel
- Quarter, half and full-bridge completion
- NI-DAQ driver software simplifies configuration and measurement
- 2 shunt calibration circuits per channel
- Remote sensing
- Random scanning
- Onboard calibration reference

Operating Systems
- Windows 2000/NT/XP/Me/9x

Recommended Software
- LabVIEW
- LabWindows/CVI
- Measurement Studio for Visual Basic
- VI Logger

Driver Software
- NI-DAQ

Calibration Certificate Included
See page 21

Module	Signal Compatibility			
	Quarter-Bridge (120 Ω, 350 Ω)	Half-Bridge (120 Ω, 350 Ω)	Full-Bridge (120 Ω, 350 Ω)	Force, Load, Torque, Pressure
SCXI-1520	✔	✔	✔	✔

Table 1. Module Compatibility

Overview
The National Instruments SCXI-1520 is an 8-channel universal strain-gauge input module that offers all of the features you need for simple or advanced strain measurements. With this single module, you can read signals from strain, force, torque, and pressure sensors. Each NI SCXI-1520 is shipped with a NIST-traceable calibration certificate, and includes an onboard reference for automatic calibration in changing environments.

For simple strain measurements, the SCXI-1520 offers a programmable amplifier and programmable 4-pole Butterworth filter on each channel. Each channel also has an independent 0-10 V programmable excitation source. In addition, the SCXI-1520 system offers a half-bridge completion resistor network in the module, and a socketed 350 Ω quarter-bridge completion resistor in the SCXI-1314 terminal block. A 120 Ω quarter-bridge completion resistor is also included with the terminal block.

For more advanced applications, the SCXI-1520 also offers an automatic null compensation circuit, remote sensing, and two shunt calibration circuits per channel. In addition, the SCXI-1520 includes track-and-hold circuitry for simultaneous sampling applications.

Each SCXI-1520 module multiplexes its signals into a single channel of the controlling DAQ device, and you can add modules to increase channel count.

Analog Input
The eight analog inputs of the SCXI-1520 consist of programmable instrumentation amplifiers, 4-pole Butterworth filters, and track-and-hold (T/H) circuitry. You can program the gain of each channel individually to one of 48 input ranges from ±10 mV to ±10 V. You can program each lowpass filter individually for 10 Hz, 100 Hz, 1 kHz, 10 kHz, or bypass mode. The 4-pole Butterworth filters provide a sharp cutoff to block noise while maintaining maximum flatness in the passband. Finally, the SCXI-1520 implements random scanning, so you acquire data from only the channels you select, thereby reducing your overall scan times. For applications requiring fewer than eight strain gauges, you can use the extra analog input channels for general-purpose analog signals.

INFO CODES
For more information or to order products online, visit *ni.com/info* and enter:

scxi1520

BUY ONLINE!

Simultaneous Sampling
Each channel of the SCXI-1520 includes T/H circuitry so you can digitize simultaneous events with negligible skew time between channels. The outputs of the T/H amplifiers follow their inputs until they receive a hold signal from the DAQ device (typically at the start of a scan). At the hold signal, the T/H amplifiers simultaneously freeze, holding the input signal levels constant. The DAQ device then digitizes each frozen signal sequentially, giving you simultaneous sampling between channels.

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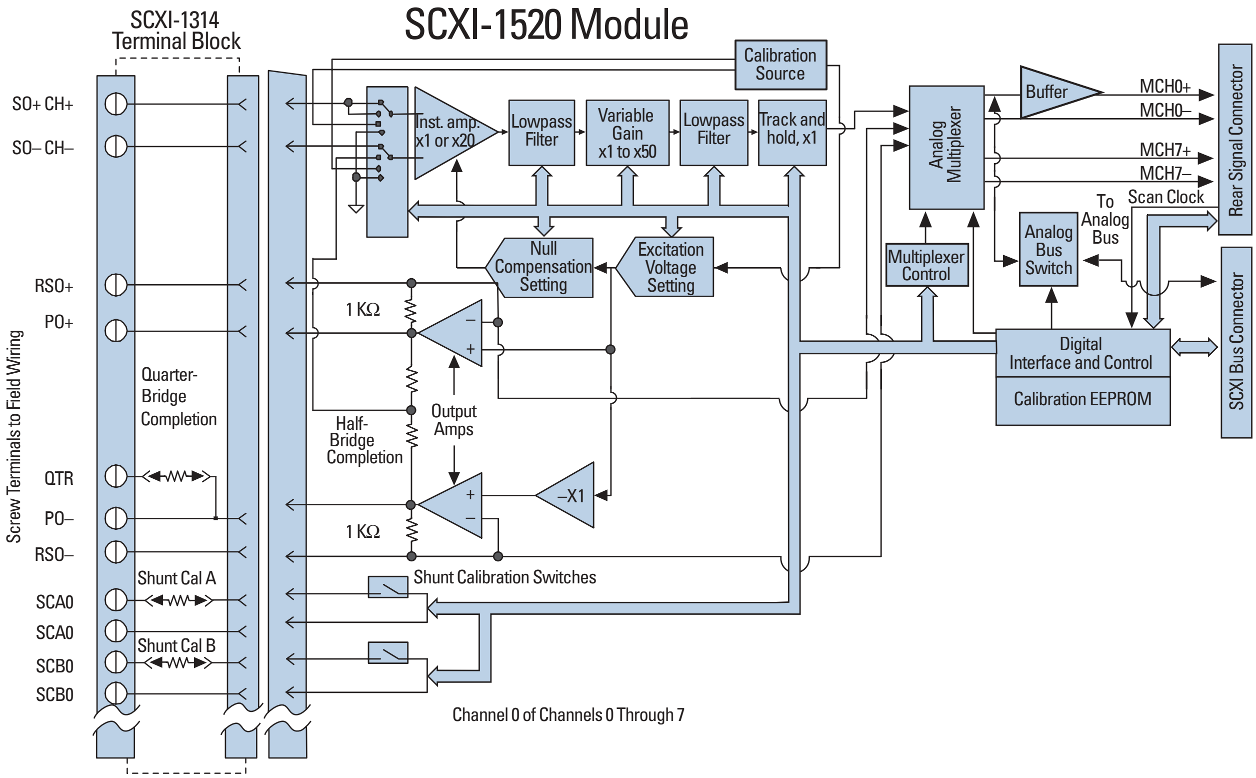

Figure 1. SCXI-1520 Block Diagram

To determine the allowable scanning rate, total the following:

- SCXI-1520 acquisition time (7 µs for 12-bit accuracy)
- SCXI system scan interval (3 µs with a PCI-MIO-16E-1) multiplied by the number of channels minus one.

For example, you can scan 16 channels of two SCXI-1520 modules with the PCI-6071 in [7+ 3(16-1)]µs = 52 µs or 19.23 kS/s.

Excitation

Each channel of the SCXI-1520 has an independent voltage excitation source. You can program each excitation channel to one of 17 voltage excitation levels from 0 to 10 V. These sources can drive a 350 Ω full bridge to the maximum 10 V level. Each excitation channel incorporates remote sensing circuitry to compensate for voltage drops due to lead resistance. This circuitry boosts the excitation level so the programmed excitation level is applied at the sensor. You can also monitor these excitation sources to detect open or fault situations.

Strain Gauge	Signal Compatibility		
	Quarter-Bridge	Half-Bridge	Full-Bridge
120 Ω	6.25 V	6.9 V	3.125 V
350 Ω	10.00 V	10.0 V	10.000 V

Table 2. Signal Compatibility

Automatic Null Compensation

Each input channel of the SCXI-1520 includes a circuit to remove bridge offset voltage. Driver software nulls the offset voltage to zero in seconds. You do not need to manually adjust a potentiometer. By removing this offset through the measurement hardware, you can increase your system gain to achieve better measurement sensitivity and resolution.

Bridge Completion

The SCXI-1520 accepts quarter, half, and full-bridge sensors. Half-bridge completion is provided in the SCXI-1520, and you can enable it through software. The RN-55 style quarter-bridge completion resistors are provided in the SCXI-1314 front-mounting terminal block. They are socketed, so you can replace them with your resistors.

Shunt Calibration

Each input channel of the SCXI-1520 includes two independent shunt calibration circuits, with which you can simulate two separate loading effects on your strain-based device and compensate for any possible gain errors. The RN-55 style shunt calibration resistors are in sockets and located in the SCXI-1314 front-mounting terminal block. You enable or disable the shunt resistors through software commands.

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Calibration

The SCXI-1520 provides simple yet powerful calibration capabilities. Each module includes a precision onboard calibration source, which you can programmatically route to any analog input channel. By using simple software commands, you perform calibrations to compensate for environmental changes without connecting external hardware. Each module has an onboard calibration EEPROM that stores calibration constants for each channel; factory calibration constants are stored in a protected area of the EEPROM. Additional user-modifiable locations mean calibration can occur under your exact operating conditions. NI-DAQ transparently uses the calibration constants to correct for gain and offset errors for each channel.

Ordering Information

SCXI-1520 777966-20

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

See page 252 to configure your complete SCXI system.

Terminal Block	Type	CJ Sensor	Compatible Modules	Cabling	Special Functions	Page
SCXI-1314 (777687-14)	Screw terminals	N	SCXI-1520 Front-mounting	–	Quarter-bridge completion	452

Table 3. Terminal Block Options for the SCXI-1520

Specifications

Typical for 25 °C unless otherwise noted

Complete Accuracy Table, Voltage

Module	Absolute Accuracy (15 to 35 °C)						Temperature Drift	
					System Noise (peak, 3 sigma)			
Module	Range	Gain	% of Reading Max	Max Offset	Single Pt.	100 Pt. Avg	Gain Drift	Offset Drift
SCXI-1520	±10.0 V	1.0	±0.1%	±3.0 mV	10.0 mV	1.0 mV	±0.03%/°C	±25 µV/°C
	±5.0 V	2.0	±0.1%	±1.5 mV	5.0 mV	0.5 µV	±0.03%/°C	±25 µV/°C
	±1.8 V	4.2	±0.1%	±0.5 mV	2.0 mV	0.2 mV	±0.03%/°C	±25 µV/°C
	±1.0 V	10.0	±0.1%	±0.3 mV	1.0 mV	0.1 mV	±0.03%/°C	±25 µV/°C
	±500.0 mV	20.0	±0.1%	±150.0 µV	0.5 mV	50.0 µV	±0.03%/°C	±5 µV/°C
	±180.0 mV	42.0	±0.1%	±75.0 µV	0.2 mV	20.0 µV	±0.03%/°C	±5 µV/°C
	±100.0 mV	100.0	±0.1%	±50.0 µV	100.0 µV	10.0 µV	±0.03%/°C	±5 µV/°C
	±50.0 mV	200.0	±0.1%	±50.0 µV	50.0 µV	5.0 µV	±0.03%/°C	±5 µV/°C
	±18.0 mV	420.0	±0.1%	±50.0 µV	20.0 µV	2.0 µV	±0.03%/°C	±5 µV/°C
	±10.0 mV	1000.0	±0.1%	±50.0 µV	20.0 µV	2.0 µV	±0.03%/°C	±5 µV/°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) x 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. Excitation is set to zero Volts.

Complete Accuracy Table, Strain, GF = 2.0, Excitation = 5 V

Module	Absolute Accuracy (15 to 35 °C)							Temperature Drift	
						System Noise (peak, 3 sigma)			
Module	Bridge	Range	Gain	% of Reading Max	Hardware Nulling Range	Single Pt.	100 Pt. Avg	Gain Drift	Offset Drift
SCXI-1520	Quarter Bridge	±40,000 µε	100	±0.1%	±80,000 µε	±40 µε	±4 µε	±0.03%/°C	±80 µe/°C
		±7,000 µε	560	±0.1%	±80,000 µε	±7 µε	±2 µε	±0.03%/°C	±16 µe/°C
		±4,000 µε	1000	±0.1%	±80,000 µε	±4 µε	±1 µε	±0.03%/°C	±8 µe/°C
	Half Bridge	±2,500 µε	1000	±0.1%	±40,000 µε	±2 µε	±0.5 µε	±0.03%/°C	±4 µe/°C
	Full Bridge	±1,250 µε	1000	±0.1%	±20,000 µε	±1 µε	±0.2 µε	±0.03%/°C	±2 µe/°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.

SCXI Universal Strain Gauge Input Module

Specifications (continued)

Analog Input Characteristics

Number of channels	8
Voltage gain settings	X1 to X1000 with the following gain settings: 1; 1.15; 1.3; 1.5; 1.8; 2; 2.2; 2.4; 2.7; 3.1; 3.6; 4.2; 5.6; 6.5; 7.5; 8.7; 10; 11.5; 13; 15; 18; 20; 22; 24; 27; 31; 36; 42; 56; 65; 75; 87;100; 115; 130; 150; 180; 200; 220; 270; 310; 360; 420; 560; 750; 870; 1,000
Input coupling	DC
Maximum working voltage	Either input should remain within ±10 V of ground. Both inputs should be within ±10 V of one another.
Overvoltage protection	±35 V powered on, ±25 V powered off
Inputs protected	<0...7>

Transfer Characteristics

Nonlinearity	Better than 0.02%
Gain error	±.35% of setting, +0.1% of EEPROM value
Offset error	
Gain>20	150 μV max
Gain<20	3 mV max

Amplifier Characteristics

Input Impedance (DC)	>1 GΩ
Input bias current	±20 nA max
Input offset current	±20 nA max

CMRR

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

Dynamic Characteristics

Scan Interval (per channel, any gain)	
±0.0125% accuracy	3 μs
±0.006% accuracy	10 μs
±0.0015% accuracy	20 μs
Noise RTI, gain=200, 0.1 to 10 Hz	2.0 μV pp
Spot noise RTI, gain=200, 1000 Hz	16 nV/√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

Hold mode settle time	1 μs typical
Interchannel skew	±50 ns maximum
Intermodule skew	±100 ns maximum
Droop rate	30 mV/s typ, 100mV/s maximum

Analog Input Stability

Recommended warm-up time	15 minutes
Gain drift:	±40 ppm/C maximum
Offset drift	
Gain>20	2 μV/˚C typical, ±5 μV/ ˚C max
Gain<20	10 μV/˚C typical, ±25 μV/ ˚C ax

Null Compensation Characteristics

Range	±4% of excitation voltage, 20,000 counts of resolution (±80,000 μe, 4 μe resolution for quarter bridge, GF = 2.0)

Excitation Characteristics

Type	constant voltage
Settings	0.0 to 10.0 V in 0.625 V increments
Error	±20 mV +.3% absolute ±0.1% of EEPROM setting
Short circuit current limit	50 mA minimum
Regulation, no load to 120 Ω	
With remote sense	±0.003%
Without remote sense	±0.08%
Drift	±0.005%/C ±30 μV/C maximum
Noise	DC to 10 kHz: 200 μV
Remote sense	Error less than ±0.02%/Ω of lead resistance
Protection	Surge arrestors in parallel with excitation terminals, shunt to ground.

Bridge Completion[1]

Half bridge	5 kΩ precision resistor network internal to module
Quarter bridge	Resistor in accessory terminal block SCXI-1314

Shunt Calibration[2]

Type	2 independent points
Resistor	in terminal block
Switch Resistance	32 Ω
Switch off Leakage	<1 nA
Switch break-down voltage	±60 VDC

Physical

Dimensions	3.0 by 17.2 by 20.3 cm (1.2 by 6.9 by 8.0 in.)

Environment

Operating temperature	0 to 50 °C
Storage temperature	-20 to 70 °C
Relative humidity	10 to 90% noncondensing

Certifications and Compliances

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

Australia & New Zealand Compliance

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

Notes
[1]Half-bridge completion is inside the module and configured under software control. Quarter-bridge completion resistor is in SCXI-1314 terminal block and socketed. Resistors shipped with SCXI-1314 are 120 Ω and 350 Ω RN-55 style (0.25 W) Tolerance is ±0.1%. Temperature coefficient is ±10 ppm/˚C maximum. [2]Shunt calibration resistors are in SCXI-1314 terminal block and socketed. Resistors shipped with SCXI-1314 are 100 kΩ RN-55 style (0.25 W) Tolerance is ±0.1%. Temperature coefficient is ±10 ppm/˚C max

Accuracy Specifications for Signal Conditioning

Every Measurement Counts

There is little room for error in your measurements. From sensor to software, your system must deliver accurate results. NI provides detailed specifications for our products so that you do not have to guess how they perform. Along with traditional specifications, our signal conditioning products include accuracy tables to assist you in selecting the appropriate hardware for your application. These tables are found on the specification pages for each product.

Absolute Accuracy

Absolute accuracy is the specification you must use to determine the overall maximum possible error of your measurement. Absolute accuracy does assume your signal conditioning equipment has been calibrated within the last year. There are four main components of an absolute accuracy specification:

- % of Reading is an uncertainty factor that is multiplied by the actual imput voltage for the measurement
- Offset is a constant value applied to all measurements
- System Noise is based on noise and depends on the number of points averaged for each measurement
- Temperature Drift is based on variations in your ambient temperature.

Absolute Acuracy RTI stands for relative to the input

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

Absolute Accuracy = (Actual Input Voltage x % of Reading)
+ Offset + System Noise + Temperature Drift

Absolute Accuracy RTI = ±(Absolute Accuracy/Actual Input Voltage)

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

Temperature Drift = ± (Actual Input Voltage x % of Reading/°C + Offset/°C)
x Temperature Difference

Below is an example for calculating the absolute accuracy for the 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 pge 262, you find the following numbers for the calculation:

Actual Input Voltage = 0.014
Percent 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

Accuracy Specifications for Signal Conditioning

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 Accuracy RTI = ±(0.00003815 / 0.014) = ±0.273 %

If you are making single-point measurements, use the Single-Point System Noise specification from the accuracy table. If you are averaging multiple points for each measurement, the value for System Noise changes. The Average System Noise provided in the accuracy table assumes that you average 100 points per measurement. If you are averaging a different number of points, use the following equation to determine your system noise:

System Noise = Average System Noise from table x SQRT(100/number of points)

For example, if you are averaging 1,000 points per measurement with the SCXI-1102 in the ±100 mV range, the system noise is determined by:

System Noise = 5 µV x SQRT (100/1000) = 1.58 µV

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. See page 194 for information on how to calculate the Absolute Accuracy RTI for your particular DAQ device.

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 described in the first example, and a PCI-MIO-16XE-50 with an Absolute Accuracy RTI of 0.00368%.

Total System Accuracy RTI = ±SQRT [(0.00273)2 + (0.00003682)] = ±0.273%

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.

For an example calculation, we want to determine the absolute system accuracy of an SCXI-1102 system with a PCI-MIO-16XE-50, 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 ±0.59%. This means the possible voltage reading is anywhere from 5.237 to 5.299 mV.
(3) Using the same thermocouple conversion table, these values represent a temperature spread of 99.4 to 100.6 °C.

Therefore, the absolute system accuracy is ±0.6 °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 below:

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

To maintain your measurement accuracy, you must calibrate your measurement device at set intervals. Calibration improves your accuracy and ensures that your end product meets its required specifications. We are continually updating the calibration services available for our products. For a current list of SCXI signal conditioning products with calibration services, please visit ***ni.com/calibration***