Analog Signal Conditioning Modules

5B Series

- For low-channel-count systems requiring isolation
- Isolated input and output modules available
- Requires module carrier (see page 346)

Solutions

- Temperature and strain measurements
- Voltage measurements from ±10 mV range to ±20 V range
- Process Control
- Design Validation

Overview

The 5B Series modules perform single-channel analog signal conditioning for National Instruments E Series and basic multifunction DAQ devices. These modules are mounted in an 8 or 16-channel backplane or the 8-channel NI SC-2311 shielded carrier for assorted signal conditioning on a channel-by-channel basis. The 5B Series provides isolation, noise rejection, and amplification for millivolt sources, volt sources, 4 to 20 mA sources, 0 to 20 mA sources, RTDs, thermocouples, strain gauges, potentiometer, and frequency inputs. Analog voltage and current output modules are also available.

5B30/31/40/41 Specifications

Output range	±5 V
Accuracy	
5B30, 5B40	±0.05% FSR ±10 µV
5B31, 5B41	±0.05% FSR ±0.2 µV
CMRR (50 or 60 Hz)	
5B30, 5B31	160 dB
5B40	100 dB
5B41	90 dB
Input offset stability	±1 µV/°C for 5B30, 5B40 ±20 µV/°C for 5B31, 5B41
Output offset stability	±20 µV/°C for SB30, SB31 ±40 µV/°C for 5B40, 5B41
Gain stability	±25 ppm/°C for 5B30, 5B40 ±50 ppm/°C for 5B31, 5B41
Power requirement	30 mA at +5 VDC

5B32 Specifications

Accuracy	±0.05% FSR
CMRR (50 or 60 Hz)	160 dB
Offset stability	±25 ppm/°C of I_z[1]
Gain stability	±25 ppm/°C
Resistor stability	±10 ppm/°C
Power requirement	30 mA at +5 VDC

[1] I_z is the nominal input current that results in a 0 V output.

Model	Input Range	Bandwidth	Part Number
5B30	±10 mV	4 Hz	776228-01
	±50 mV	4 Hz	776228-05
	±100 mV	4 Hz	776228-10
5B31	±1 V	4 Hz	776229-01
	±5 V	4 Hz	776229-05
	±10 V	4 Hz	776229-10
	±20 V	4 Hz	776229-20
5B40	±10 mV	10 kHz	776230-01
	±50 mV	10 kHz	776230-05
	±100 mV	10 kHz	776230-10
5B41	±1 V	10 kHz	776231-01
	±5 V	10 kHz	776231-05
	±10 V	10 kHz	776231-10
	±20 V	10 kHz	776231-20

Table 1. 5B30/31/40/41 Voltage Input

Input Range	Output Range	Bandwidth	Part Number
4 to 20 mA	0 to +5 V	4 Hz	776232-01
0 to 20 mA	0 to +5 V	4 Hz	776232-02

Table 2. 5B32 Process Current Input

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Sensor	Range	Part Number
100 Ω Pt*	-100 to 100 °C	776233-P1
100 Ω Pt*	0 to 100 °C	776233-P2
100 Ω Pt*	0 to 200 °C	776233-P3
100 Ω Pt*	0 to 600 °C	776233-P4
10 Ω Cu (at 0 °C)	0 to 120 °C	776233-C1
10 Ω Cu (at 25 °C)	0 to 120 °C	776233-C2
120 Ω Ni	0 to 300 °C	776233-N1

*a = 0.00385

Table 3. 5B34 RTD Input – Isolated 2 or 3-Wire RTD

Sensor	Range	Part Number
100 Ω Pt*	-100 to 100 °C	778015-01
100 Ω Pt*	0 to 100 °C	778015-02
100 Ω Pt*	0 to 200 °C	778015-03
100 Ω Pt*	0 to 600 °C	778015-04

*a = 0.00385

Table 4. 5B35 RTD Input – Isolated 4-Wire RTD

Input Range	Output Range	Part Number
0 to 100 Ω	0 to +5 V	778016-01
0 to 500 Ω	0 to +5 V	778016-02
0 to 1 kΩ	0 to +5 V	778016-03
0 to 10 kΩ	0 to +5 V	778016-04

Table 5. 5B36 Potentiometer Input

Thermocouple Type	Temperature Range	Part Number
J	-100 to 760 °C	776289-J
K	-100 to 1350 °C	776289-K
T	-100 to 400 °C	776289-T
E	0 to 900 °C	776289-E
R	0 to 1750 °C	776289-R
S	0 to 1750 °C	776289-S
B	0 to 1800 °C	776289-B

Cold junction compensation sensor not included

Table 6. 5B37 Thermocouple Input with Cold-Junction Compensation

Input	Transducer Impedance	Excitation	Sensitivity	Part Number
Full Bridge	100 Ω to 10 kΩ	3.333 V	3 mV/V	776342-01
Full Bridge	300 Ω to 10 kΩ	10 V	3 mV/V	776342-02
Half Bridge	100 Ω to 10 kΩ	3.33 V	3 mV/V	776342-03
Half Bridge	300 Ω to 10 kΩ	10 V	3 mV/V	776342-04
Full Bridge	300 Ω to 10 kΩ	10 V	2 mV/V	776342-05

Table 7. 5B38 Strain Gauge Input

5B34 Specifications

Output range........ 0 to +5 V
Bandwidth........ 4 Hz
Accuracy 2 .... ±0.05% FSR ±0.1 Ω (±0.025 Ω for 10 Ω Cu)
CMRR (50 or 60 Hz)........ 160 dB
Excitation current........ 0.25 mA (1.0 mA for 10 Ω Cu)
Input offset stability........ ±0.02 °C/°C
Output offset stability........ ±20 µV/°C
Gain stability .... ±50 ppm/°C
Power requirement........ 30 mA at +5 VDC

[2] Includes the combined effects of repeatability, hysteresis, and nonlinearity.

5B35 Specifications

Output range........ 0 to +5 V
Bandwidth........ 4 Hz
Accuracy .... ±0.05 FSR
CMRR (50 or 60 Hz)........ 190 dB
Excitation current........ 0.25 mA
Input offset stability........ ±0.01 °C/°C
Output offset stability........ ±20 mV/°C
Gain stability........ ±30 ppm/°C
Power requirement........ 15 mA at +5 VDC

5B36 Specifications

Accuracy .... ±0.08% FSR
Bandwidth........ 4 Hz
CMRR (50 or 60 Hz) .... 170 dB
Input offset stability........ ±0.004 Ω/°C ±0.010 Ω/°C (for 10 kΩ)
Output offset stability........ ±20 mV/°C
Gain stability........ ±30 ppm/°C
Excitation current........ 0.25 mA 0.1 mA (for 10 kΩ)
Power requirement........ 15 mA at +5 VDC

5B37 Specifications

Output range........ 0 to +5 V
Bandwidth........ 4 Hz
Accuracy .... ±0.05% FSR ± 10 µV + CJC sensor error
CJC sensor error........ ±0.25 °C (at 25 °C), ±0.5 °C (5 to 45 °C)
CMRR (50 or 60 Hz)........ 160 dB
Input offset stability........ ±1 µV/°C
Output offset stability........ ±20 µV/°C
Gain stability .... ±25 ppm/°C
Power requirement........ 30 mA at +5 VDC

5B38 Specifications

Output range........ ±5 V
Bandwidth........ 10 kHz
Accuracy .... ±0.08% FSR ±10 µV
CMRR (50 or 60 Hz)........ 100 dB
Input offset stability........ ±1 µV/°C
Output offset stability........ ±40 µV/°C
Gain stability .... ±25 ppm/°C
Excitation stability .... ±15 ppm/°C
Power requirement........ 200 mA at +5 VDC (full load)

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Model	Input Range	Output Range	Part Number
5B39	0 to +5 V	4 to 20 m	A776365-01
5B49	±5 V	± V	777234-02
	±10 V	±10 V	777234-05

* Analog output modules require an SC-205x Series adapter for connection to two analog output channels of a DAQ device. Only available for use with the 5B01 16-channel backplane.

*Table 8. 5B39/49 Current and Voltage Output**

Input Range	Output Range	Bandwidth	Part Number
4 to 20 mA	+1 to +5 V	100 Hz	778017-01
0 to 20 mA	+2 to +10 V	100 Hz	778017-02

Table 9. 5B42 Process Current Input with external regulated 20 VDC loop

Input Range	Output Range	Part Number
0 to 500 Hz	0 to +5 V	776977-01
0 to 1 kHz	0 to +5 V	776977-02
0 to 2.5 kHz	0 to +5 V	776977-03
0 to 5 kHz	0 to +5 V	776977-04
0 to 10 kHz	0 to +5 V	776977-05
0 to 25 kHz	0 to +5 V	776978-01
0 to 50 kHz	0 to +5 V	776978-02
0 to 100 kHz	0 to +5 V	776978-03

Table 10. 5B45/46 Frequency Input

Thermocouple Type	Temperature Range	Accuracy*	Part Number
J	0 to 760 °C	±1.1 °C	776234-J1
J	-100 to 300 °C	±0.5 °C	776234-J2
J	0 to 500 °C	±0.6 °C	776234-J3
K	0 to 1000 °C	±1.3 °C	776234-K1
K	0 to 500 °C	±0.6 °C	776234-K2
T	-100 to 400 °C	±1.4 °C	776234-T1
T	0 to 200 °C	±0.5 °C	776234-T2
E	0 to 1000 °C	±1.7 °C	776234-E
R	500 to 1750 °C	±2.5 °C	776234-R
S	500 to 1750 °C	±2.4 °C	776234-S
B	500 to 1800 °C	±5.1 °C	776234-B

* Does not include accuracy of cold-junction compensation (CJC) sensor.
Cold junction compensation sensor not included

Table 11. 5B47 Linearized Thermocouple Input with Cold-Junction Compensation

5B39/49 Specifications

Bandwidth .... 400 Hz
Accuracy .... ±0.05% FSR
CMRR .... 90 dB
Offset stability .... ±25 ppm/°C
Gain stability .... ±20 ppm/°C
Power requirement .... 170 mA at +5 VDC

5B42 Specifications

Accuracy .... ±0.05% FSR ±4 µA RTI
CMRR (50 or 60 Hz) .... 140 dB
Input offset stability .... ±0.5 µV/°C
Output offset stability .... ± 5 mV/°C
Gain stability .... ± 25 ppm/°C
Loop supply voltage .... 20 V @ 4 to 20 mA
Power requirement .... 200 mA at +5 VDC

5B45/46 Specifications

Input threshold .... TTL-level and zero crossing
Input voltage (pk-pk) .... 60 V max, 100 mV min
Minimum pulsewidth .... 4 µs
Accuracy .... ± 0.05% FSR
CMRR (50 or 60 Hz) .... 120 dB
Offset stability .... ±40 ppm/°C
Gain stability .... ±40 ppm/°C
Power requirement .... 110 mA at +5 VDC

5B47 Specifications

Output range .... 0 to +5 V
Bandwidth .... 4 Hz
CJC sensor error .... ±0.25 °C (at 25 °C), ±0.5 °C (5° to 45 °C)
CMRR (50 or 60 Hz) .... 160 dB
Input offset stability .... ±1 mV/°C
Output offset stability .... ±20 mV/°C
Gain stability .... ±25 ppm/°C
Power requirement .... 30 mA at +5 VDC

Common Module Specifications

Nonlinearity .... ±0.02% FSR
Common-mode voltage isolation
Input to output, continuous .... 1,500 V_{rms} maximum
Normal-mode input protection .... 240 V_{rms}, continuous
Transient protection .... Meets IEEE STD 472 (SWC)
Module power .... +5 VDC
Hold down .... Captive, metric screw
Packaging .... Hard potted in plastic case
Module size .... 5.7 by 5.7 by 1.5 cm (2.25 by 2.25 by 0.60 in.)
Operating temperature .... -25 to 85 °C

Certifications and Compliances

CE Mark Compliance CE

This product meets applicable EU directive(s) as follows:
Safety isolation .... Low voltage directive EN 61010
EMC Directive
Immunity .... EN 50082-1:1994
Emissions .... EN 55011:1991 Group I Class A at 10 m

Carriers/Backplanes for 5B Series

Overview

5B Series modules must be installed in a carrier or backplane, for a power source as well as for connectivity to both the raw signals and the DAQ device. The NI SC-2311 shielded carrier cables directly to an E Series device and offers a variety of connectivity options to signals and sensors. The SC-2311 is ideal for analog input applications because of its shielding. For analog output signal applications, you must use a 5B Series Backplane.

Ordering Information

NI SC-2311

U.S. 120 VAC	778192-01
Universal Euro 240 VAC	778192-04
United Kingdom 240 VAC	778192-06
Japan 100 VAC	778192-07

For ordering information on panelettes, see page 468

Backplane/Accessories

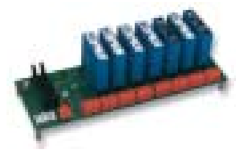
5B Series Backplanes, (without cables)	
5B08, 8-channel	777309-91
5B01, 16-channel	776291-91
5B01 Rack-mount accessory	776236-01
CA-1000 Rack Mount Kit (2U)	187374-01
Power supplies, +5 VDC, 1 A	
115 VAC source	776237-01
220 VAC source	776237-31
±5 VDC, 5 A	
85 to 250 VAC	776237-35

Cables

NB7 (5B to SC-205x)	
20 cm	180924-02
40 cm	180924-04
NB9 (5B to 50-pin MIO)	
1 m	180555-10
68F-50M MIO adapter	183139-01

SC-2311 Shielded Carrier

- Holds up to 8 5B Series analog input modules and up to 8 SSR Series digital conditioning modules
- Cables directly to your E Series or basic multifunction DAQ device
- Custom connectivity options via panelettes
- Rack-mount accessory available
- 120/240 VAC power options



The SC-2311 is a shielded carrier that holds up to eight 5B analog input signal conditioning modules and eight SSR digital signal conditioning modules. Modules are installed vertically into the SC-2311, which makes it easy to remove or replace modules. The SC-2311 includes its own power supply.

The SC-2311 includes a user-configurable signal connection and interface scheme using panelettes. You can mount up to 18 panelettes, choosing different types of panelettes, including BNC, SMB, LEMO (B-Series), MIL-Spec, banana jack, thermocouple jack, 9-pin D-Sub connectors, rocker switches, toggle switches, momentary switches, potentiometers, and LEDs. You can connect each panelette to any I/O signal available in the SC-2311.

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

sc2311
5b

BUY ONLINE!

5B Series Backplanes

For applications requiring analog output conditioning modules, choose an 8-channel or 16-channel backplane.

You must provide power to the 5B Series backplanes from a 5 VDC power supply, available from NI. An optional rack-mount bracket is available for these backplanes, and it includes a space for a power supply.

		5B 8-Channel and 16-Channel Backplanes	
DAQ Device	SC-2311 Shielded Carrier	Direct Cabling (used with input modules only)	Using SC-205x Adapter
68-pin E Series (except DAQCards)	SH68-68-EP	68F-50M MIO adapter and NB9 cable	Page 349
100-pin E Series	SH1006868	SH1006868, 68F-50M MIO adapter and NB9 cable	Page 349
Latching E Series DAQCards: 6062E, 6024E	SHC6868-EP	Not Available	Page 349
Nonlatching E Series DAQCards: AI-16E-4, AI-16XE-50	PSHR68-68 Shielded Cable Kit	PSHR68-68M, 68F-50M MIO adapter and NB9 cable	Page 349

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***