SCC-RTD01 Resistance Temperature Detector Input Module User Guide

The SCC-RTD01 resistance temperature detector (RTD) input module accepts up to two RTD input signals from 2-, 3-, or 4-wire RTDs of the following types:

- Pt100 (–100 to 850 °C), α = 0.00385 or 0.00392
- Ni120 (–80 to 320 °C)
- Cu10 (0 to 260 °C)

The SCC-RTD01 filters RTD inputs and passes them through a differential amplifier with a fixed gain of 25 resulting in a maximum input voltage of 400 mVDC. The output of the amplifier passes through a three-pole, 30 Hz Butterworth lowpass filter. The SCC-RTD01 provides a 1 mA excitation current source for RTDs.

Conventions

The following conventions are used in this guide:

This icon denotes a note, which alerts you to important information.

This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash. When this symbol is marked on the product, refer to the *Read Me First: Safety and Radio-Frequency Interference* document, shipped with the product, for precautions to take.

» The » symbol leads you through nested menu items and dialog box options to a final action. The sequence **File»Page Setup»Options** directs you to pull down the **File** menu, select the **Page Setup** item, and select **Options** from the last dialog box.

bold Bold text denotes items that you must select in software, such as menu items and dialog box options. Bold text also denotes parameter names.

italic Italic text denotes variables, emphasis, a cross reference, or an introduction to a key concept. This font also denotes text that is a placeholder for a word or value that you must supply.

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NATIONAL INSTRUMENTS

`monospace`	Text in this font denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames and extensions, and code excerpts.
SC-2345	SC-2345 refers to both the SC-2345 connector block and the SC-2345 with configurable connectors.
SCC	SCC refers to any SCC Series signal conditioning module.

What You Need to Get Started

To set up and use the SCC-RTD01, you need the following items:

- ❑ SC-2345 with one of the following:
  - SCC-PWR01
  - SCC-PWR02 and the PS01 power supply
  - SCC-PWR03 (requires a 7 to 42 VDC power supply, not included)
- ❑ One or more SCC-RTD01 modules
- ❑ *Read Me First: Safety and Radio-Frequency Interference*
- ❑ *SCC-RTD01 Resistance Temperature Detector Input Module User Guide*
- ❑ *SC-2345 User Manual*
- ❑ SC-2345 Quick Reference Label
- ❑ 68-pin E Series data acquisition (DAQ) device, documentation, and 68-pin cable
- ❑ 1/8 in. flathead screwdriver
- ❑ Numbers 1 and 2 Phillips screwdrivers
- ❑ Wire insulation strippers
- ❑ NI-DAQ (current version) for Windows 2000/NT/XP/Me/9*x*

If you do not have the current version of NI-DAQ or one of the documents, you can download them from the National Instruments Web site at `ni.com` or contact an NI sales representative.

Note Software scaling of measurements is not supported on the Mac OS. Refer to the *Converting Voltage Measurements to Temperature Measurements* section for information about software scaling.

Unpacking the Module

SCC modules are shipped in antistatic envelopes to prevent electrostatic damage to the modules. Electrostatic discharge (ESD) can damage several components on these products.

Caution *Never* touch the exposed pins of connectors.

To avoid damage from ESD when you handle the module, take the following precautions:

- Ground yourself by using a grounding strap or by touching a grounded object.
- Touch the antistatic envelope to a metal part of the computer chassis before removing the module from the packaging.

Remove the module from the envelope and inspect the module for loose components or any sign of damage. Notify NI if the module appears damaged in any way. Do *not* install a damaged module.

Store the module in the antistatic envelope when it is not in use.

Installing the Module

Caution Refer to the *Read Me First: Safety and Radio-Frequency Interference* document before removing equipment covers or connecting/disconnecting any signal wires.

A blue stripe on the label identifies the SCC-RTD01 as an analog input (AI) module. The label also displays the icon shown in Figure 1.

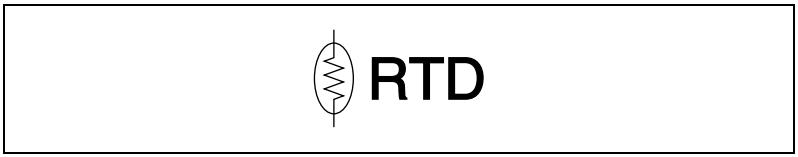


Figure 1. SCC-RTD01 Icon

You can plug the SCC-RTD01 into any AI socket on the SC-2345. The SCC-RTD01 can function as a single-stage module or as the first stage of a dual-stage signal conditioning configuration. The socket you choose

determines which E Series DAQ device channels receive the SCC-RTD01 signals, as explained in the *Connecting the Input Signals* section.

Note NI-DAQ versions 6.9.*x* and Measurement & Automation Explorer (MAX) 2.*x* do not support the SCC-RTD01 in a dual-stage configuration.

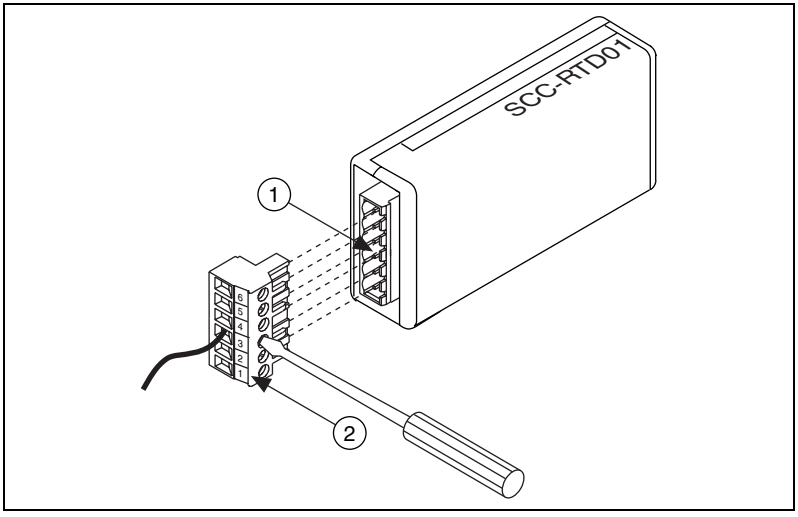
For single-stage input conditioning, plug the SCC-RTD01 into any socket J(*X*+1), where *X* is 0 to 7, and connect the input signals to the module as described in the *Connecting the Input Signals* section.

If you use the SCC-RTD01 in a dual-stage configuration, the SCC-RTD01 must be the first stage. Plug the SCC-RTD01 into any socket J(*X*+9) and plug the second-stage SCC into socket J(*X*+1), where *X* is 0 to 7. Connect the input signals to the SCC-RTD01 as described in the *Connecting the Input Signals* section. The SC-2345 connects the output signals of the first-stage SCC to the inputs of the second-stage SCC. An example of dual-stage conditioning is an SCC-AI*XX* isolated analog input module followed by an SCC-LP*XX* lowpass filter module.

Note Refer to the *SC-2345 User Manual* for more information on single-stage and dual-stage signal conditioning and configuration.

Connecting the Input Signals

The SCC has a fixed screw-terminal receptacle and a removable screw-terminal block, as shown in Figure 2.



1 SCC Screw-Terminal Receptacle 2 Removable Screw-Terminal Block

Figure 2. SCC-RTD01 Two-Part Screw-Terminal System

After you install the SCC-RTD01, attach the input signals to the screw terminals of the module.

1. Remove power from the signal lines.
2. Strip 7 mm (0.28 in.) of insulation from the ends of the signal wires.
3. Insert the wires into the screw terminals.
4. Tighten the screws to 0.5 to 0.6 N · m (4.4 to 5.3 lb · in.) of torque.

The SCC-RTD01 has six pins and provides two differential AI channels for measuring the voltage across RTDs. Pins 1 and 2 form a differential channel routed to E Series DAQ device channel *X*+8, and pins 3 and 4 form a second differential channel routed to E Series DAQ device channel *X*, where *X* is 0 to 7 depending on the socket of the SCC-RTD01. Pins 5 and 6 carry the 1 mA constant-current excitation source.

Refer to the *I/O Connector Pin Assignments* section for information on how the I/O pins on the bottom of the SCC-RTD01 correspond to signals on the E Series DAQ device.

Signal sources can be floating or ground-referenced. The SCC-RTD01 has high-impedance bias resistors typically required for floating sources. Therefore, floating signal sources do not require external bias resistors connected to ground.

Note For floating signal sources in high-noise environments, connect the negative terminal of the signal source to the AISENSE terminal on the SC-2345 screw-terminal block to reduce common-mode noise.

You can connect one or two RTDs to the SCC-RTD01 in 2-, 3-, and 4-wire configurations. Figure 3 contains wiring diagrams for connecting one 2-, 3-, or 4-wire RTD to the SCC-RTD01.

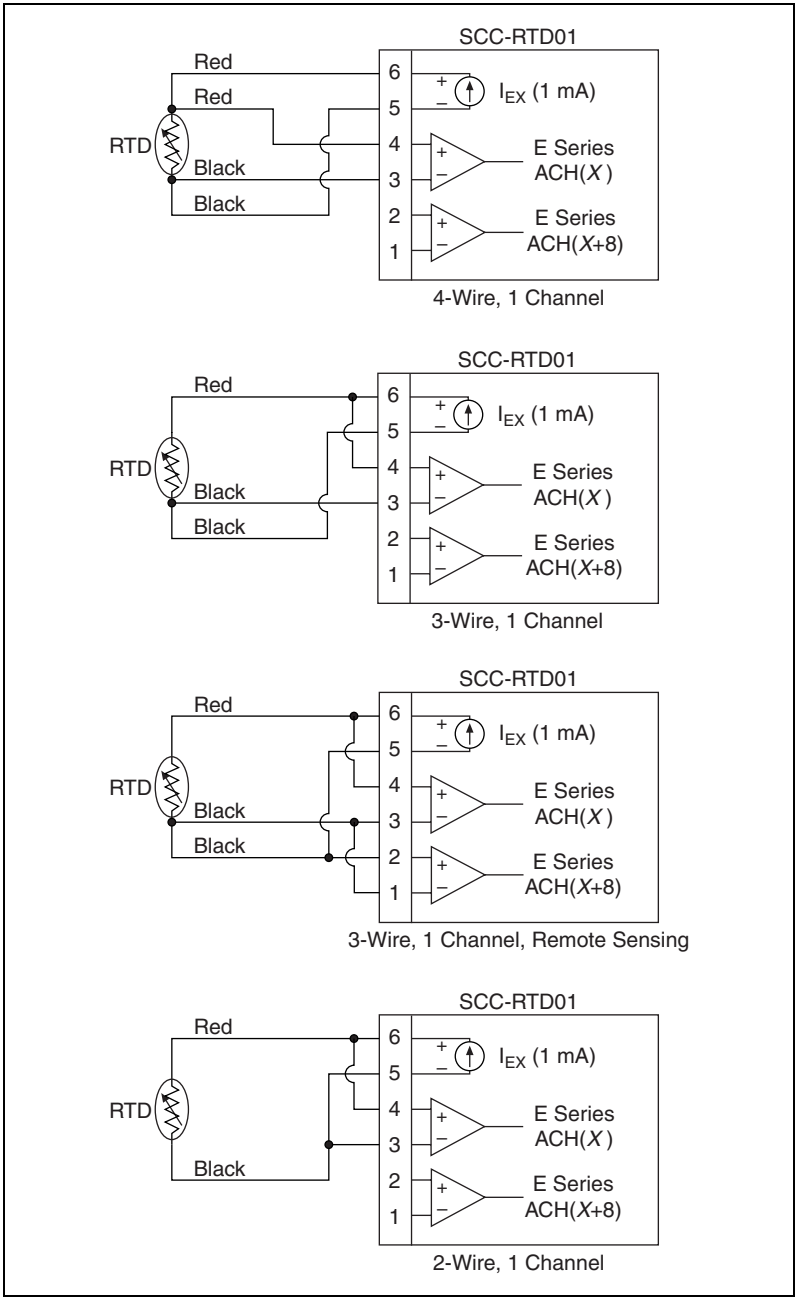


Figure 3. SCC-RTD01 Single-Channel Wiring Diagrams

Figure 4 contains wiring diagrams for connecting two 2-, 3-, or 4-wire RTDs to the SCC-RTD01.

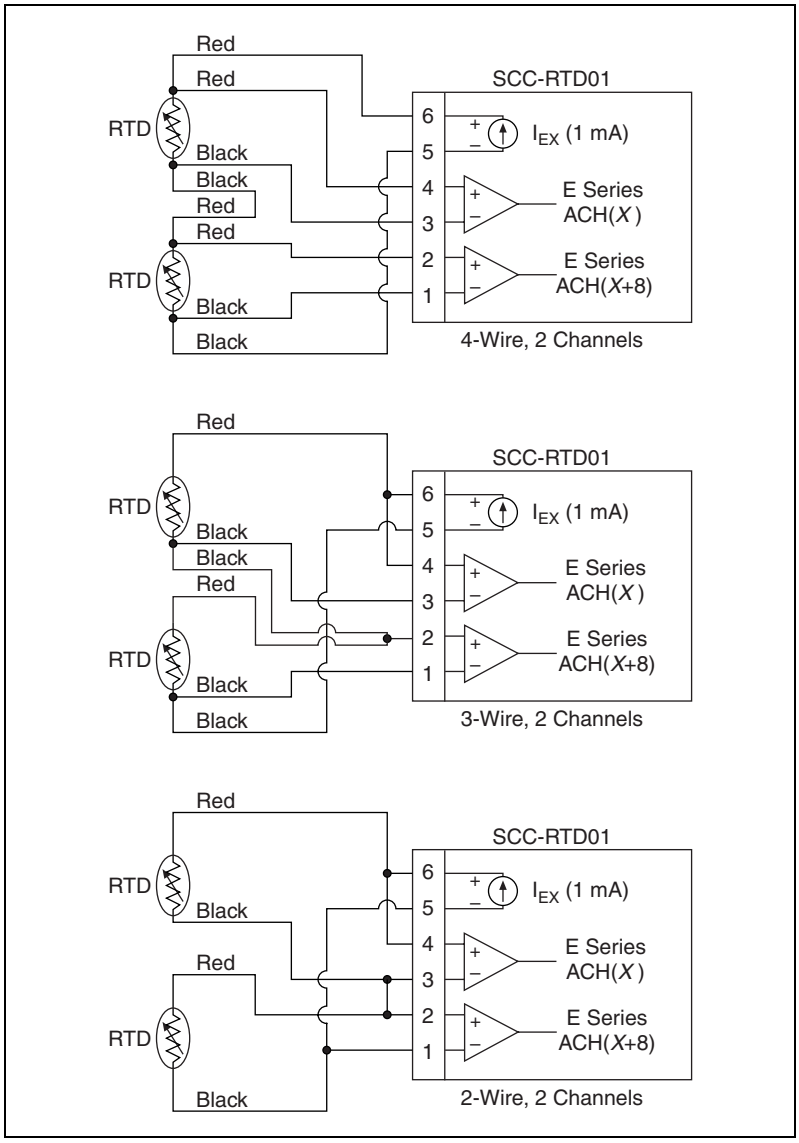


Figure 4. SCC-RTD01 Two-Channel Wiring Diagrams

Note Use 4-wire transducer connections for a more accurate measurement. Lead resistance in 2- and 3-wire connections can introduce measurement errors.

Configuring the SCC System

Run MAX to configure the SCC system. Complete the following steps:

1. Launch **Measurement & Automation Explorer**.
2. Expand **Devices and Interfaces**.
3. Right-click the E Series DAQ device connected to the SC-2345 and select **Properties**.
4. Select the **Accessory** tab.
5. Under **Accessory:**, select **SC-2345**.
6. Click **Configure**. A new window appears listing the sockets (connector reference designators) of the SC-2345.
7. Select the SC-2345 socket where you installed an SCC.
8. Click **Add** and select the SCC you installed. If the module name does not appear in the list, either the module is not allowed in that location or you do not have the current version of NI-DAQ.
9. If you make a selection mistake, select the socket and click **Remove**.
10. Repeat steps 7 and 8 for each newly installed SCC.
11. Click **OK** after completing all SCC entries.
12. Click **OK** to complete the configuration process and close MAX.

Note When you configure the SCC system using MAX, you automatically set the E Series DAQ device AI mode to nonreferenced single-ended. If you configure DIO SCC modules, the individual DIO lines are automatically set to the appropriate direction, input or output.

Converting Voltage Measurements to Temperature Measurements

If you use MAX to configure the SCC-RTD01, the reading you get from the E Series DAQ device is properly scaled. Otherwise, you must scale the readings and convert the voltage measurement to temperature by performing the following steps:

1. Measure the RTD voltage.
   a. Read the RTD channel on the E Series DAQ device and call the value $V_{ESERIES}$[CH(X)].
   b. Calculate the RTD voltage using the following formula:

$$V_{RTD} = \frac{V_{ESERIES}}{25}$$

   where

   V_{RTD} is the SCC-RTD01 input voltage.

   $V_{ESERIES}$ is the E Series DAQ device voltage.

2. Use polynomial expressions or a conversion table to convert the RTD voltage to temperature.

Note NI programming environments include RTD conversion utilities that implement the voltage-to-temperature conversions. Refer to the software documentation for more information on these utilities.

Although the RTD resistance-versus-temperature curve is relatively linear, accurately converting resistance to temperature requires curve fitting. The Callendar-Van Dusen equation is commonly used to approximate the RTD curve:

$$R_t = R_0[1 + At + Bt^2 + C(t - 100)^3]$$

where

R_t is the resistance of the RTD at temperature t.

R_0 is the resistance of the RTD at 0 °C.

A, B, and C are the Callendar-Van Dusen coefficients shown in Table 1.

t is the temperature in °C.

Table 1. Callendar-Van Dusen Coefficients for Platinum RTDs

Standard	Temperature Coefficient	A	B	C
DIN 43760	0.003850	3.9080×10^{-3}	-5.8019×10^{-7}	-4.2735×10^{-12}
American	0.003911	3.9692×10^{-3}	-5.8495×10^{-7}	-4.3235×10^{-12}
ITS-90	0.003926	3.9848×10^{-3}	-5.870×10^{-7}	-4.0000×10^{-12}

For temperatures above 0 °C, the C coefficient equals 0. Therefore, for temperatures above 0 °C, this equation reduces to a quadratic. If you pass a known current, I_{EX}, through the RTD and measure the voltage developed across the RTD, V_0, you can use the following formula to solve for t:

$$t = \frac{2(V_0 - I_{EX}R_0)}{I_{EX}R_0[A + \sqrt{A^2 + (4B(V_0 - I_{EX}R_0))/(I_{EX}R_0)}]}$$

where

V_0 is the measured RTD voltage.

I_{EX} is the excitation current.

Most platinum RTD curves conform to one of the following three standardized curves:

- DIN 43760 standard
- U.S. Industrial or American standard
- International Temperature Scale (ITS)–90 (for use with wire-wound RTDs)

Specifications

These ratings are typical at 25 °C unless otherwise stated.

Analog Input

Number of input channels.....2 differential

Input range.....±400 mVDC (fixed gain of 25 on each channel)

Overvoltage protection.....±42 VDC powered on
±25 VDC powered off

Input impedance
Normal powered on.....2 MΩ in parallel with 4.7 nF
Powered off.....20 kΩ min
Overload.....20 kΩ min

Filter type.....3-pole Butterworth lowpass filter
–3 dB cutoff frequency.....30 Hz

System noise.....4.5 μV_{rms} (referred to the input [RTI][1])

Transfer Characteristics

Gain.....25

Gain error.....±1.2%

Gain-error temperature coefficient.....±10 ppm/°C

Offset error.....±250 µV (RTI)

Offset-error temperature coefficient.....±1.6 µV/°C

[1] Calculated relative to the input range of the module

Nonlinearity ..... 10 ppm of full scale

Recommended warm-up time ..... 5 minutes

Amplifier Characteristics

Common-mode rejection ratio ..... 110 dB at 60 Hz

Output range..... ±10 V

Excitation

Number of channels 1

Constant-current source ..... 1 mA, ± 0.4 µA or 0.04%

Maximum voltage level
without regulation loss ..... 24 V

Drift..... ±127 ppm/°C

Power Requirement

Analog power..... 135 mW max
+15 V ..... 4.5 mA max
–15 V..... 4.5 mA max

Digital power..... 153 mW max
+5 V ..... 30.6 mA max

Physical

Dimensions..... 8.89 by 2.92 by 1.85 cm
(3.50 by 1.15 by 0.73 in.)

I/O connectors ..... 20-pin right-angle
male connector,
6-pin screw terminal

Field-wiring diameter..... 28 to 16 AWG

Maximum Working Voltage

Maximum working voltage
(signal plus common mode)..... Each input should remain within
±12 V of ground

Environmental

Operating temperature .....0 to 50 °C

Storage temperature .....–20 to 70 °C

Humidity .....5 to 90% relative humidity, noncondensing

Maximum altitude.....2,000 m

Pollution Degree (indoor use only) 2

Safety

This product is designed to meet the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use:

- EN 61010-1, IEC 61010-1
- UL 3111-1
- CAN/CSA C22.2 No. 1010.1

Note For UL and other safety certifications, refer to the product label or to `ni.com`.

Electromagnetic Compatibility

Emissions.....EN 55011 Class A at 10 m
FCC Part 15A above 1 GHz

Immunity .....Evaluated to EN 61326-1: 1997+A1:1998, Table 1

CE, C-Tick, and FCC Part 15 (Class A) Compliant

Note For EMC compliance, operate this device with shielded cabling.

CE Compliance

This product meets the essential requirements of applicable European directives, as amended for CE Marking, as follows:

Low-Voltage Directive (safety).....73/23/EEC

Electromagnetic Compatibility Directive (EMC) 89/336/EEC

Note Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain the DoC for this product, click **Declarations of Conformity Information** at `ni.com/hardref.nsf`.

I/O Connector Pin Assignments

Figure 5 shows the I/O connector pins on the bottom of the module.

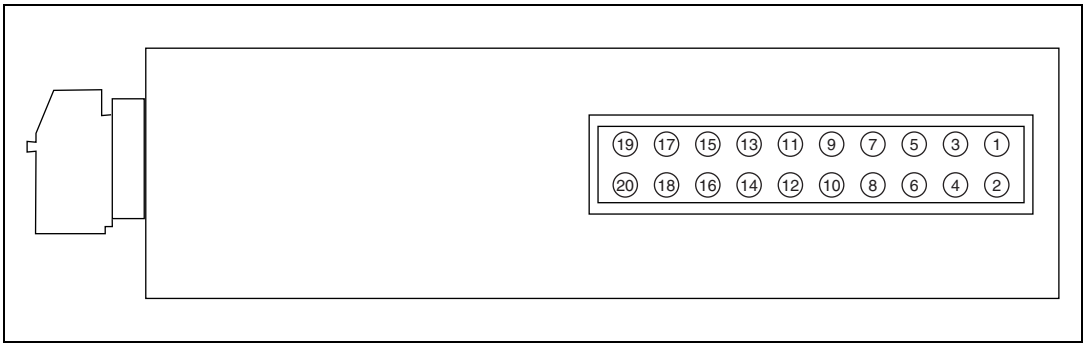


Figure 5. SCC Module Bottom View

Table 2 lists the signal connection corresponding to each pin. ACH(*X*) and ACH(*X*+8) are the AI signal channels of the E Series DAQ device. AIGND is the AI ground signal and is the reference for ACH(*X*) and ACH(*X*+8). AGND is the reference for the ±15 V supplies and REF5V. AIGND and AGND connect to the SC-2345 at the SCC-PWR connector. GND is the reference for the +5 V supply.

Table 2. SCC-RTD01 Pin Signal Connections

Pin Number	Signal
1	E Series ACH(*X*)
2	—
3	—
4	E Series ACH(*X*+8)
5	—
6	AIGND
7	—
8	—
9	+5V

Table 2. SCC-RTD01 Pin Signal Connections (Continued)

Pin Number	Signal
10	GND
11	AGND
12	—
13	+15V
14	–15V
15	—
16	—
17	—
18	—
19	—
20	—