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USER GUIDE

SCC-TC Series Thermocouple Input Modules

The SCC-TC Series thermocouple input modules, SCC-TC01 and SCC-TC02, accept input signals from B-, E-, J-, K-, N-, R-, S-, and T-type thermocouples. Each module contains thermistor circuitry powered by 2.5 V, to compensate for cold-junction effects and can detect open thermocouple circuits. Each module has one thermocouple input channel, which consists of a gain of 100 differential amplifier and a dual-pole 2 Hz filter.

Note Alternatively, you can use the SCC-TC02 as a 2 Hz lowpass bandwidth ±100 mV input module.

Conventions

The following conventions are used in this guide:

» 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.

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.

When symbol is marked on a product, it denotes a warning advising you to take precautions to avoid electrical shock.

When symbol is marked on a product, it denotes a component that may be hot. Touching this component may result in bodily injury.

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bold	Bold text denotes items that you must select in the 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. Italic text also denotes text that is a placeholder for a word or value that you must supply.
`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.
SC-2345	SC-2345 refers to both the SC-2345 connector block and the SC-2345 configurable connector.
SCC	SCC refers to any SCC series signal conditioning module.

What You Need to Get Started

To set up and use the SCC-TC0*X*, you need the following items:

- ❑ Hardware
  - SCC-68

    or
  - SC-2345/2350 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-0*X*
  - 68-pin E/M Series DAQ device
  - 68-pin cable
  - Quick Reference Label
- ❑ Software
  - The latest version of NI-DAQmx

- ❑ Documentation
  - – One of the following:
    - • *SC-2345/2350 User Manual*
    - • *SCC-68 User Guide*
  - – *SCC-TC Series Thermocouple Input Modules User Guide*
  - – *Read Me First: Safety and Radio-Frequency Interference*
  - – *SCC Quick Start Guide*
- ❑ Tools
  - – 1/8 in. flathead screwdriver
  - – Numbers 1 and 2 Phillips screwdrivers
  - – Wire insulation strippers

You can download needed documents from `ni.com/manuals`.

Note Software scaling of measurements is not supported on the Macintosh operating system. Refer to the *Scaling Voltage Measurements* section for more information about measurement scaling.

Device Specific Information

Note For general SCC module installation and signal connection information, and information about the SC-2345 or SC-2350 carriers, refer to the *SCC Quick Start Guide*.

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.

You can plug the SCC-TC0*X* into any analog input socket on the SCC carrier. The socket you select determines which E/M Series DAQ device channels receive the SCC-TC0*X* signals.

For single-stage input conditioning, plug the SCC-TC0*X* 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-TC0*X* in a dual-stage configuration, the SCC-TC0*X* must be the first-stage module. Plug it 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 SCC-TC0*X* 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 in an SCC-TC0*X* followed by an SCC-LP01 lowpass filter module.

Sockets J9 to J16 also are available for digital input/output (DIO) conditioning or control. Refer to the *SC-2345/2350 User Manual* for more information on configuring, connecting, and installing SCC modules

Note SCC-TC0*X* dual-stage configuration is only available in NI-DAQmx 7.1 or later.

Connecting the Input Signals

Note The signal names have changed. Refer to `ni.com/info` and enter `rdtntg` to confirm the signal names.

The SCC-TC01 has a two-prong uncompensated thermocouple miniconnector that accepts any miniature or subminiature two-prong male thermocouple connector. The SCC-TC02 has a three-position screw-terminal connector that accepts 28 to 16 AWG thermocouple wires. The screw-terminal connector provides a ground connection for shielded thermocouples. Otherwise, the two modules function identically.

To use an SCC-TC01, plug the male thermocouple connector into the module.

The SCC-TC02 accepts up to three signals: TC+, TC–, and GND. TC+ is the positive thermocouple lead and TC– is the negative thermocouple lead.[1] The GND terminal connects to AI GND on the E/M Series DAQ device.

The SCC-TC0*X* has a 10 MΩ bias resistor connected from the negative thermocouple input to ground. This resistor allows the thermocouple to be ground-referenced or floating without requiring external bias resistors connected to ground.

The amplified thermocouple signal and cold-junction sensor signal are measured by E/M Series DAQ device channel *X* and channel *X*+8 respectively, where *X* is 0 to 7 depending on where you plug the SCC-TC0*X*. Refer to Figure 1 for SCC-TC0*X* signal connections.

[1] For ANSI color-coded J-type thermocouples, the red wire is negative and the white wire is positive. Refer to the thermocouple data sheet if possible. You can find information about other color-coding schemes in the NI KnowledgeBase at `ni.com/support`.

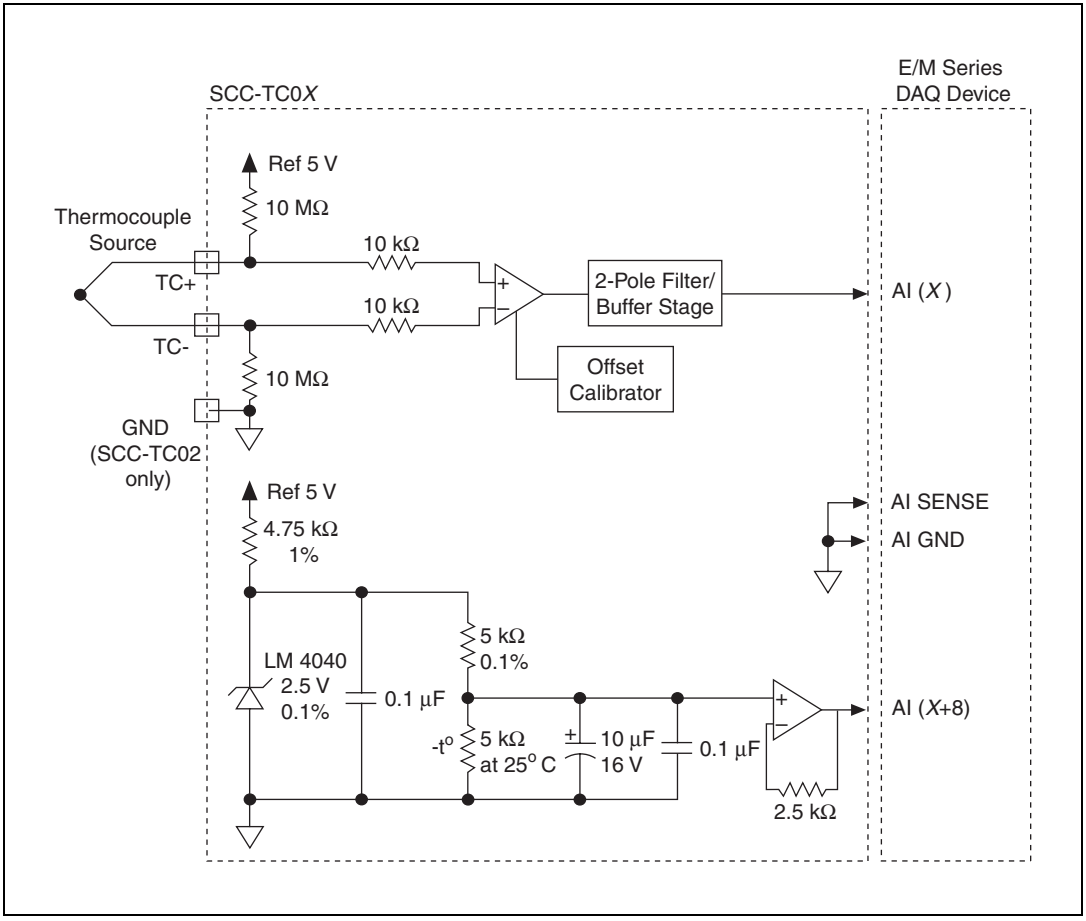


Figure 1. SCC-TC0*X* Signal Connections

For more information about how to configure the SCC-TC0*X* module using NI-DAQmx, refer to the *SCC Quick Start Guid*e.

Using the TC0*X*

Scaling Voltage Measurements

Note NI-DAQmx includes thermocouple and thermistor conversion utilities that implement the conversions required in steps 3 and 5 of the following procedure. Refer to your software documentation for more information on these utilities.

Your software environment may return only voltage measurements from E/M Series DAQ devices. If so, you must convert voltage measurements to

temperature measurements. To make this conversion, complete the following steps:

1. Measure the thermocouple voltage.
   a. Read the thermocouple channel on the E/M Series DAQ device $V_{ESERIES}$ [CH(*X*)].
   b. Calculate the thermocouple voltage by using the following formula:

$$V_{TC} = \frac{V_{ESERIES}}{100}$$

   where

   V_{TC} is thermocouple voltage.

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

   This step provides proper scaling for the thermocouple amplifier in the SCC-TC0*X*.
2. Measure the reference-junction (cold-junction) temperature.
   a. Read the thermistor voltage [AI (*X*+8)].
   b. Convert the thermistor voltage to cold-junction temperature using the formula in the *Cold-Junction Sensor* section.
3. Calculate the cold-junction compensation voltage by converting the cold-junction temperature from step 2 to a thermocouple voltage. Use the polynomial expressions applicable to the type of thermocouple you are using.
4. Apply the cold-junction compensation to the thermocouple reading by adding the cold-junction compensation voltage from step 3 to V_{TC}.
5. Calculate the thermocouple temperature by converting the voltage result from step 4 to a temperature. Use the polynomial expressions applicable to the type of thermocouple you are using. This calculation gives you a linearized temperature measurement.

Note Polynomials are from NIST Monograph 175.

Uncompensated Connectors and Accuracy

If you are using an SCC-TC02 with an uncompensated SCC panelette, temperature gradients between the module and the junctions on the panelette affect the accuracy of the measurements.

Detecting Open Thermocouples

The SCC-TC0*X* contains a 10 MΩ pull-up resistor that connects to +5 V to detect open thermocouples. To determine if you have an open thermocouple, check whether the corresponding E/M Series DAQ device channel is saturated. The pull-up and bias resistors saturate the channel by applying +2.5 V at the input of an open channel. This results in saturation to either the positive or negative rails of the EM Series DAQ device (±10 V).

Errors Due to Open-Thermocouple Detection Circuitry

The open-thermocouple detection circuitry can cause measurement errors. These errors are the results of common-mode voltage at the input of the SCC and current leakage into the signal leads. The 10 MΩ bias resistor in the SCC-TC0*X* causes this error to be negligible. With the 10 MΩ bias resistor connected to ground and the 10 MΩ pull-up resistor connected to +5 VDC, a current leakage of approximately 0.25 μA (5 V/20 MΩ) flows into the unbroken floating thermocouple. Long thermocouple leads result in larger voltage drops due to lead resistance.

For example, if you have a 24 AWG J-type thermocouple that is 20 ft long, a voltage drop of approximately

$$4\ \mu V = (0.145\ \Omega/ft + 0.658\ \Omega/ft) \times 20\ ft \times 0.25\ \mu A$$

can develop in the thermocouple, which corresponds to an error of 0.09 °C.

With 10 MΩ pull-up and bias resistors, a common-mode voltage of +2.5 VDC develops if the thermocouple is floating. The common-mode rejection of the SCC-TC0*X* is sufficiently high, which results in the offset voltage being negligible in most applications.

If your application demands extremely high accuracy, you can eliminate these errors by calibrating the system. Refer to the *Calibrating the SCC-TC0X Using a Thermocouple Calibrator* section for more information.

Cold-Junction Sensor

The cold-junction sensor voltage output varies from 1.91 to 0.58 V over a 0 to 55 °C temperature range.

Note NI-DAQmx includes thermistor conversion utilities that implement the equations listed below. Refer to your software documentation for more information on these utilities.

You can use the following formulas to convert the cold-junction sensor voltage to cold-junction temperature:

$$T(°\mathrm{C}) = T_K - 273.15$$

where T_K is the temperature in degrees kelvin.

$$T_K = \frac{1}{[a + b(\ln R_T) + c(\ln R_T)^3]}$$

where

$a = 1.295361 \times 10^{-3}$

$b = 2.343159 \times 10^{-4}$

$c = 1.018703 \times 10^{-7}$

R_T is the resistance of the thermistor in ohms.

$$R_T = 5{,}000\left(\frac{V_{TEMPOUT}}{2.5 - V_{TEMPOUT}}\right)$$

where $V_{TEMPOUT}$ is the output voltage of the cold-junction sensor.

$$T(°\mathrm{F}) = \frac{[T(°\mathrm{C})]9}{5} + 32$$

where T(°F) and T(°C) are the temperature readings in degrees Fahrenheit and Celsius, respectively.

Note $V_{TEMPOUT}$ varies from 1.91 V (at 0 °C) to 0.58 V (at 55 °C). For best resolution, use the maximum gain for this range on the analog input channel.

For the cold-junction sensor measurement accuracy, refer to the *Specifications* section.

For more information about how to configure the SCC-TC0*X* using NI-DAQmx, refer to the *SCC Quick Start Guide*.

Calibrating System Offsets

To calibrate the offset voltage of the SCC-TC0*X* in the system using the E/M Series DAQ device, complete the following steps. The E/M Series DAQ device must be powered for 30 minutes before you calibrate the offset voltage.

1. Select the desired channel and gain on the E/M Series DAQ device.
2. Short the inputs on the SCC-TC0*X* screw terminals or miniplug.
3. While acquiring data on the selected channel, use a screwdriver to adjust the potentiometer protruding through the top of the module until you read 0 VDC.

Calibrating the SCC-TC0*X* Using a Thermocouple Calibrator

To calibrate the system using a thermocouple calibrator, complete the following steps:

1. Make sure that the thermocouple connections at both the SCC and the thermocouple calibrator are at the same temperature.
2. Connect the thermocouple calibrator to the SCC-TC0*X*. For best results, use thermocouple wire of the same length and type that you use in the thermocouple.
3. Set the thermocouple calibrator to the required calibration temperature.
4. Measure the calibrator voltage using the SCC-TC0*X*.
5. Convert the measured calibrator voltage to a temperature measurement as described in the *Scaling Voltage Measurements* section.
6. Adjust the potentiometer on the top of the SCC-TC0*X* so that the measured temperature is equal to the calibration temperature.

Specifications

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

Analog Input

Number of input channels.....1 DIFF

Input signals.....Thermocouples of types B, E, J, K, N, R, S, and T

Input signal range .....±100 mV

Input impedance .....10 MΩ powered on,
10 kΩ powered off or overload

Bandwidth.....2 Hz

Amplifier Characteristics

Open thermocouple detection current.....250 nA max[1]
(assuming floating thermocouple)

Common-mode rejection ratio.....110 dB min[1]

Output range .....±10 V max[1]

Transfer Characteristics

Gain 100

Gain error.....±0.08% max[1]

Gain stability.....±0.0005%/°C max[2]

Offset error .....±5 µV max (post calibration)[1]

Offset stability .....±0.6 µV/°C max[2]

Nonlinearity .....±0.004% max[1]

Recommended warm-up time.....5 min

[1] Temperature range is 23 °C ±5 °C.

[2] Temperature range is 0 to 50 °C.

Measurement Accuracy[1]

Thermocouple Type	Temperature Range (°C)	Maximum Inaccuracy (±°C)	Typical Inaccuracy (±°C)
B	400 to 600 600 to 1,800	2.5 2	0.31 0.13
E	–200 to –100 –100 to 600 600 to 1,000	2 1 1.5	1.76 1 0.6
J	–200 to –100 –100 to 500 500 to 1,100	2 1 1.5	1.6 0.9 0.72
K	–200 to –100 –100 to 600 600 to 1,200	2.5 1.25 2	1.25 0.67 0.45
N	–200 to –100 –100 to 1,300	2.5 2	2 0.7
R	–50 to 0 0 to 100 100 to1,600	3 2 1.75	1.24 0.82 0.4
S	–50 to 0 0 to 1,400 1,400 to 1,600	3 2 2.5	1.3 1 1
T	–200 to –100 –100 to 400	2.5 1	2 0.9

[1] Total system measurement error for operating temperature within ±5 °C of calibration temperature. Includes PCI/AT-MIO-16XE-50 one-year accuracy specification of 0.01% ±412 µV. SCC-TC01/02 accuracy specification of 0.08% ±5 µV, and reference junction measurement accuracy of 0.5 °C. Assumes averaging. Non-averaged, single-point reading has an additional uncertainty (up to ±0.1 °C for J-type thermocouple).

Cold-Junction Sensor

Cold-junction sensor accuracy.....±0.4 °C max from 15 to 35 °C,
±0.75 °C max from 0 to 15 °C
and 35 to 55 °C

Output .....1.91 V (0 °C) to 0.58 V (55 °C)

Note The accuracy specification includes the combined effects of the temperature sensor accuracy and the temperature difference between the temperature sensor and any thermocouple connector. The temperature sensor accuracy includes component tolerances, temperature drifts, and self-heating effects. It does not include measurement device errors.

Open Thermocouple Detection

Pull-up resistor.....10 MΩ

Bias resistor .....10 MΩ

Maximum field wire gauge.....16 AWG

Power Requirement

Analog power .....60 mW max

+15 V .....2 mA max

–15 V .....2 mA max

Digital power (+5 V) .....0.0 mW

Physical

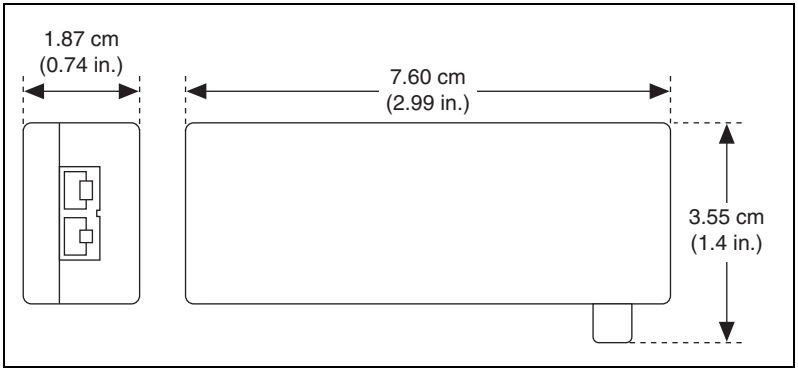


Figure 2. SCC-TC01 Dimensions

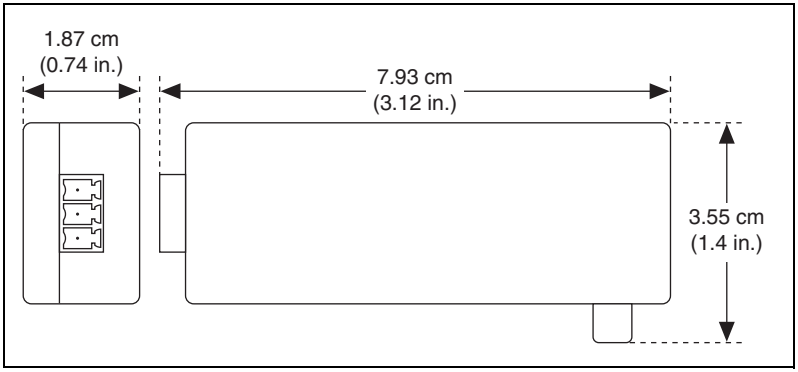


Figure 3. SCC-TC02 Dimensions

Weight

TC-01 ..... 25 g (0.9 oz)

TC-02 ..... 22 g (0.8 oz)

Screw terminal wire gauge..... 24 to 12 AWG

I/O ..... One 20-pin right angle male connector, 3-pin screw terminal system (SCC-TC02); two-prong mini-connector (SCC-TC01)

Screw terminal field-wiring gauge (SCC-TC02) ..... 28 to 16 AWG

Maximum Working Voltage

Maximum working voltage refers to the signal voltage plus the common-mode voltage.

Each input must remain within ±12 V of chassis ground.

Measurement Category I

Environmental

Operating temperature .....0 to 50 °C

Storage temperature .....–20 to 70 °C

Humidity .....10 to 90% RH, 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:

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

Note For UL and other safety certifications, refer to the product label or visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

Electromagnetic Compatibility

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

- EN 61326 EMC requirements; Minimum Immunity
- EN 55011 Emissions; Group 1, Class A
- CE, C-Tick, ICES, and FCC Part 15 Emissions; Class A

Note For EMC compliance, operate this device according to product documentation. In addition, all covers and filler panels must be installed.

CE Compliance

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

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

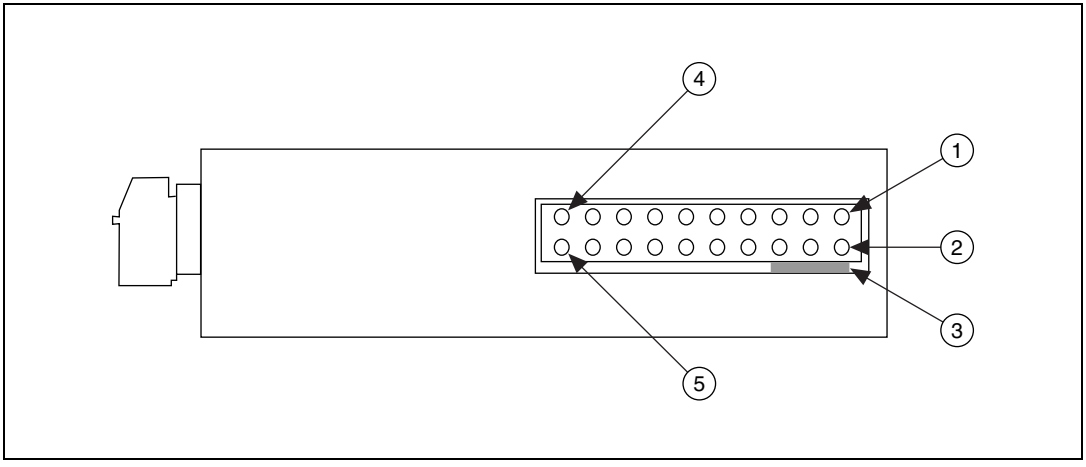
Note Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain the DoC for this product, visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

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I/O Connector Pin Assignments

Figure 4 shows the I/O connector pins on the bottom of the module.



1	Pin 1	2	Pin 2	3	PWB Key	4	Pin 19	5	Pin 20

Figure 4. SCC Module Bottom View

Table 1 lists the signal connection corresponding to each pin. AI (*X*) and AI (*X*+8) are the analog input signal channels of the E/M Series DAQ device. AI GND is the analog input ground signal and is the reference for AI (*X*) and AI (*X*+8). A GND is the reference for the ±15 V supplies and REF 5V. AI GND and A GND connect to the SC-2345/2350 at the SCC-PWR connector.

Table 1. SCC Module Pin Signal Connections for SCC-TC0*X* Modules

Pin Number	Signal
1	AI (*X*)
2	—
3	—
4	AI (*X*+8)
5	—
6	DAQ Device AI GND
7	—
8	—
9	—
10	—
11	A GND
12	REF 5 V
13	+15 V
14	–15 V
15	—
16	—
17	—
18	—
19	—
20	—

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