INSTALLATION GUIDE

BNC/TC-2095 Rack-Mount Adapter

This installation guide describes how to install the National Instruments BNC-2095 and the TC-2095 rack-mount adapters and use them with SCXI-1100, SCXI-1102/B/C, and SCXI-1104/C modules. The BNC-2095 also can be used with the SCXI-1581.

The BNC-2095 adapter has 32 BNC connectors to connect field signals to the SCXI module inputs. The TC-2095 adapter has 32 uncompensated miniconnectors to connect the thermocouples to the SCXI module inputs. Both the BNC-2095 and TC-2095 adapters have the following features:

- A 96-pin connector to connect to the SCXI module using an SH96-96 shielded cable or an R9696 ribbon cable
- Rack-mount construction for use with 19-in. racks
- A shielded, metal enclosure to minimize noise

The TC-2095 also features isothermal construction to minimize the temperature gradients across the thermocouple junctions and a high-accuracy thermistor for cold-junction temperature sensing.

The BNC-2095 and the TC-2095 have pull-up resistors connected between CH+ and +5 VDC and ground-referencing resistors connected between CH– and chassis ground through switches located on the rear of the adapter. The bias resistor is a ground-referencing pull-down resistor for referencing floating signals; the pull-up resistor is used for open thermocouple detection. The pull-up resistors enable open thermocouple detection by detecting saturation in the SCXI module amplifier output and ground-referenced floating signals.

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Conventions

The following conventions are used in this guide:

♦ — The ♦ symbol indicates that the text following it applies only to a specific product, a specific operating system, or a specific software version.

<> — Angle brackets that contain numbers separated by an ellipsis represent a range of values associated with a bit or signal name—for example, DBIO<3..0>. Angle brackets also can denote a variable in a channel name—for example, ACH<i>.

» — 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.

bold — Bold text denotes items that you must select or click in the software, such as menu items and dialog box options. Bold text also denotes parameter names and hardware labels.

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.

`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.

What You Need To Get Started

To install and use the BNC/TC-2095, you need the following items:

- ❑ One of the following:
  - – BNC-2095 rack-mount adapter with BNC connectors
  - – TC-2095 rack-mount adapter with thermocouple miniconnectors
- ❑ *BNC/TC-2095 Rack-Mount Adapter Installation Guide*
- ❑ *Read Me First: Safety and Radio-Frequency Interference*
- ❑ Four 10 MΩ resistor networks
- ❑ SCXI chassis and documentation
- ❑ One of the following SCXI modules and its documentation:
  - – SCXI-1100
  - – SCXI-1102/B/C
  - – SCXI-1104/C
  - – SCXI-1581
- ❑ One of the following cable assemblies:
  - – SH96-96 cable assembly (recommended)
  - – R9696 cable assembly
- ❑ TBX cable adapter (included in cable assembly kit)
- ❑ Number 1 Phillips screwdriver
- ❑ 1/8 in. flathead screwdriver
- ❑ Long-nose pliers

Connecting Signals

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

This section describes how to connect field signals to the adapter and how to connect the adapter to the SCXI module.

Connecting Field Signals

- BNC-2095

  The BNC-2095 has 32 BNC connectors, one for each channel of a SCXI module. Each BNC connector is labeled with the corresponding channel number. The center pin of the BNC connector is the CH+, and the outer shield is the CH– of each channel. The CH– is isolated from the chassis ground, so you can use it for ground-referenced differential signals. To ensure CH– is isolated from chassis ground, do not use bias resistors.

Caution Do *not* force the BNC connector on the BNC-2095. If you have difficulty making the connection, completely remove the connector and try again.

  Connect the BNC connector of the cable to the BNC connector of the BNC-2095 by aligning and inserting the connector and turning the cable connector clockwise.

- TC-2095

  The TC-2095 has 32 universal thermocouple miniconnectors that you can use to connect a thermocouple to each channel of the SCXI module. Each connector is labeled with the corresponding channel number. The miniconnector indicates the positive and negative terminals.

Caution Do *not* force the miniconnector into the socket. If you have difficulty inserting the miniconnector, check that the polarity is correct.

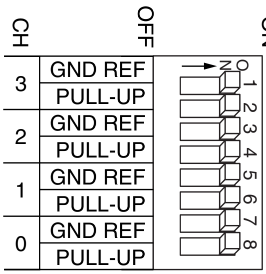
  Connect the thermocouple wire to the TC-2095 by inserting the miniconnector into the socket. Each miniconnector consists of two spades of different widths. The differing widths guarantee correct polarity if both connectors are correctly wired.

  Both contacts of the thermocouple miniconnector are made of copper. This could cause offset errors in T-, R-, and S-type thermocouple measurements because each of these types of thermocouples has one copper contact. Only one contact forms a cold junction with T, R, and S-type thermocouples.

Configuring Open-Thermocouple/Signal Detection and Signal Ground-Referencing

Refer to Table 1 to configure the BNC/TC-2095 for operating with open-thermocouple or signal detection, and for properly ground-referencing the signals.

Table 1. Configuring Open-Thermocouple/Signal Detection and Signal Ground-Referencing

<table>
<tr><th>Switch Settings</th><th>Signal Type</th><th>Detects Open Thermocouple</th><th>Comments</th></tr>
<tr><td>
</td><td>Floating signal or thermocouple</td><td>Yes</td><td>BNC-2095—Use this setting for detecting floating signals or open signal leads. When detecting open signal leads, the positive input is pulled to +5 VDC if the measured signal is <5 VDC. Only use this setting or configuration with signals between ±5 VDC.

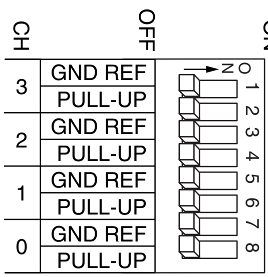
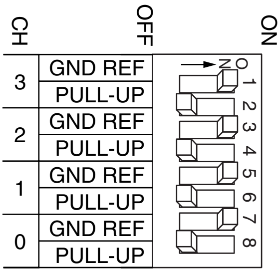
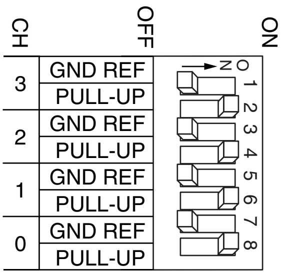
TC-2095—Use this setting to detect open thermocouples and when the thermocouple is floating.</td></tr>
<tr><td>
</td><td>Ground-referenced signal or thermocouple</td><td>No</td><td>BNC-2095 or TC-2095—Use this setting when the signal or thermocouple is ground-referenced and you want to disable open-thermocouple detection.</td></tr>
</table>

Table 1. Configuring Open-Thermocouple/Signal Detection and Signal Ground-Referencing (Continued)

Switch Settings	Signal Type	Detects Open Thermocouple	Comments
	Floating thermocouple or signal	No	BNC-2095 or TC-2095—Use this setting when the signal or thermocouple is floating and you want to disable open-thermocouple detection.
	Ground-referenced thermocouple or signal	Yes	BNC-2095—Use this setting for detecting ground-referenced signals or open signal leads. When detecting open signal leads, the positive input is pulled to +5 VDC if the measured signal is <5 VDC. Only use this setting or configuration with signals between ±5 VDC. TC-2095—Use this setting to detect open thermocouples for ground-referenced thermocouples.

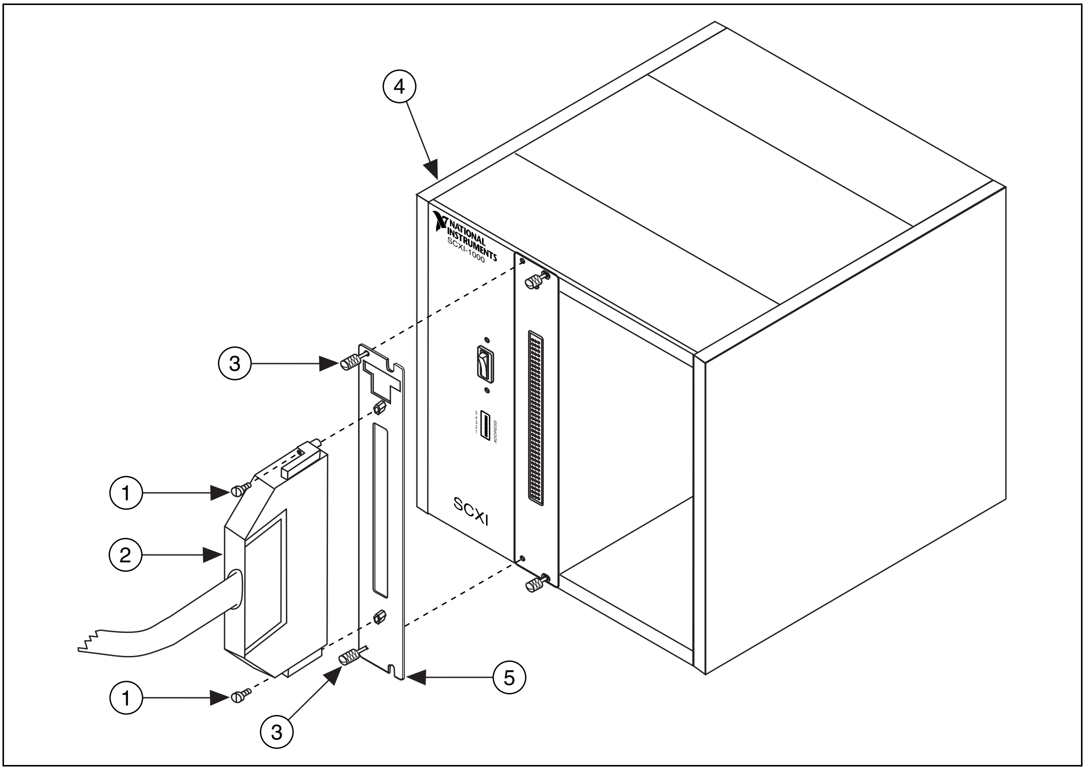
Caution Connecting an external ground-referenced signal with the 10 Ω resistor network in place can cause permanent damage to the resistor network and the traces on the BNC/TC-2095 printed circuit board. NI is *not* liable for any damage or injuries resulting from improper signal connections. Refer to the *Temperature Sensor Output and Accuracy* section for more information.

Connecting the BNC/TC-2095 to the SCXI Module

Complete the following steps to mount the SH96-96 cable assembly and connect the BNC/TC-2095 to the SCXI module. Refer to Figures 1 and 2 as needed.

Caution Refer to the *Connecting Signals* section before connecting the signals. If signal wires are connected to the terminal block, dangerous voltages can exist even when the equipment is powered off.

1. Power off the SCXI chassis.
2. Power off the computer that contains the E Series data acquisition (DAQ) device, or disconnect the computer from the SCXI chassis.
3. Connect the TBX cable adapter to the SCXI module, and secure the adapter by tightening both thumbscrews.
4. Connect either end of the SH96-96 cable to the TBX cable adapter and SCXI module, and secure the cable by tightening both backshell mounting screws.



1	Backshell Mounting Screws	3	Thumbscrews	5	TBX Cable Adapter
2	SH96-96 Cable	4	SCXI Chassis		

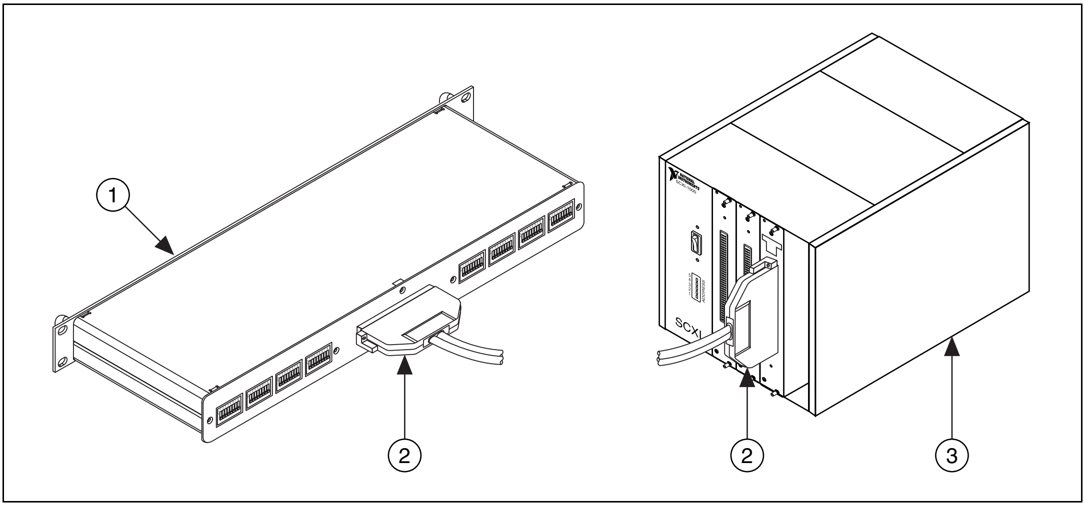
Figure 1. Connecting the SH96-96 Cable to the SCXI Module

5. Mount the BNC/TC-2095 onto a 19-in. rack or place it on a workbench near the SCXI chassis. If you do not rack-mount the BNC/TC-2095, attach the four adhesive rubber feet included in the kit to the bottom of the adapter to keep it stationary.

Note To minimize the temperature gradient inside the TC-2095 and maintain its isothermal properties for accurate cold-junction compensation, keep the adapter from extreme temperature differentials.

6. Connect the other end of the 96-pin cable to the BNC/TC-2095 96-pin connector and screw down the backshell.

Caution The cable connectors of the cables are keyed. Do *not* force the connection. If you encounter difficulty, verify that the keying of the cable connectors is correct.



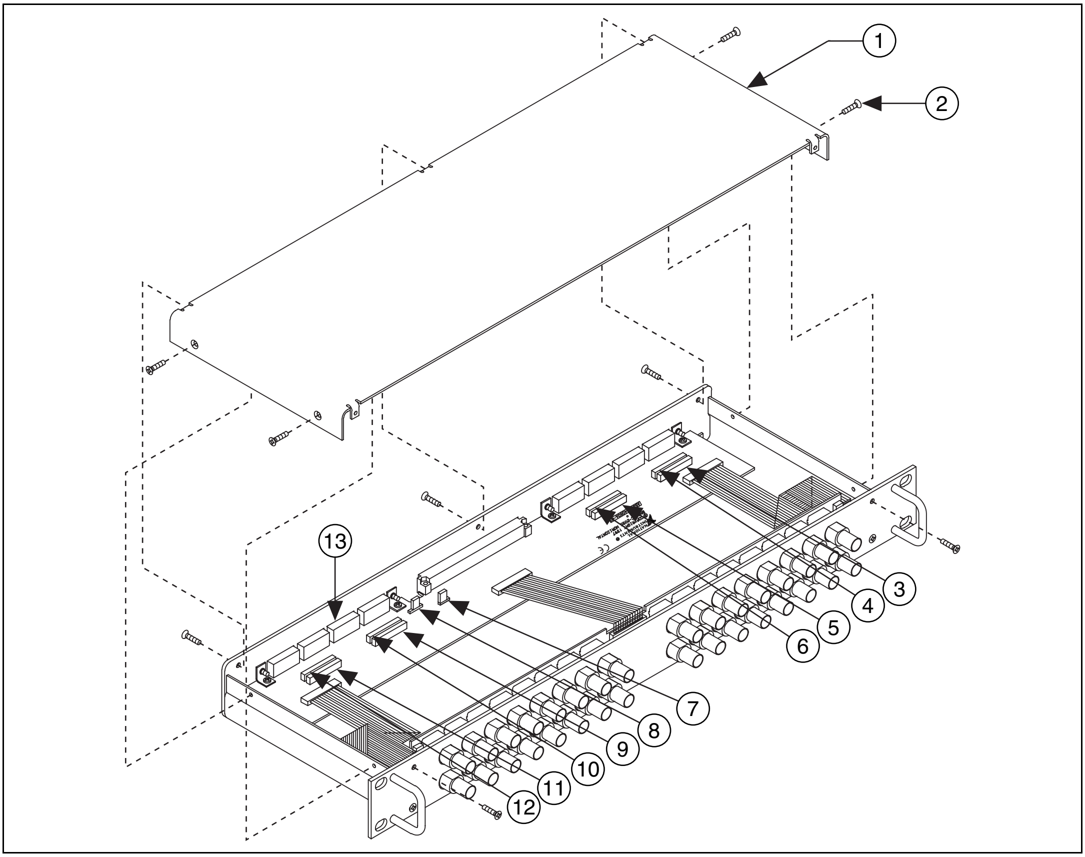
1 BNC/TC-2095	2 96-Pin Backshell	3 SCXI Chassis

Figure 2. BNC/TC-2095 Connected to SCXI Module

Configuring the BNC/TC-2095

To access jumpers W1 and W2 and the resistor networks, refer to Figure 3 as you complete the following steps:

1. Remove the nine cover screws that secure the BNC/TC-2095 cover.
2. Remove the cover.
3. Set jumpers W1 and W2 as needed. For more information about setting the jumpers, refer to the *Configuring the Shield Ground Jumper* and *Configuring the Cold-Junction Sensor (TC-2095 Only)* sections.
4. Replace the cover and secure it with the cover screws.



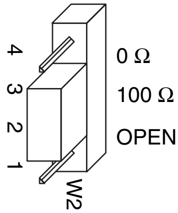
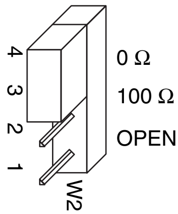
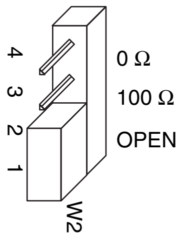
1) Cover	6) RP5	11) RP4
2) Cover Screws (9)	7) W1	12) RP8
3) RP1	8) W2	13) Switches
4) RP5	9) RP3	
5) RP2	10) RP7	

Figure 3. BNC-2095 Parts Locator Diagram

Configuring the Shield Ground Jumper

Jumper W2 connects the metal case and shield to the analog ground of the SCXI module directly or through a 100 Ω resistor. The factory-default setting is through the 100 Ω resistor. Refer to Table 2 for configuration options for jumper W2.

Table 2. BNC/TC-2095 Shield Ground Jumper Configuration

Jumper W2 Configuration	Description	When to Use a Setting
	100 Ω (factory-default)—Connects the BNC/TC-2095 housing to SCXI chassis ground through a 100 Ω resistor, while minimizing any potential ground loop current.	Use this setting when you are using the SH96-96 cable, and if one of the following is true: • You have not rack-mounted the BNC/TC-2095. • You have rack-mounted the BNC/TC-2095, but are unsure whether the rack and the BNC/TC-2095 are grounded.
	0 Ω—Connects the BNC/TC-2095 housing to SCXI chassis ground.	Use this setting only if the factory-default setting is inadequate for noise rejection, you are using the R9696 cable, and if one of the following is true: • You have not rack-mounted the BNC/TC-2095. • You have rack-mounted the BNC/TC-2095 and are sure that the rack and the BNC/TC-2095 are not grounded.
	Open—Disconnects the BNC/TC-2095 metal housing from SCXI chassis ground.	Use this setting only if all of the following are true: • Factory-default setting was inadequate for noise rejection. • You are using either the SH96-96 cable or the R9696 cable. • You have rack-mounted the BNC/TC-2095. • You are sure that the rack and the BNC/TC-2095 are grounded.

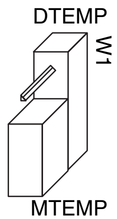
Configuring the Cold-Junction Sensor (TC-2095 Only)

The TC-2095 jumper W1 is set by factory-default to multiplexed temperature sensor (MTEMP) mode. This setting multiplexes the cold-junction sensor for SCXI modules operating in multiplexed mode. Refer to Figure 3 for the location of jumper W1.

Do *not* change the factory-default position of jumper W1.

Table 3 shows the jumper W1 settings.

Table 3. Jumper W1 Settings for the TC-2095

Jumper W1 Position	Description
	MTEMP (CJTEMP) mode—Factory-default setting. Do not change the jumper position.

Temperature Sensor Output and Accuracy

The TC-2095 temperature sensor voltage output varies from 1.91 to 0.58 VDC over the 0 to 55 °C temperature range. Table 4 shows the temperature sensor output accuracy.

Table 4. Temperature Sensor Voltage Output Accuracy

Temperature Range	Voltage Output Accuracy[1]
0 to 15 °C	±1.0 °C
15 to 35 °C	±0.65 °C
< 35 to 55 °C	±1.0 °C

[1] Includes the combined effects of the temperature sensor accuracy and the temperature difference between the temperature sensor and any screw terminal. The terminal sensor accuracy includes tolerances in all component values, the effects caused by temperature and loading, and self-heating.

To select and read the temperature sensor, refer to the driver software documentation for programming information.

Alternatively, you can follow these steps to convert the cold-junction sensor voltage to the cold-junction temperature.

1. Calculate the resistance of the thermistor in Ω.

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

$V_{TEMPOUT}$ = output voltage of the temperature sensor

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

The SCXI-1100 does not have a filter on the $V_{TEMPOUT}$ signal. Therefore, use an average of a large number of samples to obtain an accurate measurement. For example, sample for one second and average. Noisy environments require more samples for greater accuracy.

The SCXI-1102/B/C has a 2 Hz filter on the $V_{TEMPOUT}$ signal input channel.

2. Calculate the cold-junction temperature in Kelvin.

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

$a = 1.295361 \times 10^{-3}$
$b = 2.343159 \times 10^{-4}$
$c = 1.018703 \times 10^{-7}$
R_T = resistance of the thermistor

3. Convert the temperature to Celsius and Fahrenheit.

$$T(°\mathrm{C}) = T_K - 273.15$$

T_K = temperature in Kelvin

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

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

Temperature Sensor Circuit Diagram

The circuit diagram in Figure 4 is optional information that you can use if you want more details about the TC-2095 temperature sensor.

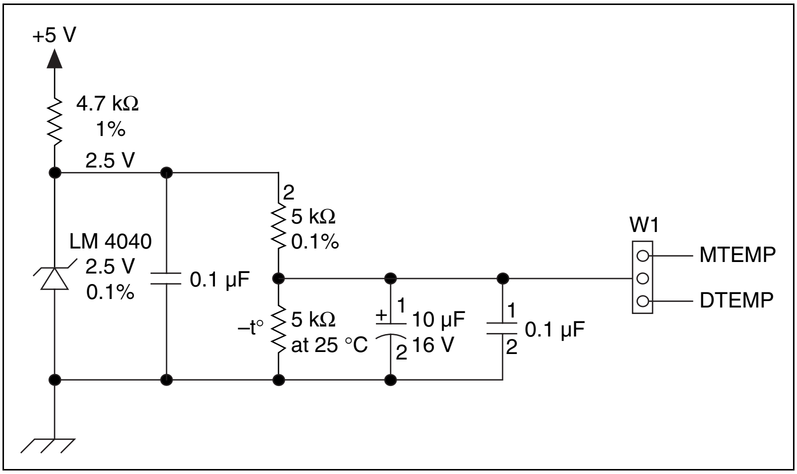


Figure 4. Temperature Sensor Circuit Diagram

Configuring the Resistor Networks

When using an SCXI-1102/B/C, you can use the package of 10 MΩ resistor networks included in the BNC/TC-2095 kit. You can install these resistor networks as RP1, RP2, RP3, and RP4. Refer to Figure 3 for the locations of RP<1...8>. If you use this configuration and you have the ground-referencing switch powered on, the thermocouples or signals with low-impedance sources (less than 100 Ω) either float without affecting the measurement or are ground-referenced.

Figure 5 shows how the pull-up and ground-referencing resistors are connected to the CH± inputs of the SCXI module.

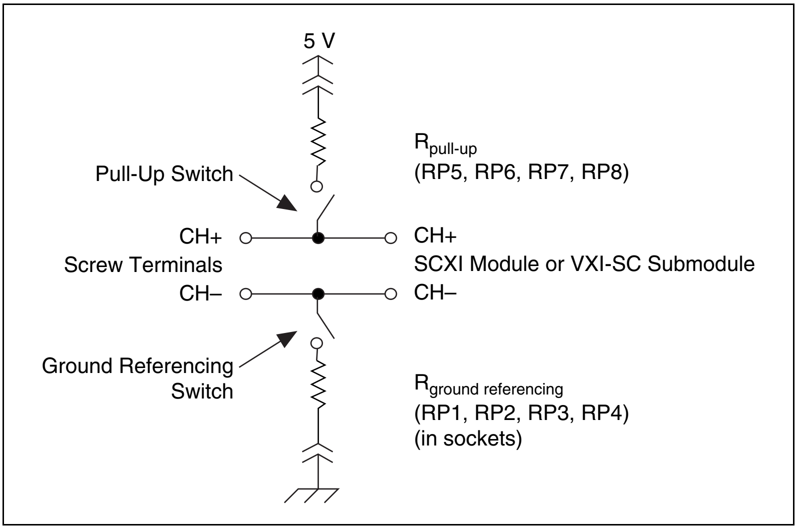


Figure 5. Resistor Connections

Table 5 shows which resistors are associated with each group of channels.

Table 5. Channel Input Signals and Resistor Network

Channel	Pull-Up Resistor Network	Ground-Referencing Resistor Network
<0...7>	RP8	RP4
<8...15>	RP7	RP3
<16...23>	RP6	RP2
<24...31>	RP5	RP1

SCXI-1102/B/C Module

You can replace the 10 Ω ground-referencing resistor networks (factory-default configuration) in the BNC/TC-2095 with the 10 MΩ resistor networks supplied in the kit. The 10 MΩ resistor networks allow the signal to be ground-referenced or floating. Channels with open thermocouples saturate at all sample rates.

Use long-nose pliers to remove or replace the resistor networks in the sockets. Be careful not to damage the network package. Make sure pin 1 of each network is in the correct socket. Refer to Figures 6 and 7 as needed.

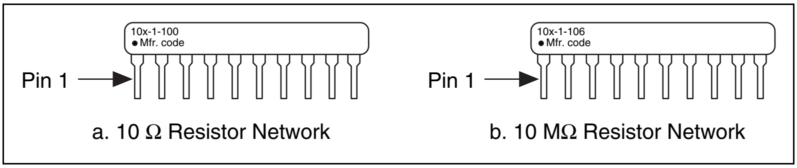


Figure 6. Resistor Networks

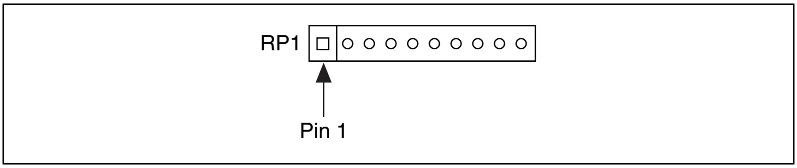


Figure 7. Pin 1 Location on BNC/TC-2095 for Ground-Referencing Resistor Socket

Each resistor network is labeled with descriptive numbers on the left front side, and pin 1 is located directly beneath the darkened symbol within these numbers. The 10 Ω resistor network is labeled **10x-1-100** (10×10^0 Ω); the 10 MΩ resistor network is labeled **10x-1-106** (10×10^6 Ω). Figure 6 shows examples of these resistors.

SCXI-1100 Module

For the open thermocouple channel to saturate without disturbing the measurements on any other channel, use an interchannel delay of 200 µs or greater at a gain of 100 or higher, which corresponds to a sample rate of 5 kHz.

After installing the 10 Ω bias resistors, you can accurately measure at the maximum sampling rate of the module. The open thermocouple channel may not saturate if the interchannel delay is less than 200 µs or if the sample rate is more than 5 kHz at a gain of 100 or higher.

If you want fast open thermocouple detection and you have short thermocouple leads, or if high accuracy is not important, you can replace the pull-up resistors with a lower value resistor network. For example, you can replace the pull-up resistor with a 1 MΩ, 10-pin bused configuration resistor network (not included) and have a sample rate of 20 kHz, with an interchannel delay of 50 µs typical. With a 1 MΩ bias resistor network, the current leakage would be 5 µA (5 VDC ÷ 1 MΩ), which can result in a larger offset error because of thermocouple lead resistance.

Use long-nose pliers to remove or replace the resistor networks in the sockets. Be careful not to damage the network package. Make sure that pin 1 of each network is in the correct socket.

Errors Due to Open-Thermocouple Detection Circuitry

Open-thermocouple detection circuitry can cause two types of measurement errors. These errors are the results of common-mode voltage at the input of the SCXI module and current leakage into the signal leads.

Common-Mode Voltage at the Input of the SCXI Module

With 10 MΩ pull-up and bias resistors, a common-mode voltage of 2.5 VDC develops if the thermocouple is floating. At a gain of 100, the common-mode rejection of the SCXI-1102/B/C module is sufficiently high that the resulting offset error is negligible.

If the application demands extremely high accuracy, you can eliminate this offset error by calibrating the system with both the pull-up and ground-referencing resistor switches ON. You also can turn off the pull-up resistor switch, which eliminates the open-thermocouple detection feature, or use the 10 Ω ground-referencing resistor networks, which brings the common-mode voltage down to nearly 0 VDC.

Current Leakage

The open-thermocouple detection circuitry results in a small current leakage into the thermocouple. With the 10 MΩ bias and pull-up resistor networks, the current leakage results in a negligible error. With the 10 Ω bias resistor, the 10 MΩ pull-up resistor connected to 5 VDC causes a current leakage of approximately 0.5 µA (5 VDC/10 MΩ) to flow into the unbroken thermocouple.

If the thermocouple is lengthy, a voltage drop develops in the thermocouple because of lead resistance. For example, if you have a 24 AWG J-type thermocouple that is 20 feet long, a voltage drop of approximately 8 µV can develop in the thermocouple, which corresponds to an error of 0.18 °C according to the following equation:

$$\text{Voltage drop value} = (0.145\ \Omega/\text{ft} + 0.658\ \Omega/\text{ft}) \times 20\ \text{ft} \times 0.5\ \mu\text{A}$$

If the application demands high accuracy, you can eliminate the voltage drop inaccuracy error by turning off the appropriate pull-up resistor network or by calibrating the system offset. For the location of these switches, refer to Figure 3.

Specifications

All specifications are typical at 25 °C, unless otherwise specified.

Electrical

Cold-junction sensor (TC-2095 Only)

Accuracy[1]	0.65° from 15 to 35 °C 1.0° from 0 to 15 °C and 35 to 55 °C
Repeatability	0.35° from 15 to 35 °C
Output	1.91 (at 0 °C) to 0.58 VDC (at 55 °C)

Open-thermocouple detection

Pull-up resistor	10 MΩ
Ground-referencing resistor	10 Ω default or 10 MΩ

Physical

Dimensions	48.3 cm by 4.4 cm by 19.0 cm (19.0 in. by 1.7 in. by 7.7 in.)

Maximum Working Voltage

Maximum working voltage (signal + common mode)	Each input should remain within ±10 VDC of chassis ground

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

[1] Includes the combined effects of the temperature sensor accuracy and the temperature difference between the temperature sensor and any screw terminal. The temperature sensor accuracy includes tolerances in all component values, the effect caused by temperature and loading, and self-heating.

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 3111-1, UL 61010B-01
- CAN/CSA C22.2 No. 1010.1

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

Electromagnetic Compatibility

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

Immunity .... EN 61326:1997+A2:2001,
Table 1

EMC/EMI .... CE, C-Tick, and FCC Part 15
(Class A) Compliant

Note For EMC compliance, you *must* 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, visit `ni.com/hardref.nsf`, search by model number or product line, and click the appropriate link in the Certification column.

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