BNC/TC-2095 RACK-MOUNT ADAPTER

This installation guide describes how to install the BNC-2095 and the TC-2095 rack-mount adapters and use them with 32-channel SCXI modules and VXI-SC-1102 submodules.

To set up and get started using your adapter, you need to read through the *Signal Connections* section only. Read this rest of this guide only for special configuration instructions.

Introduction

The BNC-2095 adapter consists of a shielded box with 32 BNC connectors to connect your field signals to the input of 32-channel SCXI modules or VXI-SC submodules. The 96-position connector on this adapter connects to the front connector of a 32-channel SCXI module or a VXI-SC submodule using an SH96-96 shielded cable or an R96-96 ribbon cable. This adapter is designed specifically for ease of use with field signals using BNC cables. It features rack-mount construction for use with 19-in. racks and a shielded, metal enclosure to minimize noise.

The TC-2095 adapter consists of a shielded box with 32 miniconnectors to connect your thermocouples to the inputs of 32-channel SCXI modules or VXI-SC submodules. The 96-position connector on this adapter connects to the front connector of an 32-channel SCXI module or a VXI-SC submodule using an SH96-96 shielded cable or an R96-96 ribbon cable. This adapter is designed specifically for ease of use with thermocouples. It features rack-mount construction for use with 19-in. racks, a shielded metal enclosure to minimize noise, isothermal construction to minimize the temperature gradients across the thermocouple junctions, and a high-accuracy thermistor for cold-junction temperature sensing.

Both the BNC-2095 and the TC-2095 have pull-up resistors connected between CH+ and +5 V and ground-referencing resistors connected between CH– and chassis ground via switches located on the rear of the adapter. These resistors help you detect open thermocouples by detecting module amplifier output saturation and to help you ground reference floating signals.

321731A-01 *September 1997*

What You Need To Get Started

You need the following items to set up and use your BNC-2095 or TC-2095:

- ❑ One of the following:
  - BNC-2095 32-Channel, Rack-Mount Adapter with BNC Connectors
  - TC-2095 32-Channel, Rack-Mount Adapter with Thermocouple Miniconnectors
- ❑ *BNC/TC-2095 Installation Guide*
- ❑ One package of four 10 MΩ resistor networks (included)
- ❑ 1/8 in. flathead screwdriver (included)
- ❑ An SCXI chassis
- ❑ One of the following SCXI 32-channel modules or VXI-SC submodules:
  - SCXI-1100
  - SCXI-1102/B/C
  - VXI-SCXI-1102/B/C
- ❑ One of the following cable assemblies:
  - SH96-96 cable assembly (recommended)
  - R96-96 cable assembly
- ❑ No. 1 Phillips-head screwdriver

Signal Connections

This section describes how to connect field signals to your adapter and how to connect the adapter to your SCXI module and VXI-SC submodule.

Connecting Field Signals

- BNC-2095
  The BNC-2095 has 32 BNC connectors, one for each channel of a 32-channel SCXI module or VXI-SC submodule. Each BNC connector is labeled with the corresponding channel number. The center pin of the BNC connector is the CH+, and the outer shield or metal is the CH– of each channel. The CH– is isolated from the chassis ground so you can use it for differential signals.

  Connect the BNC connector of your cable to the BNC connector of the BNC-2095 by pushing the connectors together and turning the cable connector clockwise.

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

- TC-2095
  The TC-2095 has 32 universal thermocouple miniconnectors that you can connect your thermocouple to each of the channels on an SCXI 32-channel module and VXI-SC submodule. Each connector is labeled with the corresponding channel number. The positive and negative terminals are indicated on the miniconnector with raised lettering.

  Connect the thermocouple wire to the TC-2095 by pushing the connectors together. Each miniconnector consists of two spades of different widths, which polarize the miniconnector.

☞ **Note** ***Do not force the miniconnector; if you have difficulty inserting the miniconnector, check to see if the polarity is correct.***

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

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

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

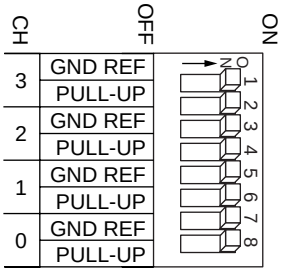
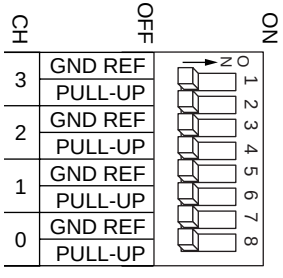
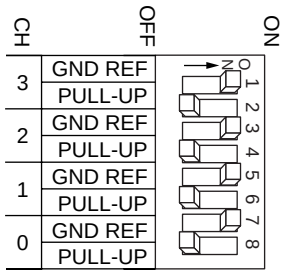
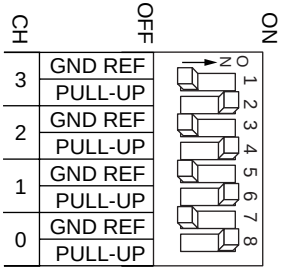
Switch Settings	Signal Type	Open Thermocouple	Comments
	Floating signal or thermocouple	Yes	Use this setting on the BNC-2095 for detecting open signal leads if the measured signal is <5 V by pulling the positive input to 5 V and when your signal is floating. Use this setting on the TC-2095 to detect open thermocouples and when your thermocouple is floating.
	Ground-referenced signal or thermocouple	No	Use this setting with either the BNC-2095 or TC-2095 when your signal is ground-referenced and you want to disable open-thermocouple detection.

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

Switch Settings	Signal Type	Open Thermocouple	Comments
	Floating thermocouple or signal	No	Use this setting with either the BNC-2095 or TC-2095 when your signal or thermocouple is floating and you want to disable open-thermocouple detection.
	Ground-referenced thermocouple or signal	Yes	Use this setting on the TC-2095 to detect open thermocouples for ground-referenced thermocouples. Use this setting on the BNC-2095 for detecting open signal leads if the measured signal is <5 V by pulling the positive input to 5 V and when your signal is ground-referenced.

Warning ***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. National Instruments is NOT liable for any damage or injuries resulting from improper signal connections. Refer to the*** *Configuring the Resistor Networks* ***section for more information.***

Connecting the BNC/TC-2095 to Your SCXI Module and to Your VXI-SC Submodule

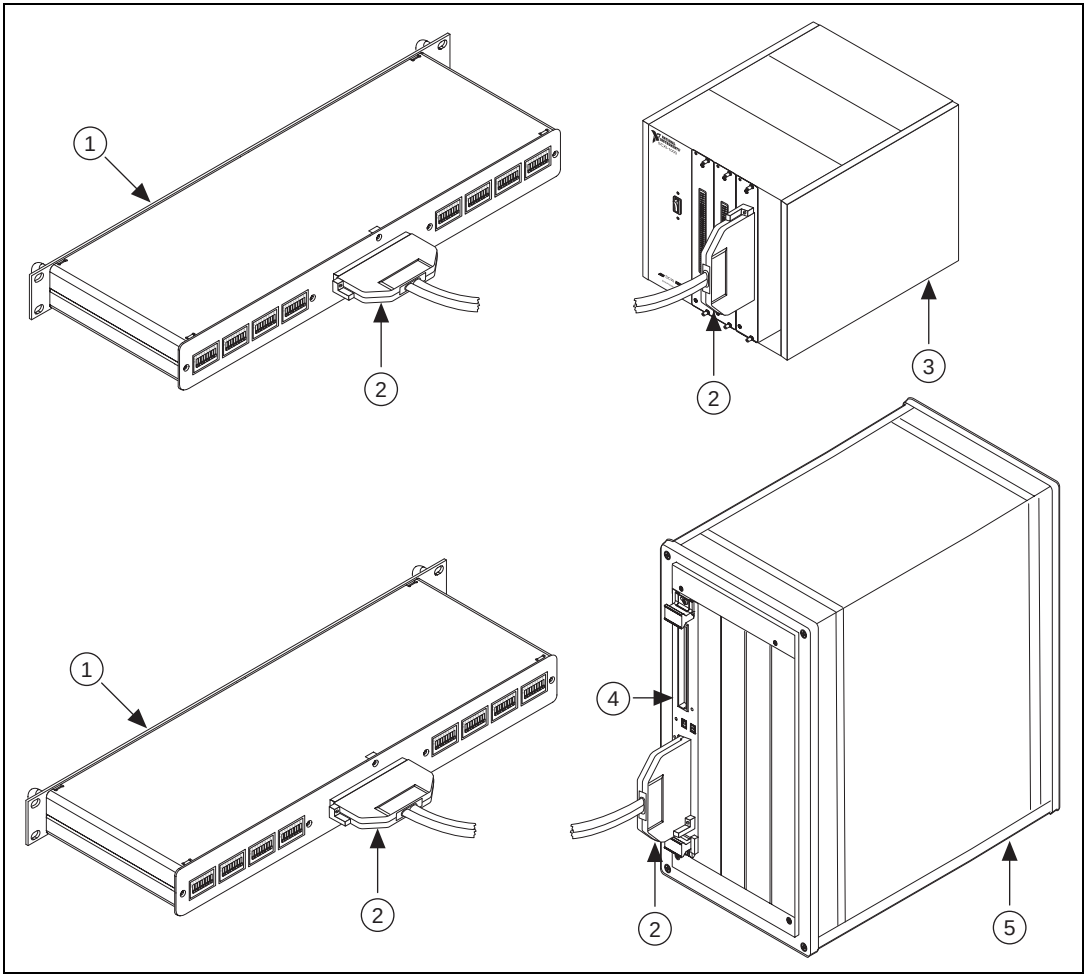
You can mount the BNC/TC-2095 onto a 19-in. rack or place it on a workbench near the SCXI or VXI chassis. If you do not rack-mount the BNC/TC-2095, attach the four adhesive rubber feet included in your kit to the bottom of the adapter to help keep it stationary.

Note ***To minimize the temperature gradient inside the TC-2095 and thus maintain its isothermal nature for accurate cold-junction compensation, place the adapter away from extreme temperature differentials.***

Refer to Figure 1 as you perform the following steps to connect the BNC/TC-2095 to the SCXI module or to the VXI-SC submodule.

1. Connect one end of the 96-pin cable to the BNC/TC-2095 96-pin connector and screw down the backshell.
2. Connect the other end of the cable to the SCXI module or the VXI-SC submodule in the same manner as above.

Caution ***The cable connectors of the cables are polarized. Do not force the cable. If you encounter difficulty, check to see if the polarity is correct.***



1 BNC/TC-2095 2 96-Pin Backshell 3 SCXI Chassis 4 VXI-SC Submodule 5 VXI Chassis

Figure 1. BNC/TC-2095 Connected to SCXI Module or VXI Chassis

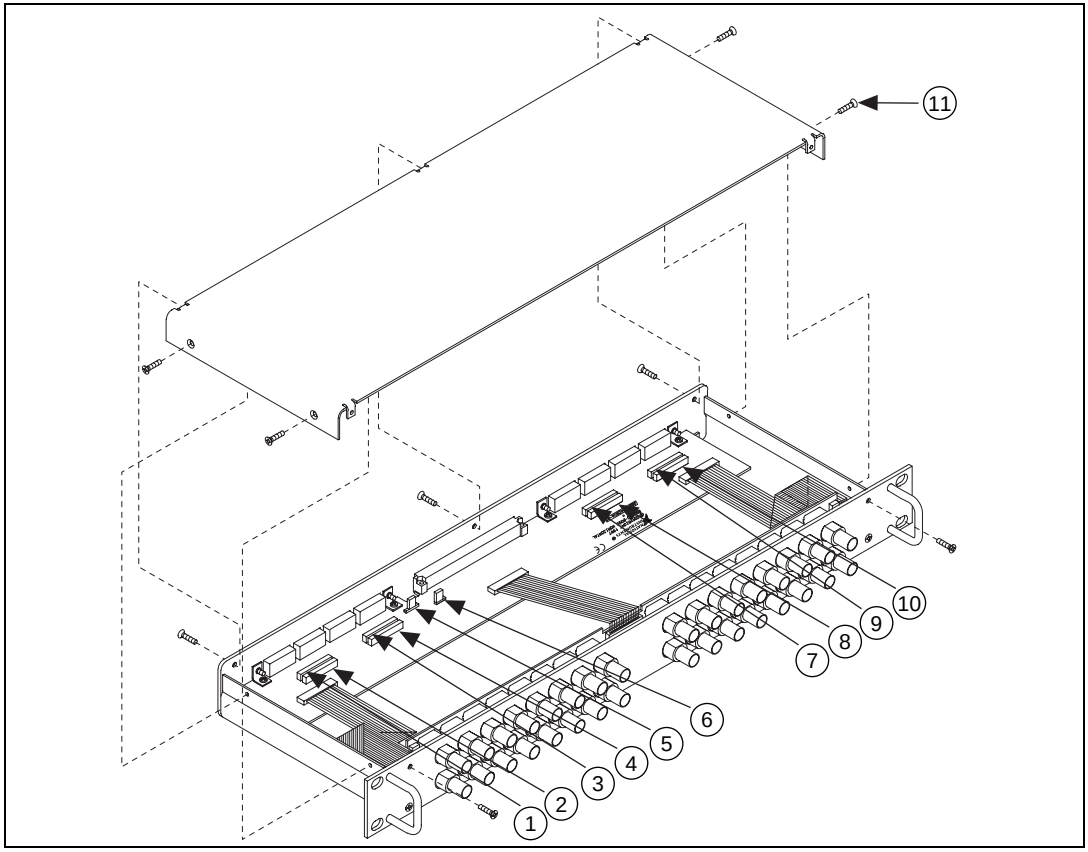
Your BNC/TC-2095 is ready to use. Read the *Configuration* section only if you need to learn more about ground-referencing or resistor network configuration with the SCXI-1102 module or the VXI-SC-1102 submodule or for further configuration of your adapter shield and cold-junction sensor.

Configuration

This section describes how to open your BNC/TC-2095 to access your internal jumpers and resistor networks for changing the factory default settings.

Refer to Figure 2 as you perform the following steps to access jumpers W1 and W2 and your resistor networks.

1. Using the No. 1 Phillips-head screwdriver, remove the nine screws that secure the adapter cover.
2. Pull the cover up and off.
3. Set jumpers W1 and W2 as needed. For more information about setting your jumpers, refer to Tables 2 and 3.
4. Reassemble in reverse order.



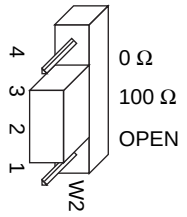
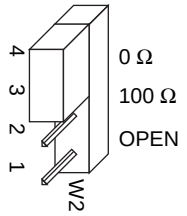
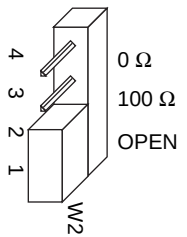
1 RP8	4 RP3	7 RP6	10 RP1
2 RP4	5 W2	8 RP2	11 Cover Screws (9)
3 RP7	6 W1	9 RP5	

Figure 2. Assembly Figure (BNC-2095)

Shield Ground Configuration

Jumper W2, located inside the BNC/TC-2095, connects the metal case and shield to the analog ground of the SCXI module directly or through a 100 Ω resistor. Or, you can disconnect jumper W2. The factory-default setting is through the 100 Ω resistor.

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

Jumper W2 Configuration	Description	When to Use a Setting
	100 Ω (factory default)—This setting connects the BNC/TC-2095 housing to SCXI or VXI chassis ground through a 100 Ω resistor, while keeping any potential ground loop current very small.	Use this setting when you are using the SH96-96 cable, and 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—This setting connects the BNC/TC-2095 housing to SCXI or VXI chassis ground.	Use this setting only if the factory-default setting is inadequate for noise rejection, when you are using the R96-96 cable, and 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—This setting disconnects the BNC/TC-2095 metal housing from SCXI or VXI chassis ground.	Use this setting only if the factory-default setting was inadequate for noise rejection, when you are using either the SH96-96 cable or the R96-96 cable, you have rack-mounted the BNC/TC-2095, and you are sure that the rack and the BNC/TC-2095 *are grounded*.

Cold-Junction Sensor Configuration (TC-2095 Only)

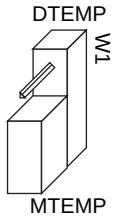
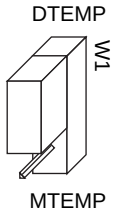
The TC-2095 has a thermistor temperature sensor for cold-junction compensation to enable you to use thermocouples with your SCXI module or VXI-SC submodule.

You can connect the cold-junction sensor to an SCXI module or VXI-SC submodule in either of two ways:

- Multiplexed temperature sensor (MTEMP) mode—Set jumper W1 to the MTEMP position. This is the factory default setting and the mode you need to use in most cases. Refer to Table 2 to learn more about jumper W1 settings for the TC-2095.
- Direct temperature sensor (DTEMP) mode—Set the jumper W1 to the DTEMP position. This mode connects the temperature sensor to a separate DAQ channel through your SCXI module. Refer to your SCXI module documentation to configure your SCXI module for DTEMP mode.

Table 2 shows the terminal block jumper settings for the TC-2095.

Table 3. Jumper W1 Settings for the TC-2095

Jumper W1 Position	Description
	MTEMP mode— factory default setting; preferred mode.
	DTEMP mode— connect to a separate DAQ channel on some SCXI modules.

☞ **Note** ***On the SCXI-1102 module and the VXI-SC-1102 submodule, the MTEMP and DTEMP modes are equivalent.***

Configuring the Resistor Networks

If you are an SCXI-1102 or a VXI-SC-1102 user, you can use a package of 10 MΩ resistor networks included in the BNC/TC-2095 kit. These resistor networks can be installed as RP1, RP2, RP3, and RP4. See Figure 3 for the location of RP1 through RP8. If you use this configuration and you have the ground-referencing switch turned on, the thermocouples or signals with low impedance source (less than 100 Ω) can be either ground-referenced or floating without affecting your measurement.

Figure 3 shows how the pull-up and ground-referencing resistors are connected to the CH± inputs of the 32-channel SCXI module or VXI-SC submodule.

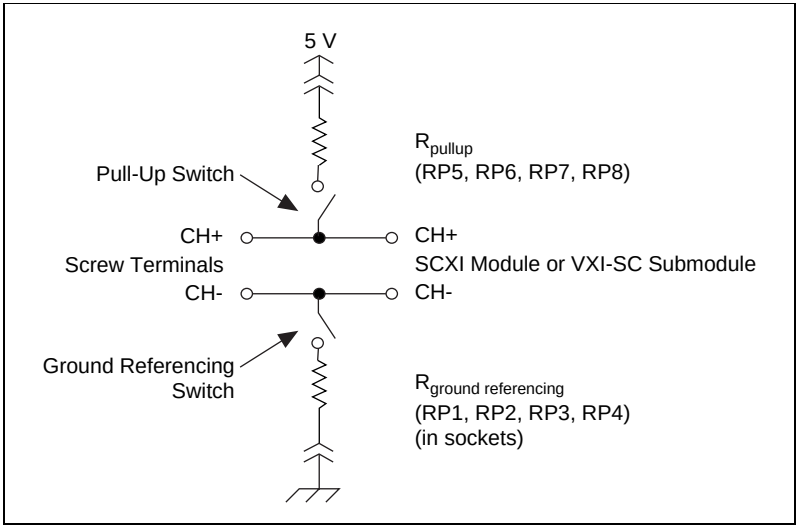


Figure 3. Resistor Connections

Table 3 shows which resistor networks to use for your SCXI module, signal type, and application.

Table 4. 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

Using Resistor Networks with SCXI Modules and VXI-SC Submodules

This section describes how to use resistor networks with the SCXI-1100 and SCXI-1102 modules, and the VXI-SC-1102 submodule.

SCXI-1102 Module and VXI-SC-1102 Submodule

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. With the 10 MΩ resistor networks, it does not matter whether your signal is ground-referenced or floating. The 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 (see Figures 4 and 5).

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 MΩ resistor network is labeled `106` ($10 * 10^6$ Ω). Figures 4 and 5 show examples of these resistors.

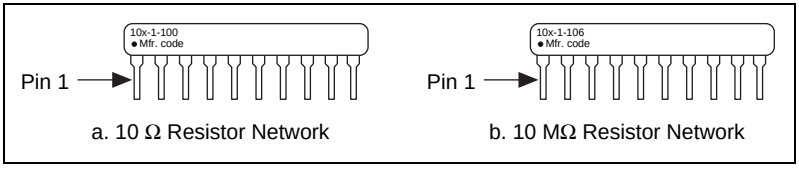


Figure 4. Resistor Networks

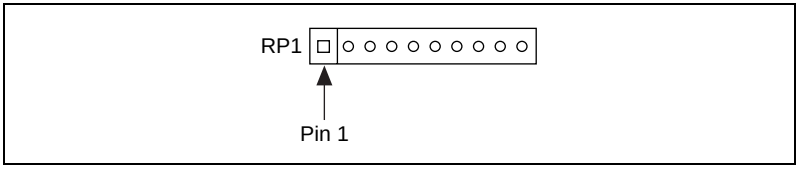


Figure 5. Pin 1 Location on BNC/TC-2095 for Ground-Referencing Resistor Socket

SCXI-1100 Module

Your SCXI-1100 module must be set at a gain of 100 or higher if you want the open thermocouple to saturate when the open-thermocouple detection is switched ON. If you do not want the measurements on any other channel to be disturbed, you must use an interchannel delay of 200 µs, which corresponds to a sample rate of 5 kHz.

Faster sampling rates will still result in accurate measurements; however, if a channel has an open thermocouple, this channel might not saturate and if it does, it affects the measurement accuracy of other channels on the same module.

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 or VXI-SC submodule and current leakage into your signal leads.

Common-Mode Voltage at the Input of the SCXI Module or VXI-SC Submodule

With 10 MΩ pull-up and ground-referencing 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 module or VXI-SC submodule is sufficiently high that the resulting offset error is negligible.

If your application demands extremely high accuracy, you can eliminate this offset error by calibrating your 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 ground-referencing and pull-up resistor networks, the current leakage results in a negligible error. With the 10 Ω ground-referencing resistor, the 10 MΩ pull-up resistor connected to 5 VDC causes a current leakage of approximately 0.5 µA (5 V/10 MΩ) to flow into the unbroken thermocouple. If the thermocouple is very long, 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 ft long, a voltage drop of approximately 8.78 µV (0.878 Ω/double ft × 20 double ft × 0.5 µA) can develop in the thermocouple, which corresponds to an error of 0.18° C.

If your application demands very high accuracy, you can eliminate this error by turning off the appropriate pull-up resistor switch or by calibrating the system offset. See Figure 3 for the location of these switches.

Temperature Sensor Output and Accuracy

The TC-2095 temperature sensor voltage output varies from 1.91 to 0.58 V over the 0° to 55° C temperature range. Table 5 shows the temperature sensor output accuracy.

Table 5. Temperature Sensor Voltage Output Accuracy

Temperature Range	Voltage Output Accuracy*
0° to > 15° C	±1.0° C
15° to 35° C	±0.65° C
< 35° to 55° C	±1.0° C

* 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 your data acquisition software documentation for programming information.

Alternatively, you can use the following formula to convert the cold-junction sensor voltage to cold-junction temperature:

$T(°C) = T_K - 273.15$

where T_K is the temperature in kelvin

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

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

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

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

R_T = resistance of the thermistor in Ω

$$R_T = 5000 \cdot \left(\frac{V_{TEMPOUT}}{2.5 - V_{TEMPOUT}} \right)$$

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

$$T(°F) = \frac{[T(°C)]9}{5} + 32$$

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 signal range on the analog input channel of your DAQ device.***

The SCXI-1102 and the VXI-SC-1102 have a 2 Hz filter on the $V_{TEMPOUT}$ signal.

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 the most accurate measurement. Noisy environments require more samples for greater accuracy.

Temperature Sensor Circuit Diagram

The circuit diagram in Figure 6 shows details about the BNC/TC-2095 temperature sensor.

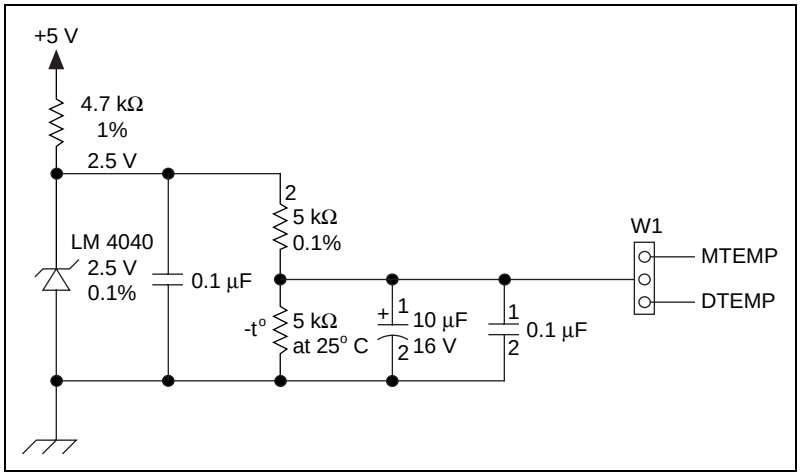


Figure 6. Temperature Sensor Circuit Diagram

Specifications

Cold-junction sensor (TC-2095 Only)

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

Maximum working voltage

(signal + common mode)	Each input should remain within ±10 V of chassis ground.

Dimensions ..... 47.6 by 4.4 cm (19 in. by 1.75 in.)

[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.

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