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Installation Guide

TBX-1303 32-Channel Isothermal Terminal Block

This guide describes how to install and use the TBX-1303 32-channel isothermal terminal block with SCXI-1100 and SCXI-1102 modules.

Introduction

The TBX-1303 32-channel isothermal terminal block is a DIN rail-mountable terminal block that consists of a shielded board with screw terminals to connect to the SCXI-1100 or SCXI-1102 module input connector. The TBX-1303 has a high-accuracy thermistor, cold-junction temperature sensor and an isothermal copper plane to minimize the temperature gradients across the screw terminals when you measure with thermocouples. The TBX-1303 mounts on most European standard DIN EN mounting rails.

The terminal block has 108 screw terminals for easy connection. Thirty-two sets of three screw terminals connect to the 32 differential inputs of the SCXI module and provide a shield for each input. Four terminals connect to the SCXI module OUTPUT, AOREF, and AIREF pins and to the SCXIbus guard. One pair of terminals labeled *GND* connects to the chassis ground pins of the SCXI module. All of the other terminals—OUT0+, OUT0-, OUT1+, OUT1-, and their shields—are reserved for future use.

The TBX-1303 has a pullup resistor connected between CH+ and +5 V and a bias resistor connected between CH- and chassis ground. These resistors help you detect open thermocouples by detecting module amplifier output saturation.

What You Need to Get Started

- ❑ TBX-1303 32-channel isothermal terminal block kit
  - TBX-1303 32-channel isothermal terminal block
  - *TBX-1303 32-Channel Isothermal Terminal Block Installation Guide*
  - One package of four 10 MΩ resistor networks
  - $^1/_8$ in. flathead screwdriver
- ❑ SCXI chassis

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- [ ] SCXI-1100 or SCXI-1102 module and documentation
- [ ] One of the following cable assemblies:
  SH96-96 cable assembly
  R9696 cable assembly
  SBS-96F shielded backshell
- [ ] Long-nose pliers
- [ ] $^{3}/_{16}$ in. wrench
- [ ] No. 1 Phillips-head screwdriver

Installation

Perform the following steps to mount your cable assembly and connect the TBX-1303 to your SCXI module. Refer to Figures 1 and 2 as needed.

1. Turn off your SCXI chassis.
2. Turn off the computer that contains your data acquisition (DAQ) device or disconnect the device from your SCXI chassis.
3. Slide the SCXI module out of the SCXI chassis.
4. Unscrew the SCXI module cover grounding screw and remove the module cover with a No. 1 Phillips-head screwdriver (see Figure 1).

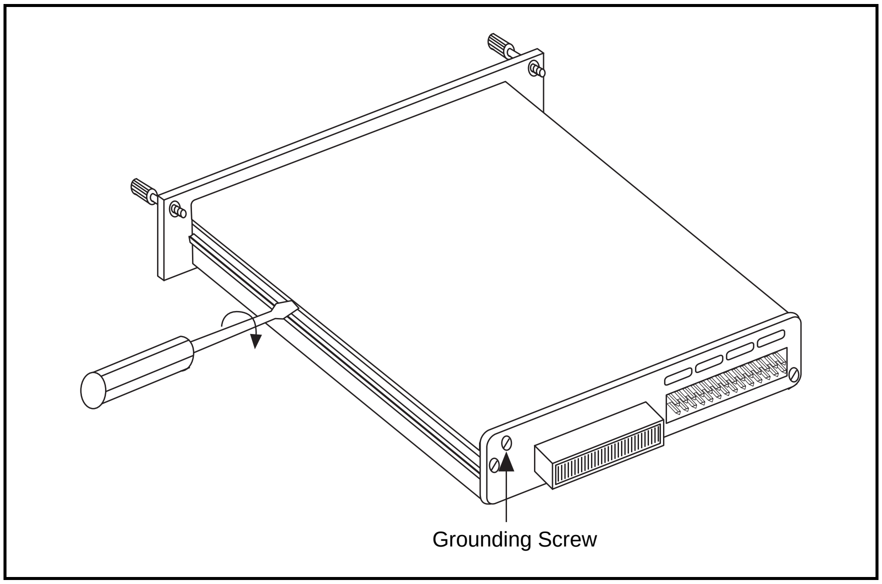
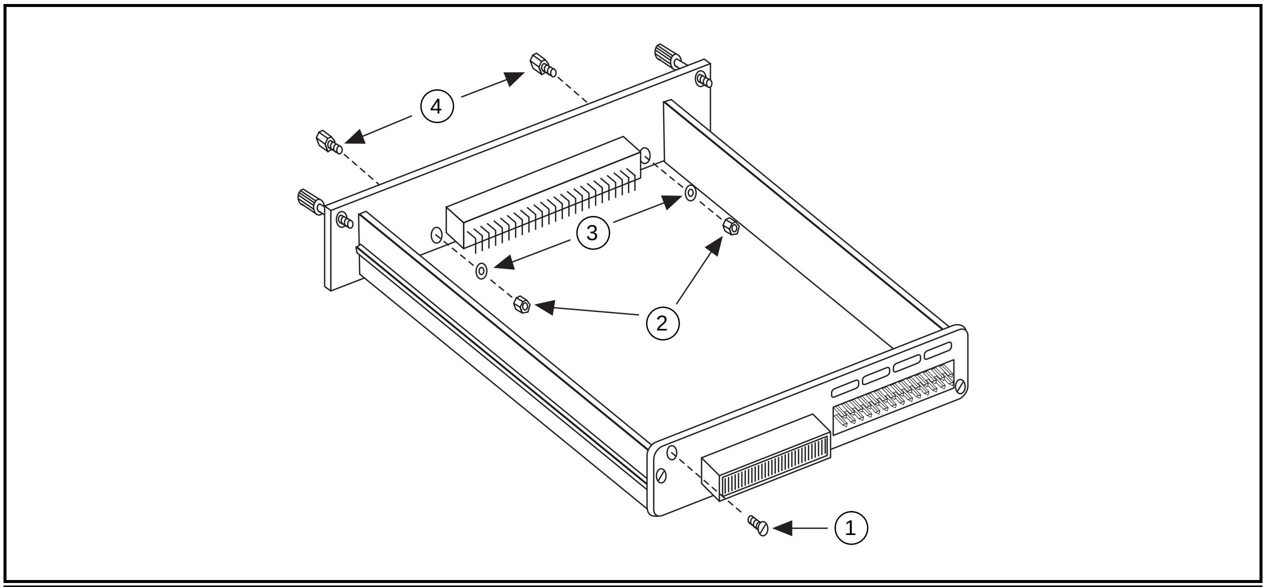


Figure 1. Removing the SCXI Module Cover

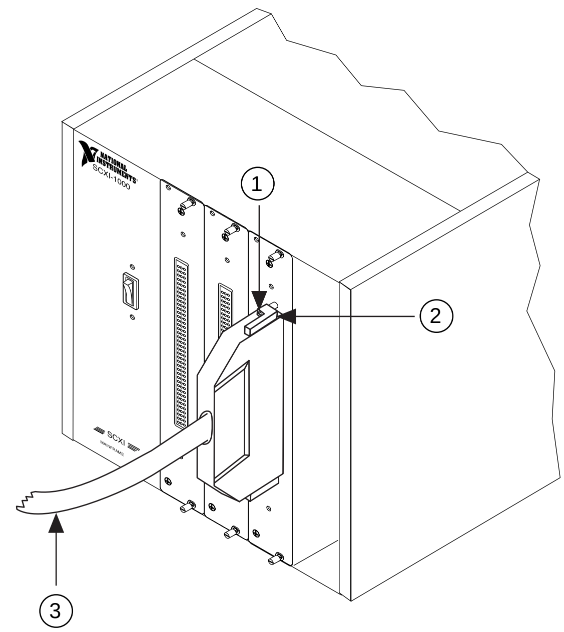
5. Place one jack screw as shown in Figure 2.
6. While holding the jack screw in place, insert the lockwasher and then the nut. Use long-nose pliers to do this.
7. Tighten the nut by holding it firmly and rotating the jack screw with a $^{3}/_{16}$ inch wrench.
8. Repeat steps 5 through 7 for the second jack screw.
9. Replace the SCXI module cover and tighten the grounding screw.



1	Grounding Screw	3	Lock Washers
2	Nuts	4	Jack Screws

Figure 2. Preparing the SCXI Module for the Cable Assembly

10. Slide the SCXI module back into place in the SCXI chassis.
11. Verify that the four backshell mounting ears are in the position shown in Figure 3. If not, remove the backshell mounting ears and install them in the position shown.
12. Connect one end of the cable assembly to your SCXI module front connector and secure your cable by tightening both backshell mounting screws with your $^{1}/_{8}$ inch flathead screwdriver.



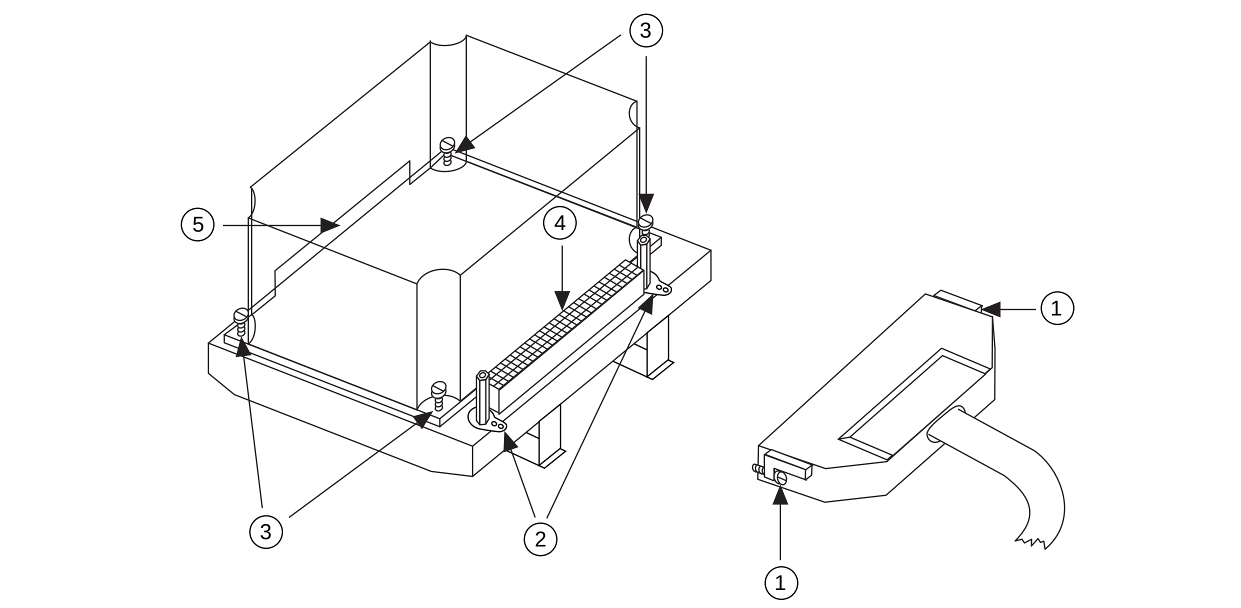
1	Backshell Mounting Screw	3	SH96-96 Cable
2	Backshell Mounting Ear		

Figure 3. Connecting the SH96-96 Cable to the SCXI Module

13. Connect the other end of your cable assembly to your TBX-1303 terminal block connector and secure the cable by tightening both backshell mounting screws. See Figure 4.

Note: ***To minimize the temperature gradient inside the terminal block and maintain its isothermal nature for accurate cold-junction compensation, place the TBX-1303 terminal block away from extreme temperature differentials.***

See Figure 5 for the completed installation.



1	Backshell Mounting Screws and Ears	3	Captive Cover Screws	5	Signal Wire Entry
2	Shield Grounding Solder Lugs	4	Terminal Block Connector		

Note: ***The SH96-96 cable is not shown in the exact position for proper connection to the terminal block connector. See Figure 5 for the completed connection.***

Figure 4. Connecting the SH96-96 Cable to the TBX-1303 Terminal Block

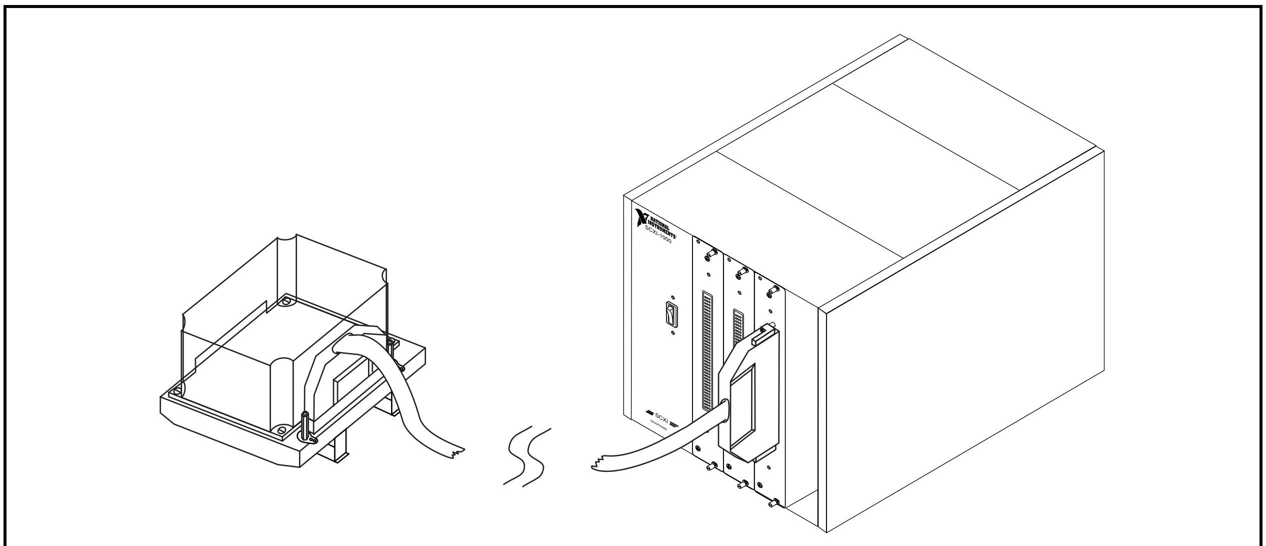


Figure 5. The Completed Installation

Rack Mounting

When you have completed the above installation instructions, you are ready to mount the TBX assembly in your rack. If you are using the National Instruments TBX Rack-Mount Assembly, refer to the *TBX Rack-Mount Installation Guide* for instructions. If you are not using this rack-mount assembly, perform the following steps to mount the TBX assembly directly onto your DIN rail.

1. Snap the TBX terminal block onto the DIN rail with a firm push.

   To remove the TBX terminal block from the DIN rail, place a flathead screwdriver into the slot above the terminal block base and pry it from the rail.

2. Install the SCXI chassis using the appropriate chassis rack-mount kit.

Signal Connection

Warning: ***Do not connect hazardous voltage levels to this product.***

To connect your field signals to the TBX-1303 for use with the SCXI-1100 or SCXI-1102 modules, refer to Figures 4 and 6 as you perform the following instructions:

1. Remove the TBX-1303 terminal block cover by unscrewing the four captive cover screws in the cover corners. These screws stay attached to the cover without falling out.

2. Connect the signal wires to the screw terminals. Refer to your SCXI module user manual for examples of how to connect to field signals and loads. Notice that the GND terminals are connected to the SCXI module CHASSIS GROUND via the cable, not the shield. In addition, each channel has its own shield terminal (labeled *S* on the board) for connecting your signal shields. Allow your signal wires to exit through the terminal block cover opening (see Figure 4).

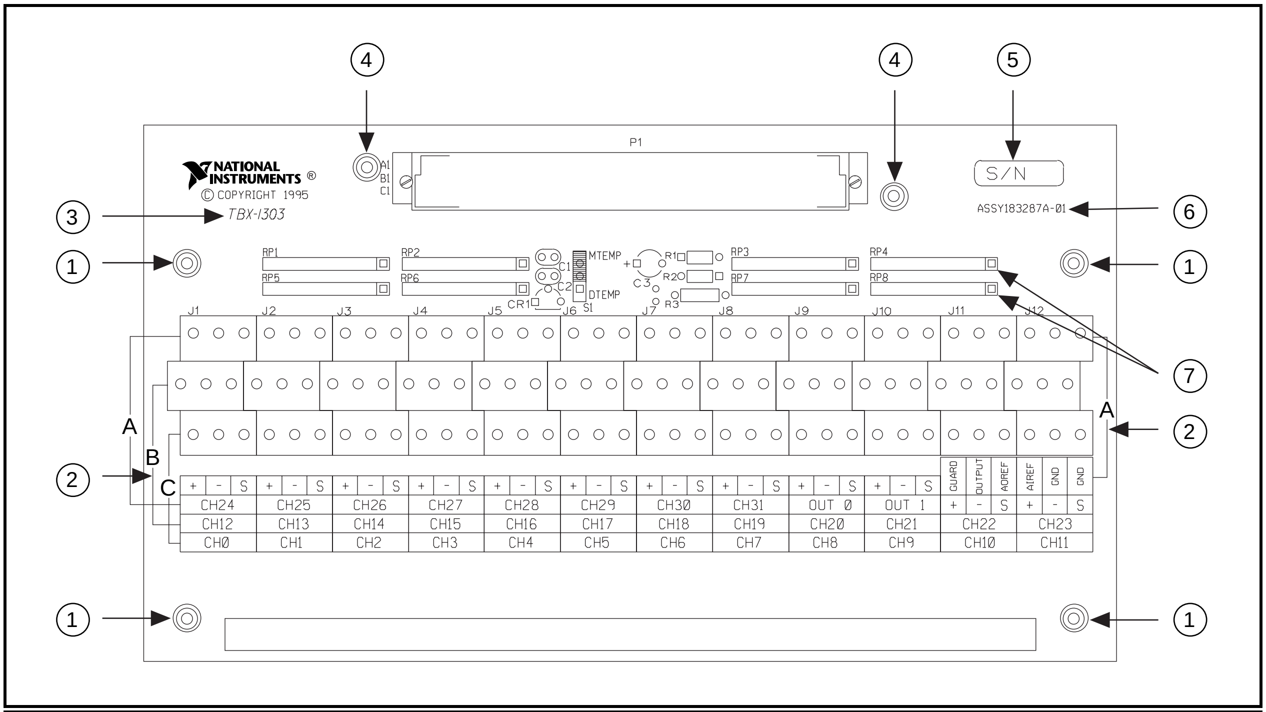
Note: ***The board has corresponding rows labeled A, B, and C to help you make the correct connections, as shown in Figure 6, item 2.***

3. Verify that you have the resistor networks appropriate to your SCXI module, signal type, and application. See Table 4 in the *Configuring Resistor Networks* section for information about resistor networks.

4. Replace the TBX-1303 terminal block cover and tighten the captive cover screws.

Note: ***This terminal block does not provide strain relief for field signal wires. Add strain relief, insulation, and padding for your field signal wires, if necessary.***

The installation and signal connection are now complete. Figure 6 shows the TBX-1303 parts locator diagram.



1	Cover Mounting Nuts	3	Product Name	5	Serial Number	7	Resistor Network, Pin 1
2	Corresponding Rows	4	Backshell Mounting Nut	6	Assembly Number		

Figure 6. TBX-1303 Parts Locator Diagram

Temperature Sensor and Switch Configuration

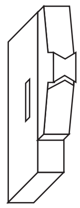
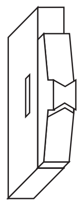
To enable you to use thermocouples with SCXI modules, the TBX-1303 terminal block has a thermistor temperature sensor for cold-junction compensation.

You can connect the temperature sensor to an SCXI module in either of two ways:

- Multiplexed Temperature Sensor (MTEMP) mode—Set the TBX-1303 terminal block switch S1 to the MTEMP position. This is the factory-default setting.
- Direct Temperature Sensor (DTEMP) mode—Set the TBX-1303 terminal block switch S1 to the DTEMP position. This mode connects the temperature sensor to a separate DAQ channel via your SCXI module. Refer to your SCXI module documentation to configure your SCXI module for DTEMP mode.

Table 1 shows the terminal block switch settings.

Table 1. Switch S1 Settings

Switch S1 Position	**Description**
	MTEMP mode selected; factory setting; preferred mode and parking position
	DTEMP mode selected; connect to a separate DAQ channel

Note: ***On the SCXI-1102 module, the MTEMP and DTEMP modes are equivalent.***

Temperature Sensor Output and Accuracy

The TBX-1303 temperature sensor voltage output varies from 1.91 to 0.58 V over the 0° to 55° C temperature range. The temperature sensor output accuracy is shown in Table 2.

Table 2. 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

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

Alternatively, you can use the following formulas 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

[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 effects caused by temperature and loading, and self-heating.

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

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

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

$V_{TEMPOUT}$ = 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 has 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.

Configuring the Resistor Networks

Note to SCXI-1102 Users: ***A package of 10 MΩ resistor networks is included in the TBX-1303 kit. These resistor networks can be installed as RP5, RP6, RP7, and RP8. With this recommended configuration, it does not matter whether the thermocouples are ground-referenced or floating.***

The TBX-1303 terminal block has a pullup resistor connected between CH+ and +5 V and a bias resistor connected between CH- and chassis ground.

Figure 7 shows how the pullup and bias resistors are connected to the CH± inputs.

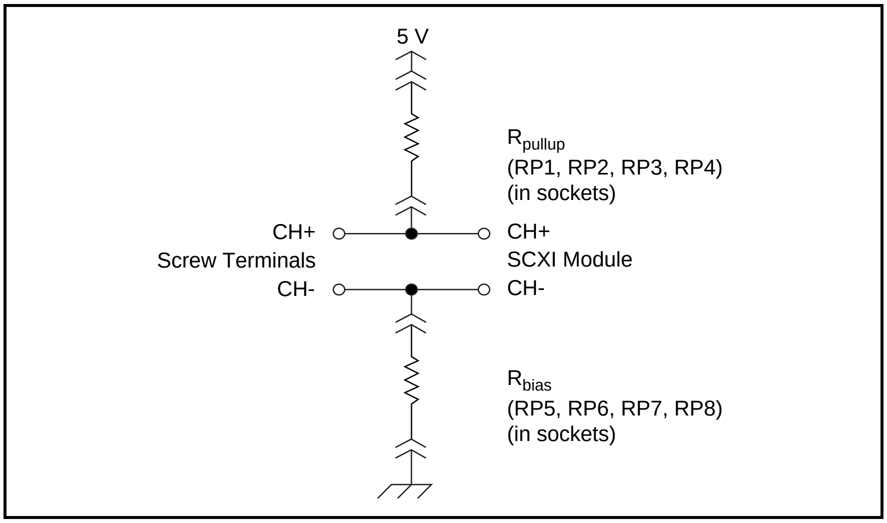


Figure 7. Resistor Connections

Table 3 shows the relationship between the channel input signals and the resistor networks.

Table 3. Channel Input Signals and Resistor Networks

Channel	**Pullup Resistor Network**	**Bias Resistor Network**
0–7	RP1	RP5
8–15	RP2	RP6
16–23	RP3	RP7
24–31	RP4	RP8

Table 4 shows which resistor networks to use for your SCXI module, signal type, and application.

Table 4. Selecting the Appropriate Resistor Networks

Module	Bias Resistor	Pullup Resistor	Source Impedance	Signal (Floating or Ground-referenced)	Open Thermocouple Detection?	Comments
SCXI-1102	10 MΩ	10 MΩ	Low	Both	Yes	Recommended configuration for the SCXI-1102
	10 Ω	10 MΩ	Low	Floating	Yes	Factory-shipping configuration
	10 Ω	None	High or low	Floating	No	—
	None	None	High or low	Ground-referenced	No	—
SCXI-1100	10 MΩ	10 MΩ	—	—	—	Not recommended
	10 Ω	10 MΩ	Low	Floating	Yes	Factory-shipping configuration
	10 Ω	None	High or low	Floating	No	—
	None	None	High or low	Ground-referenced	No	—
Low source impedance: ≤50 Ω High source impedance: >50 Ω						

Warning: ***Connecting an external ground-referenced signal with the 10 Ω resistor network in place may cause permanent damage to the resistor network and the traces on the TBX-1303 printed circuit board. National Instruments is NOT liable for any damage or injuries resulting from improper signal connections.***

Open Thermocouple Detection

The TBX-1303 circuitry helps you detect an open thermocouple. To detect whether any thermocouple is open, check whether the corresponding SCXI module channel is saturated. The pullup and bias resistors on the TBX-1303 saturate the channel by applying +5 V at the input of an open channel. Notice that this will result in saturation to either of the positive or negative rails.

SCXI-1102 Module

You can replace the 10 Ω bias resistor networks (factory-default configuration) in the TBX-1303 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 will saturate at all sample rates of the module.

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 6 and 8).

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 *100* (10 x 10^0 Ω); the 10 MΩ resistor network is labeled *106* (10 x 10^6 Ω). Figure 8 shows examples of these resistors.

a. 10 Ω Resistor Network   b. 10 MΩ Resistor Network

Figure 8. Resistor Networks

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 at a gain of 100 or higher, which corresponds to a sample rate of 5 kHz.

With the 10 Ω bias resistors installed in the TBX-1303, you can measure accurately at the module's maximum sampling rate, but 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 a short thermocouple, or if high accuracy is not important, you can replace the pullup resistors with a lower value resistor network. For example, you can replace the pullup resistor with a 1 MΩ, 10-pin bused configuration resistor network (not included) and have a sample rate of 20 kHz (interchannel delay of 50 µs typical). With a 10 Ω bias resistor network, the current leakage would be 5 µA (5 V/1 MΩ), which may 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 pin 1 of each network is in the correct socket (see Figures 6 and 8). Each 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 *100* (10 x 10^0 Ω); the 10 MΩ resistor network is labeled *106* (10 x 10^6 Ω). See Figure 8 for an example of each of these resistors.

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 your signal leads.

Common-Mode Voltage at the Input of the SCXI Module

With 10 MΩ pullup 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 module is sufficiently high that the resulting offset voltage is negligible.

If your application demands extremely high accuracy, you can eliminate this offset error by calibrating your system. You can also remove the pullup resistor, which eliminates the open-thermocouple detection feature, or use the 10 Ω bias 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 pullup resistor networks, the current leakage results in a negligible error. With the 10 Ω bias resistor, the 10 MΩ pullup 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 feet long, a voltage drop of approximately 8.78 µV (0.878 Ω/double ft x 20 double ft x 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 removing the appropriate pullup resistor network or by calibrating the system offset.

Temperature Sensor Circuit Diagram

The circuit diagram in Figure 9 provides details about the TBX-1303 temperature sensor.

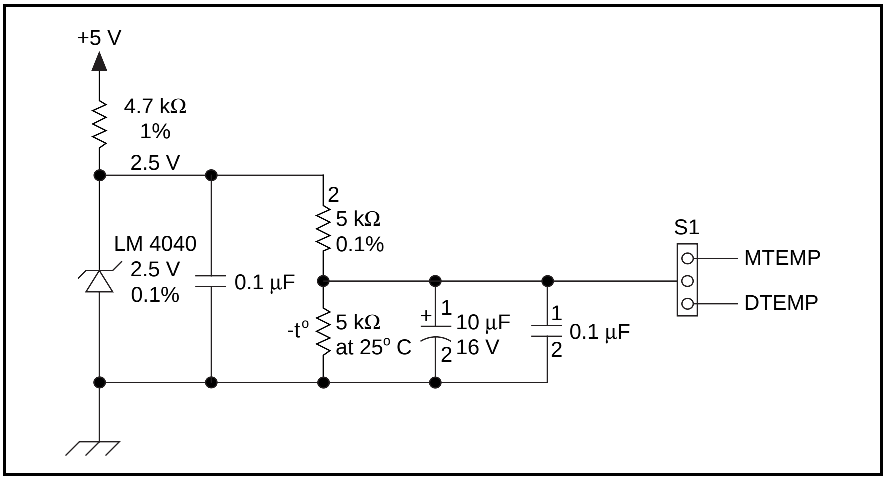


Figure 9. Temperature Sensor Circuit Diagram

Specifications

Cold-junction sensor

- Accuracy[2] .... 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 V (at 0° C) to 0.58 V (at 55° C)

Open thermocouple detection

- Pullup resistor .... 10 MΩ
- Bias resistor .... 10 Ω or 10 MΩ
- Maximum Field Wire Gauge .... 26-14 AWG

Compatible DIN rails .... DIN EN 50 022
DIN EN 50 035

Terminal block dimensions .... 17.81 x 7.62 x 11.18 cm (7.8 x 3 x 4.4 in.)

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

[2]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 effects caused by temperature and loading, and self-heating.