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**SCXI-1102B**

# SCXI™-1303 32-CHANNEL ISOTHERMAL TERMINAL BLOCK

This guide describes how to install and use the SCXI-1303 terminal block with SCXI-1102, SCXI-1102B, SCXI-1102C, and SCXI-1100 modules.

## Introduction

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The SCXI-1303, 32-channel isothermal terminal block is a shielded device with screw terminals that connect to the SCXI-1102/B/C and SCXI-1100 modules. The SCXI-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 take measurements with thermocouples.

The terminal block has 78 screw terminals for easy signal connection. Thirty-two pairs of screw terminals connect to the 32 differential inputs of the SCXI modules. One pair of terminals connects to the chassis ground pins of the module. Three terminals connect to the SCXI module OUTPUT and AOREF pins and to the SCXIbus GUARD. All of the other terminals—OUT0+, OUT0–, OUT1+, OUT1–, OUT2+, OUT2–, OUT3+, OUT3–, and AIREF—are reserved for future use.

For each input channel, the terminal block 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 saturating the module amplifier output.

## What You Need to Get Started

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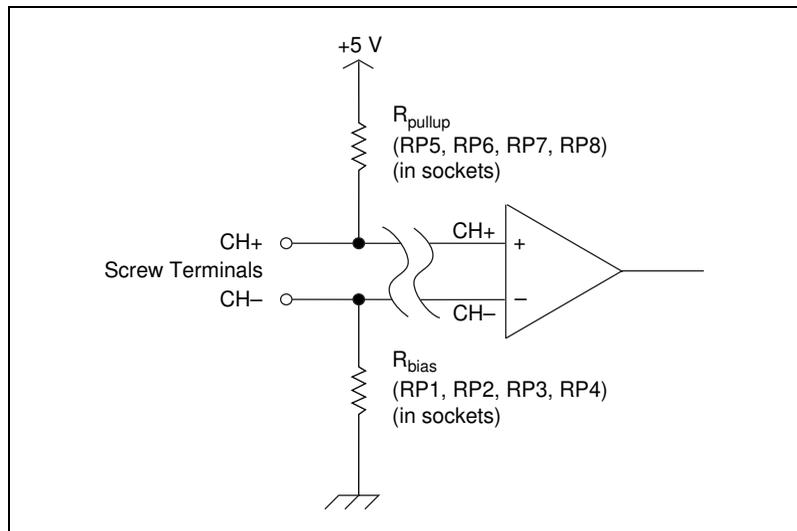
To set up and use your SCXI-1303, you need the following items:

- SCXI-1303 32-channel isothermal terminal block
- SCXI-1303 32-Channel Isothermal Terminal Block Installation Guide*

- ❑ SCXI chassis
- ❑ SCXI-1102/B/C or SCXI-1100 module
- ❑ One package of four 10  $\Omega$  resistor networks
- ❑ Number 1 and 2 Phillips-head screwdrivers
- ❑ 1/10 in. and 1/4 in. flathead screwdrivers
- ❑ Long-nose pliers

## Open Thermocouple Detection

The SCXI-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 SCXI-1303 has pullup and bias resistors that saturate the channel by applying +5 V at the input of the open channel. This results in saturation to the positive rail. The SCXI-1303 ships with 10  $\Omega$  and 10 M $\Omega$  bias resistors. Use the 10 M $\Omega$  factory-installed resistors with the SCXI-1102/B/C modules. Your kit contains four 10  $\Omega$  networks for use with the SCXI-1100 module. To replace the bias resistors, refer to the [Changing Resistor Networks](#) section. Figure 1 shows an example of open thermocouple detection circuitry.



**Figure 1.** Open Thermocouple Detection Circuitry

## SCXI-1102/B/C Module

When you use the SCXI-1303 with an SCXI-1102/B/C module, use the factory-installed 10 M $\Omega$  bias resistors for open thermocouple detection. With the 10 M $\Omega$  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.

## SCXI-1100 Module

When you use the SCXI-1100 module with open thermocouple detection, National Instruments recommends that you replace the factory installed 10 M $\Omega$  bias resistor networks of the SCXI-1303 with the 10  $\Omega$  resistors supplied with the kit. With the 10  $\Omega$  bias resistors installed in the SCXI-1303, you can measure accurately at the maximum sampling rate of the module, but the open thermocouple channel may not saturate if the interchannel delay is less than 200  $\mu$ s or if the sample rate is more than 5 kS/s at a gain of 100 or higher.

If you want fast open thermocouple detection and you have a thermocouple with short leads or if high accuracy is not important, you can replace the pullup resistors with a lower value resistor network. For example, you could replace the pullup resistor network with a 1 M $\Omega$ , 10-pin based-configuration resistor network (not supplied) and have a sample rate of 20 kS/s (interchannel delay of 50  $\mu$ s typical). With a 10  $\Omega$  bias resistor network, the current leakage would be 5  $\mu$ A (5 V/1 M $\Omega$ ), which may result in a larger offset error because of thermocouple lead resistance. To replace your resistor networks, refer to the [Changing Resistor Networks](#) section.

## Errors Due to Open-Thermocouple Detection Circuitry

Open-thermocouple detection circuitry can cause three 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 M $\Omega$  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/B/C 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, thus giving up the open thermocouple detection feature, or use the 10  $\Omega$  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 M $\Omega$  bias and pullup resistor networks, the current leakage results in a negligible error. With the 10  $\Omega$  bias resistor, the 10 M $\Omega$  pullup resistor connected to 5 VDC causes a current leakage of approximately 0.5  $\mu$ A (5 V/10 M $\Omega$ ) to flow into the unbroken thermocouple. If the thermocouple is very long, a voltage drop can develop 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  $\mu$ V (0.878  $\Omega$ /double ft  $\times$  20 double ft  $\times$  0.5  $\mu$ A) can develop in the thermocouple, which corresponds to an error of 0.18  $^{\circ}$ 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.

## DAQ Device Overload

When sampling an open thermocouple channel, the multiplexed output of the SCXI module is driven toward the positive power-supply rail. Since this output voltage exceeds +11 V, the DAQ device input channel is momentarily driven into *overload*. This does not harm the DAQ device, but you must allow time for the DAQ device to recover from overload before it can make accurate voltage measurements again. If the scan rate is too high to permit overload recovery to occur after an open thermocouple channel is sampled, channel readings immediately subsequent to an open thermocouple channel may be too high.

# Temperature Sensor Output and Accuracy

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The SCXI-1303 temperature sensor outputs 1.91 to 0.58 V from 0 to 55  $^{\circ}$ C and has an accuracy of  $\pm 0.5$   $^{\circ}$ C over the 15 to 35  $^{\circ}$ C range and  $\pm 0.9$   $^{\circ}$ C over the 0 to 15  $^{\circ}$ C and 35 to 55  $^{\circ}$ C ranges<sup>1</sup>.

National Instruments software can convert a thermistor voltage to the thermistor temperature for the circuit diagram shown later in this guide. In LabVIEW, you can use the Convert Thermistor Reading VI in the **Data Acquisition»Signal Conditioning** palette. If you are using LabWindows/CVI or NI-DAQ, use the `Thermistor_Convert` function. The VI takes the output voltage of the temperature sensor, the reference voltage, and the precision resistance and returns the thermistor temperature.

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<sup>1</sup> This 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, plus the effects caused by temperature and self-heating.

Alternatively, you can use the following formulas:

$$T(^{\circ}\text{C}) = T_K - 273.15$$

where  $T_K$  is the temperature in Kelvin

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

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

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

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

$R_T$  = resistance of the thermistor in ohms

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

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

$$T(^{\circ}\text{F}) = \frac{[T(^{\circ}\text{C})]9}{5} + 32$$

where  $T(^{\circ}\text{F})$  and  $T(^{\circ}\text{C})$  are the temperature readings in degrees Fahrenheit and degrees 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 permitted gain for this signal range on the analog input channel.

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

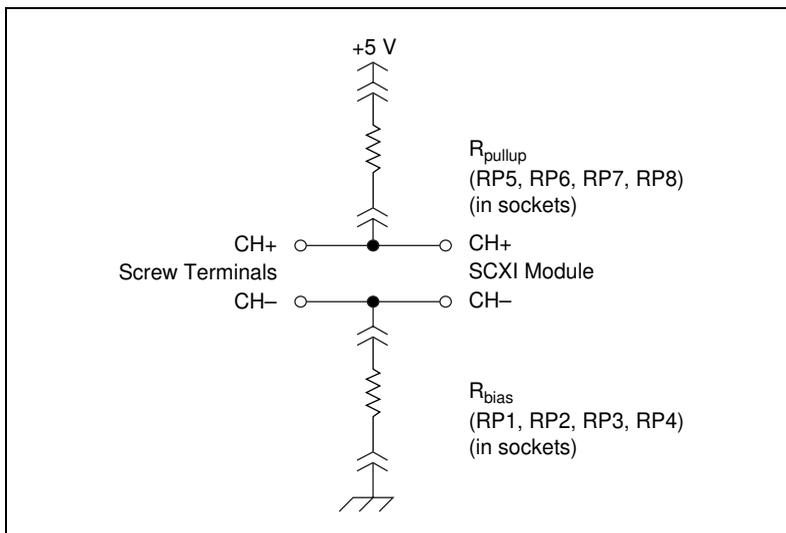
The SCXI-1100 does not have a filter on the  $V_{TEMPOUT}$  signal. Therefore, calculate an average of a large number of samples to obtain the most accurate measurement. Electrically noisy environments require more samples for greater accuracy.

# Configuring the Resistor Networks



**Note** A package of 10  $\Omega$  resistor networks is included in the SCXI-1303 kit. If you are using the SCXI-1100 module, you can install these resistor networks as RP1, RP2, RP3, and RP4. With this configuration, the thermocouples must be floating.

For each channel, the SCXI-1303 terminal block has a pullup resistor connected between CH+ and +5 V and a bias resistor connected between CH- and chassis ground. Figure 2 shows how the pullup and bias resistors connect to the CH $\pm$  inputs.



**Figure 2.** Resistor Connections

Table 1 shows the relationship between the channel input signals and the resistor networks.

**Table 1.** Channel Input Signals and Resistor Networks

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

Table 2 shows which resistor networks to use for your SCXI module, signal type, and application.

**Table 2.** Selecting the Appropriate Resistor Networks

Module	Bias Resistor	Pullup Resistor	Source Impedance <sup>1, 2</sup>	Signal (Floating or Ground-referenced)	Open Thermocouple Detection?	Comments
SCXI-1102/B/C	10 M $\Omega$	10 M $\Omega$	Low	Either	Yes	Recommended configuration for the SCXI-1102/B/C. Factory-shipping configuration
	10 $\Omega$	10 M $\Omega$	Low	Floating	Yes	—
	10 $\Omega$	None	High or low	Floating	No	—
	None	None	High or low	Ground-referenced	No	—
SCXI-1100	10 M $\Omega$	10 M $\Omega$	—	—	—	Not recommended
	10 $\Omega$	10 M $\Omega$	Low	Floating	Yes	—
	10 $\Omega$	None	High or low	Floating	No	—
	None	None	High or low	Ground-referenced	No	—
<sup>1</sup> low source impedance $\leq 50 \Omega$ <sup>2</sup> high source impedance $> 50 \Omega$						



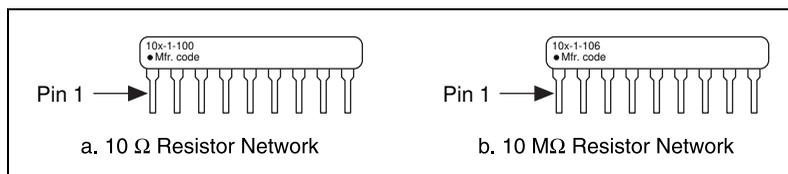
**Warning** Connecting an external ground-referenced signal with the 10  $\Omega$  bias resistor network in place can cause permanent damage to the resistor network and the traces on the SCXI-1303 printed circuit board. National Instruments is *not* liable for any damage or injuries resulting from improper signal connections.

# Changing Resistor Networks

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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 position in the socket. Refer to Figure 5 to locate pin 1 for each resistor network 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  $\Omega$  resistor network is labeled 100 ( $10 \times 10^0 \Omega$ ); the 10 M $\Omega$  resistor network is labeled 106 ( $10 \times 10^6 \Omega$ ). Figure 3 shows examples of these resistor networks.



**Figure 3.** Resistor Networks



**Note** You can purchase 10  $\Omega$  and 10 M $\Omega$  replacement resistor networks from National Instruments.

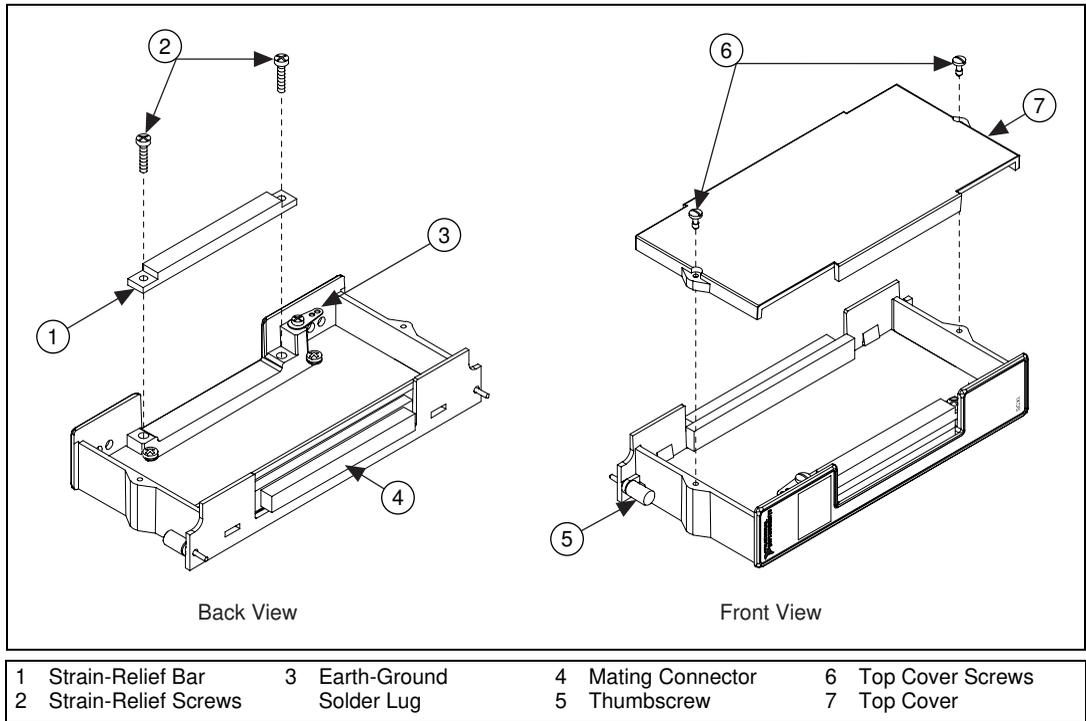
## Signal Connection

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To connect the signal to the terminal block, perform the following steps, referring to Figures 4 and 5 as necessary:

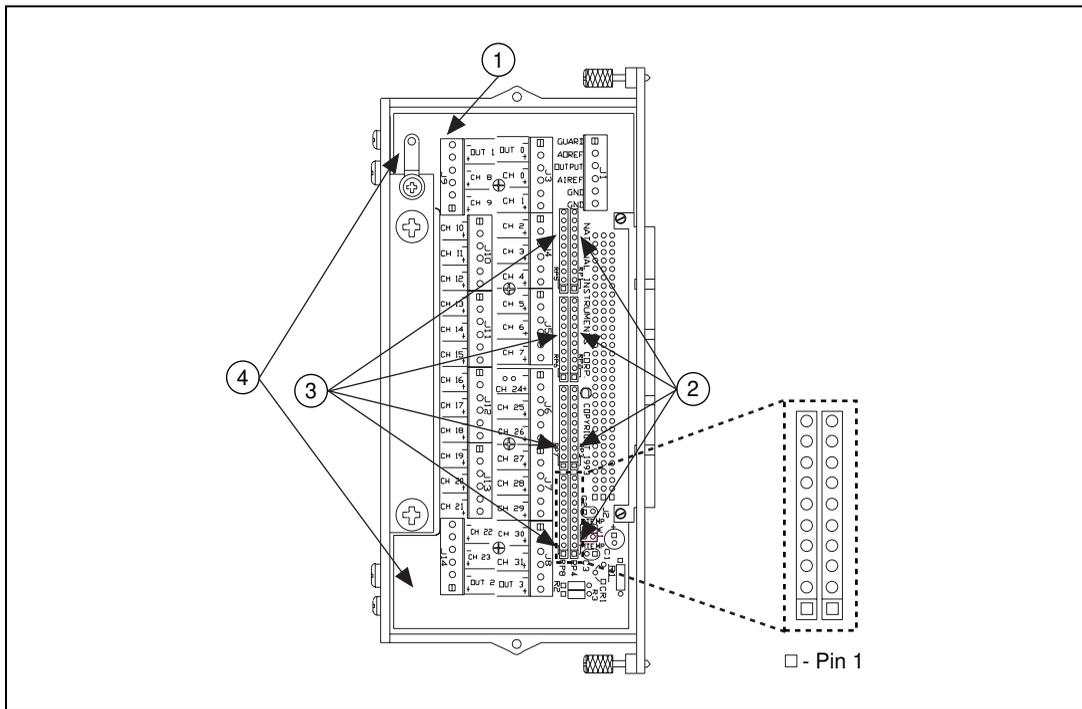
1. Unscrew the top cover screws and remove the cover.
2. Loosen the strain-relief screws and remove the strain-relief bar.

3. Run the signal wires through the strain-relief opening. You can add insulation or padding if necessary.



**Figure 4.** SCXI-1303 Parts Locator Diagram

4. Prepare your signal wire by stripping the insulation no more than 7 mm.
5. Connect the wires to the screw terminals by inserting the stripped end of the wire fully into the terminal. No bare wire should extend past the screw terminal. Exposed wire increases the risk of a short circuit in adjacent channels.
6. Tighten the screw terminal to a torque of 5–7 in.-lb.



- 1 Screw Terminals
- 2 Bias Resistor Networks

- 3 Pullup Resistor Networks
- 4 Product Name and Assembly Number

**Figure 5.** SCXI-1303 Signal Connections

7. Reinstall the strain-relief bar and tighten the strain-relief screws.
8. Reinstall the top cover and tighten the top cover screws.
9. Connect the terminal block to the module front connector as explained in the *Installation* section.

## Installation

To connect the terminal block to the SCXI module front connector, perform the following steps:

1. Connect the module front connector to its mating connector on the terminal block.
2. Tighten the top and bottom thumbscrews on the back of the terminal block to hold it securely in place.



**Note** For accurate cold-junction compensation, place the SCXI chassis away from an extreme temperature differential.

# Cleaning the Terminal Block

Clean the terminal block by brushing off light dust with a soft, nonmetallic brush. Remove other contaminants with deionized water and a stiff nonmetallic brush. The unit must be completely dry and free from contaminants before returning to service.

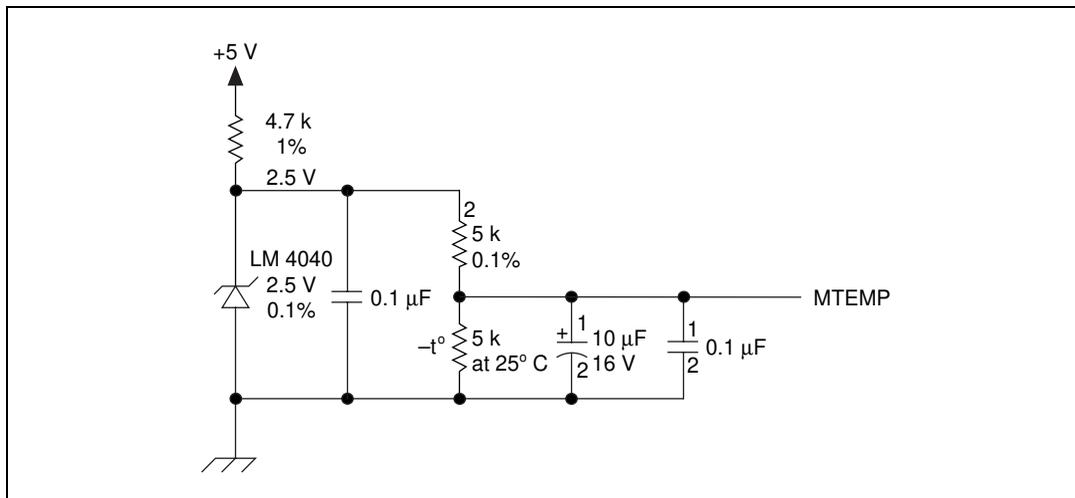
## Specifications

Cold-junction sensor

Sensor type.....	thermistor
Accuracy <sup>1</sup> .....	0.5 °C from 15 to 35 °C 0.9 °C from 0 to 15 °C and 35 to 55 °C
Repeatability .....	0.2 °C from 15 to 35 °C
Output .....	1.91 to 0.58 V from 0 to 55 °C

## Temperature Sensor Circuit Diagram

The circuit diagram in Figure 6 provides optional details about the SCXI-1303 temperature sensor.



**Figure 6.** Temperature Sensor Circuit Diagram

<sup>1</sup> This 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, plus the effects caused by temperature and self-heating.



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