CALIBRATION PROCEDURE
TB-9212

This document contains the verification procedure for the TB-9212 with screw terminal and TB-9212 with mini-TC. In this document, TB-9212 with screw terminal and TB-9212 with mini-TC are inclusively referred to as TB-9212. For more information about calibration solutions, visit ni.com/calibration.

Note Refer to the NI 9212 Calibration Procedure on ni.com/manuals for instructions on calibrating the NI 9212 module.

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Calibrating the TB-9212 requires the installation of NI-DAQmx 15.1 or later on the calibration system. You can download NI-DAQmx from ni.com/downloads. NI-DAQmx supports LabVIEW, LabWindows™/CVI™, ANSI C, and .NET. When you install NI-DAQmx, you only need to install support for the application software that you intend to use.

Documentation

Consult the following documents for information about the TB-9212, NI-DAQmx, and your application software. All documents are available on ni.com and help files install with the software.

- **NI cDAQ-9174/9178 Quick Start**
  NI-DAQmx installation and hardware setup

- **NI 9212 Getting Started Guide**
  NI 9212 with TB-9212 specific information

- **NI 9212 Datasheet**
  NI 9212 with TB-9212 specifications and calibration interval

- **NI-DAQmx Readme**
  Operating system and application software support in NI-DAQmx

- **LabVIEW Help**
  LabVIEW programming concepts and reference information about NI-DAQmx VIs and functions

- **NI-DAQmx C Reference Help**
  Reference information for NI-DAQmx C functions and NI-DAQmx C properties

- **NI-DAQmx .NET Help Support for Visual Studio**
  Reference information for NI-DAQmx .NET methods and NI-DAQmx .NET properties, key concepts, and a C enum to .NET enum mapping table
# Test Equipment

Table 1 lists the equipment recommended for the performance verification procedure. If the recommended equipment is not available, select a substitute using the requirements listed in Table 1.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Recommended Model</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermocouple Calibrator</td>
<td>Ectron 1140A</td>
<td>A high-precision thermocouple source with an accuracy of ≤0.11 °C and an output impedance of ≤10 Ω.</td>
</tr>
<tr>
<td>NI 9212</td>
<td>—</td>
<td>An NI 9212 module that is verified to be within product specifications.</td>
</tr>
<tr>
<td>Chassis</td>
<td>cDAQ-9178</td>
<td>—</td>
</tr>
<tr>
<td>Barrier Strip Assembly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermocouple Wire</td>
<td>TT-E-24-SLE-100</td>
<td>E-type SLE 24 AWG, 20 m to 30 m</td>
</tr>
<tr>
<td>Mini Thermocouple Connector</td>
<td>Omega SMPW-E-M</td>
<td>E-type, must fit the output terminal of the thermocouple calibrator</td>
</tr>
<tr>
<td>Thermocouple Barrier Strips</td>
<td>Omega BS16A</td>
<td>8 channels</td>
</tr>
<tr>
<td>Thermocouple Barrier Strip Jackets (x8)</td>
<td>Omega BSJ-E</td>
<td>E-type, 8 channels</td>
</tr>
<tr>
<td>Thermocouple Spade Lugs (x32)</td>
<td>Omega SLCH-20</td>
<td>16 lugs of chromel to match the E-type wires</td>
</tr>
<tr>
<td></td>
<td>Omega SLCO-20</td>
<td>16 lugs of constantan to match the E-type wires</td>
</tr>
<tr>
<td>Spade-Lug Crimping Tool</td>
<td>Omega CRIMPING TOOL-P</td>
<td>Must effectively crimp the spade lugs with the 24 AWG wire.</td>
</tr>
</tbody>
</table>
Building the Barrier Strip Assembly

Complete the following steps to build the barrier strip assembly.

1. Build the barrier strip according to Figure 1.

   **Note** Spade-lug colors in Figure 1 are for illustration purposes only and are used to easily differentiate chromel and constantan spade lugs.

   **Figure 1.** Building the Barrier Strip Assembly

   1 Use a single thermocouple wire, spade lugs, spade-lug crimping tool, and mini thermocouple connector to make a wire assembly. Crimp the chromel spade lugs to the chromel wire to create 8 positive spade lugs. Crimp the constantan spade lugs to the constantan wire to create 8 negative spade lugs.
   2 Use the thermocouple wire, spade lugs, and spade-lug crimping tool to make 8 wires with bare leads on one end and the spade lugs on the other end. Crimp the chromel spade lug to the chromel wire and the constantan spade lug to the constantan wire.
   3 Assemble the barrier strips and barrier strip jackets as indicated by the manufacturer.
   4a (TB-9212 with screw terminal) Connect the wire assembly with the mini thermocouple connector and 8 wires to the barrier strip.
   4b (TB-9212 with mini-TC) Connect the wire assembly with the mini thermocouple connector and 8 wires to the barrier strip.

2. Place the barrier strip section in any manner of enclosed setup, or controlled environment, to reduce the affect of air currents and rapid temperature transients.
Test Conditions

The following setup and environmental conditions are required to ensure the TB-9212 meets published specifications.

- Keep connections to the TB-9212 as short as possible. Long cables and wires act as antennas, picking up extra noise that can affect measurements.
- Verify that all connections to the TB-9212 are secure.
- Use thermocouple wire for all cable connections to the TB-9212.
- Maintain an ambient temperature of 23 °C ± 5 °C. The TB-9212 temperature will be greater than the ambient temperature.
- Keep relative humidity below 80%.
- Allow a warm-up time of at least 15 minutes to ensure that the NI 9212 measurement circuitry is at a stable operating temperature.

Initial Setup

Refer to the NI cDAQ-9174/9178 Quick Start for information about how to install the software and hardware and how to configure the device in Measurement & Automation Explorer (MAX).

Complete the following steps to set up the TB-9212.

1. Install NI-DAQmx.
   
   **Note** Ensure that you install NI-DAQmx 15.1 or later. Calibrating the TB-9212 using NI-DAQmx 14.5 or earlier may result in inaccurate readings.

2. Make sure the cDAQ-9178 power source is not connected.
3. Connect the cDAQ-9178 to the system safety ground.
   a. Attach a ring lug to a 14 AWG (1.6 mm) wire.
   b. Connect the ring lug to the ground terminal on the side of the cDAQ-9178 using the ground screw.
   c. Attach the other end of the wire to the system safety ground.
4. Install the NI 9212 in slot 8 of the cDAQ-9178 chassis. Leave slots 1 through 7 of the cDAQ-9178 chassis empty.
5. Connect the cDAQ-9178 chassis to your host computer.
6. Connect the power source to the cDAQ-9178 chassis.
8. Right-click the device name and select **Self-Test** to ensure that the module is working properly.
Verification

The following performance verification procedure describes the sequence of operation and provides test points required to verify the TB-9212. The verification procedure assumes that adequate traceable uncertainties are available for the calibration references.

Terminal Block CJC Verification

Complete the following procedure to determine the As-Found status of the TB-9212.

1. If you are using a TB-9212 with screw terminal, loosen the captive screws and remove the top cover. If you are using a TB-9212 with mini-TC, you do not need to remove the top cover.

2. Connect the thermocouple calibrator to the TB-9212 using the barrier strip assembly created in the Building the Barrier Strip Assembly section. Refer to Figure 2 for a connection diagram.

3. If you are using a TB-9212 with screw terminal, reinstall the top cover.

4. Connect the TB-9212 to the NI 9212.

5. Power on the thermocouple calibrator and set the thermocouple type to E-type.

6. Wait 15 minutes or the warm-up time required by the thermocouple calibrator, whichever is longer.

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Figure 2. TB-9212 Verification Connections

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TC Calibrator
Mini TC Connector
Barrier Strip Assembly

NI TB-9212

TC0+
TC0–
TC1+
TC1–
TC6+
TC6–
TC7+
TC7–

E0+
E0–
E1+
E1–
E6+
E6–
E7+
E7–
7. Acquire and average a CJC\textsubscript{temp\_x} value.
   a. Create and configure an AI Temp Built-in Sensor task for CJC channel _cjtempx on the NI 9212 according to Table 2.

   \textbf{Table 2. NI 9212 CJC Channel Configuration}

<table>
<thead>
<tr>
<th>Physical Channels</th>
<th>Timing Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>_cjtemp0:1</td>
<td>High Resolution</td>
</tr>
</tbody>
</table>

   b. Configure the AI Temp Built-in Sensor task for CJC channel _cjtempx according to Table 3.

   \textbf{Table 3. NI 9212 CJC Channel Timing Configuration}

<table>
<thead>
<tr>
<th>Sample Mode</th>
<th>Samples Per Channel</th>
<th>Rate (S/s)</th>
<th>Timeout (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finite</td>
<td>20</td>
<td>1.8</td>
<td>30</td>
</tr>
</tbody>
</table>

c. Start the task.
d. Average the readings and record the value as CJC\textsuperscript{temp\_x}.
e. Clear the task.

8. Set the thermocouple calibrator output to CJC\textsubscript{tempx} to obtain the readings for the first four physical channels, ai0:3. This ensures that during the thermocouple measurements, the input channel measures very close to 0 V, which eliminates gain errors in the NI 9212.

9. Acquire and average samples.
   a. Create and configure an AI temperature thermocouple channel for the NI 9212 according to Table 4.

   \textbf{Table 4. NI 9212 Thermocouple Channel Configuration}

<table>
<thead>
<tr>
<th>CJC Channel</th>
<th>Physical Channels</th>
<th>Minimum Value</th>
<th>Maximum Value</th>
<th>Unit</th>
<th>Thermocouple Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>CJCtemp0</td>
<td>ai0:3</td>
<td>0</td>
<td>100</td>
<td>°C</td>
<td>E</td>
</tr>
<tr>
<td>CJCtemp1</td>
<td>ai4:7</td>
<td>0</td>
<td>100</td>
<td>°C</td>
<td>E</td>
</tr>
</tbody>
</table>

   b. Configure the AI temperature thermocouple channel timing according to Table 5.

   \textbf{Table 5. NI 9212 Thermocouple Channel Timing Configuration}

<table>
<thead>
<tr>
<th>Timing Mode</th>
<th>Sample Mode</th>
<th>Samples Per Channel</th>
<th>Rate (S/s)</th>
<th>Timeout (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Resolution</td>
<td>Finite</td>
<td>20</td>
<td>1.8</td>
<td>30</td>
</tr>
</tbody>
</table>

c. Start the task.
**Notes** Make sure the thermocouple calibrator and NI 9212 are completely settled at the desired temperature setting before acquiring data.

Wait at least 300 ms for the Ectron 1140A to settle before acquiring data with the NI 9212.

Wait at least 1 second to compensate for the open thermocouple settling time of the NI 9212.

d. Average the readings for each channel. Record the average of the readings for each as \( \text{Temp}_{\text{ai}x} \) where \( x \) is the channel number.

e. Clear the task.

10. Set the thermocouple calibrator output to CJC\(_\text{temp1}\) to obtain the readings for the next four physical channels, ai4:7. This ensures that during the thermocouple measurements, the input channel measures very close to 0 V, which eliminates gain errors in the NI 9212.


12. Perform the following calculation using the recorded \( \text{Temp}_{\text{ai}x} \) and CJC\(_\text{temp}_x\) values.

\[
\text{Temp}_{\text{ErrorCh}0:3} = \text{Temp}_{\text{ai}0:3} - \text{CJC}_{\text{temp0}}
\]

\[
\text{Temp}_{\text{ErrorCh}4:7} = \text{Temp}_{\text{ai}4:7} - \text{CJC}_{\text{temp1}}
\]

13. Compare the calculation result for each channel to the Upper Limit and Lower Limit values in Table 6.

14. Remove the TB-9212 from the NI 9212.

15. Disconnect the barrier strip assembly from the TB-9212.

**Table 6. TB-9212 Verification Test Limits**

<table>
<thead>
<tr>
<th>Connector</th>
<th>Timing Mode</th>
<th>Test Point Value (°C)</th>
<th>Error</th>
<th>1-Year Limits (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TB-9212 with Screw</td>
<td>High</td>
<td>CJC(_\text{temp}_x)</td>
<td>(\text{Temp}_{\text{ErrorCh}})</td>
<td>Lower Limit: -0.44 Upper Limit: 0.44</td>
</tr>
<tr>
<td>Terminal</td>
<td>Resolution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TB-9212 with Mini-TC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note** The test limits listed in Table 6 are based upon the 374389A-01 edition of the **NI 9212 with NI TB-9212 Datasheet**. Refer to the most recent **NI 9212 with NI TB-9212 Datasheet** online at ni.com/manuals.

If the verification procedure determines that the TB-9212 is outside of the limits, refer to **Where to Go for Support** for assistance in returning the device to NI.
Where to Go for Support

The NI website is your complete resource for technical support. At ni.com/support you have access to everything from troubleshooting and application development self-help resources to email and phone assistance from NI Application Engineers.

Visit ni.com/services for NI Factory Installation Services, repairs, extended warranty, and other services.

Visit ni.com/register to register your NI product. Product registration facilitates technical support and ensures that you receive important information updates from NI.

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