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CALIBRATION PROCEDURE
NI 9212

This document contains the verification and adjustment procedures for the NI 9212. For more information about calibration solutions, visit `ni.com/calibration`.

Note Refer to the *NI TB-9212 Calibration Procedure* on `ni.com/manuals` for instructions on calibrating the NI TB-9212.

Contents

NATIONAL INSTRUMENTS

Software

Calibrating the NI 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 NI 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 with NI TB-9212 Getting Started Guide

NI 9212 with NI TB-9212 specific information

NI 9212 with NI TB-9212 Datasheet

NI 9212 with NI 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 and adjustment procedures. If the recommended equipment is not available, select a substitute using the requirements listed in Table 1.

Table 1. Recommended Equipment

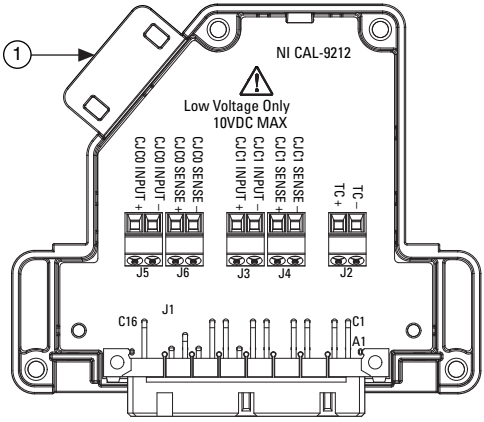
Equipment	Recommended Model	Where Used	Requirements
Calibrator	Fluke 5522A locked in the 3.3 V range	Voltage Verification, Voltage Adjustment, CJC Adjustment	A high-precision voltage source with an accuracy of ≤70 ppm when sourcing up to 50 µA.
	Fluke 5522A	CJC Verification	A high-precision resistance source with 2-wire compensation and an accuracy of at least • 660 ppm at 1,099.999 Ω range, • 18 ppm at 32,999.99 Ω range, • 30 ppm at 109,999.9 Ω range. If the resistance source does not have 2-wire compensation, the leadwire resistance must be included in the total resistance source accuracy.
Chassis	NI cDAQ-9178	All	—
Connection Accessory	NI CAL-9212	All	—
Digital Multimeter	NI PXI-4071	CJC Adjustment	A multiranging 7.5 digit digital multimeter with an accuracy of at least • 8 ppm at 100 mV range • 6 ppm at 10 V range

Connecting the NI 9212

The NI CAL-9212 eases the calibration process by providing a thermocouple connection that is internally routed to all eight thermocouple channels, as well as input and sense connections to two CJC channels. Refer to Figure 1 for a pinout of the NI CAL-9212.

Caution Do not connect voltages greater than 10 VDC to the NI CAL-9212.

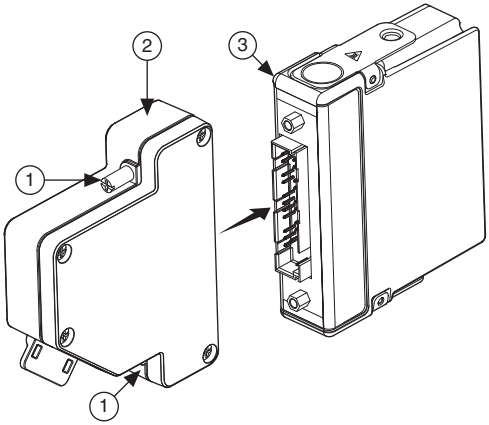
Figure 1. NI CAL-9212 Pinout



1	Ground Lug (on the bottom side of the NI CAL-9212 enclosure)

Connect the NI CAL-9212 to the NI 9212 front connector as shown in Figure 2. Tighten the two jackscrews on the NI CAL-9212 to hold it securely in place. Do not overtighten the jackscrews.

Figure 2. Installing the NI CAL-9212



1	Jackscrews	2	NI CAL-9212	3	NI 9212

Test Conditions

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

- Keep connections to the NI 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 NI 9212 are secure.
- Use shielded copper wire for all cable connections to the NI 9212. Use twisted-pairs wire to eliminate noise and thermal offsets.
- Maintain an ambient temperature of 23 °C ±5 °C. The NI 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 NI 9212.

1. Install NI-DAQmx.

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

2. Make sure the NI cDAQ-9178 power source is not connected.
3. Connect the NI 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 NI cDAQ-9178 using the ground screw.
   c. Attach the other end of the wire to the system safety ground.
4. Install the module in slot 8 of the NI cDAQ-9178 chassis. Leave slots 1 through 7 of the NI cDAQ-9178 chassis empty.
5. Connect the NI cDAQ-9178 chassis to your host computer.
6. Connect the power source to the NI cDAQ-9178 chassis.
7. Launch Measurement & Automation Explorer (MAX).
8. Right-click the device name and select **Self-Test** to ensure that the module is working properly.

Verification

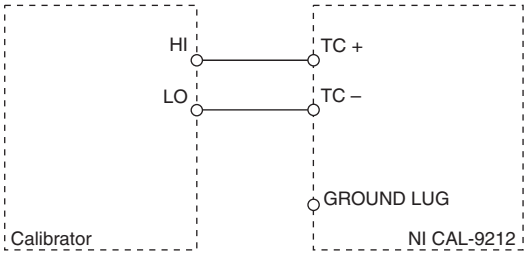
The following performance verification procedures describe the sequence of operation and test points required to verify the NI 9212. The verification procedures assume that adequate traceable uncertainties are available for the calibration references.

Voltage Verification

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

1. Loosen the captive screws and remove the top cover from the NI CAL-9212.
2. Connect the calibrator to the NI CAL-9212, as shown in Figure 3.

Figure 3. Voltage Channel Verification Connections



3. Reinstall the top cover on the NI CAL-9212.
4. Connect the NI CAL-9212 to the NI 9212, as shown in Figure 2.
5. On the Fluke 5522A calibrator, lock the voltage range to 3.3 V to reduce loading error.
   a. Set the output voltage to 2.0 V.
   b. Press the **3.3 V auto** button to lock the 3.3 V range.
6. Set the calibrator output to a Test Point value indicated in Table 4.
7. Set the calibrator to Operate mode (OPR).
8. Acquire and average samples.
   a. Create and configure an AI voltage channel on the NI 9212 according to Table 2.

Table 2. NI 9212 Voltage Channel Configuration

Physical Channels	Input Range (mV)		Scaled Units	Terminal Configuration
	Min	Max		
cDAQ1Mod8/ai0:7	-78.125	78.125	Volts	Differential

b. Configure the AI voltage channel timing according to Table 3.

Table 3. NI 9212 Voltage Channel Timing Configuration

ADC Timing Mode	Sample Mode	Samples to Read	Rate (S/s)	Timeout (s)
High Resolution	Finite	20	1.8	30
Best 50 Hz Rejection		80	7.1	
Best 60 Hz Rejection		100	8.3	
High Speed		1,000	95	

c. Start the task.

d. Average the readings.

e. Clear the task.

9. Set the calibrator to Standby mode (STBY).
10. Compare the average to the limits in Table 4.
11. Repeat steps 6 through 10 for each test point.
12. Repeat steps 6 through 11 for each ADC timing mode on the NI 9212.

Table 4. NI 9212 Voltage Verification Test Limits for Positive and Negative Test Points

ADC Timing Mode	Range (mV)		Test Point		1-Year Limits	
	Min	Max	Location	Value (mV)	Lower Limit (mV)	Upper Limit (mV)
High Resolution, Best 50/60 Hz Rejection	-78.125	78.125	Negative FS	-70	-70.020	-69.980
			Negative Mid	-35	-35.013	-34.987
			Positive Mid	35	34.987	35.013
			Positive FS	70	69.980	70.020
High Speed			Negative FS	-70	-70.022	-69.978
			Negative Mid	-35	-35.014	-34.986
			Positive Mid	35	34.986	35.014
			Positive FS	70	69.978	70.022

Note The test limits listed in Table 4 are derived using the values in Table 11.

13. Loosen the captive screws and remove the top cover from the NI CAL-9212.
14. Disconnect the calibrator from the NI CAL-9212.
15. Short the TC+ and TC- terminals on the NI CAL-9212 together.
16. Reinstall the top cover on the NI CAL-9212.
17. Acquire and average samples.
    a. Create and configure an AI voltage channel on the NI 9212 according to Table 2.
    b. Configure the AI voltage channel timing according to Table 3.
    c. Start the task.
    d. Average the readings.
    e. Clear the task.
18. Compare the average to the limits in Table 5.

Table 5. NI 9212 Voltage Verification Test Limits for Zero Test Points

ADC Timing Mode	Range (mV)		Test Point		1-Year Limits	
	Min	Max	Location	Value (mV)	Lower Limit (mV)	Upper Limit (mV)
High Resolution	-78.125	78.125	Zero	0	-0.0051	0.0051
Best 50/60 Hz Rejection					-0.0052	0.0052
High Speed					-0.0056	0.0056

Note The test limits listed in Table 5 are derived using the values in Table 11.

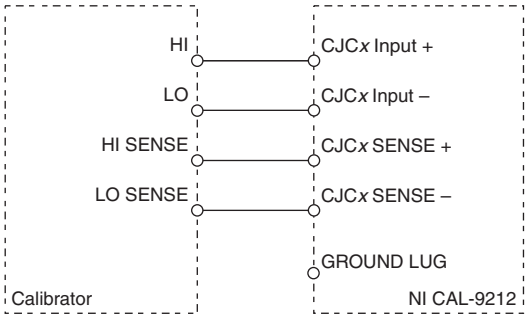
19. Repeat steps 17 through 18 for each ADC timing mode on the NI 9212.
20. Remove the NI CAL-9212 from the NI 9212.
21. Loosen the captive screws and remove the top cover from the NI CAL-9212.
22. Disconnect the short from the NI CAL-9212.

CJC Verification

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

1. Loosen the captive screws and remove the top cover from the NI CAL-9212.
2. Connect the calibrator to the NI CAL-9212, as shown in Figure 4.

Figure 4. CJC Channel Verification Connections



3. Reinstall the top cover on the NI CAL-9212.
4. Connect the NI CAL-9212 to the NI 9212, as shown in Figure 2.
5. Set the calibrator to 2-Wire Compensation mode.
6. Set the calibrator output to a Test Point value indicated in Table 8.
7. Set the calibrator to Operate mode (OPR).
8. Wait at least 15 seconds for the NI 9212 to settle before proceeding to the next step.
9. Acquire and average samples.
   a. Create and configure an AI voltage channel on the NI 9212 according to Table 6.

Table 6. NI 9212 CJC Channel Configuration

Physical Channels	Input Range (V)		Scaled Units	Terminal Configuration
	Min	Max		
cDAQ1Mod8/_cjtemp*x*	-2.5	2.5	Volts	RSE

   b. Configure the AI voltage channel timing according to Table 7.

Table 7. NI 9212 CJC Channel Timing Configuration

ADC Timing Mode	Sample Mode	Samples to Read	Rate (S/s)	Timeout (s)
High Resolution	Finite	20	1.8	30
Best 50 Hz Rejection		80	7.1	
Best 60 Hz Rejection		100	8.3	
High Speed		1,000	95	

c. Start the task.

d. Average the readings.

e. Clear the task.

10. Perform the following calculation to scale the voltage average to resistance.

$$\text{Resistance} = 28000 \times \frac{\text{Voltage}}{(2.5 - \text{Voltage})}$$

11. Compare the calculated resistance to the limits in Table 8.
12. Repeat steps 9 through 11 for each ADC timing mode on the NI 9212.
13. Repeat steps 6 through 12 for each test point.
14. Set the calibrator to Standby mode (STBY).
15. Remove the NI CAL-9212 from the NI 9212.
16. Loosen the captive screws and remove the top cover from the NI CAL-9212.
17. Disconnect the calibrator from the NI CAL-9212.
18. Repeat steps 2 through 17 for the other CJC channel on the NI 9212.

Table 8. NI 9212 CJC Verification Test Limits

ADC Timing Mode	Test Point		1-Year Limits	
	Location	Value (Ω)	Lower Limit (Ω)	Upper Limit (Ω)
High Resolution	Offset	1,000	998.31	1,001.69
	Gain 1	19,000	18,983.26	19,016.74
	Gain 2	100,000	99,870.09	100,129.91
Best 50/60 Hz Rejection	Offset	1,000	998.2	1,001.8
	Gain 1	19,000	18,982.76	19,017.24
	Gain 2	100,000	99,864.75	100,135.25
High Speed	Offset	1,000	997.37	1,002.63
	Gain 1	19,000	18,908.53	19,091.47
	Gain 2	100,000	99,125.27	100,874.73

Note The test limits in Table 8 are derived using the values in Tables 6 and 12.

Adjustment

The following performance adjustment procedure describes the sequence of operation required to adjust the NI 9212.

Voltage Adjustment

Complete the following procedure to adjust the voltage accuracy of the NI 9212.

1. Loosen the captive screws and remove the top cover from the NI CAL-9212.
2. Connect the calibrator to the NI CAL-9212, as shown in Figure 3.
3. Reinstall the top cover on the NI CAL-9212.
4. Connect the NI CAL-9212 to the NI 9212, as shown in Figure 2.
5. Initialize a calibration session on the NI 9212. The default password is `NI`.
6. Adjust the NI 9212 voltage.
   a. Input the external temperature in degrees Celsius using the set temperature C Series function.
   b. Call the Get NI 9212 Calibration Adjustment Points function and set the physical channel according to Table 9 to obtain an array of recommended calibration voltages for the NI 9212.
   c. On the Fluke 5522A calibrator, lock the voltage range to 3.3 V to reduce loading error.
   d. Set the calibrator to a reference value determined by the array of adjustment points.
   e. Set the calibrator to Operate mode (OPR).
   f. Call and configure the Adjust NI 9212 Calibration function according to Table 9.

Table 9. Voltage Adjustment Configuration

Physical Channel	Reference Value
cDAQ1Mod8/ai0:7	A reference value from the array of adjustment points

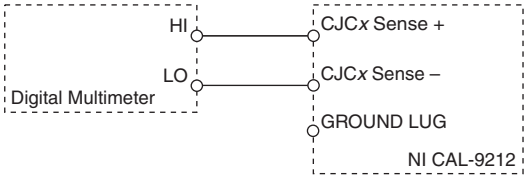
   g. Set the calibrator to Standby mode (STBY).
   h. Repeat steps d through g for each calibration voltage in the array.
7. Remove the NI CAL-9212 from the NI 9212.
8. Loosen the captive screws and remove the top cover from the NI CAL-9212.
9. Disconnect the calibrator from the NI CAL-9212.
10. Close the calibration session.

CJC Adjustment

Complete the following procedure to adjust the CJC accuracy of the NI 9212.

1. Loosen the captive screws and remove the top cover from the NI CAL-9212.
2. Connect the digital multimeter to the NI CAL-9212, as shown in Figure 5. Ensure that CJC*x* Input+ and CJC*x* Input- are left unconnected.

Figure 5. CJC Channel Adjustment Coefficient Acquisition Connections

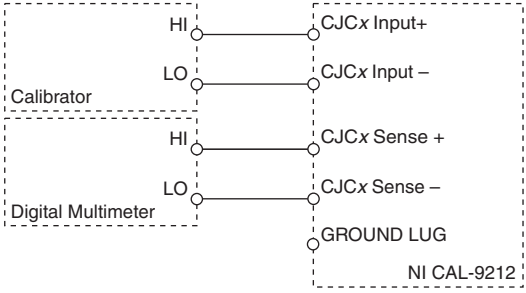


3. Reinstall the top cover on the NI CAL-9212.
4. Connect the NI CAL-9212 to the NI 9212, as shown in Figure 2.
5. Wait at least 15 seconds for the NI 9212 to settle before proceeding to the next step.
6. Acquire the adjustment coefficient.
   a. On the digital multimeter, set the range to 10 V.
   b. On the digital multimeter, set the input resistance to greater than 10 GΩ.
   a. Take five digital multimeter readings.
   b. Average the digital multimeter readings.
   c. Perform the following calculations to obtain the adjustment coefficient.

$$\text{Adjustment coefficient} = \frac{2.5}{\text{Averaged digital multimeter reading}}$$

7. Remove the NI CAL-9212 from the NI 9212.
8. Loosen the captive screws and remove the top cover from the NI CAL-9212.
9. Connect the calibrator and digital multimeter to the NI CAL-9212, as shown in Figure 6.

Figure 6. CJC Channel Adjustment Connections



10. Reinstall the top cover on the NI CAL-9212.
11. Connect the NI CAL-9212 to the NI 9212, as shown in Figure 2.
12. Initialize a calibration session on the NI 9212. The default password is `NI`.

Note You only need to initialize the calibration session once.

13. Adjust the NI 9212 CJC.
    a. Input the external temperature in degrees Celsius using the set temperature C Series function.
    b. Call the Get NI 9212 Calibration Adjustment Points function and set the physical channel according to Table 10 to obtain an array of recommended calibration voltages for a CJC channel of the NI 9212.
    c. On the Fluke 5522A calibrator, lock the voltage range to 3.3 V to reduce loading error.
    d. On the digital multimeter, set the range to the appropriate range according to a reference value determined by the array of adjustment points.
    e. Set the calibrator to a reference value determined by the array of adjustment points.
    f. Set the calibrator to Operate mode (OPR).
    g. Wait at least 15 seconds for the NI 9212 to settle before proceeding to the next step.
    h. Take five digital multimeter readings.
    i. Average the digital multimeter readings.
    j. Perform the following calculations to obtain the CJC Cal Value.

    CJC Cal Value = Averaged digital multimeter reading × Adjustment coefficient

    k. Call and configure the Adjust NI 9212 Calibration function according to Table 10.

Table 10. Voltage Adjustment Configuration

Physical Channel	Reference Value
cDAQ1Mod8/_cjtemp*x*	CJC Cal Value

    l. Set the calibrator to Standby mode (STBY).
    m. Repeat steps d through m for each calibration voltage in the array.
14. Remove the NI CAL-9212 from the NI 9212.
15. Loosen the captive screws and remove the top cover from the NI CAL-9212.
16. Disconnect the calibrator and digital multimeter from the NI CAL-9212.
17. Repeat steps 2 through 11, then steps 13 c through 16 for the other CJC channel on the NI 9212.
18. Close the calibration session.

EEPROM Update

When an adjustment procedure is completed, the NI 9212 internal calibration memory (EEPROM) is immediately updated.

If you do not want to perform an adjustment, you can update the calibration date and onboard calibration temperature without making any adjustments by initializing an external calibration, setting the C Series calibration temperature, and closing the external calibration.

Reverification

Repeat the *Verification* section to determine the As-Left status of the device.

Note If any test fails Reverification after performing an adjustment, verify that you have met the *Test Conditions* before returning your device to NI. Refer to *Worldwide Support and Services* for assistance in returning the device to NI.

Accuracy Under Calibration Conditions

The values in the following table are based on calibrated scaling coefficients, which are stored in the onboard EEPROM.

The following accuracy table is valid for calibration under the following conditions:

- Ambient temperature 23 °C ± 5 °C
- NI 9212 installed in slot 8 of an NI cDAQ-9178 chassis
- Slots 1 through 7 of the NI cDAQ-9178 chassis are empty

Note The test limits listed in Tables 4 and 5 are derived using the values in Tables 2 and 11.

Note The test limits listed in Table 8 are derived using the values in Tables 6 and 12.

Table 11. NI 9212 Voltage Accuracy Under Calibration Conditions

Mode	±PPM of Reading	±PPM of Range
High Resolution	212.69	65.14
Best 50/60 Hz	215.20	66.14
High Speed	237.22	71.57

Table 12. NI 9212 CJC Channel Accuracy Under Calibration Conditions

Mode	Value (Ω)	±PPM of Reading	±PPM of Range
High Resolution	1,000	649.21	33.88
	19,000	453.08	28.98
	100,000	253.19	23.99
Best 50/60 Hz Rejection	1,000	656.50	37.28
	19,000	460.37	32.39
	100,000	260.48	27.39
High Speed	1,000	704.92	63.34
	19,000	508.78	951.43
	100,000	308.90	1,243.43

Note For operational specifications, refer to the most recent *NI 9212 with NI TB-9212 Datasheet* online at `ni.com/manuals`.

Worldwide Support and Services

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.

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