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CALIBRATION PROCEDURE

NI 9234

4-Channel, ±5 V, 24-Bit Software-Selectable
IEPE and AC/DC Analog Input Module

Français Deutsch 日本語 한국어 简体中文
ni.com/manuals

This document contains the verification and adjustment procedures for the National Instruments 9234. For more information on calibration, visit ni.com/calibration.

Contents

Software

Calibrating the NI 9234 requires the installation of NI-DAQmx 9.2 or later on the calibration system. You can download NI-DAQmx from ni.com/downloads. NI-DAQmx supports LabVIEW, LabWindows™/CVI, C/C++, C#, and Visual Basic .NET. When you install NI-DAQmx you only need to install support for the ADE that you intend to use.

NATIONAL INSTRUMENTS™

Documentation

Consult the following documents for information about the NI 9234, NI-DAQmx, and your application software. All documents are available on `ni.com` and help files install with the software.

NI cDAQ-9174/9178 USB Chassis Quick Start

NI-DAQmx installation and hardware setup

NI 9234 Operating Instructions and Specifications

NI 9234 specific information, 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 5700A	Accuracy, Adjustment	Use a high-precision voltage source with an accuracy ≤100 ppm and an output that is able to be not grounded (floating).
Function Generator	NI 4461	Gain Matching	Use a function generator capable of sourcing 1 kHz and 10 kHz ±4.5 V_{pk} AC sinusoidal signals with amplitude uncertainty of ±10% or less.
		Phase Matching	Use a function generator capable of sourcing both 1 kHz and 10 kHz ±4.5 V_{pk} AC sinusoidal signals with amplitude uncertainty of ±10% or less.
		CMRR	Use a function generator capable of sourcing 1 kHz ±4.5 V_{pk} AC sinusoidal signals with amplitude uncertainty of ±0.04dB or less.
DMM	NI 4070	IEPE Current	Use DMM in current mode in the smallest range to measure 2 mA DC with a measurement uncertainty ≤0.5%.
Source Measure Unit (SMU)	Keithley Model 2400	IEPE Compliance Voltage	Use an SMU capable of sourcing 20 V DC with an accuracy ≤0.1% while sinking >2 mA DC.
BNC Cable	—	All	Use a length appropriate for your application.
Chassis	NI cDAQ-9178	All	—

Test Conditions

The following setup and environmental conditions are required to ensure the NI 9234 meets published specifications.

- Keep connections to the device 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 device are secure.
- Use shielded copper wire for all cable connections to the device. Use twisted-pairs wire to eliminate noise and thermal offsets.
- Maintain an ambient temperature of 23 ±5 °C. The device temperature will be greater than the ambient temperature.
- Keep relative humidity below 80%.
- Allow a warm-up time of at least 10 minutes to ensure that the NI 9234 measurement circuitry is at a stable operating temperature.

Initial Setup

Complete the following steps to set up the NI 9234.

1. Install NI-DAQmx.
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

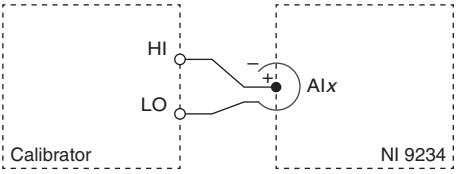
The following performance verification procedures describe the sequence of operation and test points required to verify the NI 9234 and assumes that adequate traceable uncertainties are available for the calibration references.

Accuracy Verification

Complete the following procedure to determine the As-Found status of the NI 9234.

1. Set the calibrator to Standby mode (STBY).
2. Connect the NI 9234 to the calibrator as shown in Figure 1.

Figure 1. Accuracy Verification Connections to the NI 9234



3. Verify that the calibrator output is not grounded (floating).

Notes The analog inputs on the NI 9234 are grounded, so the calibrator must be not grounded (floating) to prevent ground loop measurement errors.

To float the output of the Fluke 5700A, enable External Guard mode (EX GRD).

4. Set the calibrator voltage to a Test Point value indicated in Table 4.
5. Set the calibrator to Operate mode (OPR).
6. Acquire and average samples.
   a. Create an AI voltage task on the NI 9234 according to Table 2.

Table 2. NI 9234 Configuration for Accuracy Verification

Min (V)	Max (V)	Scaled Units	Channel Configuration
-5	5	Volts	DC Coupled

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

Table 3. NI 9234 Timing Configuration

Sample Mode	Samples Per Channel	Rate (kHz)
Finite Samples	10240	10.24

   c. Start the task.

d. Average the readings and record the average.
e. Compare the average to the limits in Table 4.
f. Clear the task.

7. Set the calibrator to Standby mode (STBY).
8. Repeat steps 3 through 7 for each test point in Table 4.

Table 4. NI 9234 Verification Test Limits for Accuracy

Test Point		1-Year Limits	
Location	**Value (V)**	**Lower Limit (V)**	**Upper Limit (V)**
Max	4.0	3.9952	4.0048
Mid	0.0	-0.0012	0.0012
Min	-4.0	-4.0048	-3.9952

Note The test limits listed in Table 4 are derived using the values in Table 21.

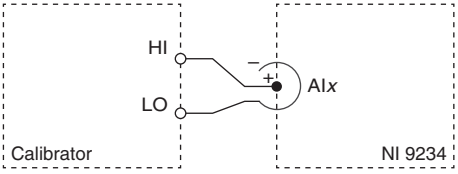
9. Disconnect the calibrator from the device.
10. Repeat steps 1 through 9 for each channel on the NI 9234.

Gain Matching Verification

Complete the following procedure to determine the As-Found status of the NI 9234.

1. Set the calibrator to Standby mode (STBY).
2. Connect the NI 9234 to the calibrator. Refer to Figure 2 for a connection diagram.

Figure 2. Gain Matching Verification Connections to the NI 9234



3. Verify that the calibrator output is not grounded (floating).

Notes The analog inputs on the NI 9234 are grounded, so the calibrator must be not grounded (floating) to prevent ground loop measurement errors.

To float the output of the Fluke 5700A, enable External Guard mode (EX GRD).

4. Set the calibrator voltage to 4.0 V.
5. Set the calibrator to Operate mode (OPR).

6. Acquire and average samples.
   a. Create an AI voltage task on the NI 9234 according to Table 5.

Table 5. NI 9234 Configuration for Gain Matching Verification

Min (V)	Max (V)	Scaled Units	Channel Configuration
-5	5	Volts	DC Coupled

   b. Configure the AI voltage task timing according to Table 6.

Table 6. Timing Configuration

Sample Mode	Samples Per Channel	Rate (kHz)
Finite Samples	10240	10.24

   c. Start the task.
   d. Average the readings and record the average as V_1.
   e. Clear the task.
   f. Set the calibrator to Standby mode (STBY).
   g. Set the calibrator voltage to -4.0 V.
   h. Set the calibrator to Operate mode (OPR).
   i. Start the task.
   j. Average the readings and record the average as V_2.
   k. Clear the task.
7. Set the calibrator to Standby mode (STBY).
8. Disconnect the calibrator from the device.
9. Perform the following calculation using the recorded V_1 and V_2 values.

$$Gain(dB) = \left(20 \times \log_{10}\left(\frac{V_1 - V_2}{8}\right)\right)$$

10. Repeat steps 1 through 9 for each channel.
11. Compare the channel-to-channel gain difference to the maximum limit of ±40 mdB.

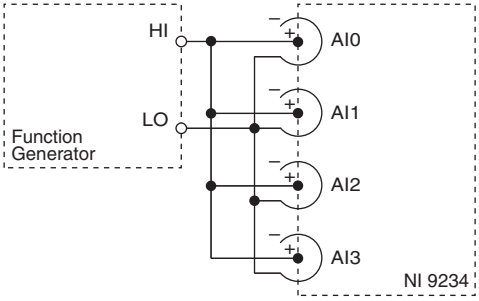
If the Gain Matching verification procedure determines that the NI 9234 is outside of the limits, refer to *Worldwide Support and Services* for assistance in returning the device to NI.

Phase Matching Verification

Complete the following procedure to determine the As-Found status of the NI 9234.

1. Connect the NI 9234 to the function generator as shown in Figure 3.

Figure 3. Phase Matching Verification Connections to the NI 9234



2. Configure function generator according to Table 7.

Table 7. Function Generator Configuration for Phase Matching Verification

Signal Type	Amplitude (V_{pk})
Sinewave	±4.5

3. Set the function generator frequency to a value indicated in Table 10.
4. Acquire and average samples.
   a. Create an AI voltage task on the NI 9234 according to Table 8.

Table 8. NI 9234 Configuration for Phase Matching Verification

Min (V)	Max (V)	Scaled Units	Channel Configuration
-5	5	Volts	AC Coupled

Note Wait 20 s for the AC coupling filter on the NI 9234 to settle.

   b. Configure the AI voltage task timing according to Table 9.

Table 9. NI 9234 Timing Configuration

Sample Mode	Samples Per Channel	Rate (kHz)
Finite Samples	16384	51.2

   c. Enable the function generator.
   d. Start the task.

e. Disable the function generator.

f. Clear the task.

5. Calculate the phase for each channel on the NI 9234. NI recommends using the Extract Single Tone Information VI to calculate phase.
6. Compare the channel-to-channel phase difference to the limits in Table 10.
7. Repeat steps 2 through 6 for each test point in Table 10.

Table 10. NI 9234 Verification Test Limits for Phase Matching

Generator Frequency (kHz)	Phase Matching Channel-to-Channel Limit
1	±0.085°
10	±0.49°

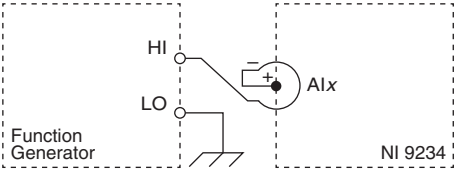
If the Phase Matching verification procedure determines that the NI 9234 is outside of the limits, refer to *Worldwide Support and Services* for assistance in returning the device to NI.

Common-Mode Rejection Ratio Verification

Complete the following procedure to determine the As-Found status of the NI 9234.

1. Connect the NI 9234 to the function generator and short the positive pin and negative shell of the NI 9234 channel.
2. Connect the function generator to the chassis ground as shown in Figure 4.

Figure 4. CMRR Verification Connections to the NI 9234



3. Configure the function generator according to Table 11.

Table 11. Function Generator Configuration for CMRR Verification

Signal Type	Amplitude (V_{pk})	Frequency (kHz)
Sinewave	±0.5	1

4. Acquire a reference amplitude.
   a. Create and configure an AI voltage task on the NI 9234 according to Table 12.

Table 12. NI 9234 Configuration for CMRR Verification

Min (V)	Max (V)	Scaled Units	Channel Configuration
-5	5	Volts	DC Coupled

   b. Configure the AI voltage task timing according to Table 13.

Table 13. NI 9234 Timing Configuration

Sample Mode	Samples Per Channel	Rate (kHz)
Finite Samples	16384	51.2

   c. Enable the function generator.
   d. Start the task.
   e. Record the measured amplitude as $\text{Amplitude}_{\text{Acq}}$.
   f. Disable the function generator.
   g. Clear the task.
5. Perform the following calculation using the recorded $\text{Amplitude}_{\text{Acq}}$.

$$CMRR = -20 \times \log_{10}\left(\frac{Amplitude_{Acq}}{0.5}\right)$$

   h. Compare the calculation result to the minimum CMRR limit of 40 dB.
6. Repeat steps 1 through h for each channel.

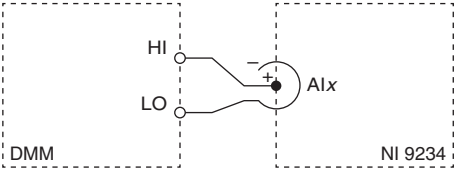
If the Common-Mode Rejection Ratio verification procedure determines that the NI 9234 is outside of the limits, refer to *Worldwide Support and Services* for assistance in returning the device to NI.

IEPE Current Verification

Complete the following procedure to determine the As-Found status of the NI 9234.

1. Connect the NI 9234 to the DMM as shown in Figure 5.

Figure 5. IEPE Current Verification Connections to the NI 9234



2. Configure the DMM for a DC current measurement in the lowest appropriate range to measure 2 mA.
3. Measure IEPE Source short circuit current.
   a. Create an AI voltage task on the NI 9234 according to Table 14.

Table 14. NI 9234 Configuration for IEPE Current Verification

Min (V)	Max (V)	Scaled Units	Channel Configuration	IEPE Excitation
-5	5	Volts	AC Coupled	Enabled

   b. Configure the AI voltage task timing according to Table 15.

Table 15. NI 9234 Timing Configuration

Sample Mode	Rate (kHz)
Continuous Samples	51.2

   c. Start the task.
   d. Record the DMM measurement.
   e. Clear the task.
4. Compare the DMM measurement to the minimum current limit of 2.0 mA.
5. Repeat steps 1 through 4 for each channel.

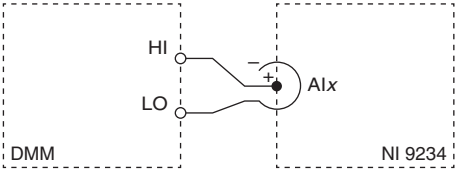
If the IEPE Current verification procedure determines that the NI 9234 is outside of the limits, refer to *Worldwide Support and Services* for assistance in returning the device to NI.

IEPE Compliance Voltage Verification

Complete the following procedure to determine the As-Found status of the NI 9234.

1. Connect the NI 9234 to the DMM as shown in Figure 6.

Figure 6. IEPE Compliance Voltage Verification Connections to the NI 9234 (IEPE Source Short Circuit Current Measurement)



2. Configure the DMM for a DC current measurement in the lowest appropriate range to measure 2 mA.
3. Measure IEPE Source short circuit current.
   a. Create an AI voltage task on the NI 9234 according to Table 16.

Table 16. NI 9234 Configuration for IEPE Voltage Verification

Channel Configuration	IEPE Excitation
AC Coupled with IEPE	Enabled

   b. Configure the AI voltage task timing according to Table 17.

Table 17. NI 9234 Timing Configuration

Sample Mode	Rate (kHz)
Continuous Samples	51.2

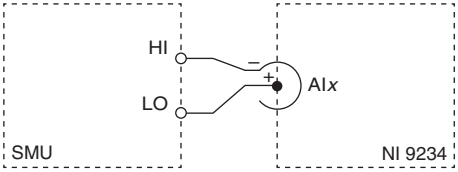
   c. Start the task.
   d. Record the DMM measurement $DMM_{Current}$.
   e. Perform the following calculation using the recorded $DMM_{Current}$ value.

$$SMU_{SourceCurrent} = -(0.95 \times DMM_{Current})$$

4. Record the calculation result as $SMU_{SourceCurrent}$.

5. Connect the SMU to the channel you want to verify on the NI 9234. Refer to Figure 7 for a connection diagram.

Figure 7. IEPE Compliance Voltage Verification Connections to the NI 9234 (IEPE Source Compliance Voltage Measurement)



6. Configure the SMU as a current source and set the voltage limit to the lowest appropriate range to measure 24 V.
7. Measure IEPE Source compliance voltage.
   a. Create and configure an AI voltage task on the NI 9234 according to Table 18.

Table 18. IEPE Compliance Verification Equipment Configuration

Channel Configuration	IEPE Excitation
AC Coupled with IEPE	Enabled

   b. Configure the AI voltage task timing according to Table 19.

Table 19. NI 9234 Timing Configuration

Sample Mode	Rate (kHz)
Continuous Samples	51.2

   c. Set the source current on the SMU to the recorded $SMU_{SourceCurrent}$ value.
   d. Start the task.
   e. Enable the SMU.
   f. Record the SMU measurement $SMU_{Voltage}$.
   g. Disable the SMU.
   h. Clear the task.
8. Compare the voltage measurement from the SMU to the minimum voltage limit of 19 V.
9. Repeat steps 1 through 8 for each channel.

If the IEPE Compliance Voltage verification procedure determines that the NI 9234 is outside of the limits, refer to *Worldwide Support and Services* for assistance in returning the device to NI.

Adjustment

The following performance adjustment procedure describes the sequence of operations required to adjust the NI 9234.

Accuracy Adjustment

Complete the following procedure to adjust the accuracy performance of the NI 9234.

1. Set the calibrator to Standby mode (STBY).
2. Connect the NI 9234 to the calibrator as shown in Figure 1.
3. Adjust the NI 9234.
    a. Initialize a calibration session on the NI 9234. The default password is `NI`.
    b. Input the external temperature in degrees Celsius.
    c. Call the NI 9234 get C Series adjustment points function to obtain an array of recommended calibration voltages for the NI 9234.
    d. Set the calibrator to a reference value determined by the array of recommended calibration voltages.
    e. Set the calibrator to Operate mode (OPR).
    f. Call and configure the NI 9234 gain instance of the DAQmx adjustment function according to Table 20.

Table 20. Adjustment Configuration

Physical Channel	Reference Value
cDAQMod8/ai*x*	The 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.
    i. Disconnect the NI 9234 from the calibrator.
    j. Short AI+ and AI- on the BNC connector together for the channel under adjustment on the NI 9234.
    k. Take a measurement using the NI 9234 offset instance of the DACQmx adjust function for the channel under adjustment.
    l. Close the calibration session.
4. Repeat steps 1 through 3 for each channel on the NI 9234.

EEPROM Update

When an adjustment procedure is completed, the NI 9234 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 following calibration specifications are valid under the following conditions:

- Ambient temperature 23 ±5 °C
- NI 9234 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 Table 4 are derived using the values in Table 21.

Table 21. NI 9234 Accuracy Under Calibration Conditions

Percent of Reading (Gain Error)	Percent of Range* (Offset Error)
±0.09%	±0.024% (±1.2 mV)
* Range equals 5.1 V	

Note For operational specifications, refer to the most recent *NI 9234 Operating Instructions and Specifications* online at `ni.com/manuals`.

Worldwide Support and Services

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