CALIBRATION PROCEDURE

PXIe-4309

32 Ch (8 ADC), 2 MS/s, 18 - 28 bit, Flexible Resolution PXI Analog Input Module

This document contains the verification and adjustment procedure for the PXIe-4309 module.

📝 **Note** To maintain forced air cooling in the PXI Express system, refer to the *Maintain Forced-Air Cooling Note to Users*.

Contents

Software

Calibrating the PXIe-4309 requires the installation of NI-DAQmx on the calibration system. Driver support for calibrating the PXIe-4309 was first available in NI-DAQmx 17.1. For the list of devices supported by a specific release, refer to the *NI-DAQmx Readme*, available on the version-specific download page or installation media.

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 application software that you intend to use.

No other software is required to verify the operation of the TB-4309 (ST), TB-4309 (MT), or CAL-4309.

NATIONAL INSTRUMENTS™

Documentation

Consult the following documents for information about the PXIe-4309, NI-DAQmx, and your application software. All documents are available on `ni.com`, and help files install with the software.

PXIe-4309 and TB-4309 (ST)/TB-4309 (MT) Getting Started Guide and Terminal Block Specifications

NI-DAQmx driver software installation and hardware setup.

PXIe-4309 User Manual

PXIe-4309 usage and reference information.

PXIe-4309 Specifications

PXIe-4309 specifications and calibration interval.

NI-DAQmx Readme

Operating system and application software support in NI-DAQmx.

NI-DAQmx Help

Information about creating applications that use the NI-DAQmx driver.

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 of the PXIe-4309. If the recommended equipment is not available, select a substitute using the requirements listed in Table 1.

Table 1. Recommended Equipment for PXIe-4309 Verification and Adjustment

Equipment	Recommended Model	Requirements
Calibrator	Fluke 5700A	Output Range: ±15 V, ±10 V, ±1 V and ±0.1 V Accuracy: 10 ppm of output (±15 V, ±10 V, ±1 V) 20 ppm of output (±0.1 V) Output Impedance: ≤50 Ω.
DMM	PXI-4071 or PXIe-4081	DC Voltage Input Range: 10 V Accuracy: 12 ppm of reading, 0.5 ppm of range
PXI Express Chassis	PXIe-1062Q	If this chassis is unavailable, use another PXI Express chassis, such as the PXIe-1082 or PXIe-1078.
Connection Accessory	CAL-4309	For automated verification use the CAL-4309. For manual verification use the TB-4309 (ST) or TB-4309 (MT). When using these terminal blocks for verification connect only one channel to the calibrator at a time.
Low thermal EMF test lead kit	Pomona Model 72928	Low thermal EMF banana-to-banana and banana-to-probe test lead sets.
Low thermal EMF double banana plug shorting bar	Pomona Model 5145	Low thermal EMF double banana plug shorting bar.

Test Conditions

The following setup and environmental conditions are required to ensure the PXIe-4309 meets published specifications.

- Keep connections to the PXIe-4309 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 terminal block are secure.
- Use shielded copper wire for all cable connections to the TB-4309. Use twisted-pair wire to eliminate noise and thermal offsets.
- Maintain an ambient temperature of 23 °C ±5 °C. The PXIe-4309 temperature will be greater than the ambient temperature. Maintain an internal device temperature range of $T_{selfcal}$ ±1 °C.

> **Note** $T_{selfcal}$ is the internal device temperature recorded by the PXIe-4309 at the completion of the last self-calibration. Call `SelfCal.LastTemp` to query $T_{selfcal}$ from the PXIe-4309.

- Keep relative humidity below 80%.
- Allow a warm-up time of at least 15 minutes to ensure that the PXIe-4309 measurement circuitry is at a stable operating temperature.
- Ensure that the PXI/PXI Express chassis fan speed is set to HIGH, that the fan filters are clean, and that the empty slots contain filler panels. For more information, refer to the *Maintain Forced-Air Cooling Note to Users* document available at ni.com/manuals.
- Allow adequate warm-up time for all of the instruments and equipment according to the manufacturer instructions.

Initial Setup

Refer to the *PXIe-4309 and TB-4309 (ST)/TB-4309 (MT) Getting Started Guide and Terminal Block Specifications* for information about how to install the software and hardware and how to configure the device in Measurement & Automation Explorer (MAX).

> **Note** When a device is configured in MAX, it is assigned a device identifier. Each function call uses this identifier to determine which DAQ device to verify or to verify and adjust. This document uses `Dev1` to refer to the device name. In the following procedures, use the device name as it appears in MAX.
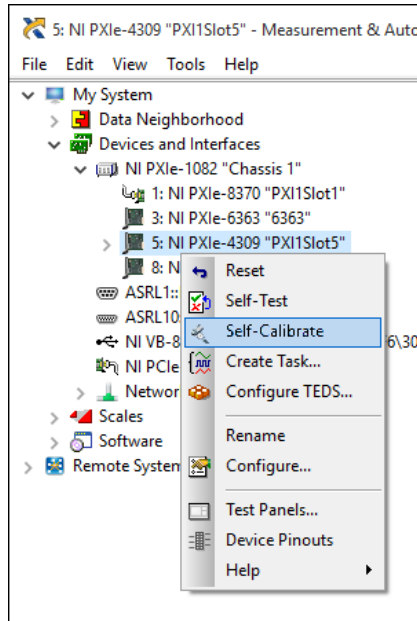
Self-Calibration

The PXIe-4309 includes a temperature controlled internal reference and self-calibration circuitry used during self-calibration to adjust for drift over time and temperature.

> **Note** No signal connections are needed for self-calibration.

Complete the following steps to self-calibrate the device.

1. Wait 15 minutes for the device to warm up.
2. Launch MAX.
3. Select **My System»Devices and Interfaces**, and then select the PXIe-4309 device to self calibrate.
4. Right-click the device and select **Self-Calibrate**.

📝 **Note** The PXIe-4309 specifications assume that the internal device temperature is within ±1 °C of the last self-calibration. To ensure this requirement is met, follow the warm-up time and maintain a constant ambient temperature.

Verification

The following procedures describe the sequence of operation and provide test points required to verify the PXIe-4309. The verification procedures assume that adequate traceable uncertainties are available for the calibration references.

📝 **Note** The verification procedure requires performing a self-calibration as a first step unless self-verification is done immediately after an adjustment. Refer to the *Self-Calibration* section for instructions on performing a self-calibration.

Warranted specifications have *As-Found Limits (V)* for verification *before adjustment* and *As-Left Limits (V)* for reverification *after adjustment*. Warranted specifications unaffected by adjustment have test limits with no additional qualification.

> **Note** If any test fails verification or reverification, confirm 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.

DC Offset Accuracy

Complete the following steps to verify the DC offset accuracy:

> **Note** Measure the internal device temperature periodically every 60 seconds. If the internal device temperature exceeds $T_{selfcal} \pm 1 \,°C$, perform self-calibration.

1. Short input channels 0 through 31. Depending on the terminal block used for verification, refer to step a or b for specifics about how to short the input channels of the PXIe-4309.

    a. **CAL-4309**. Connect the double banana plug shorting bar to the input of the CAL-4309 as shown in Figure 1. This connection shorts all 32 input channels of the PXIe-4309.

       i. Attach the CAL-4309 terminal block to the PXIe-4309 module.

       ii. Tighten the mounting screw at the top of the terminal block to secure the terminal block to the module.

       iii. Wait ten minutes for the thermal EMF to stabilize.

       iv. Connect the double banana plug shorting bar to the input of the CAL-4309 as shown in Figure 1.

   v. Wait two minutes for the thermal EMF to stabilize.

       Figure 1. PXIe-4309 DC Offset Verification Setup Using the CAL-4309
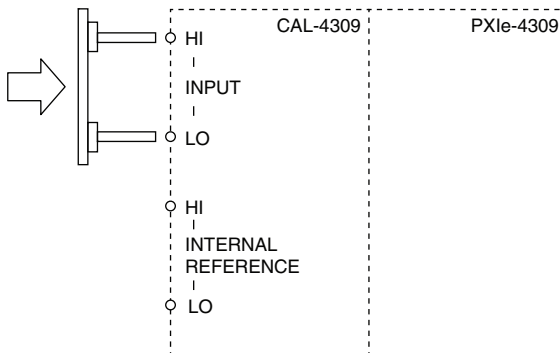
    b. **TB-4309 (ST)**. Use nickel plated copper wire to short channels 0 through 31 as shown in Figure 2.

       i. Loosen the top cover screws and remove the top cover.

       ii. Use nickel plated copper wire to short channels 0 through 31 as shown in Figure 2.

       iii. Reinstall the top cover and tighten the top cover screws.

       iv. Attach the TB-4309 (ST) terminal block to the PXIe-4309 module.

v.   Tighten the mounting screw at the top of the terminal block to secure the terminal block to the module.

vi.   Wait ten minutes for the thermal EMF to stabilize.

Figure 2. PXIe-4309 DC Offset Verification Setup Using the TB-4309 (ST)
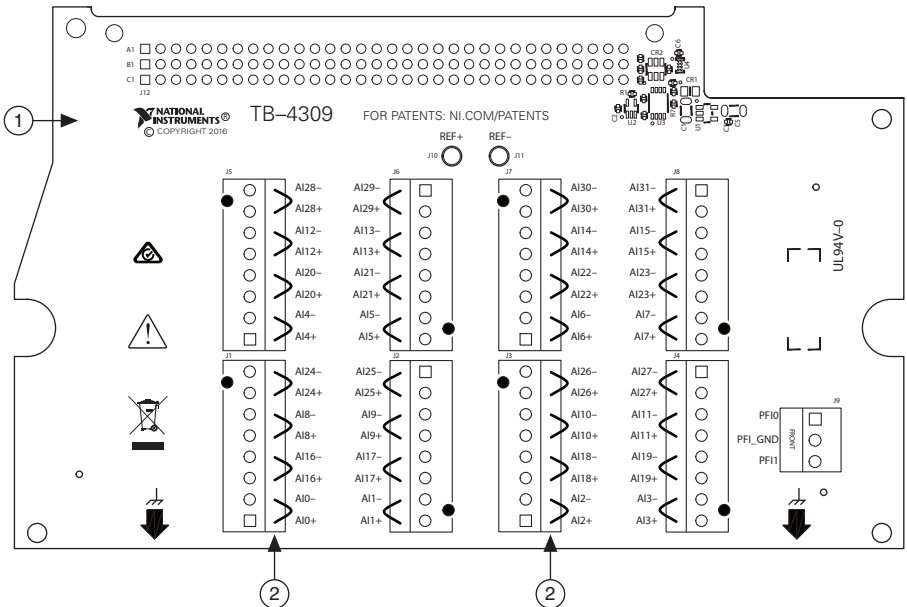
| 1 | TB-4309 (ST) Terminal Block | 2 | AI*n* Input Short |

2. Verify the accuracy for each specified configuration in Table 2.

    a. Configure an AI voltage channel task using the values in Table 3.

    b. Start the task.

    c. Acquire the samples with the PXIe-4309.

    d. Drop the first sample acquired for each channel.

    e. Average the remaining samples on a per channel basis.

    f. Stop and clear the task.

    g. Compare the averaged values to the specified test limits in Table 2.

Table 2. DC Offset Verification Test Limits

PXIe-4309 Configuration				Test Limits (μV)	
Channels	**Input Range**	**Auto Zero**	**Chopping**	**Lower**	**Upper**
AI0..31*	±0.1 V	None**	Disabled	-6	6
	±1.0 V			-10	10
	±10 V			-100	100
	±15 V			-150	150
AI0..31*	±0.1 V	Once	Disabled	-5	5
	±1.0 V				
	±10 V			-50	50
	±15 V			-75	75
AI0..31*	±0.1 V	Every Sample	Disabled	-4	4
	±1.0 V				
	±10 V				
	±15 V				
AI0..15†	±0.1 V	None	Enabled	-2	2
	±1.0 V				
	±10 V				
	±15 V				

*Verification of channels 0 through 31 provides coverages of each of the 32 independent input paths of the PXIe-4309.

**Auto Zero None Test Limits include residual offset + temperature coefficient for ±1.0 °C.

†Verification of channels 0 through 15 provides coverage of each of the 16 independent matching chopping pairs of the PXIe-4309.

Table 3. AI Setup for DC Voltage Verification

Configuration	Value
Physical Channels	`dev1/aix`, where `x` refers to the channel number.
Input Range	Input range from Table 2.
Input Terminal Configuration	Differential
Rate	10 S/s
Sample Mode	Finite
Samples per Channel	11
Auto Zero	Auto Zero configuration from Table 2.
Chopping	Chopping configuration from Table 2.

DC Voltage Accuracy

Complete the following steps to verify the DC voltage accuracy:

> **Note** Measure the internal device temperature periodically every 60 seconds. If the internal device temperature exceeds $T_{selfcal} \pm 1$ °C, perform self-calibration.

1. Connect the calibrator output to the input channel being tested. Depending on the terminal block used for verification, refer to step a or b for specifics about how to connect the calibrator output to the PXIe-4309 input.

> **Note** Keep the test lead set loop area as small as possible.

   a. **CAL-4309**. Use a low thermal EMF banana-to-banana test lead set to connect the input of the CAL-4309 to the calibrator output as shown in Figure 3. This connects all 32 input channels of the PXIe-4309 to the calibrator output.

   i. Attach the CAL-4309 terminal block to the PXIe-4309 module.

   ii. Tighten the mounting screw at the top of the terminal block to secure the terminal block to the module.

   iii. Wait ten minutes for the thermal EMF to stabilize.

   iv. Use a low thermal EMF banana-to-banana test lead set to connect the input of the CAL-4309 to the calibrator output as shown in Figure 3.

   v. Wait two minutes for the thermal EMF to stabilize.

Figure 3. PXIe-4309 DC Voltage Verification Setup Using CAL-4309.
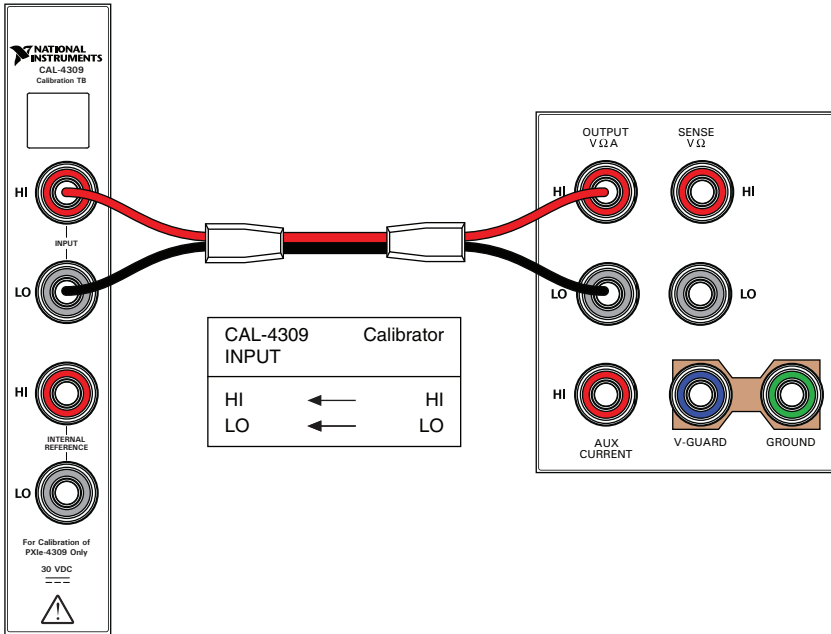
b. **TB-4309 (ST)**. Attach eight individual twisted-pair nickel-plated copper wires to terminals AI0 through AI7 to allow the connection of the PXIe-4309 inputs to the calibrator, one channel at a time.

   i.   Loosen the top cover screws and remove the top cover.

   ii. Attach eight individual twisted-pair nickel-plated copper wires to AI0 through AI7 to allow the connection of the PXIe-4309 inputs to the calibrator, one channel at a time.

   iii. Reinstall the top cover and tighten the top cover screws.

   iv. Attach the TB-4309 (ST) terminal block to the PXIe-4309 module.

   v.   Tighten the mounting screw at the top of the terminal block to secure the terminal block to the module.

   vi. Wait ten minutes for the thermal EMF to stabilize.

Figure 4. PXIe-4309 DC Voltage Verification Setup Using TB-4309 (ST).

| 1 | TB-4309 (ST) Terminal Block | 2 | To Calibrator HI Input | 3 | To Calibrator LO Input |
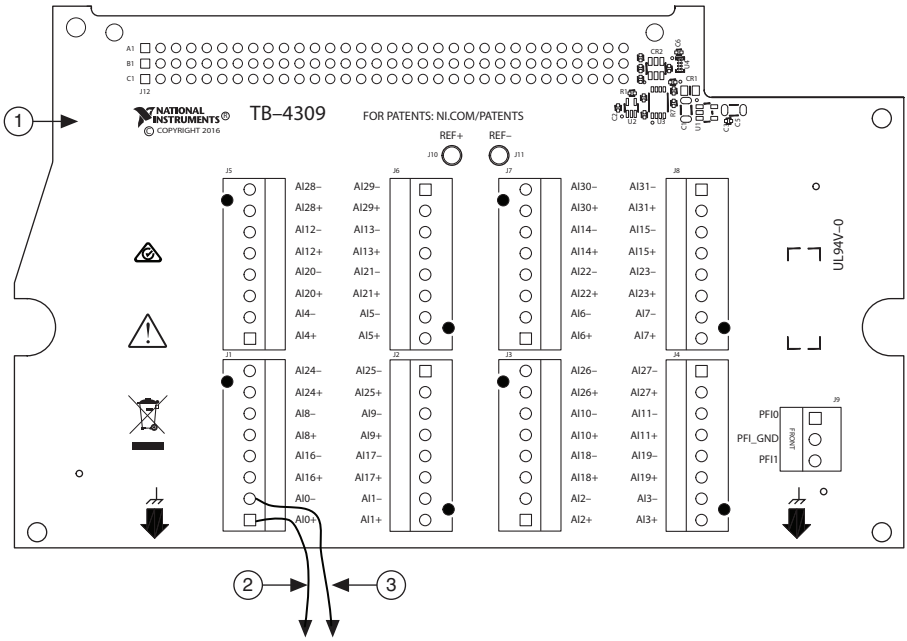
> **Note** When using the TB-4309 (ST) or TB-4309 (MT) to perform the DC voltage verification, connect only one channel to the calibrator at a time.

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

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

3. Set the calibrator voltage to 0 V.
4. Set the calibrator to Operate mode (OPR).
5. Verify the accuracy for each specified configuration in Table 4.
   a. Set the calibrator to the listed configuration and allow it to settle.
   b. Configure an AI voltage channel task using the values in Table 5.
   c. Start the task.
   d. Drop the first sample acquired for each channel.
   e. Average the remaining samples on a per channel basis.
   f. Stop and clear the task.

g.   Compare the averaged values to the specified test limits in Table 4.

Table 4. DC Voltage Verification Test Limits

PXIe-4309 Configuration		Calibrator Settings	As-Found Limits (V)		As-Left Limits (V)	
Channels[*]	Input Range	DCV Amplitude	Lower	Upper	Lower	Upper
AI0..7[†]	±0.1 V	+0.1 V	0.0999893	0.1000107	0.0999920	0.1000080
		-0.1 V	-0.1000107	-0.0999893	-0.1000080	-0.0999920
	±1.0 V	+1.0 V	0.9999357	1.0000643	0.9999627	1.0000373
		-1.0 V	-1.0000643	-0.9999357	-1.0000373	-0.9999627
	±10 V	+10 V	9.999445	10.000555	9.999715	10.000285
		-10 V	-10.000555	-9.999445	-10.000285	-9.999715
	±15 V	+15 V	14.999019	15.000981	14.999424	15.000576
		-15 V	-15.000981	-14.999019	-15.000576	-14.999424

*When using the TB-4309 (ST) or TB-4309 (MT) to perform the DC voltage verification, connect only one channel to the calibrator at a time.
†Verification of channels 0 through 7 provides coverage of each of the 8 independent signal conditioning   paths and ADCs of the PXIe-4309.

Table 5. AI Setup for DC Voltage Verification

Configuration	Value
Physical Channels	`dev1/aix`, where `x` refers to the channel number.
Input Range	Input range from Table 4
Input Terminal Configuration	Differential
Rate	10 S/s
Sample Mode	Finite
Samples per Channel	11
Auto Zero	Every Sample
Chopping	Disabled

Adjustment

An adjustment is recommended at least once every two years to warrant the published specifications for the next calibration interval. An adjustment is recommended even if the PXIe-4309 successfully passed each verification procedures within the *As-Left Limits (V) without adjustment*. Performing an adjustment procedure improves the device accuracy and resets the calibration interval.

Upon successful completion of an adjustment procedure, the calibration constants, date, and temperature in the device EEPROM are automatically updated.

To update the calibration date without performing an adjustment, refer to the instructions in the *EEPROM Update* section.

The following procedure describes the sequence of operations required to adjust the PXIe-4309. Depending on the terminal block used for verification, refer to step a or b for specifics about how to connect the calibrator output to the PXIe-4309 input.
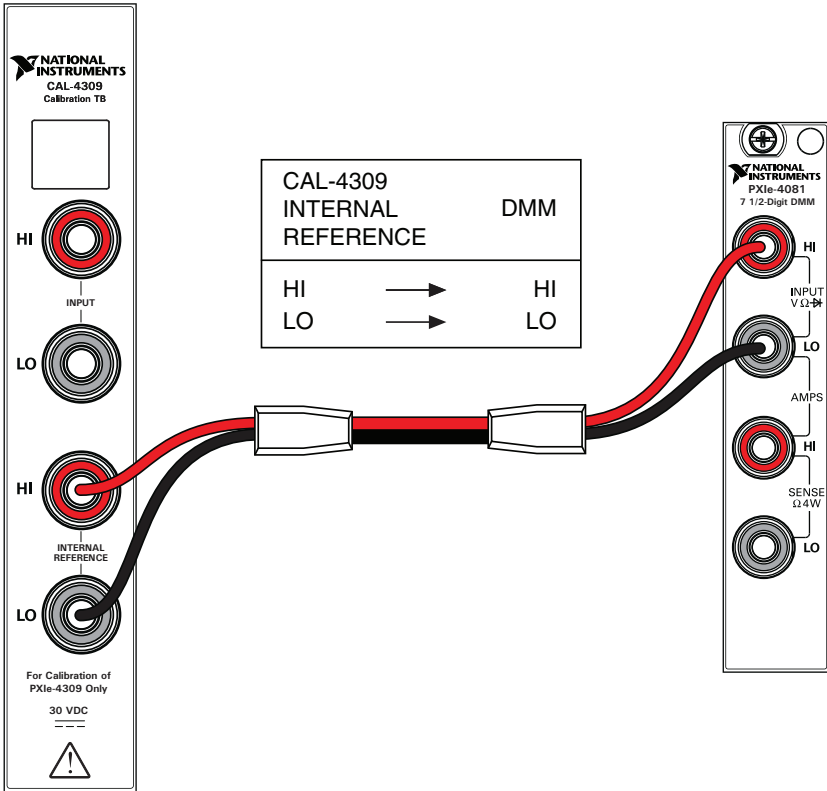
1. Measure the PXIe-4309 Internal Reference.

   Note Keep the test lead set loop area as small as possible.

   a. **CAL-4309** — Use a low thermal EMF banana-to-banana test lead set to connect the internal reference of the PXIe-4309 to the DMM input as shown in Figure 5.

      i. Attach the CAL-4309 terminal block to the PXIe-4309 module.

      ii. Tighten the mounting screw at the top of the terminal block to secure the terminal block to the module.

   iii. Wait ten minutes for the thermal EMF to stabilize.

iv. Use a low thermal EMF banana-to-banana test lead set to connect the internal reference of the PXIe-4309 to the DMM input as shown in Figure 5.

v. Wait two minutes for the thermal EMF to stabilize.

Figure 5. PXIe-4309 Internal Reference Measurement Setup Using CAL-4309.

b. **TB-4309 (ST)** — Use a low thermal EMF banana-to-probe test lead set to connect the internal reference of the PXIe-4309 to the DMM input as shown in Figure 6.

i. Loosen the top cover screws and remove the top cover.

ii. Attach the TB-4309 (ST) terminal block to the PXIe-4309 module.

iii. Tighten the mounting screw at the top of the terminal block to secure the terminal block to the module.

iv. Wait ten minutes for the thermal EMF to stabilize.

v. Use a low thermal EMF banana-to-probe test lead set to connect the internal reference of the PXIe-4309 to the DMM input as shown in Figure 6.

vi. Wait two minutes for thermal EMF to stabilize.

Figure 6. PXIe-4309 Internal Reference Measurement Setup Using TB-4309 (ST)
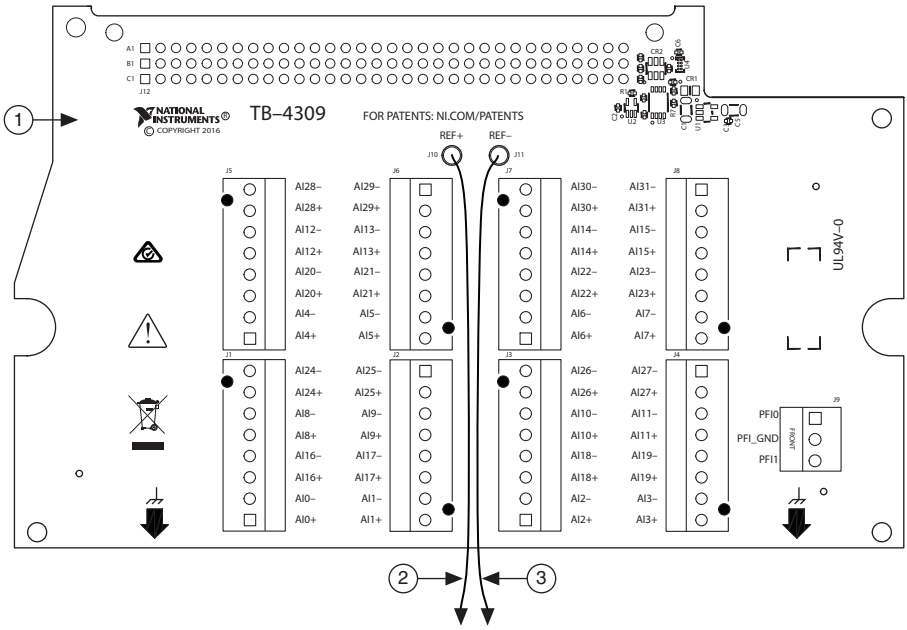
| 1 | TB-4309 (ST) | 2 | To DMM HI Input | 3 | To DMM LO Input |

c. Configure the DMM using the values in Table 6.

Table 6. DMM Configuration

Configuration	Value
Measurement	Voltage
Range	10 V
Digits of Resolution	7.5 digits
Aperture Time	100 ms
Input Impedance	> 10 GΩ
Auto Zero	On
ADC Calibration	On
DC Noise rejection	High Order

d. Use the DMM to measure the internal reference of the PXIe-4309 and record the measurement for future use.

e. Compare the internal reference measurement to the test limits in Table 7.

Table 7. Internal Reference Test Limits

Lower Test Limit (V)	Higher Test Limit (V)
6.741	7.298

Note If the reference measurement falls outside of the test limits, verify that the measurement connections and configurations are correct.

2. Call `DAQmx Initialize External Calibration` (DAQmxInitExtCal) with the following parameters:

   deviceName: `Dev_name`

   password: `NI` (default)

Use the *calhandle out* from this function to reference the current session.

3. Call the 4309 instance of DAQmx Adjust SC Express Calibration Polymorphic (DAQmxAdjust4309Cal) and enter the measured internal reference value.

4. Call `DAQmx Close External Calibration` (DAQmxCloseExtCal) to close the session.

5. Use the action `cancel` if there has been any error during the calibration or if you do not want to save the new calibration constants in the device EEPROM.

6. Use the action `commit` if you want to save the new calibration constants in the device EEPROM.

EEPROM Update

Upon successful completion of an adjustment procedure, the calibration constants, date, and temperature in the device EEPROM are automatically updated.

You can update the calibration date and onboard calibration temperature without making any adjustments by initializing an external calibration and closing the external calibration with a commit action.

Reverification

After completing the adjustment procedure, repeat the *Verification* section for warranted specifications that are affected by adjustment. Warranted specifications affected by the adjustment procedure have *As-Found Limits (V)* for verification *before adjustment* and *As-Left Limits (V)* for verification *after adjustment*.

Note If any test fails reverification, confirm 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.

Specifications

Refer to the *PXIe-4309 Specifications* document for detailed PXIe-4309 specification information.

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.

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

A Declaration of Conformity (DoC) is our claim of compliance with the Council of the European Communities using the manufacturer's declaration of conformity. This system affords the user protection for electromagnetic compatibility (EMC) and product safety. You can obtain the DoC for your product by visiting `ni.com/certification`. If your product supports calibration, you can obtain the calibration certificate for your product at `ni.com/calibration`.

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