PXIe-4147

Calibration Procedure

July 2021

This document contains the verification and adjustment procedures for the PXIe-4147. Use the procedures in this document to automate calibration or to conduct manual calibration. Review and become familiar with the entire procedure before beginning the calibration process.

Contents

Terms and Definitions

DUT	DUT is an acronym for Device Under Test, and refers to the NI product being calibrated. For this procedure, DUT refers to the PXIe-4147.
As-Found Limits	These limits are derived from the published specifications for the DUT. NI uses these limits to determine if the DUT is performing within the recommended calibration interval specifications at the time of calibration and before any adjustment is performed.
As-Left Limits	These limits are derived from the published specifications for the DUT minus guardband to ensure a high probability that the DUT will meet its specifications over the next recommended calibration interval.
Functional Test	Functional Tests determine whether the DUT is operating correctly. Functional tests are not directly related to performance specifications.
Verification	Verification evaluates the measured calibration results against the defined As-Found Limits. The result of the evaluation is expressed as a Pass/Fail condition in the calibration certificate using an established evaluation formula.
Adjustment	Adjustment performs a set of operations on the DUT to optimize the measurement performance and conform it to the assigned calibrated values.
Reverification	Reverification evaluates the measured calibration results against the As-Left limits after adjustment. The As-Left limits may be tighter than the As-Found limits.
Recommended Calibration Interval	This interval indicates the recommended period between each round of verification and adjustment of the DUT. There is a high probability that, within this interval, the DUT will remain within the published warranted performance specifications. Some measurement DUTs have warranted specifications for different calibration intervals, for example: 24 hours, 90 days, 1 year, and 2 years. In this case, the specification depends on the calibration cycle chosen by the user.

Calibration Overview

Recommended Calibration Interval
1 year

Password
NI

Note
This is the default password for all password-protected operations. This password is site-specific.

Task	Estimated Test Time	Operator Connections	Test Points
Setup	5 minutes	1	—
Warm Up	30 minutes	—	—
Verify, Adjust, and Reverify	2 hours	60	276
Verify only	45 minutes	25	136
Adjust only	30 minutes	10	4

Note
Estimated test times assume the user is conducting a manual calibration. For most procedures, automating the calibration significantly reduces test times.

Environmental Conditions	Verification	Adjustment
Ambient temperature	23 °C ±5 °C	23 °C ±1 °C
Internal DUT temperature range[1]	T_{cal}[2] ±5 °C	T_{cal} ±1 °C
Relative humidity	Between 10% and 70%, noncondensing	

Calibration Condition Guidelines

- For maximum accuracy, perform the ACAL function of the digital multimeter (DMM) prior to calibration if it has not been performed within the last 24 hours or when the multimeter's temperature changes by ±1 °C from the last autocalibration. Always disconnect any input signals before performing autocalibration.
- Ensure that all connections to the DUT, including front panel connections and screws, are secure.
- Conduct tests with only one DUT in the chassis. Ensure all remaining slots are empty and contain filler panels.
- When making measurements, configure the following aperture time-related settings:
  - Set the **niDCPower Aperture Time** property or `NIDCPOWER_ATTR_APERTURE_TIME` attribute to 2 power-line cycles (PLCs) on the device.
  - Set the **niDCPower Aperture Time Units** property or `NIDCPOWER_ATTR_APERTURE_TIME_UNITS` attribute to power-line cycles (PLCs).
  - Set the **niDCPower Configure Power Line Frequency** property or the `NIDCPOWER_ATTR_POWER_LINE_FREQUENCY` attribute to either

[1] The internal temperature of the DUT is greater than the ambient temperature.
[2] T_{cal} is the internal device temperature recorded by the PXIe-4147 at the completion of the last self-calibration.

50 Hz or 60 Hz depending on the frequency of the AC power line in your location.

- Configure the DMM to the following settings for all measurements:
  - Set the DMM NPLC to 10.
  - Set 7.5 digits of resolution.
  - Set the Guard switch to LO.
- Do not use the NI-DCPower Soft Front Panel (SFP) to request test points for any adjustment functions because you cannot set aperture time using the SFP.
- Ensure that properties or attributes for the device that are not specified in calibration procedures are set to their default values.
- If the DUT fails reverification after adjustment, ensure that the Test Conditions have been met before returning the DUT to NI.

Calibration Resources

Required Software

Install the following software on the calibration system:

> **Note**
> Ensure that the most recent version of the required driver software is installed before conducting the calibration.

- NI-DCPower 20.0 or later
- Supported application development environment (ADE) — LabVIEW or LabWindows™/CVI™
- Supported operating system — Windows

When you install NI-DCPower, you need to install support only for the application software that you intend to use.

ADE	Calibration Support Location
LabVIEW	NI-DCPower Calibration palette
LabWindows/CVI	NI-DCPower function panel (`niDCPower.fp`)

Recommended Documentation

Go to `ni.com/manuals` to locate the following documentation for more information when performing this calibration:

- PXIe-4147 Getting Started Guide
- NI DC Power Supplies and SMUs Help
- NI-DCPower Readme
- LabVIEW Help

Test Equipment

This section lists the equipment NI recommends for the performance verification and adjustment procedures within this calibration procedure.

NI Calibration Executive Users
Refer to the Calibration Executive Help to find the list of recommended test equipment for this calibration procedure.

Table 1: Test Equipment

<table>
<tr><th>Standard</th><th>Recommended Model</th><th>Where Used</th><th>Functional Requirement(s)</th></tr>
<tr><td>Digital multimeter (DMM)</td><td>Keysight 3458A</td><td>Voltage Measurement and Output Accuracy, Remote Sense Voltage Offset Accuracy, Current Measurement and Output Accuracy</td><td>—</td></tr>
<tr><td>1 MΩ current shunt</td><td>IET Labs SRL-1M/Triax</td><td>1 μA and 10 μA Current Measurement and Output</td><td>—</td></tr>
<tr><td>333 mΩ current shunt</td><td>Ohm Labs CS-3</td><td>1 A and 3 A Current Measurement and Output</td><td>Only available on request; use the following format: CS-3-1 = 3 A, 1 V, 0.333 Ω.</td></tr>
<tr><td>Low Thermal EMF Copper Cables</td><td>Fluke 5440A-7003 24 inch</td><td>1 μA and 10 μA Current Measurement and Output and 1 A and 3 A Current Measurement and Output</td><td>Low Thermal Copper EMF Plug-In Cables, Spade Connectors</td></tr>
<tr><td>PXI Express Chassis</td><td>PXIe-1095</td><td>—</td><td>If this chassis is unavailable, use a PXI Express chassis with ≥58 W slot cooling capacity.</td></tr>
<tr><td>PXIe-4147 Calibration Accessories Kit</td><td>NI part number 787792-01

Kit includes:
• DB25 to Low-Thermal EMF Spade Lug Assembly
• DB25 to Triax/Spade Lug Assembly
• HI Sense Verification Assembly
• LO Sense Verification Assembly
• Output Shorting Assembly</td><td>All parameters</td><td>—</td></tr>
</table>

Table 2: DB25 to Low-Thermal EMF Spade Lug Assembly Wire Identification

Channel	Signal	Color	DSUB Pin
CH 0	HI	Pink	14
	HI Sense	Gray	2
	LO	Black	16
	LO Sense	Purple/Black	3
CH 1	HI	Brown	17
	HI Sense	Blue	5
	LO	Black	19
	LO Sense	White	6
CH 2	HI	Purple	20
	HI Sense	Orange	8
	LO	Black	22
	LO Sense	Green	9
CH 3	HI	Red	23
	HI Sense	Black	11
	LO	Black	25
	LO Sense	Yellow	12
	Ground	Black	Shell

Table 3: DB25 to Triax/Spade Lug Assembly Wire Identification

Channel	Signal	Termination	Color	DSUB Pin
CH 0	HI	Triax	Black	14
	Guard			15
	Ground			Shell
	LO	Spade	Black	16
CH 1	HI	Triax	Black	17
	Guard			18
	Ground			Shell
	LO	Spade	Red	19
CH 2	HI	Triax	Black	20
	Guard			21
	Ground			Shell
	LO	Spade	Green	22
CH 3	HI	Triax	Black	23
	Guard			24
	Ground			Shell
	LO	Spade	White	25

Warm Up the DUT

Warm up time starts after the installed DUT is powered on in the chassis and after NI-DCPower loads and recognizes the DUT. Warm up time resets after the DUT is removed from the chassis. This DUT requires 30 minutes to warm up prior to conducting any tests.

Note
Observe adequate warm up time for all components of the calibration system.

Perform Self-Calibration

Self-calibration should be performed after the DUT has warmed up for the recommended time period. This function measures the onboard references of the DUT and adjusts the self-calibration constants to account for any errors caused by short-term fluctuations in the environment.

Complete the following steps to conduct self-calibration using Measurement & Automation Explorer (MAX).

Note
Disconnect all external signals before beginning self-calibration.

1. Launch MAX.
2. Select **My System»Devices and Interfaces»*[DUT model name]***.
3. Start self-calibration using one of the following methods:
   - Click **Self-Calibrate** in the upper right corner of MAX.
   - Right-click the name of the DUT in the MAX configuration tree and select **Self-Calibrate** from the pull-down menu.

Perform Verification

Voltage Measurement and Output

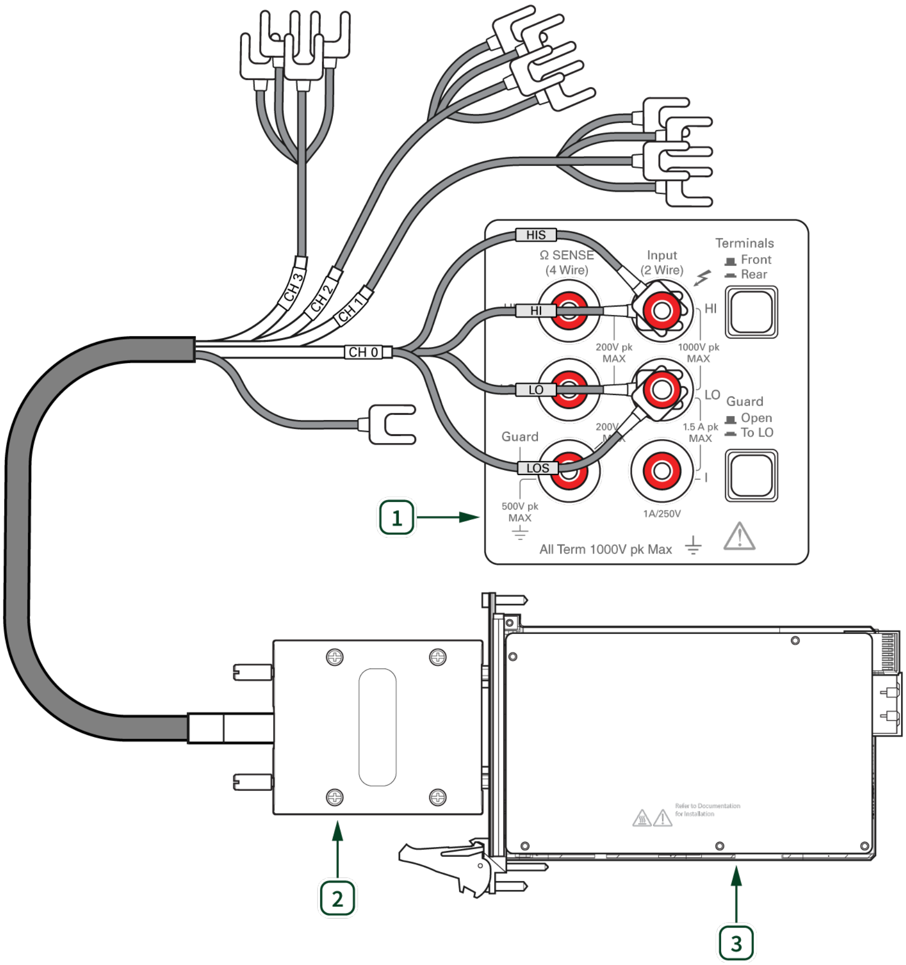
Test Limits

Table 4: Voltage Measurement and Output Test Limits

Level Range	Limit Range and Limit	Test Point	DMM Range	As-Found Measurement Test Limit (% of Voltage + Offset)	As-Left Measurement Test Limit (% of Voltage + Offset)
1 V	1 mA	-1 V	1 V	0.02% + 70 µV	0.012% + 25 µV
		0 V			
		1 V			
8 V	1 mA	-8 V	10 V	0.015% + 400 µV	0.008% + 85 µV
		0 V			
		8 V			

Initial Test Connection

Figure 1: Voltage Measurement and Output Connection



1. DMM
2. DB25 to Low-Thermal EMF Spade Lug Assembly[3]
3. PXIe-4147

[3] Individual wire labels on CH1, CH2, and CH3 omitted for readability. Individual wire colors differ from figure. Use wire labels as the primary method of identification. Details on wire colors can be found in *Table 2: DB25 to Low-Thermal EMF Spade Lug Assembly Wire Identification*.

Verification Procedure

1. Install the DB25 to low-thermal EMF spade lug assembly on the DUT.
2. Set the **niDCPower Output Function** property or NIDCPOWER_OUTPUT_FUNCTION attribute to DC Voltage for the DUT.

Repeat 4 times, once for each channel.

3. Connect the spade lug assembly wires for one channel to the DMM.

Repeat 2 times, once for each level range.

4. Set the level range, limit range, and limit on the DUT.
5. Set the **niDCPower Sense** property or NIDCPOWER_ATTR_SENSE attribute to Local.
6. Measure the internal device temperature and perform self-calibration if necessary.

Note
If the internal device temperature exceeds T_{cal} ±5 °C, wait up to five minutes for the temperature to stabilize to within T_{cal} ±5 °C. If the stable temperature still exceeds T_{cal} ±5 °C after five minutes, call the self-calibration VI or function.

Repeat 3 times, once for each test point in the level range.

7. Set the level on the DUT to the test point.
8. Wait 1 second to ensure the system has adequate time to settle.
9. Take a voltage measurement using the DMM.

10. Calculate the lower and upper voltage measurement test limits using the following formula:

    *Voltage Measurement Test Limits = Test Point ± (|Test Point| * % of Voltage + Offset)*

11. Verify the DMM measurement falls within the test limits.

Remote Sense Voltage Offset

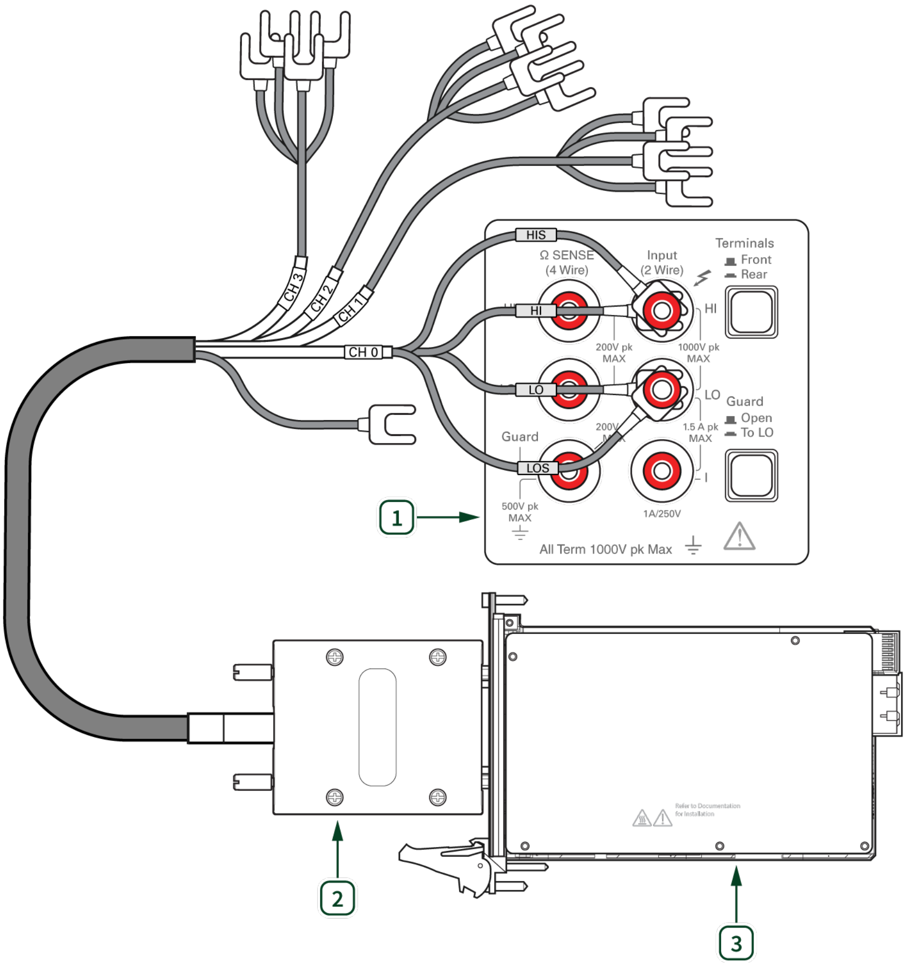
Test Limits

Table 5: Remote Sense Voltage Offset Test Limits

Level Range	Limit Range and Limit	Test Point	DMM Range	As-Found Measurement Test Limit	As-Left Measurement Test Limit
1 V	1 mA	0 V	100 mV	±70 μV	±25 μV
8 V				±400 μV	±85 μV

Initial Test Connection

Figure 2: Remote Sense Voltage Offset Test Diagram



1. DMM
2. DB25 to Low-Thermal EMF Spade Lug Assembly[4]
3. PXIe-4147

[4] Individual wire labels on CH1, CH2, and CH3 omitted for readability. Individual wire colors differ from figure. Use wire labels as the primary method of identification. Details on wire colors can be found in *Table 2: DB25 to Low-Thermal EMF Spade Lug Assembly Wire Identification*.

Verification Procedure

1. Install the DB25 to low-thermal EMF spade lug assembly on the DUT.

Repeat 4 times, once for each channel.

2. Connect the spade lug assembly wires for one channel to the DMM.

Repeat 2 times, once for each level range.

3. Set the level range, limit range, and limit on the DUT.
4. Set the **niDCPower Sense** property or `NIDCPOWER_ATTR_SENSE` attribute to Remote.
5. Set the level on the DUT to 0 V.
6. Wait 1 second to ensure the system has adequate time to settle.
7. Take a voltage measurement using the DMM.
8. Verify the DMM measurement falls within the test limits.

Voltage Remote Sense

Test Limits

Table 6: Voltage Remote Sense HI Test Limits

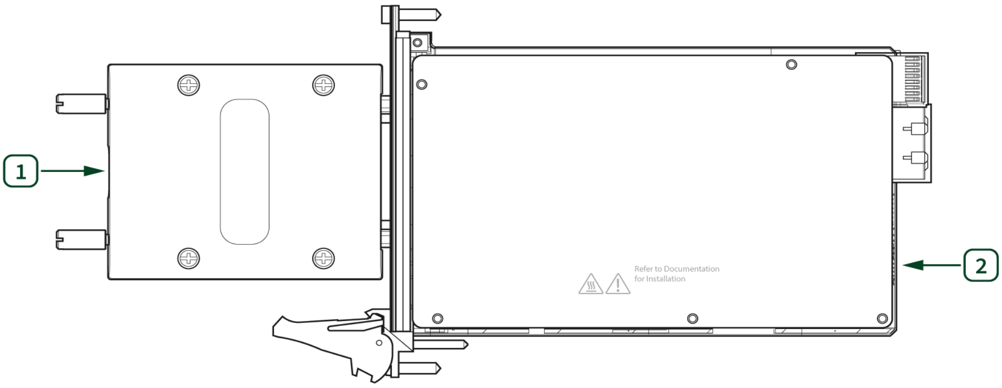
Level Range	Limit Range and Limit	Test Point	Voltage Remote Sense HI Test Limit
1 mA	1 V	0 mA	≤10 µV
		1 mA	

Table 7: Voltage Remote Sense LO Test Limits

Level Range	Limit Range and Limit	Test Point	Voltage Remote Sense LO Test Limit
1 mA	1 V	0 mA	≤35 μV
		1 mA	

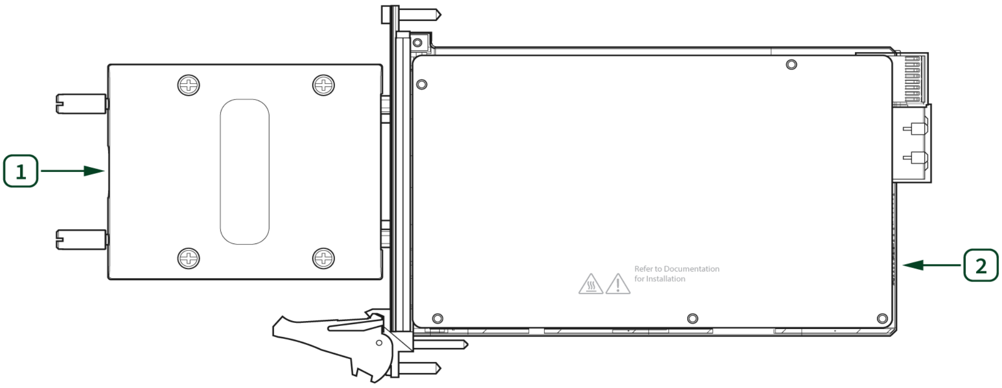
Test Connections

Figure 3: Voltage Remote Sense HI Connection Diagram



1. HI Sense Verification Assembly
2. PXIe-4147

Figure 4: Voltage Remote Sense LO Connection Diagram



1. LO Sense Verification Assembly
2. PXIe-4147

Verification Procedure

1. Set the **niDCPower Output Function** property or `NIDCPOWER_OUTPUT_FUNCTION` attribute to DC Current for the DUT.
2. Set the **niDCPower Sense** property or `NIDCPOWER_ATTR_SENSE` attribute to Remote.

Repeat 4 times, once for each channel.

Repeat 2 times, once for each load configuration: Voltage Drop HI and Voltage Drop LO.

3. Install one of the two fixtures on the DUT:
   - HI sense verification assembly
   - LO sense verification assembly
4. Set the level range, limit range, and limit on the DUT.
5. Measure the internal device temperature and perform self-calibration, if necessary.

Note
If the internal device temperature exceeds T_{cal} ±5 °C, wait up to five minutes for the temperature to stabilize to within T_{cal} ±5 °C. If the stable temperature still exceeds T_{cal} ±5 °C after five minutes, call the self-calibration VI or function.

Repeat 2 times, once for each test point.

6. Set the level on the DUT to the test point.
7. Wait 1 second to ensure the system has adequate time to settle.
8. Take a voltage measurement using the DUT.
9. Record the voltage.

Note
Record the voltage measured for the first test point as *V1*. Record the voltage measured for the second test point as *V2*.

10. Calculate the remote sense error using the following formula and record the value.

$$Remote\ Sense\ Error = |V2 - V1|$$

11. Verify that the recorded value falls within the test limits.

Current Offset

> **Note**
> Complete this procedure only after successfully completing all previous verification procedures.

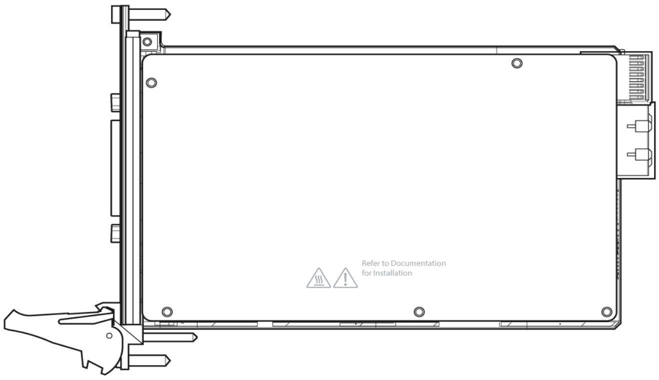
Test Limits

Table 8: Current Offset Test Limits

Level Range	Limit Range and Limit	Test Point	As-Found Offset Test Limit		As-Left Offset Test Limit	
			Lower Limit	Upper Limit	Lower Limit	Upper Limit
1 V	1 μA	0 mV	-150 pA	150 pA	-50 pA	50 pA
	10 μA		-1 nA	1 nA	-300 pA	300 pA
	100 μA		-8 nA	8 nA	-1.5 nA	1.5 nA
	1 mA		-70 nA	70 nA	-15 nA	15 nA
	10 mA		-700 nA	700 nA	-150 nA	150 nA
	100 mA		-7 μA	7 μA	-1.5 μA	1.5 μA
	3 A		-400 μA	400 μA	-60 μA	60 μA

Initial Test Connection

Figure 5: Current Offset Connection Diagram



Verification Procedure

1. Uninstall all fixtures from the DUT.
2. Measure the internal device temperature and perform self-calibration, if necessary.

Note
If the internal device temperature exceeds T_{cal} ±5 °C, wait up to 5 minutes for the temperature to stabilize to within T_{cal} ±5 °C. If the stable temperature still exceeds T_{cal} ±5 °C after five minutes, call the self-calibration VI or function.

Repeat 4 times, once for each channel.

Repeat 7 times, once for each limit range.

3. Wait 1 second to ensure the system has adequate time to settle.
4. Take a current measurement.
5. Record the value from the previous step.
6. Verify that the recorded value falls within the test limits.

Load Regulation

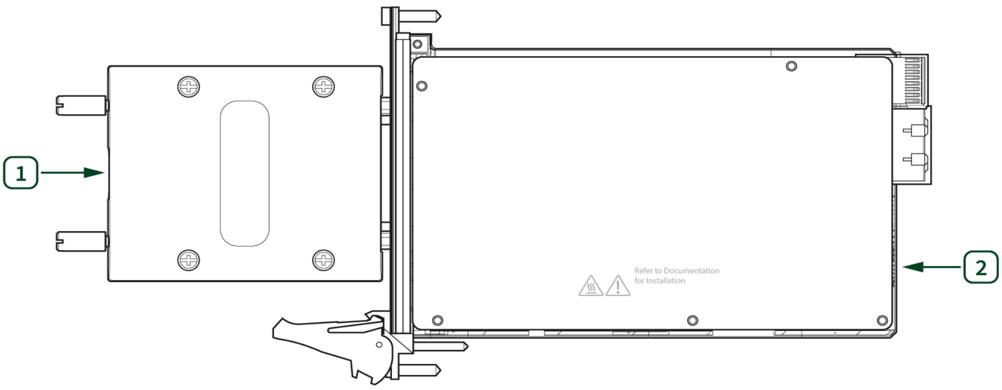
Test Limits

Table 9: Load Regulation Test Limits

Level Range	Limit Range and Limit	Test Point	As-Found/As-Left Limit
10 mA	1 V	10 mA	≤2 mV

Initial Test Connection

Figure 6: Load Regulation Connection Diagram



1. Output Shorting Assembly
2. PXIe-4147

Verification Procedure

1. Install the output shorting assembly on the DUT.

Repeat 4 times, once for each channel.

2. Set the **niDCPower Output Function** property or `NIDCPOWER_OUTPUT_FUNCTION` attribute to DC Current for the DUT.
3. Set the **niDCPower Sense** property or `NIDCPOWER_ATTR_SENSE` attribute to Local.
4. Set the level range, limit range, and limit on the DUT.
5. Measure the internal device temperature and perform self-calibration if necessary.

Note
If the internal device temperature exceeds T_{cal} ±5 °C, wait up to five minutes for the temperature to stabilize to within T_{cal} ±5 °C. If the stable temperature still exceeds T_{cal} ±5 °C after five minutes, call the self-calibration VI or function.

6. Set the level on the DUT to 10 mA.
7. Wait 1 second to ensure the system has adequate time to settle.
8. Take a voltage measurement.
9. Verify the DMM measurement falls within the test limits.

1 μA and 10 μA Current Measurement and Output

Note
Complete this procedure only after successfully completing all previous verification procedures.

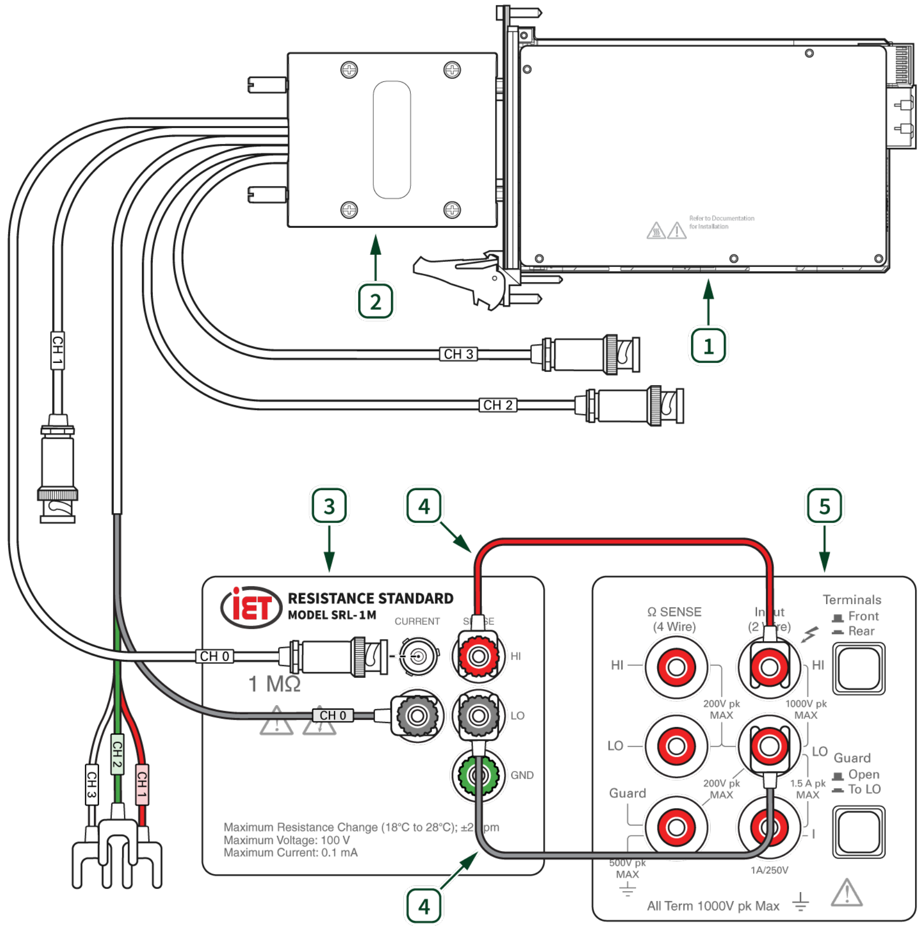
Test Limits

Table 10: 1 μA and 10 μA Current Measurement and Output Test Limits

<table>
<tr><th>Level Range</th><th>Limit Range and Limit</th><th>Shunt</th><th>Test Point</th><th>DMM Range</th><th>As-Found Measurement Test Limit (% of Current + Offset)</th><th>As-Left Measurement Test Limit (% of Current + Offset)</th></tr>
<tr><td rowspan="2">1 V</td><td rowspan="2">1 μA</td><td rowspan="4">1 MΩ</td><td>-0.9 V</td><td rowspan="2">1 V</td><td rowspan="2">0.035% + 150 pA</td><td rowspan="2">0.021% + 50 pA</td></tr>
<tr><td>0.9 V</td></tr>
<tr><td rowspan="2">8 V</td><td rowspan="2">10 μA</td><td>-8 V</td><td rowspan="2">10 V</td><td rowspan="2">0.035% + 1 nA</td><td rowspan="2">0.020% + 300 pA</td></tr>
<tr><td>8 V</td></tr>
</table>

Initial Test Connection

Figure 7: 1 µA and 10 µA Current Measurement and Output Connection Diagram



1. PXIe-4147
2. DB25 To Triax/Spade Lug Assembly[5]
3. 1 MΩ current shunt
4. Low Thermal EMF Copper Cables[6]
5. DMM

[5] Individual wire labels on CH1, CH2, and CH3 omitted for readability. Individual wire colors differ from figure. Use wire labels as the primary method of identification. Details on wire colors can be found in *Table 3: DB25 to Triax/Spade Lug Assembly Wire Identification*.

[6] Low Thermal EMF Copper Cables in the diagram are shown separated for ease of understanding and are not an exact match of the actual 5440A-7003 cables.

Verification Procedure

1. Install the DB25 to triax/spade lug assembly on the DUT.
2. Connect the shunt to the DMM.
3. Set the **niDCPower Output Function** property or `NIDCPOWER_OUTPUT_FUNCTION` attribute to DC Voltage for the DUT.

Repeat 4 times, once for each channel.

4. Connect the triax/spade lug assembly wires for one channel to the shunt.

Repeat 2 times, once for each level range.

5. Set the level range, limit range, and limit on the DUT.
6. Measure the internal device temperature and perform self-calibration if necessary.

Note
If the internal device temperature exceeds T_{cal} ±5 °C, wait up to five minutes for the temperature to stabilize to within T_{cal} ±5 °C. If the stable temperature still exceeds T_{cal} ±5 °C after five minutes, call the self-calibration VI or function.

Note
Complete the following steps within 5 minutes or less of completing step 4 in order to ensure the internal device temperature remains stable.

Repeat 2 times, once for each test point for the level range.

7. Set the level on the DUT to the test point.
8. Wait 1 second to ensure the system has adequate time to settle.
9. Take a voltage measurement across the shunt using the DMM.
10. Divide the voltage measurement by the calibrated value of the shunt.

11. Record the calculated value as *DMM Measured Current*.

12. Calculate the lower and upper current measurement test limits using the following formula:

*Current Measurement Test Limits = DMM Measured Current ± (|DMM Measured Current| * % of Current + Offset)*

13. Disconnect the shunt from the DMM, leaving the DUT output on.

14. Take a current measurement.

15. Verify that the value falls within the *Current Measurement Test Limits*.

100 µA to 100 mA Current Measurement and Output

Note
Complete this procedure only after successfully completing all previous verification procedures.

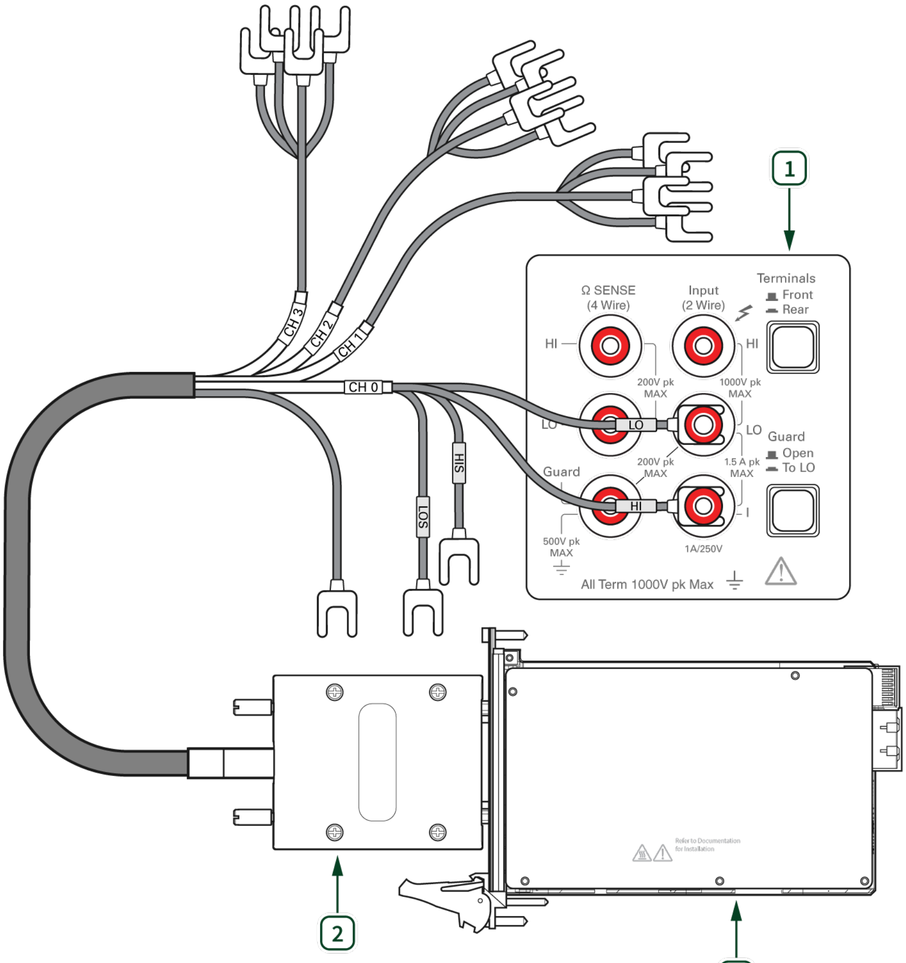
Test Limits

Table 11: 100 µA to 100 mA Current Measurement and Output Test Limits

Level Range	Limit Range and Limit	Test Point	DMM Range	As-Found Measurement Test Limit (% of Current + Offset)	As-Left Measurement Test Limit (% of Current + Offset)
100 µA	8 V	-100 µA	100 µA	0.035% + 8 nA	0.02% + 1.5 nA
		100 µA			
1 mA		-1 mA	1 mA	0.03% + 70 nA	
		1 mA			
10 mA		-10 mA	10 mA	0.03% + 700 nA	
		10 mA			
100 mA		-100 mA	100 mA	0.035% + 7 µA	
		100 mA			

Initial Test Connection

Figure 8: 100 µA to 100 mA Current Measurement and Output Connection Diagram



Legend

1	DMM
2	DB25 to Low-Thermal EMF Spade Lug Assembly[7]
3	PXIe-4147

[7] Individual wire labels on CH1, CH2, and CH3 omitted for readability. Individual wire colors differ from figure. Use wire labels as the primary method of identification. Details on wire colors can be found in *Table 2: DB25 to Low-Thermal EMF Spade Lug Assembly Wire Identification*.

Verification Procedure

1. Install the DB25 to low-thermal EMF spade lug assembly on the DUT.
2. Set the **niDCPower Output Function** property or `NIDCPOWER_OUTPUT_FUNCTION` attribute to DC Current for the DUT.

Repeat 4 times, once for each channel.

3. Connect the spade lug assembly wires for one channel to the DMM.

Repeat 4 times, once for each level range.

4. Set the level range, limit range, and limit on the DUT.
5. Measure the internal device temperature and perform self-calibration if necessary.

Note If the internal device temperature exceeds T_{cal} ±5 °C, wait up to five minutes for the temperature to stabilize to within T_{cal} ±5 °C. If the stable temperature still exceeds T_{cal} ±5 °C after five minutes, call the self-calibration VI or function.

Repeat 2 times, once for test point for the level range.

6. Set the level on the DUT to the test point.
7. Wait 1 second to ensure the system has adequate time to settle.
8. Take a current measurement using the DMM.
9. Calculate the lower and upper current measurement test limits using the following formula:

*Current Measurement Test Limits = Test Point ± (|Test Point| * % of Current + Offset)*

10. Verify the DMM measurement falls within the *Current Measurement Test Limits*.

3 A Current Measurement and Output

Note
Complete this procedure only after successfully completing all previous verification procedures.

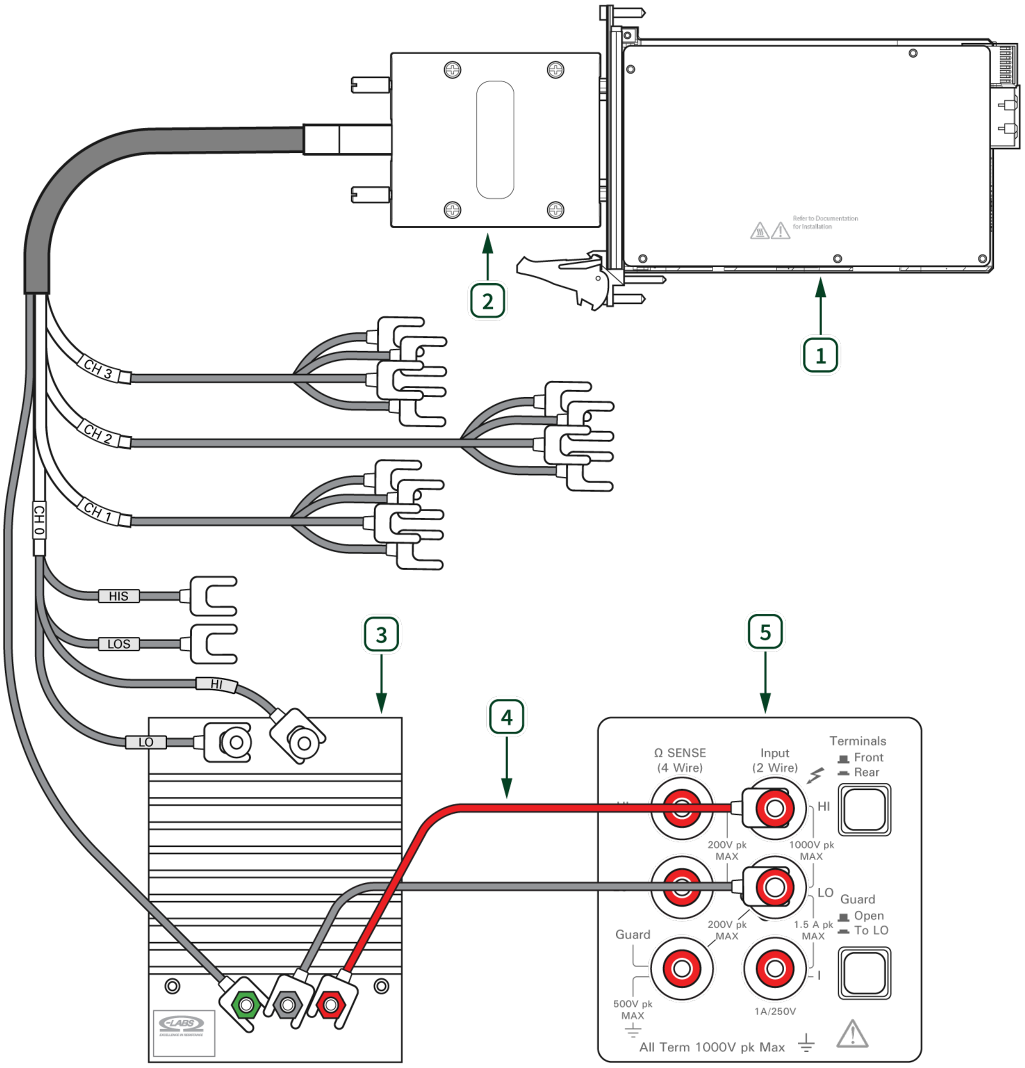
Test Limits

Table 12: 3 A Current Measurement and Output Test Limits

Level Range	Limit Range and Limit	Shunt	Test Point	DMM Range	As-Found Measurement Test Limit (% of Current + Offset)	As-Left Measurement Test Limit (% of Current + Offset)
3 A	8 V	333 mΩ	-3 A	1 V	0.07% + 400 µA	0.032% + 60 µA
			3 A			

Initial Test Connection

Figure 9: 3 A Current Measurement and Output Connection Diagram



1. PXIe-4147
2. DB25 to Low-Thermal EMF Spade Lug Assembly[8]
3. 333 mΩ current shunt
4. Low Thermal EMF Copper Cables[9]
5. DMM

[8] Individual wire labels on CH1, CH2, and CH3 omitted for readability. Individual wire colors differ from figure. Use wire labels as the primary method of identification. Details on wire colors can be found in *Table 2: DB25 to Low-Thermal EMF Spade Lug Assembly Wire Identification*.

[9] Low Thermal EMF Copper Cables in the diagram are shown separated for ease of understanding and are not an exact match of the actual 5440A-7003 cables.

Verification Procedure

1. Install the DB25 to low-thermal EMF spade lug assembly on the DUT.
2. Connect the shunt to the DMM.
3. Set the **niDCPower Output Function** property or `NIDCPOWER_OUTPUT_FUNCTION` attribute to DC Current for the DUT.

Repeat 4 times, once for each channel.

4. Connect the spade lug assembly wires for one channel to the shunt.
5. Set the level range, limit range, and limit on the DUT.
6. Measure the internal device temperature and perform self-calibration if necessary.

> **Note**
> If the internal device temperature exceeds T_{cal} ±5 °C, wait up to five minutes for the temperature to stabilize to within T_{cal} ±5 °C. If the stable temperature still exceeds T_{cal} ±5 °C after five minutes, call the self-calibration VI or function.

Repeat 2 times, once for test point for the level range.

7. Wait 1 second to ensure the system has adequate time to settle.
8. Take a voltage measurement across the shunt using the DMM.
9. Divide the voltage measurement by the calibrated value of the shunt.
10. Record the calculated value as *DMM Measured Current*.
11. Calculate the lower and upper current measurement test limits using the following formula:

*Current Measurement Test Limits = Test Point ± (|Test Point| * % of Current + Offset)*

12. Verify that the recorded *DMM Measured Current* value falls within the test limits.

Perform Adjustment

Perform an adjustment at least once within the calibration interval. Adjustment automatically updates the calibration constants, the date, and the temperature in the DUT EEPROM. If the DUT passes the verification procedures within the As-Left test limits, an adjustment is not required. Proceed to the *Update the Onboard Calibration Information* section.

Note
NI recommends an adjustment to optimize the measurement performance of the DUT even if it passes verification within the As-Left limits.

1. Wait 5 minutes after verification for the DUT temperature to stabilize.
2. Open an external calibration session to the instrument.
3. Uninstall all fixtures from the DUT.
4. Call self-calibration from the Cal API.

Voltage Adjustment

Note
Make the following connections on channel 0 only.

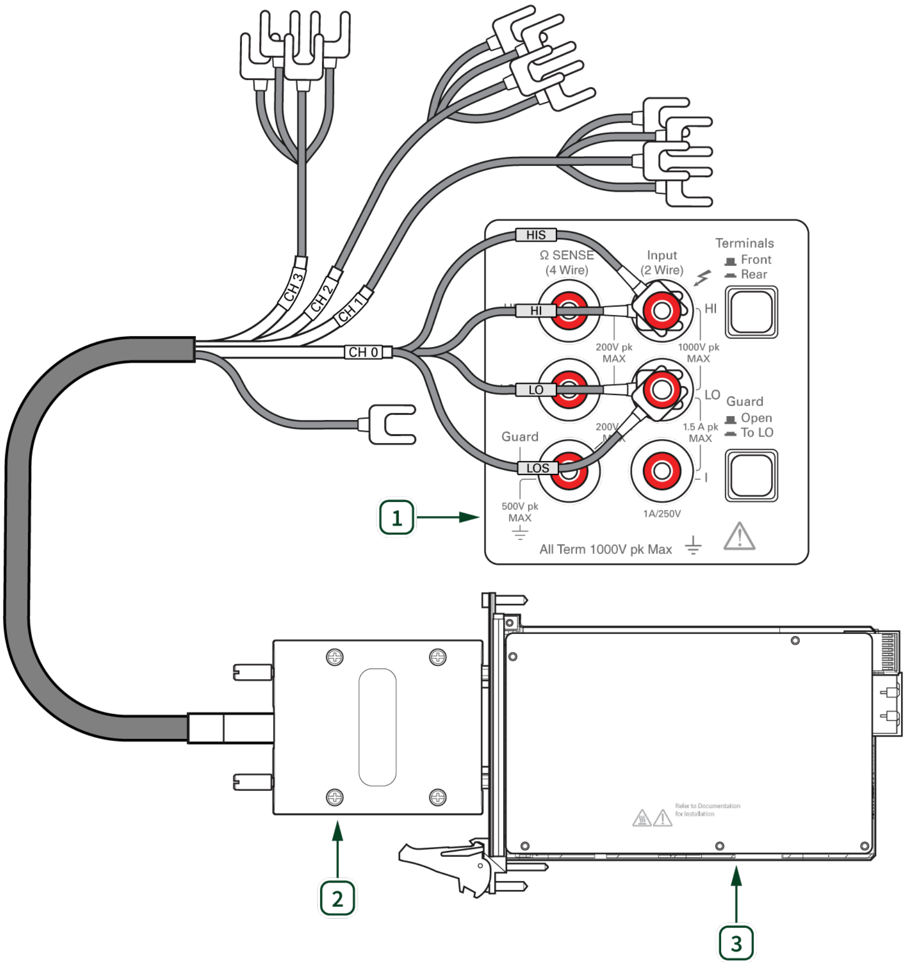
Test Limits

Table 13: Voltage Adjustment Test Limits

Level Range	Limit Range and Limit	Test Point	DMM Range
8 V	100 mA	7 V	10 V
		-7 V	

Initial Test Connection

Figure 10: Voltage Adjustment Connection



1. DMM
2. DB25 to Low-Thermal EMF Spade Lug Assembly[10]
3. PXIe-4147

Adjustment Procedure

5. Install the DB25 to low-thermal EMF spade lug assembly on the DUT.

[10] Individual wire labels on CH1, CH2, and CH3 omitted for readability. Individual wire colors differ from figure. Use wire labels as the primary method of identification. Details on wire colors can be found in *Table 2: DB25 to Low-Thermal EMF Spade Lug Assembly Wire Identification*.

6. Connect the spade lug assembly wires for Channel 0 to the DMM.

7. Set the **niDCPower Sense** property or `NIDCPOWER_ATTR_SENSE` attribute to Remote.

8. Set the **niDCPower Output Function** property or `NIDCPOWER_OUTPUT_FUNCTION` attribute to DC Voltage for the DUT.

Repeat 2 times, once for Test Point.

9. Set the Level Range, Limit Range, and Limit on the DUT.

10. Set the level on the DUT to the first specified Test Point.

11. Wait 1 second to ensure the system has adequate time to settle.

12. Take a voltage measurement using the DMM.

13. Store the measurement value.

14. Configure and call the niDCPower Cal Adjust Voltage Level VI or `niDCPower_CalAdjustVoltageLevel` function to update the calibration constants.

Parameter	Value
Measured outputs	DMM measurement from step 12.
Requested outputs	Test point value
Range	8 V

15. Disconnect the DMM from the DUT.

16. Call self-calibration from the Cal API.

Current Adjustment

Note
Make the following connections on channel 0 only.

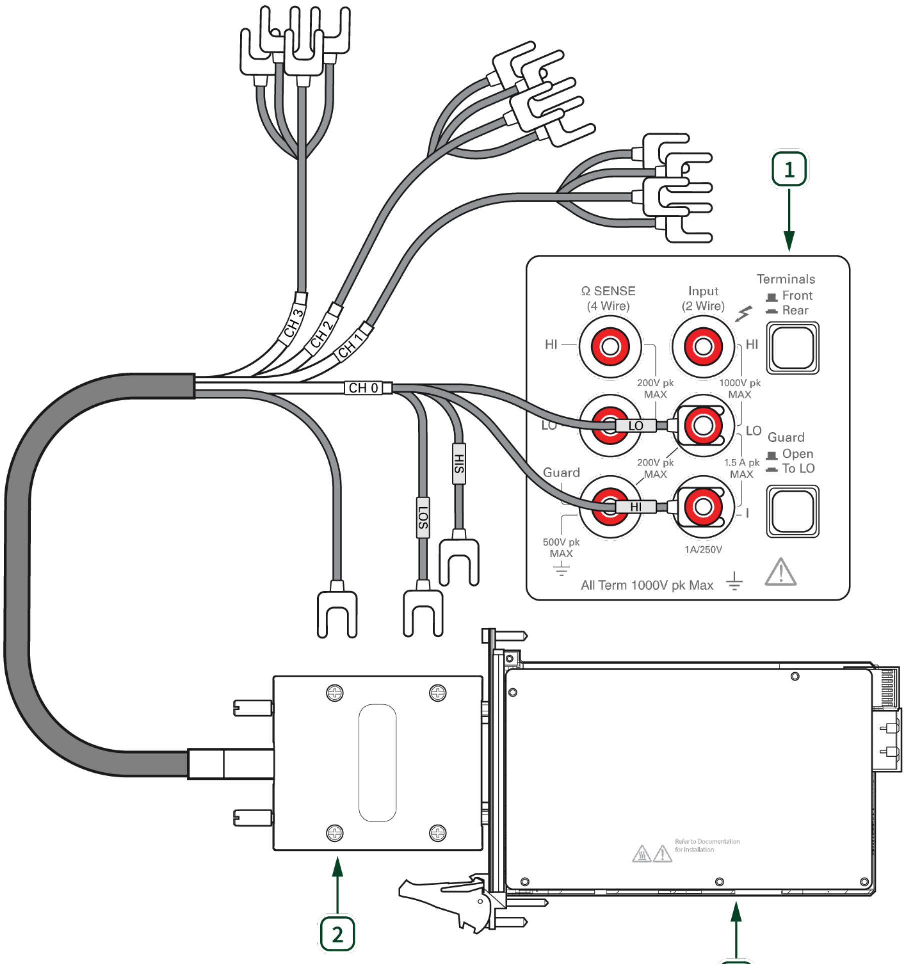
Test Limits

Table 14: Current Adjustment Test Limits

Level Range	Limit Range and Limit	Test Point	DMM Range
1 mA	8 V	900 µA	1 mA
		-900 µA	

Initial Test Connection

Figure 11: Current Adjustment Connection



1. DMM
2. DB25 to Low-Thermal EMF Spade Lug Assembly[11]
3. PXIe-4147

[11] Individual wire labels on CH1, CH2, and CH3 omitted for readability. Individual wire colors differ from figure. Use wire labels as the primary method of identification. Details on wire colors can be found in *Table 2: DB25 to Low-Thermal EMF Spade Lug Assembly Wire Identification*.

Adjustment Procedure

17. Connect the spade lug assembly wires for Channel 0 to the DMM.

Repeat 2 times, once for Test Point.

18. Set the **niDCPower Output Function** property or `NIDCPOWER_OUTPUT_FUNCTION` attribute to DC Current for the DUT.
19. Set the Level Range, Limit Range, and Limit on the DUT.
20. Set the level on the DUT to the first specified Test Point.
21. Wait 1 second to ensure the system has adequate time to settle.
22. Take a current measurement using the DMM.
23. Store the measurement value.
24. Configure and call the niDCPower Cal Adjust Current Limit VI or `niDCPower_CalAdjustCurrentLimit` function to update the calibration constants.

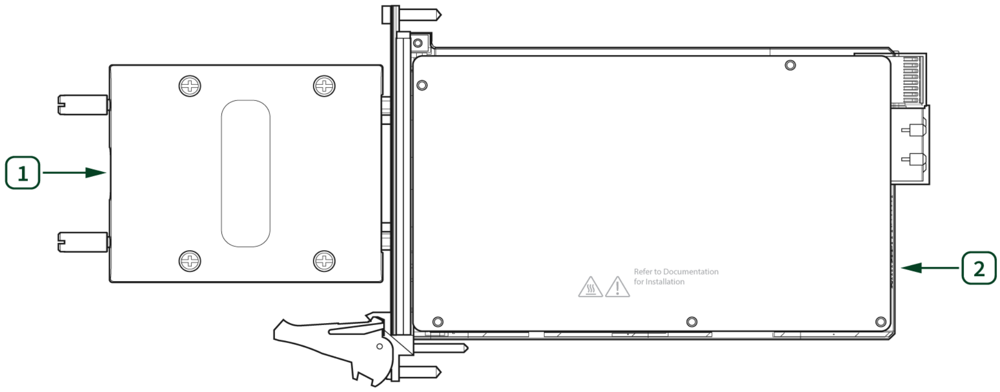
Parameter	Value
Measured outputs	DMM measurement from step 22.
Requested outputs	Test point value
Range	1 mA

25. Disconnect the DMM from the DUT.
26. Call self-calibration from the Cal API

Residual Voltage Adjustment

Initial Test Connection

Figure 12: Residual Voltage Adjustment Connection



1. Output Shorting Assembly
2. PXIe-4147

Adjustment Procedure

27. Install the Output Shorting Assembly on the DUT.
28. Set the **niDCPower Output Function** property or `NIDCPOWER_OUTPUT_FUNCTION` attribute to DC Voltage for the DUT.
29. Configure and call the niDCPower Cal Adjust Residual Voltage Offset VI or `niDCPower_CalAdjustResidualVoltageOffset` function to eliminate the residual offset voltage at 0 V.
30. Call the niDCPower Close External Calibration VI or `niDCPower_CloseExtCal` function.
31. Specify Commit as the calibration close action.

Perform Reverification

Perform all tests in the Verification section after completing Adjustment. This verification compares the As-Left limits with measurement data collected after the DUT adjustment. The As-Left limits may be tighter than the As-Found limits.

Update the Onboard Calibration Information

If your device passes all verification procedures successfully and you want to skip updating the calibration constants, you can update solely the calibration date by completing the following steps.

> **Note**
> NI recommends following all adjustment procedures in order to update the calibration constants and renew the device calibration interval.

1. Call either the niDCPower Initialize External Calibration VI or the `niDCPower_InitExtCal` function.
2. Call either the niDCPower Close External Calibration VI or the `niDCPower_CloseExtCal` function, specifying Commit in **calibration close action**.

Revision History

Revision	Section	Changes
378281A-01 July 2021	—	This is the initial release version of the PXIe-4147 Calibration Procedure.

NI Services

Visit ni.com/support to find support resources including documentation, downloads, and troubleshooting and application development self-help such as tutorials and examples.

Visit ni.com/services to learn about NI service offerings such as calibration options, repair, and replacement.

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

NI corporate headquarters is located at 11500 N Mopac Expwy, Austin, TX 78759-3504, USA.

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