CALIBRATION PROCEDURE

NI PXIe-4139

Single-Channel Precision Source-Measure Unit (SMU)

This document contains the verification and adjustment procedures for the National Instruments PXIe-4139 (NI 4139). Refer to *ni.com/calibration* for more information about calibration solutions.

Contents

Software Requirements

Calibrating the NI 4139 requires the following software on your system. All required NI software is available at *ni.com/downloads*.

- NI-DCPower 1.9 or later
- Supported application development environment (ADE)—LabVIEW or LabWindows™/CVI™
- Supported operating system—Windows

NATIONAL INSTRUMENTS

When you install NI-DCPower, you need to install support only for the application software that you intend to use. Access calibration support in the locations shown in the following table.

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

Related Documentation

Consult the following documents for information about the NI 4139, NI-DCPower, and your application software. Visit *ni.com/manuals* for the latest versions of these documents.

Table 1. Documentation Locations and Descriptions for Calibration

Document	Location	Description
NI DC Power Supplies and SMUs Getting Started Guide	Available from the Start menu and at *ni.com/manuals*.	Contains instructions for installing and configuring NI power supplies and SMUs.
NI DC Power Supplies and SMUs Help	Available from the Start menu and in HTML format at *ni.com/manuals*.	Contains detailed information about the NI 4139 and NI-DCPower LabVIEW VI and C function programming references.
NI PXIe-4139 Specifications	Available from the Start menu and at *ni.com/manuals*.	Contains the published specification values for the NI 4139.
NI-DCPower Readme	Available from the Start menu.	Contains operating system and application software support in NI-DCPower.
LabVIEW Help	Available by selecting **Help**» **LabVIEW Help** from within LabVIEW or at *ni.com/manuals*.	Contains LabVIEW programming concepts and reference information.

Password

The default password for password-protected operations is `NI`.

Calibration Interval

Recommended calibration interval.....1 year

Test Equipment

The following table lists the equipment NI recommends for the performance verification and adjustment procedures. If the recommended equipment is not available, select a substitute using the minimum requirements listed in the table.

Table 2. Required Equipment for Calibration

Required Equipment	Recommended Model(s)	Parameter Measured	Minimum Specifications
Digital multimeter (DMM)	Agilent 3458 A	All parameters except remote sense accuracy	Voltage: < ±9 ppm accuracy and < 100 nV resolution. Current: < ±25 ppm accuracy and < 10 pA resolution.
1 MΩ current shunt	IET Labs SRL-1M	1 µA and 10 µA current accuracy	< 4 ppm accuracy, < 0.2 ppm / °C tempco.
1 Ω current shunt	Ohm Labs CS-1	1 A current accuracy	<65 ppm accuracy, < 5 ppm / °C tempco.
333 mΩ current shunt	Ohm Labs CS-3	3 A current accuracy	< 120 ppm accuracy, < 5 ppm / °C tempco.
3 kΩ resistor	Vishay PTF563K0000BYEB	Remote sense accuracy	0.1% 250 mW

Test Conditions

The following setup and environmental conditions are required to ensure the NI 4139 meets published specifications:

- Keep cabling as short as possible. Long cables act as antennas, picking up extra noise that can affect measurements.
- Verify that all connections to the device, including front panel connections and screws, are secure.
- Ensure that the PXI chassis fan speed is set to HIGH, that the fan filters (if present) are clean, and that the empty slots contain slot blockers and filler panels. For more

information about cooling, refer to the *Maintain Forced-Air Cooling Note to Users* document available at *ni.com/manuals*.

- Allow a warm-up time of at least 30 minutes after the chassis is powered on and NI-DCPower is loaded and recognizes the NI 4139. Allow adequate warm-up time for all other instruments and equipment according to the manufacturer instructions. The warm-up time ensures that the NI 4139 and test instrumentation are at a stable operating temperature.
- Use shielded copper wire for all cable connections to the device. Use twisted-pair wire to eliminate noise and thermal offsets.
- To ensure the system has had adequate time to settle, wait one second after requesting a new current or voltage or after changing a load before taking a measurement.
- Keep relative humidity between 10% and 70%, noncondensing.
- Test limits in this document are based on the December 2013 edition of the *NI PXIe-4139 Specifications*, except for more recently revised remote sense test limits.
- When making measurements, 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` to power line cycles.
- 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.
- When making measurements, configure any specified digital multimeters (DMMs) with the best available levels and limits for each specified test point.

Temperature conditions specific to verification procedures:

- Maintain an ambient temperature of 23 °C ± 5 °C. Maintain an internal device temperature range of T_{cal} ± 1 °C.[1]

Temperature conditions specific to adjustment procedures:

- Maintain an ambient temperature of 23 °C ± 1 °C. The NI 4139 internal temperature will be greater than the ambient temperature.

As-Found and As-Left Limits

The *as-found* limits are the published specifications for the device. NI uses these limits to determine whether the device meets the device specifications when it is received for calibration.

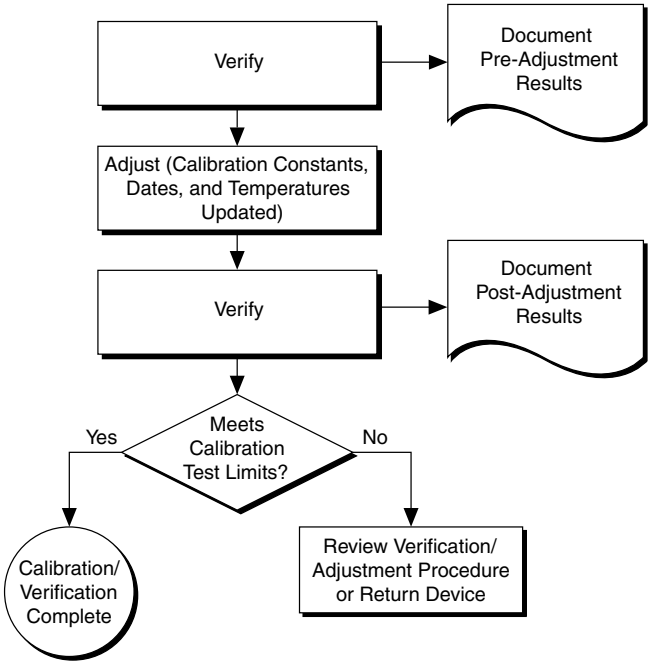
[1] T_{cal} is the internal device temperature recorded by the NI 4139 at the completion of the last self-calibration. Call the niDCPower Get Self Cal Last Temp VI to query T_{cal} from the NI 4139.

The *as-left* limits are equal to the published NI specifications for the device, less guard bands for measurement uncertainty, temperature drift, and drift over time. NI uses these limits to determine whether the device will meet the device specifications over its calibration interval.

Calibration Overview

Calibration includes the steps shown in the following figure.

Figure 1. Calibration Overview



1. Initial Setup—Install the NI 4139 and configure it in Measurement & Automation Explorer (MAX) .
2. Verification—Verify the existing operation of the NI 4139. This step confirms whether the device is operating within the published specifications prior to adjustment.
3. Adjustment—Adjust the calibration constants of the NI 4139.
4. Reverification—Repeat the Verification procedure to ensure that the device is operating within the published specifications after adjustment.

Refer to the following sections to complete each procedure.

Verification

The performance verification procedures assume that adequate traceable uncertainties are available for the calibration references.You must complete all verification procedures in the specified order.

Self-Calibrating

Complete the following steps to self-calibrate the device.

1. Disconnect or disable all connections to the device.
2. Ensure the device had 30 minutes to warm up with the PXI chassis fans set to HIGH.
3. Initialize an NI-DCPower session.
4. Call the self-calibration function.
5. Close the NI-DCPower session.

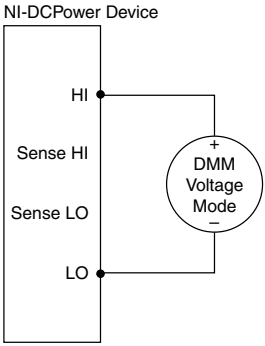
Voltage and Current Verification

You do not need to separately verify or adjust both measurement and output. The architecture of the NI 4139 ensures that if measurement is accurate, then output is as well, and vice versa.

Connecting and Configuring Equipment for Voltage Verification

1. Make the necessary connections for this procedure, as shown in the following figure.

Figure 2. Voltage Verification or Adjustment Connection Diagram



2. Set the **niDCPower Output Function** property or `NIDCPOWER_OUTPUT_FUNCTION` attribute to DC Voltage for the NI 4139.

Verifying Voltage Measurement and Output

Compare a set of voltages measured by an external DMM to the voltage test points requested by the NI 4139.

Verify ranges in the specified order.

Refer to the following table as you complete the following steps.

Table 3. Voltage Output and Measurement Verification

Level Range	Limit Range and Limit	Test Point	As-Found Measurement Test Limit (% of Voltage + Offset)	As-Left Measurement Test Limit (% of Voltage + Offset)
600 mV	1 mA	-600 mV	0.016% + 30 µV	0.0065% + 25 µV
		0 mV		
		600 mV		
6 V	1 mA	-6 V	0.016% + 90 µV	0.0045% + 85 µV
		0 V		
		6 V		
60 V	1 mA	-60 V	0.016% + 900 µV	0.0065% + 820 µV
		0 V		
		60 V		

1. Set the first specified level range, limit range, and limit on the NI 4139.
2. Measure the internal device temperature and perform self-calibration if necessary.
   a) If the internal device temperature exceeds T_{cal} ± 1 °C, wait up to 5 minutes for the temperature to stabilize to within T_{cal} ± 1 °C.
   b) If after 5 minutes the stable temperature still exceeds T_{cal} ± 1 °C, call the self-calibration VI or function.
3. Set the level on the NI 4139 to the first specified test point.
4. Compare a DMM voltage measurement to the voltage measurement test limits.
   a) Take a voltage measurement using the DMM.
   b) Calculate the lower and upper voltage measurement test limits using the following formula: Voltage Measurement Test Limits = Test Point ± (|Test Point| * % of Voltage + Offset).
   c) Verify the DMM measurement falls within the test limits.
5. Repeat the previous steps, from setting the level to the test point on the NI 4139 up to this step, for each specified test point in the level range.
6. If more than one level range is specified, repeat the previous steps using the values specified in each level range.

Verifying Voltage Remote Sense

Use the NI 4139 in constant current mode with a test circuit to simulate the voltage drop between the device and a load.

Complete this procedure only after successfully completing all previous verification procedures. Verify ranges in the specified order.

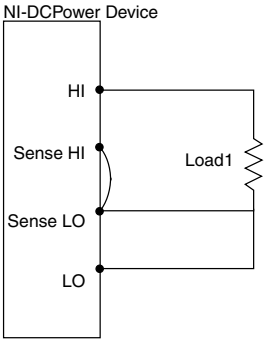
Refer to the following table as you complete the following steps.

Table 4. Voltage Remote Sense Output Verification

Level Range	Limit Range and Limit	Test Point	$Load_1$	$Load_2$	Voltage Remote Sense Test Limit	
					$Load_1$	$Load_2$
1 mA	600 mV	0 mA	3 kΩ	3 kΩ	≤38.4 µV	≤6 µV
		1 mA				

1. Set the **niDCPower Output Function** property or `NIDCPOWER_OUTPUT_FUNCTION` attribute to DC Current for the NI 4139.
2. Set the **niDCPower Sense** property or `NIDCPOWER_ATTR_SENSE` attribute to Remote.
3. Make the necessary connections for this procedure, as shown in the following figure.

Figure 3. Voltage Remote Sense Diagram, Part 1[2]

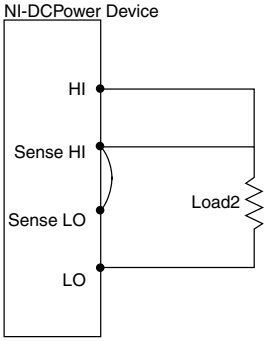


4. Set the first specified level range, limit range, and limit on the NI 4139.
5. Measure the internal device temperature and perform self-calibration if necessary.
   a) If the internal device temperature exceeds T_{cal} ± 1 °C, wait up to 5 minutes for the temperature to stabilize to within T_{cal} ± 1 °C.
   b) If after 5 minutes the stable temperature still exceeds T_{cal} ± 1 °C, call the self-calibration VI or function.
6. Set the level on the NI 4139 to the first specified test point.
7. Take a voltage measurement using the NI 4139.
8. Record the voltage from the previous step as *V1*.
9. Repeat the previous three steps for the other test point specified in the range. This time, record the value as *V2*.

[2] Follow industry best practices for minimizing thermal electromotive force (EMF) when making the necessary connections for this procedure.

10. Calculate the remote sense error using the following formula: Remote Sense Error = |V2 - V1|. Record the value.
11. Verify that the recorded value falls within the test limits.
12. Repeat the previous steps. This time, make the necessary connections as shown in the following figure:

Figure 4. Voltage Remote Sense Diagram, Part 2[3]



Verifying Offset Current

Remove all connections from the NI 4139 and confirm the current measured by the NI 4139 at 0 V falls within the test limits.

Complete this procedure only after successfully completing all previous verification procedures. Verify ranges in the specified order.

Refer to the following table as you complete the following steps.

[3] Follow industry best practices for minimizing thermal electromotive force (EMF) when making the necessary connections for this procedure.

Table 5. Current Offset Verification

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
600 mV	1 µA	0 mV	-40 pA	40 pA	-25 pA	25 pA
	10 µA		-300 pA	300 pA	-200 pA	200 pA
	100 µA		-2 nA	2 nA	-1.5 nA	1.5 nA
	1 mA		-20 nA	20 nA	-15 nA	15 nA
	10 mA		-200 nA	200 nA	-150 nA	150 nA
	100 mA		-2 µA	2 µA	-1.5 µA	1.5 µA
	1 A		-20 µA	20 µA	-15 µA	15 µA
	3 A		-600 µA	600 µA	-500 µA	500 µA

1. Disconnect all equipment from the output of the NI 4139.
2. Measure the internal device temperature and perform self-calibration if necessary.
   a) If the internal device temperature exceeds T_{cal} ± 1 °C, wait up to 5 minutes for the temperature to stabilize to within T_{cal} ± 1 °C.
   b) If after 5 minutes the stable temperature still exceeds T_{cal} ± 1 °C, call the self-calibration VI or function.
3. Take a current measurement using the NI 4139.
4. Record the value from the previous step.
5. Verify that the recorded value falls within the test limits.
6. If more than one limit range is specified, repeat the previous steps using the values specified in each limit range.

Verifying 1 µA and 10 µA Current Measurement and Output

Compare a set of measured currents reported by the NI 4139 to the currents measured by an external DMM.

Complete this procedure only after successfully completing all previous verification procedures. Verify ranges in the specified order.

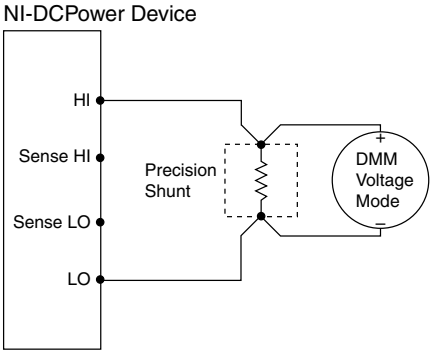
1. Refer to the following table as you complete the following steps.

Table 6. 1 µA and 10 µA Current Output and Measurement Verification

Level Range	Limit Range and Limit	Shunt	Test Point	As-Found Measurement Test Limit (% of Current + Offset)	As-Left Measurement Test Limit (% of Current + Offset)
6 V	1 µA	1 MΩ	-0.9 V	0.022% + 40 pA	0.013% + 25 pA
			0.9 V		
60 V	10 µA		-9 V	0.022% + 300 pA	0.013% + 200 pA
			9 V		

2. Make the necessary connections for this procedure, as shown in the following figure.

Figure 5. Current Connection Diagram, Part 1

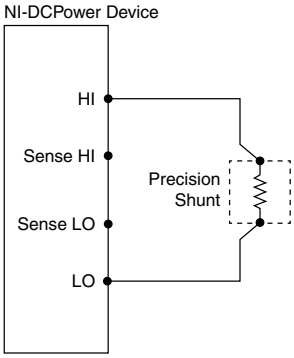


3. Set the **niDCPower Output Function** property or `NIDCPOWER_OUTPUT_FUNCTION` attribute to DC Voltage for the NI 4139.
4. Set the first specified level range, limit range, and limit on the NI 4139.
5. Measure the internal device temperature and perform self-calibration if necessary.
   a) If the internal device temperature exceeds T_{cal} ± 1 °C, wait up to 5 minutes for the temperature to stabilize to within T_{cal} ± 1 °C.
   b) If after 5 minutes the stable temperature still exceeds T_{cal} ± 1 °C, call the self-calibration VI or function.
6. Set the level on the NI 4139 to the first specified test point.

   Complete the following 4 steps within 5 minutes or less of completing the previous step in order to ensure the internal device temperature remains stable.
7. Calculate the current through the shunt by completing the following steps.
   a) Take a voltage measurement across the shunt using the DMM.
   b) Divide the voltage measurement by the calibrated value of the shunt.
   c) Record the calculated value as *DMM Measured Current*.

8. 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).
9. Disconnect the DMM. Leave the NI 4139 output on.

Figure 6. Current Connection Diagram, Part 2



10. Take a current measurement using the NI 4139.
11. Record the value from the previous step.
12. Verify that the recorded NI 4139 value falls within the test limits.
13. Repeat the previous steps, from setting the level to the test point on the NI 4139 up to this step, for each specified test point in the level range.
14. If more than one level range is specified, repeat the previous steps using the values specified in each level range.

Verifying 100 µA to 100 mA Current Measurement and Output

Compare a set of currents measured by an external DMM to the current test points requested by the NI 4139.

Complete this procedure only after successfully completing all previous verification procedures. Verify ranges in the specified order.

Refer to the following table as you complete the following steps.

Table 7. 100 µA to 100 mA Current Output and Measurement Verification

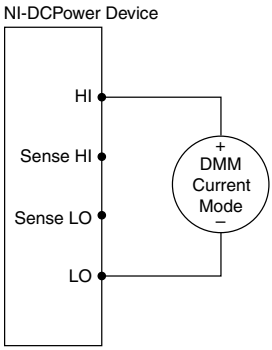
Level Range	Limit Range and Limit	Test Point	As-Found Measurement Test Limit (% of Current + Offset)	As-Left Measurement Test Limit (% of Current + Offset)
100 µA	6 V	-100 µA	0.022% + 2 nA	0.013% + 1.5 nA
		100 µA		

Table 7. 100 µA to 100 mA Current Output and Measurement Verification (Continued)

Level Range	Limit Range and Limit	Test Point	As-Found Measurement Test Limit (% of Current + Offset)	As-Left Measurement Test Limit (% of Current + Offset)
1 mA	6 V	-1 mA	0.022% + 20 nA	0.013% + 15 nA
		1 mA		
10 mA	6 V	-10 mA	0.022% + 200 nA	0.013% + 150 nA
		10 mA		
100 mA	6 V	-100 mA	0.022% + 2 µA	0.013% + 1.5 µA
		100 mA		

1. Make the necessary connections for this procedure, as shown in the following figure.

Figure 7. Current Verification Connection Diagram



2. Set the **niDCPower Output Function** property or `NIDCPOWER_OUTPUT_FUNCTION` attribute to DC Current for the NI 4139.
3. Set the first specified level range, limit range, and limit on the NI 4139.
4. Measure the internal device temperature and perform self-calibration if necessary.
   a) If the internal device temperature exceeds T_{cal} ± 1 °C, wait up to 5 minutes for the temperature to stabilize to within T_{cal} ± 1 °C.
   b) If after 5 minutes the stable temperature still exceeds T_{cal} ± 1 °C, call the self-calibration VI or function.
5. Set the level on the NI 4139 to the first specified test point.
6. Compare a DMM current measurement to the current measurement test limits.
   a) Take a current measurement using the DMM.

b) Calculate the lower and upper current measurement test limits using the following formula: Current Measurement Test Limits = Test Point ± (|Test Point| * % of Current + Offset).

c) Verify the DMM measurement falls within the test limits.

7. Repeat the previous steps, from setting the level to the test point on the NI 4139 up to this step, for each specified test point in the level range.
8. If more than one level range is specified, repeat the previous steps using the values specified in each level range.

Verifying 1 A and 3 A Current Measurement and Output

Compare a set of currents measured by an external DMM to the current test points requested by the NI 4139.

Complete this procedure only after successfully completing all previous verification procedures. Verify ranges in the specified order.

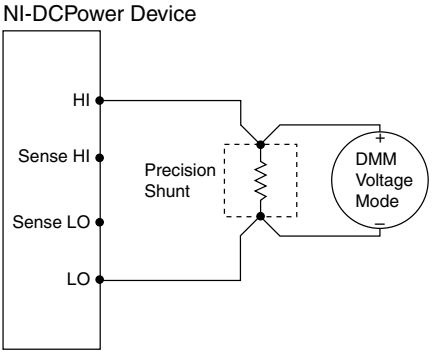
Refer to the following table as you complete the following steps.

Table 8. 1 A and 3 A Current Output and Measurement Verification

Level Range	Limit Range and Limit	Shunt	Test Point	As-Found Measurement Test Limit (% of Current + Offset)	As-Left Measurement Test Limit (% of Current + Offset)
1 A	6 V	1 Ω	-1 A	0.027% + 20 µA	0.013% + 15 µA
			1 A		
3 A	6 V	333 mΩ	-3 A	0.078% + 600 µA	0.045% + 500 µA
			3 A		

1. Make the necessary connections for this procedure, as shown in the following figure.

Figure 8. Current Verification Connection Diagram



2. Set the **niDCPower Output Function** property or `NIDCPOWER_OUTPUT_FUNCTION` attribute to DC Current for the NI 4139.
3. Set the first specified level range, limit range, and limit on the NI 4139.
4. Measure the internal device temperature and perform self-calibration if necessary.
   a) If the internal device temperature exceeds T_{cal} ± 1 °C, wait up to 5 minutes for the temperature to stabilize to within T_{cal} ± 1 °C.
   b) If after 5 minutes the stable temperature still exceeds T_{cal} ± 1 °C, call the self-calibration VI or function.
5. Set the level on the NI 4139 to the first specified test point.
6. Calculate the current through the shunt by completing the following steps.
   a) Take a voltage measurement across the shunt using the DMM.
   b) Divide the voltage measurement by the calibrated value of the shunt.
   c) Record the calculated value as *DMM Measured Current*.
7. Calculate the lower and upper current measurement test limits using the following formula: Current Measurement Test Limits = Test Point ± (|Test Point| * % of Current + Offset).
8. Verify that the recorded DMM value falls within the test limits.
9. Repeat the previous steps, from setting the level to the test point on the NI 4139 up to this step, for each specified test point in the level range.
10. If more than one level range is specified, repeat the previous steps using the values specified in each level range.

Adjustment

This section describes the steps needed to adjust the device to meet published specifications.

Following the adjustment procedure automatically updates the calibration date and temperature on the device.

Adjusted Specifications

Adjustment corrects the following specifications for the device:

- Voltage programming accuracy
- Current programming accuracy
- Voltage measurement accuracy
- Current measurement accuracy

Note You do not need to separately verify or adjust both measurement and output. The architecture of the NI 4139 ensures that if measurement is accurate, then output is as well, and vice versa.

Initiating the Adjustment Session

1. After completing verification, wait a minimum of 5 minutes for the internal device temperature to stabilize.

2. Initiate an external calibration session (a special type of NI-DCPower session) by calling the niDCPower Initialize External Calibration or `niDCPower_InitExtCal` function.
3. Call the self-calibration function.

Ensure the following conditions during adjustment:

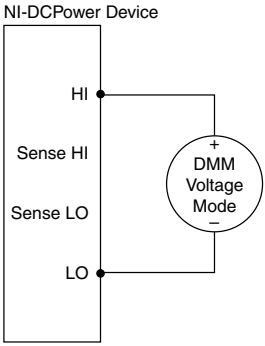
- Keep the calibration session open until you complete all adjustment procedures.
- Complete all adjustment procedures within 15 minutes or less after initiating the external calibration session.
- Complete all adjustment procedures in the specified order.
- Do not self-calibrate the device except as specified in a procedure.

Voltage and Current Output

Connecting and Configuring Equipment for Voltage Adjustment

1. Make the necessary connections for this procedure, as shown in the following figure.

Figure 9. Voltage Verification or Adjustment Connection Diagram



2. Set the **niDCPower Output Function** property or `NIDCPOWER_OUTPUT_FUNCTION` attribute to DC Voltage for the NI 4139.

Adjusting Voltage Output and Measurement

Compare a set of voltages measured by an external DMM to the voltage test points requested by the NI 4139.

Refer to the following table as you complete the following steps.

Table 9. Voltage Output and Measurement Adjustment

Level Range	Limit Range and Limit	Test Point
6 V	100 mA	5 V
		-5 V

1. Set the first specified level range, limit range, and limit on the NI 4139.
2. Set the level on the NI 4139 to the first specified test point.
3. Take a voltage measurement using the DMM.
4. Store the value from the previous step as input for the niDCPower Cal Adjust VI or function called in the following steps.
5. Repeat the previous steps, from setting the level to the test point on the NI 4139 up to this step, for each specified test point in the level range.
6. Update the output calibration constants by configuring and calling the niDCPower Cal Adjust Voltage Level VI or `niDCPower_CalAdjustVoltageLevel` function.
   a) Input the DMM measurements as the **measured outputs**.
   b) Input the test points as the **requested outputs**.
   c) Input the specified level range as the **range**.
7. If more than one level range is specified, repeat the previous steps using the values specified in each level range.

Adjusting 1 µA to 100 mA Current Output and Measurement

Complete this procedure only after successfully completing all previous adjustment procedures. Adjust ranges in the specified order.

Refer to the following table as you complete the following steps.

Table 10. 1 µA to 100 mA Current Output and Measurement Adjustment[4]

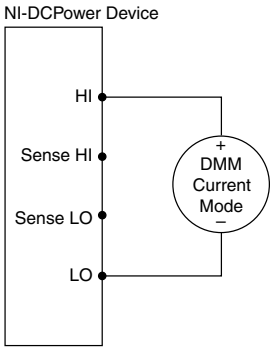
Level Range	Limit Range and Limit	Test Point
100 µA	6 V	100 µA
		-100 µA
1 mA	6 V	100 µA[5]
		-100 µA

1. Make the necessary connections for this procedure, as shown in the following figure.

[4] Adjusting the 100 µA and 1 mA level ranges automatically adjust the following ranges: 1 µA, 10 µA, 10 mA, and 100 mA.

[5] The NI 4139 requires that you adjust ±100 µA test points in the 1 mA level range.

Figure 10. Current Output and Measurement Adjustment Connection Diagram



2. Set the **niDCPower Output Function** property or `NIDCPOWER_OUTPUT_FUNCTION` attribute to DC Current for the NI 4139.
3. Set the first specified level range, limit range, and limit on the NI 4139.
4. Set the level on the NI 4139 to the first specified test point.
5. Take a current measurement using the DMM.
6. Store the value from the previous step as input for the niDCPower Cal Adjust VI or function called in the following steps.
7. Repeat the previous steps, from setting the level to the test point on the NI 4139 up to this step, for each specified test point in the level range.
8. Update the output calibration constants by configuring and calling the niDCPower Cal Adjust Current Limit or `niDCPower_CalAdjustCurrentLimit` function.
   a) Input the DMM measurements as the **measured outputs**.
   b) Input the test points as the **requested outputs**.
   c) Input the specified level range as the **range**.
9. If more than one level range is specified, repeat the previous steps using the values specified in each level range.

Adjusting 1 A and 3 A Current Output and Measurement

Compare a set of measured currents reported by the NI 4139 to the currents measured by an external DMM.

Complete this procedure only after successfully completing all previous adjustment procedures. Adjust ranges in the specified order.

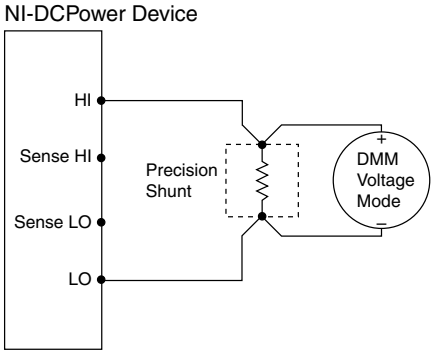
Refer to the following table as you complete the following steps.

Table 11. 1 A and 3 A Current Output and Measurement Adjustment

Level Range	Limit Range and Limit	Shunt	Test Point
1 A	6 V	1 Ω	1 A
			-1 A
3 A	6 V	333 mΩ	3 A
			-3 A

1. Make the necessary connections for this procedure, as shown in the following figure.

Figure 11. Current Output and Measurement Adjustment Connection Diagram



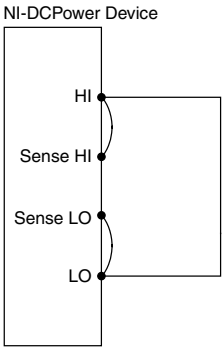
2. Set the **niDCPower Output Function** property or `NIDCPOWER_OUTPUT_FUNCTION` attribute to DC Current for the NI 4139.
3. Set the first specified level range, limit range, and limit on the NI 4139.
4. Set the level on the NI 4139 to the first specified test point.
5. Calculate the current through the shunt by completing the following steps.
   a) Take a voltage measurement across the shunt using the DMM.
   b) Divide the voltage measurement by the calibrated value of the shunt.
6. Store the value from the previous step as input for the niDCPower Cal Adjust VI or function called in the following steps.
7. Repeat the previous steps, from setting the level to the test point on the NI 4139 up to this step, for each specified test point in the level range.
8. Update the output calibration constants by configuring and calling the niDCPower Cal Adjust Current Limit or `niDCPower_CalAdjustCurrentLimit` function.
   a) Input the DMM measurements as the **measured outputs**.
   b) Input the test points as the **requested outputs**.
   c) Input the specified level range as the **range**.
9. If more than one level range is specified, repeat the previous steps using the values specified in each level range.

Residual Offset Voltage

Connecting and Configuring Equipment to Adjust Residual Offset Voltage

1. Make the necessary connections for this procedure, as shown in the following figure.

Figure 12. Residual Voltage Offset Diagram



2. Set the **niDCPower Output Function** property or `NIDCPOWER_OUTPUT_FUNCTION` attribute to DC Voltage for the NI 4139.

Adjusting Residual Voltage Offset

Short the NI 4139 terminals and call the appropriate VI or function.

Complete this procedure only after successfully completing all previous adjustment procedures.

Eliminate residual offset voltage at 0 V by configuring and calling the niDCPower Cal Adjust Residual Voltage Offset VI or `niDCPower_CalAdjustResidualVoltageOffset` function.

Closing the Adjustment Session

Close the session and commit the new constants to hardware by calling the niDCPower Close External Calibration VI or `niDCPower_CloseExtCal` function and specifying Commit as the **calibration close action**.

Alternative to Adjustment Procedures

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 National Instruments recommends following all adjustment procedures in order to update the calibration constants and renew the device calibration interval.

1. Call one of the following:
   - niDCPower Initialize External Calibration VI
   - `niDCPower_InitExtCal` function
2. Call one of the following, specifying Commit in **calibration close action**:
   - niDCPower Close External Calibration VI
   - `niDCPower_CloseExtCal` function

Reverifying

Repeat the Verification section to determine the as-left status of the device. If no as-left test limits are specified in a procedure, reuse the as-found test limits.

Note If any test fails reverification after performing an adjustment, verify that you have met the Test Conditions before returning the device to NI. Refer to *Worldwide Support and Services* for more information about support resources or service requests.

Related Information

Test Conditions on page 3

Verification on page 6

The performance verification procedures assume that adequate traceable uncertainties are available for the calibration references.You must complete all verification procedures in the specified order.

Worldwide Support and Services

The National Instruments 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 National Instruments product. Product registration facilitates technical support and ensures that you receive important information updates from NI.

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