

CALIBRATION PROCEDURE

NI PXIe-4112

Dual-Output Programmable DC Power Supply

This document contains the verification and adjustment procedures for the NI PXIe-4112 (NI 4112). Refer to ni.com/calibration for more information about calibration solutions.

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Required Software

Calibrating the NI 4112 requires you to install the following software on the calibration system:

- NI-DCPower 15.1 or later.
- Supported application development environment (ADE)—LabVIEW or LabWindows™/CVI™.
- Supported operating system—Windows.

You can download all required software from ni.com/downloads.

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

You might find the following documents helpful as you perform the calibration procedure:

- *NI PXIe-4112/4113 Getting Started Guide*
- *NI DC Power Supplies and SMUs Help*
- *NI PXIe-4112 Specifications*
- *NI-DCPower Readme*
- *LabVIEW Help*

Visit ni.com/manuals for the latest versions of these documents.

Password

The default password for password-protected operations is NI.

Calibration Interval

Recommended calibration interval	2 years
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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 1. Required Equipment for Calibration

Required Equipment	Recommended Model(s)	Parameter Measured	Minimum Specifications
Two digital multimeters (DMMs)	NI PXI-4071	All parameters	Voltage: < ± 200 ppm accuracy and < 30 μV resolution Current: < $\pm 0.05\%$ accuracy and < 4 μA resolution
Programmable electronic load	Agilent N3302 A or Sorensen SLM-60-30-150	Load regulation	Constant current and constant voltage modes: sink at least 1 A at 60 V
Two 50 Ω resistors	Vishay PTF5650R000BZEK	Remote sense output	0.1% tolerance, 1/8 W
1 k Ω resistor	Vishay PTF651K0000BYEK	Remote sense output	0.1% tolerance, 1/4 W

Test Conditions

The following setup and environmental conditions are required to ensure the NI 4112 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 4112. The warm-up time ensures that the NI 4112 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 October 2014 edition of the *NI PXIe-4112 Specifications*.
- Set the **niDCPower Aperture Time** property or `NIDCPOWER_ATTR_APERTURE_TIME` attribute to 1 power-line cycle (PLC). 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.
- Plug the chassis and the instrument standard into the same power strip to avoid ground loops.
- When making measurements, configure any specified digital multimeters (DMMs) with the best available levels and limits for each specified test point.

An external power supply capable of providing 48 V and greater than 3.5 A should be connected to the AUX Power front panel input at all times.

Temperature conditions specific to verification procedures:

- Maintain an ambient temperature of $23\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$.

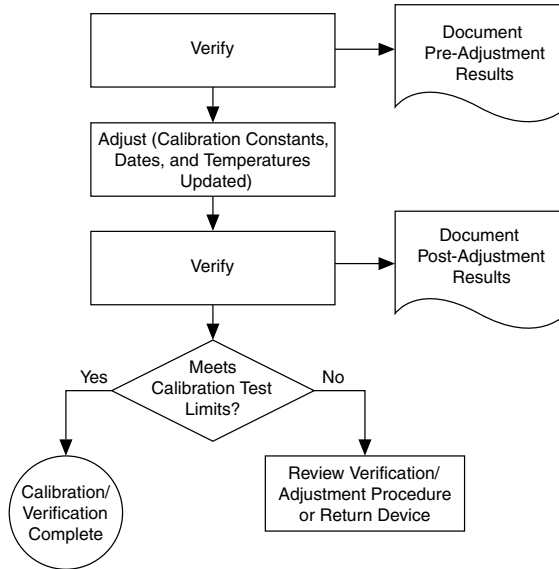
Temperature conditions specific to adjustment procedures:

- Maintain an ambient temperature of $23\text{ }^{\circ}\text{C} \pm 1^{\circ}\text{C}$. The NI 4112 temperature will be greater than the ambient temperature.

Calibration Overview

Calibration includes the steps shown in the following figure.

Figure 1. Calibration Overview



1. Initial Setup—Install the NI 4112 and configure it in Measurement & Automation Explorer (MAX) .
2. Verification—Verify the existing operation of the NI 4112.
This step confirms whether the device is operating within the published specifications prior to adjustment.
3. Adjustment—Adjust the calibration constants of the NI 4112.
4. Reverification—Repeat the Verification procedure to ensure that the device is operating within the published specifications after adjustment.

Verification

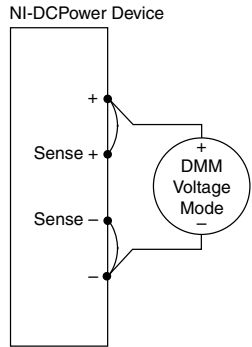
The performance verification procedures assume that adequate traceable uncertainties are available for the calibration references.

Voltage Output and Measurement

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 4112.

Verifying Voltage Output

Compare a set of voltages measured by an external DMM to the voltage test points requested by the NI 4112.

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

Table 2. Voltage Output Verification

Level Range	Limit Range and Limit	Test Point	As-Found Output Test Limit (% of Voltage + Offset)
60 V	1 A	0.1 V	0.12% + 55 mV
		60 V	

1. Set the first specified level range, limit range, and limit on the NI 4112.
2. Set the level on the NI 4112 to the first specified test point.
3. Compare a DMM voltage measurement to the voltage output test limits.
 - a) Take a voltage measurement using the DMM.
 - b) Calculate the lower and upper voltage output test limits using the following formula:
$$\text{Voltage Output Test Limits} = \text{Test Point} \pm (|\text{Test Point}| \times \% \text{ of Voltage} + \text{Offset})$$
 - c) Verify the DMM measurement falls within the test limits.
4. Repeat the previous two steps for each test point specified in the level range.
5. If more than one level range is specified, repeat the previous steps using the values specified in each level range.

Verifying Voltage Measurement

Compare a set of measured voltages reported by the NI 4112 to the voltages measured by an external DMM.

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

Table 3. Voltage Measurement Verification

Level Range	Limit Range and Limit	Test Point	As-Found Measurement Test Limit (% of Voltage + Offset)
60 V	1 A	0.1 V	0.10% + 50 mV
		60 V	

1. Set the first specified level range, limit range, and limit on the NI 4112.
2. Set the level on the NI 4112 to the first specified test point.
3. Compare an NI 4112 voltage measurement to the voltage measurement test limits.
 - a) Take a voltage measurement using the DMM, and take a voltage measurement using the NI 4112.
 - b) Calculate the lower and upper voltage measurement test limits using the following formula:

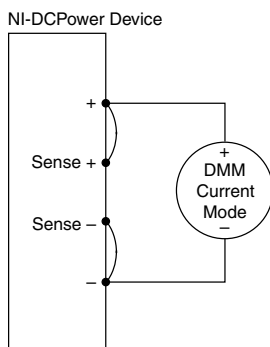
$$\text{Voltage Measurement Test Limits} = \text{DMM Measured Voltage} \pm (|\text{DMM Measured Voltage}| \times \% \text{ of Voltage} + \text{Offset})$$
 - c) Verify the NI 4112 measurement falls within the test limits.
4. Repeat the previous two steps for each test point specified in the level range.
5. If more than one level range is specified, repeat the previous steps using the values specified in each level range.

Current Output and Measurement

Connecting and Configuring Equipment for Current Verification

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

Figure 3. Current Verification or Adjustment Connection Diagram



2. Set the **niDCPower Output Function** property or `NIDCPOWER_OUTPUT_FUNCTION` attribute to DC Current for the NI 4112.

Verifying Current Output

Compare a set of currents measured by an external DMM to the current test points requested by the NI 4112.

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

Table 4. Current Output Verification

Level Range	Limit Range and Limit	Test Point	As-Found Output Test Limit (% of Current + Offset)
1 A	60 V	0.1 A	0.15% + 10 mA
		1 A	

1. Set the first specified level range, limit range, and limit on the NI 4112.
2. Set the level on the NI 4112 to the first specified test point.
3. Compare a DMM current measurement to the current output test limits.
 - a) Take a current measurement using the DMM.
 - b) Calculate the lower and upper current output test limits using the following formula:
$$\text{Current Output Test Limits} = \text{Test Point} \pm (|\text{Test Point}| \times \% \text{ of Current} + \text{Offset})$$
 - c) Verify the DMM measurement falls within the test limits.
4. Repeat the previous two steps for each test point specified in the level range.
5. If more than one level range is specified, repeat the previous steps using the values specified in each level range.

Verifying Current Measurement

Compare a set of measured currents reported by the NI 4112 to the currents measured by an external DMM.

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

Table 5. Current Measurement Verification

Level Range	Limit Range and Limit	Test Point	As-Found Measurement Test Limit (% of Current + Offset)
1 A	60 V	0.1 A	0.15% + 4 mA
		1 A	

1. Set the first specified level range, limit range, and limit on the NI 4112.
2. Set the level on the NI 4112 to the first specified test point.
3. Compare an NI 4112 current measurement to the current measurement test limits.
 - a) Take a current measurement using the DMM, and take a current measurement using the NI 4112.

- b) Calculate the lower and upper current measurement test limits using the following formula:

$$\text{Current Measurement Test Limits} = \text{DMM Measured Current} \pm (|\text{DMM Measured Current}| \times \% \text{ of Current} + \text{Offset})$$

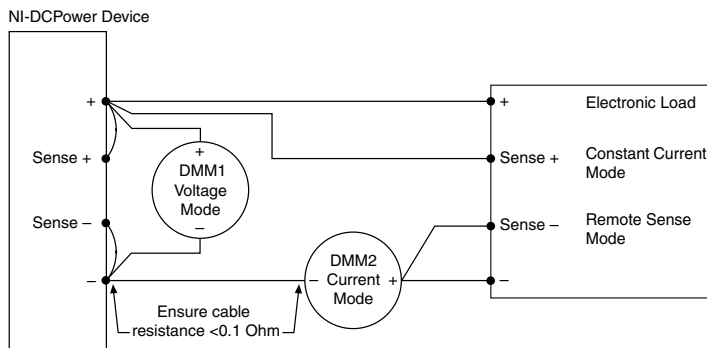
- c) Verify the NI 4112 measurement falls within the test limits.
4. Repeat the previous two steps for each test point specified in the level range.
5. If more than one level range is specified, repeat the previous steps using the values specified in each level range.

Load Regulation

Connecting and Configuring Equipment for Voltage Load Regulation Verification

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

Figure 4. Voltage Load Connection Diagram¹



2. Connect the DMM to the NI 4112 connector pins with dedicated pairs of wires to avoid including lead drop in the DMM measurement.
3. Set the **niDCPower Output Function** property or `NIDCPOWER_OUTPUT_FUNCTION` attribute to DC Voltage for the NI 4112.

Verifying Voltage Load Regulation

Use the NI 4112 in constant voltage mode to confirm the output voltage change falls within calculated limits while varying the load current.

Run this test only after successfully verifying voltage output and measurement.

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

¹ Configure the electronic load for remote sense mode, and ensure that cables not corrected by remote sense have a total resistance of $<0.1 \Omega$.

Table 6. Voltage Load Regulation Verification

Level Range	Limit Range and Limit	Test Point	Load ₁	Load ₂
60 V	1 A	60 V	0.1 A	0.9 A

1. Set the programmable electronic load to the first specified value (*Load*₁).
2. Set the first specified level range, limit range, and limit on the NI 4112.
3. Set the level on the NI 4112 to the first specified test point.
4. Take a voltage measurement across the output terminals of the NI 4112 using *DMM1*.
5. Record the voltage from the previous step as *V1*.
6. Take a current measurement using *DMM2*.
7. Record the current from the previous step as *I1*.
8. Change the load from *Load*₁ to *Load*₂. Repeat the previous four steps. This time, record the values as *V2* and *I2*.
9. Calculate the upper and lower voltage load regulation test limits using the following formula, and then record the test limits.

$$\text{Voltage Load Regulation Test Limit} = \pm (I1 - I2) \times 0.012 \text{ V/A}$$

10. Calculate the voltage change using the following formula, and record the value.

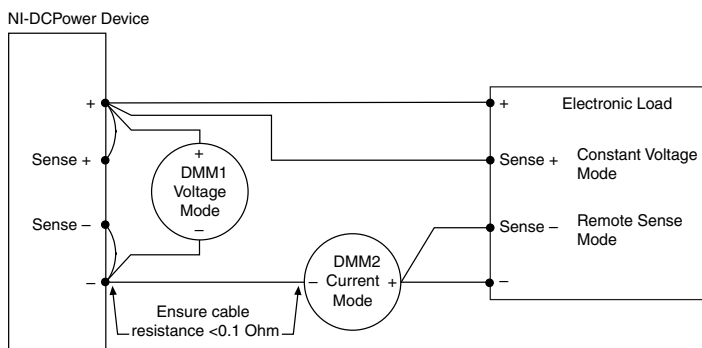
$$\text{Voltage change} = V1 - V2.$$

11. Verify the voltage change falls within the voltage load regulation test limits.
12. If more than one level range is specified, repeat the previous steps using the values specified in each level range.

Connecting and Configuring Equipment for Current Load Verification

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

Figure 5. Current Load Connection Diagram²



² Configure the electronic load for remote sense mode, and ensure that cables not corrected by remote sense have a total resistance of <0.1 Ω.

2. Connect the DMM to the NI 4112 connector pins with dedicated pairs of wires to avoid including lead drop in the DMM measurement.
3. Set the **niDCPower Output Function** property or `NIDCPOWER_OUTPUT_FUNCTION` attribute to DC Current for the NI 4112.

Verifying Current Load Regulation

Use the NI 4112 in constant current mode to confirm the output current change falls within calculated limits while varying the load voltage.

Run this test only after successfully verifying current output and measurement.

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

Table 7. Current Load Regulation Verification

Level Range	Limit Range and Limit	Test Point	Load ₁	Load ₂
1 A	60 V	1 A	6 V	54 V

1. Set the programmable electronic load to the first specified value (*Load*₁).
2. Set the first specified level range, limit range, and limit on the NI 4112.
3. Set the level on the NI 4112 to the first specified test point.
4. Take a voltage measurement across the output terminals of the NI 4112 using *DMM1*.
5. Record the voltage from the previous step as *V1*.
6. Take a current measurement using *DMM2*.
7. Record the current from the previous step as *I1*.
8. Change the load from *Load*₁ to *Load*₂. Repeat the previous four steps. This time, record the values as *V2* and *I2*.
9. Calculate the upper and lower current load regulation test limits using the following formula, and then record the test limits.

$$\text{Current Load Regulation Test Limit} = (V1 - V2) \times 0.000032 \text{ A/V}$$

10. Calculate the current change using the following formula:

$$\text{Current change} = I1 - I2$$

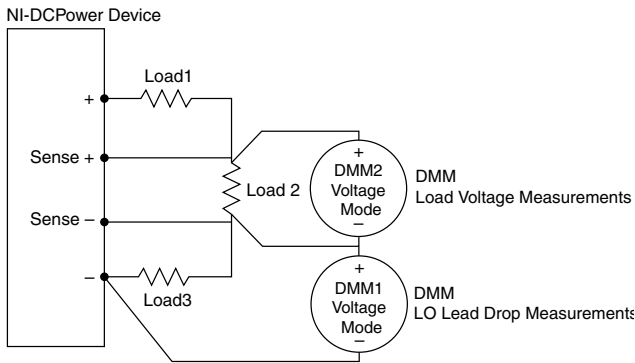
11. Verify the current change falls within the current load regulation test limits.
12. If more than one level range is specified, repeat the previous steps using the values specified in each level range.

Remote Sense

Connecting and Configuring Equipment for Voltage Remote Sense Accuracy Verification

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

Figure 6. Voltage Remote Sense Output Connection Diagram



- 2. Set the **niDCPower Sense** property or `NIDCPOWER_ATTR_SENSE` attribute to Remote.
- 3. Set the **niDCPower Output Function** property or `NIDCPOWER_OUTPUT_FUNCTION` attribute to DC Voltage for the NI 4112.

Verifying Voltage Remote Sense Accuracy

Use the NI 4112 in constant voltage 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.

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

Table 8. Voltage Remote Sense Output Verification

Level Range	Limit Range and Limit	Test Point	Load ₁	Load ₂	Load ₃	Voltage Remote Sense Test Limit	Minimum Lead Drop
60 V	1 A	10 V	50 Ω	1 kΩ	50 Ω	0.12% + 55 mV	≥0.4 V

- 1. Set the first specified level range, limit range, and limit on the NI 4112.
- 2. Set the level on the NI 4112 to the first specified test point.
- 3. Measure the LO lead drop with *DMM1* from the negative terminal of the device to the negative side of *Load2*. Record the measurement as *Lead Drop*.
- 4. Verify the *Lead Drop* measurement is greater than or equal to the minimum lead drop.
- 5. Measure the load voltage with *DMM2* across *Load2* where the sense leads connect. Record the measurement as *Load Voltage*.
- 6. Verify the *Load Voltage* measurement falls within the voltage remote sense test limits.

7. 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 NI 4112 to meet published specifications.

Adjusted Specifications

Adjustment corrects the following specifications for the device:

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

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



Note You do not need to separately adjust both measurement and output. The architecture of the NI 4112 ensures that if measurement is accurate, then output is as well, and vice versa.

Initiating the Adjustment Session

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

(Optional) You can close the session and commit the new constants to hardware after you complete each adjustment procedure.

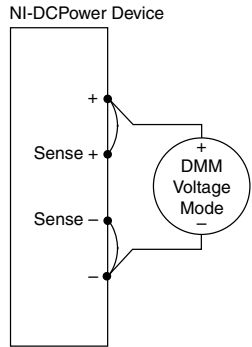
Related Information

[Closing the Adjustment Session](#) on page 16

Connecting and Configuring Equipment for Voltage Adjustment

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

Figure 7. Voltage Verification or Adjustment Connection Diagram



2. Set the **niDCPower Output Function** property or `NIDCPOWER_OUTPUT_FUNCTION` attribute to DC Voltage for the NI 4112.

Adjusting Voltage Output and Measurement

Compare a set of voltages measured by the external DMM to both a set of voltage test points requested by the NI 4112 and to the measured voltages reported by the NI 4112.

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
60 V	1 A	1.0 V
		60 V

1. Set the first specified level range, limit range, and limit on the NI 4112.
2. Set the level on the NI 4112 to the first specified test point.
3. Take a voltage measurement using the DMM, and take a voltage measurement using the NI 4112.
4. Store the values from the previous step as inputs for the `niDCPower Cal Adjust VI` or function called in the following steps.
5. Repeat the previous three steps for each test point specified in the level range.
6. Update the measurement calibration constants by configuring and calling the `niDCPower Cal Adjust Voltage Measurement VI` or `niDCPower_CalAdjustVoltageMeasurement` function.
 - a) Input the DMM measurements as the **measured outputs**.
 - b) Input the NI 4112 measurements as the **reported outputs**.
 - c) Input the specified level range as the **range**.

7. 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**.
8. If more than one level range is specified, repeat the previous steps using the values specified in each level range.

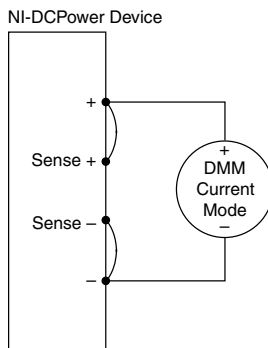
Related Information

For information about VIs or functions, refer to the programming reference of the NI DC Power Supplies and SMUs Help.

Connecting and Configuring Equipment for Current Adjustment

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

Figure 8. Current Verification or Adjustment Connection Diagram



2. Set the **niDCPower Output Function** property or NIDCPOWER_OUTPUT_FUNCTION attribute to DC Current for the NI 4112.

Adjusting Current Output and Measurement

Compare a set of currents measured by the external DMM to both a set of current test points requested by the NI 4112 and to the measured currents reported by the NI 4112.

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

Table 10. Current Output and Measurement Adjustment

Level Range	Limit Range and Limit	Test Point
1 A	60 V	0.1 A
		1 A

1. Set the first specified level range, limit range, and limit on the NI 4112.
2. Set the level on the NI 4112 to the first specified test point.
3. Take a current measurement using the DMM, and take a current measurement using the NI 4112.
4. Store the values from the previous step as inputs for the niDCPower Cal Adjust VI or function called in the following steps.
5. Repeat the previous three steps for each test point specified in the level range.
6. Update the measurement calibration constants by configuring and calling the niDCPower Cal Adjust Current Measurement VI or `niDCPower_CalAdjustCurrentMeasurement` function.
 - a) Input the DMM measurements as the **measured outputs**.
 - b) Input the NI 4112 measurements as the **reported outputs**.
 - c) Input the specified level range as the **range**.
7. Update the output calibration constants by configuring and calling the niDCPower Cal Adjust Current Limit VI or `niDCPower_CalAdjustCurrentLimit` function.
 - a) Input the calculated shunt current measurements as the **measured outputs**.
 - b) Input the test points as the **requested outputs**.
 - c) Input the specified level range as the **range**.
8. If more than one level range is specified, repeat the previous steps using the values specified in each level range.

Related Information

For information about VIs or functions, refer to the programming reference of the NI DC Power Supplies and SMUs Help.

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**.

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 the

Worldwide Support and Services section for information about support resources or service requests.

Related Information

[Test Conditions](#) on page 3

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.

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