CALIBRATION PROCEDURE

NI PXIe-4113

Dual-Output Programmable DC Power Supply

This document contains the verification and adjustment procedures for the National Instruments PXIe-4113 (NI 4113). Refer to *ni.com/calibration* for more information about calibration solutions.

Contents

Software Requirements

Calibrating the NI 4113 requires the following software on your system. All required NI software is available at *ni.com/downloads*.

- NI-DCPower 1.8 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 4113, 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 4113 and NI-DCPower LabVIEW VI and C function programming references.
NI PXIe-4113 Specifications	Available from the Start menu and at *ni.com/manuals*.	Contains the published specification values for the NI 4113.
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.....2 years

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
One digital multimeter (DMM), optional second DMM [1]	NI PXI-4071	All parameters	Voltage: <±200 ppm accuracy and <30 µV resolution
Programmable electronic load	Agilent N3302A or Sorensen SLM-60-30-150	Load regulation	Constant current and constant voltage modes: sink at least 6 A at 10 V
100 mΩ precision current shunt	Guildline 9230 A-30 or Ohm Labs CS10	Current output and measurement, voltage and current load regulation	±100 ppm tolerance, ±50 ppm stability, ±5 ppm/C temperature coefficient. Minimum current 10 A.
Two 50 Ω resistors	Vishay PTF5650R000BZEK	Remote sense output	0.1% tolerance, 1/8 W
1 kΩ resistor	Vishay PTF651K0000BYEK	Remote sense output	0.1% tolerance, 1/4 W

[1] If you make measurements using only one DMM, sequentially set up the DMM connections as specified by the procedure steps.

Test Conditions

The following setup and environmental conditions are required to ensure the NI 4113 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 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 the NI-DCPower is loaded and recognizes the NI 4113. Allow adequate warm-up time for all other instruments and equipment according to the manufacturer instructions. The warm-up time ensures that the NI 4113 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 April 2013 edition of the *NI PXIe-4113 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.

Temperature conditions specific to verification procedures:

- Maintain an ambient temperature of 23 °C ± 5 °C.

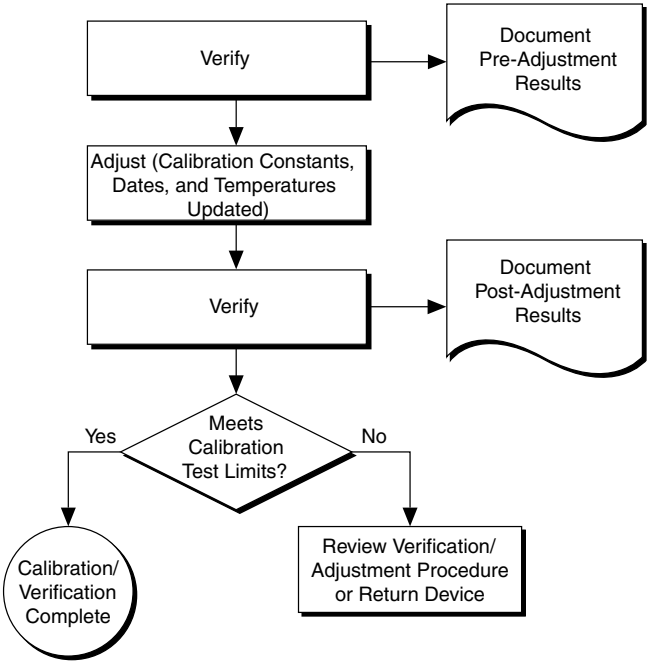
Temperature conditions specific to adjustment procedures:

- Maintain an ambient temperature of 23 °C ± 1°C. The NI 4113 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 4113 and configure it in Measurement & Automation Explorer (MAX) .
2. Verification—Verify the existing operation of the NI 4113. This step confirms whether the device is operating within the published specifications prior to adjustment.
3. Adjustment—Adjust the calibration constants of the NI 4113.
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

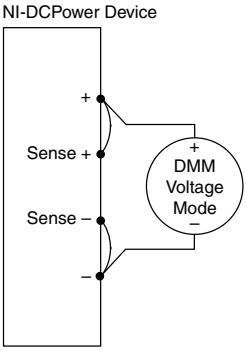
The performance verification procedures assume that adequate traceable uncertainties are available for the calibration references.

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 4113.

Verifying Voltage Output

Compare a set of voltages measured by an external DMM to the voltage test points requested by the NI 4113.

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

Table 3. Voltage Output Verification

Level Range	Limit Range and Limit	Test Point	As-Found Output Test Limit (% of Voltage + Offset)
10 V	6 A	0.1 V	0.1% + 15 mV
		10 V	

1. Set the first specified level range, limit range, and limit on the NI 4113.
2. Set the level on the NI 4113 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: Voltage Output Test Limits = Test Point ± (|Test Point| * % of Voltage + 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 4113 to the voltages measured by an external DMM.

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

Table 4. Voltage Measurement Verification

Level Range	Limit Range and Limit	Test Point	As-Found Measurement Test Limit (% of Voltage + Offset)
10 V	6 A	0.1 V	0.1% + 15 mV
		10 V	

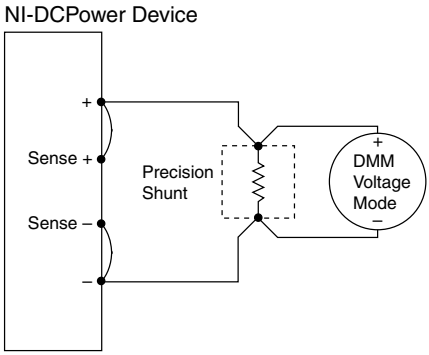
1. Set the first specified level range, limit range, and limit on the NI 4113.
2. Set the level on the NI 4113 to the first specified test point.
3. Compare a NI 4113 voltage measurement to the voltage measurement test limits.
   a) Take a voltage measurement using the DMM, and take a voltage measurement using the NI 4113.
   b) Calculate the lower and upper voltage measurement test limits using the following formula: Voltage Measurement Test Limits = DMM Measured Voltage ± (| DMM Measured Voltage| * % of Voltage + Offset).
   c) Verify the NI 4113 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 4113.

Verifying Current Output

Compare a set of currents measured by an external DMM to the current test points requested by the NI 4113.

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

Table 5. Current Output Verification

Level Range	Limit Range and Limit	Test Point	As-Found Output Test Limit (% of Current + Offset)
6 A	10 V	0.1 A	0.15% + 20 mA
		6 A	

1. Set the first specified level range, limit range, and limit on the NI 4113.
2. Set the level on the NI 4113 to the first specified test point.
3. 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*.
4. Calculate the lower and upper current output test limits using the following formula: Current Output Test Limits = Test Point ± (|Test Point| * % of Current + Offset)
5. Verify that the recorded DMM value falls within the test limits.
6. Repeat the previous four steps for each test point specified in the level range.
7. 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 4113 to the currents measured by an external DMM.

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

Table 6. Current Measurement Verification

Level Range	Limit Range and Limit	Test Point	As-Found Measurement Test Limit (% of Current + Offset)
6 A	10 V	0.1 A	0.15% + 20 mA
		6 A	

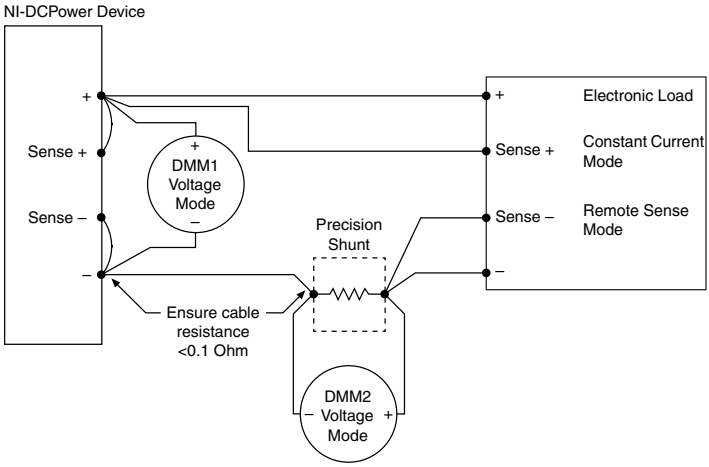
1. Set the first specified level range, limit range, and limit on the NI 4113.
2. Set the level on the NI 4113 to the first specified test point.
3. Calculate the current through the shunt by completing the following steps.
   a) Take a voltage measurement across the shunt using the DMM.
   b) Divide the voltage measurement by the calibrated value of the shunt.
   c) Record the calculated value as *DMM Measured Current*.
4. 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).
5. Take a current measurement using the NI 4113.
6. Record the value from the previous step.
7. Verify that the recorded NI 4113 value falls within the test limits.
8. Repeat the previous seven steps for each test point specified in the level range.
9. 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 Diagram[23]



2. Connect the DMM to the NI 4113 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 4113.

Verifying Voltage Load Regulation

Use the NI 4113 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.

Table 7. Voltage Load Regulation Verification

Level Range	Limit Range and Limit	Test Point	$Load_1$	$Load_2$
10 V	6 A	10 V	0.6 A	5.4 A

1. Set the programmable electronic load to the first specified value (*Load1*).
2. Set the first specified level range, limit range, and limit on the NI 4113.
3. Set the level on the NI 4113 to the first specified test point.
4. Take a voltage measurement across the output terminals of the NI 4113 using *DMM1*.
5. Record the voltage from the previous step as *V1*.

[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.

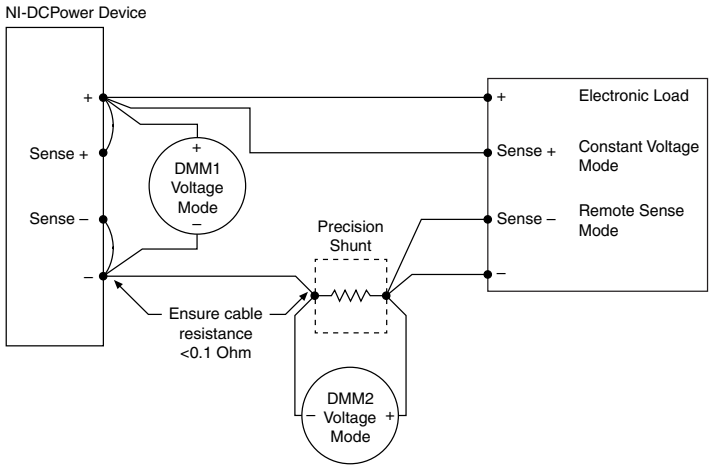
[3] If you make measurements using only one DMM, sequentially set up the DMM connections as specified by the procedure steps.

6. Calculate the current through the shunt by completing the following steps.
   a) Take a voltage measurement across the shunt using *DMM2*.
   b) Divide the voltage measurement by the calibrated value of the shunt.
7. Record the current from the previous step as *I1*.
8. Change the load from *Load1* to *Load2*. 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: Voltage Load Regulation Test Limit = ± (I1 - I2) * 0.0005 V/A . Record the test limits.
10. Calculate the voltage change using the following formula: V1 - V2. Record the value.
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 Diagram[4][5]



2. Connect the DMM to the NI 4113 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 4113.

[4] 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.

[5] If you make measurements using only one DMM, sequentially set up the DMM connections as specified by the procedure steps.

Verifying Current Load Regulation

Use the NI 4113 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 8. Current Load Regulation Verification

Level Range	Limit Range and Limit	Test Point	$Load_1$	$Load_2$
6 A	10 V	6 A	1 V	8.5 V

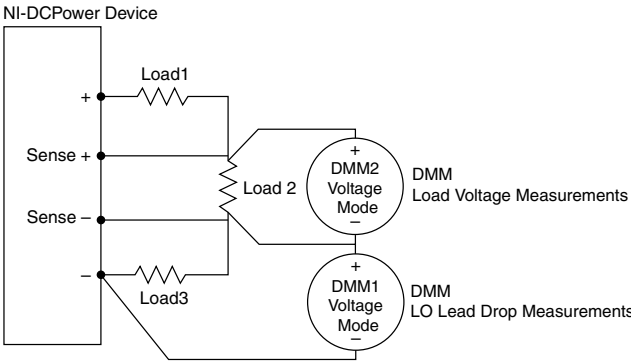
1. Set the programmable electronic load to the first specified value (*Load1*).
2. Set the first specified level range, limit range, and limit on the NI 4113.
3. Set the level on the NI 4113 to the first specified test point.
4. Take a voltage measurement across the output terminals of the NI 4113 using *DMM1*.
5. Record the voltage from the previous step as *V1*.
6. Calculate the current through the shunt by completing the following steps.
   a) Take a voltage measurement across the shunt using *DMM2*.
   b) Divide the voltage measurement by the calibrated value of the shunt.
7. Record the current from the previous step as *I1*.
8. Change the load from *Load1* to *Load2*. 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: Current Load Regulation Test Limit = (V1 - V22) * 0.00025 A/V . Record the test limits.
10. Calculate the current change using the following formula: 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[6]



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 4113.

Verifying Voltage Remote Sense Accuracy

Use the NI 4113 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 9. 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
10 V	6 A	10 V	50 Ω	1 kΩ	50 Ω	0.1% + 15 mV	≥0.4 V

1. Set the first specified level range, limit range, and limit on the NI 4113.
2. Set the level on the NI 4113 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] If you make measurements using only one DMM, sequentially set up the DMM connections as specified by the procedure steps.

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 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

Initiating the Adjustment Session

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

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

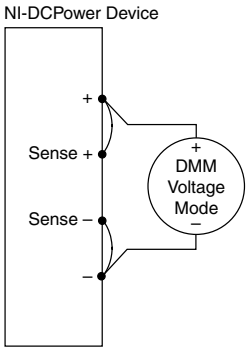
Related Information

Closing the Adjustment Session on page 17

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 4113.

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 4113 and to the measured voltages reported by the NI 4113.

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

Table 10. Voltage Output and Measurement Adjustment

Level Range	Limit Range and Limit	Test Point
10 V	6 A	0.1 V
		10 V

1. Set the first specified level range, limit range, and limit on the NI 4113.
2. Set the level on the NI 4113 to the first specified test point.
3. Take a voltage measurement using the DMM, and take a voltage measurement using the NI 4113.
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 4113 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.

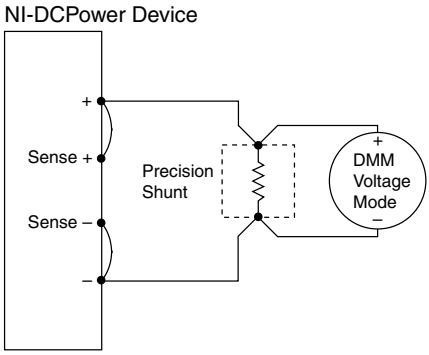
Related Information

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 4113.

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 4113 and to the measured currents reported by the NI 4113.

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

Table 11. Current Output and Measurement Adjustment

Level Range	Limit Range and Limit	Test Point
6 A	10 V	0.1 A
		6 A

1. Set the first specified level range, limit range, and limit on the NI 4113.
2. Set the level on the NI 4113 to the first specified test point.
3. 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.
4. Store the value from the previous step as input for the niDCPower Cal Adjust VI or function called in the following steps.
5. Take a current measurement using the NI 4113.
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 five steps for each test point specified in the level range.
8. Update the measurement calibration constants by configuring and calling the VI niDCPower Cal Adjust Current Measurement or niDCPower_CalAdjustCurrentMeasurement function.
   a) Input the DMM measurements as the measured outputs.
   b) Input the NI 4113 measurements as the reported outputs.
   c) Input the specified level range as the range.
9. 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..
10. 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**.

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 4

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.

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

National Instruments corporate headquarters is located at 11500 North Mopac Expressway, Austin, Texas, 78759-3504. National Instruments also has offices located around the world. For telephone support in the United States, create your service request at *ni.com/support* or dial 1 866 ASK MYNI (275 6964). For telephone support outside the United States, visit the *Worldwide Offices* section of *ni.com/niglobal* to access the branch office websites, which provide up-to-date contact information, support phone numbers, email addresses, and current events.

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