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CALIBRATION PROCEDURE

NI PXI-4132

This document contains information for calibrating the National Instruments PXI-4132 (NI 4132) precision source measure unit (SMU). For more information about calibration, visit `ni.com/calibration`.

Contents

Software Requirements

To calibrate the NI 4132, you must install NI-DCPower version 1.8 or later on the Windows calibration system. You can download the NI-DCPower instrument driver from the Instrument Driver Network website at `ni.com/idnet`. NI-DCPower supports programming an external calibration in the C and LabVIEW application development environments (ADEs). When you install NI-DCPower, you only need to install support for the ADE that you intend to use.

LabVIEW support is in the `niDCPower.llb` file, and all calibration VIs are accessible from the NI-DCPower Calibration palette. For LabWindows™/CVI™ users, the NI-DCPower function panel (`niDCPower.fp`) provides access to the calibration functions.

NATIONAL INSTRUMENTS

For the locations of files you may need to calibrate your device, refer to the *NI-DCPower Readme*, accessible at **Start»All Programs»National Instruments»NI-DCPower» Documentation»NI-DCPower Readme**.

Related Documentation

Consult the following documents for information about the NI 4132, NI-DCPower, and your application software. All documents are available at `ni.com/manuals`, and at **Start»All Programs»National Instruments»NI-DCPower»Documentation**.

NI DC Power Supplies and SMUs Getting Started Guide

Contains instructions for NI-DCPower installation, hardware installation, and hardware programming.

NI PXI-4132 Specifications

Contains NI 4132 specifications and calibration interval.

NI-DCPower Readme

Contains operating system and application software support in NI-DCPower.

NI DC Power Supplies and SMUs Help

Contains detailed information about the NI 4132.

LabVIEW Help

Contains LabVIEW programming concepts and reference information about NI-DCPower VIs and functions.

Password

The default calibration password is `NI`.

Calibration Interval

National Instruments recommends a calibration interval of one year for the NI 4132. Adjust the recommended calibration interval based on the measurement accuracy demands of your application.

Test Equipment

National Instruments recommends that you use the equipment in Table 1 for calibrating the NI 4132. If you do not have the recommended equipment, select a substitute calibration standard using the minimum requirements listed.

Table 1. Recommended Equipment

Equipment	Recommended Model	Parameter Measured	Minimum Requirements
Digital multimeter (DMM)	Agilent 3458A (using at least 7.5 digits)	All parameters	Voltage: better than ±50 ppm accuracy and better than 500 nV resolution; Current: better than ±75 ppm accuracy and better than 5 pA resolution
External resistive load	Clarostat 240C	Load regulation	Power resistor decade box with a range of 10 Ω to 900 kΩ and a tolerance of ±10%, >1 W
Two 50 Ω resistors	Vishay PTF5650R000BZEK	Remote sense output	0.1% tolerance, 1/8 W
1 kΩ resistor	Vishay PTF651K0000BYBF	Remote sense output	0.1% tolerance, 1/8 W

Test Conditions

Follow these guidelines to optimize the equipment and the environment during calibration:

- Keep connections to the device as short as possible. Long cables and wires act as antennas, picking up extra noise that can affect measurements.
- Verify that all connections to the device, including front panel connections, are secure.
- Ensure that the PXI chassis fan speed is set to HI, that the fan filters are clean, and that the empty slots contain filler panels. For more information, refer to the *Maintain Forced-Air Cooling Note to Users* document available at `ni.com/manuals`.
- Keep relative humidity between 10% and 70%, noncondensing.
- Allow a warm-up time of at least 30 minutes after loading the NI-DCPower driver. Unless manually disabled, the NI-DCPower driver automatically loads with the operating system and enables the device.
- Perform all measurements with the niDCPower Auto Zero property/attribute set to **On** and the measurement aperture set to 1 PLC.

- Perform all measurements using **Local Sense** unless otherwise noted.
- Use shielded copper wire for all cable connections to the device. Use twisted-pair wire to eliminate noise and thermal offsets.
- Plug the chassis and the instrument standard into the same power strip to avoid ground loops.

Calibration Procedures

The complete external calibration procedure consists of verifying the performance of the SMU, adjusting calibration coefficients, and re-verifying performance after the adjustments. In some cases, a complete calibration procedure may not be required.

Verification

Note You must perform verification after adjustment to ensure the NI 4132 is operating within the manufacturer's specifications.

This section provides instructions for verifying the NI 4132 specifications.

Perform verification under the following conditions:

- Adhere to the guidelines listed in the *Test Conditions* section.
- Set the niDCPower Auto Zero property/attribute to **On**
- Set the measurement aperture to 1 PLC
- Perform a self-calibration after allowing the device to warm up and prior to starting the verification procedure.
- Ensure that the ambient temperature is Tcal ±5 °C. Tcal is the internal device temperature recorded by the NI 4132 at the completion of the last self-calibration. Query Tcal from the NI 4132 by using the niDCPower Get Self Cal Last Temp VI.

NI-DCPower includes example programs that you can use to verify the NI 4132. You can also download example programs at `ni.com/devzone`.

Note Limits in the following tables are based upon the November 2009 edition of the *NI PXI-4132 Specifications*. Refer to the most recent *NI PXI-4132 Specifications* online at `ni.com/manuals`. If a more recent edition of the specifications is available, recalculate the limits based upon the latest specifications.

Voltage Output Verification

To verify voltage output, compare a set of requested voltage set points to measurements of the actual voltage at the output by an external DMM. Refer to Figure 1 for the necessary connections.

Figure 1. Voltage Verification Connection Diagram

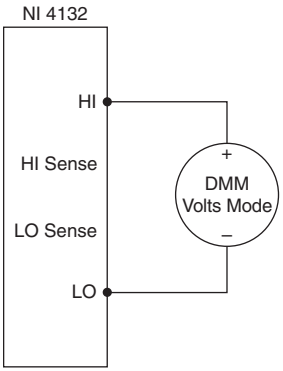


Table 2 lists the voltage set points that you must request and measure for each range to complete verification. For example, the 10 V range requires verification at 10 V, 0 V, and -10 V outputs from the NI 4132, taking measurements using the external DMM at each.

To ensure the system has had adequate time to settle, wait one second after requesting a new voltage before taking a measurement with the DMM.

Table 2. NI 4132 Voltage Output Verification Points

Range	Test Point	Limits of Accuracy		Measured	
		Lower Limit	Upper Limit	As Found	As Left
10 V	10 V	9.99450 V	10.00550 V		
	0 V	-0.00300 V	0.00300 V		
	-10 V	-10.00550 V	-9.99450 V		
100 V	100 V	99.9650 V	100.0350 V		
	75 V	74.9713 V	75.0288 V		
	50 V	49.9775 V	50.0225 V		
	25 V	24.9838 V	25.0163 V		
	0 V	-0.0100 V	0.0100 V		
	-25 V	-25.0163 V	-24.9838 V		
	-50 V	-50.0225 V	-49.9775 V		
	-75 V	-75.0288 V	-74.9713 V		
	-100 V	-100.0350 V	-99.9650 V		

Current Output Verification

To verify current output, compare a set of requested current set points to measurements of the actual current at the output by an external DMM. Refer to Figure 2 for the necessary connections.

Figure 2. Current Verification Connection Diagram

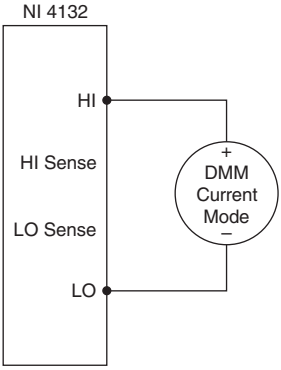


Table 3 lists the current set points that you must request and measure for each range to complete verification. For example, the 10 µA range requires verification at 10 µA, 0.2 µA, -0.2 µA, and -10 µA outputs from the NI 4132, taking measurements using the external DMM at each point.

To ensure the system has had adequate time to settle, wait one second after requesting a new current before taking a measurement with the DMM.

Table 3. NI 4132 Current Output Verification Points

Range	Test Point	Limits of Accuracy		Measured	
		Lower Limit	Upper Limit	As Found	As Left
10 µA	10 µA	9.9946 µA	10.0054 µA		
	0.2 µA	0.1979 µA	0.2021 µA		
	-0.2 µA	-0.2021 µA	-0.1979 µA		
	-10 µA	-10.0054 µA	-9.9946 µA		
100 µA	100 µA	99.946 µA	100.054 µA		
	2 µA	1.979 µA	2.021 µA		
	-2 µA	-2.021 µA	-1.979 µA		
	-100µA	-100.054 µA	-99.946 µA		

Table 3. NI 4132 Current Output Verification Points (Continued)

Range	Test Point	Limits of Accuracy		Measured	
		Lower Limit	Upper Limit	As Found	As Left
1 mA	1 mA	0.99946 mA	1.00054 mA		
	750 µA	0.74955 mA	0.75046 mA		
	500 µA	0.49963 mA	0.50037 mA		
	250 µA	0.24972 mA	0.25029 mA		
	20 µA	0.01979 mA	0.0202068 mA		
	-20 µA	-0.02021 mA	-0.01979 mA		
	-250 µA	-0.25029 mA	-0.24976 mA		
	-500 µA	-0.50037 mA	-0.49963 mA		
	-750 µA	-0.75046 mA	-0.74955 mA		
	-1 mA	-1.00054 mA	-0.99946 mA		
10 mA	10 mA	9.9946 mA	10.0054 mA		
	200 µA	0.1979 mA	0.2021 mA		
	-200 µA	-0.2021 mA	-0.1979 mA		
	-10 mA	-10.0054 mA	-9.9946 mA		
100 mA	100 mA	99.946 mA	100.054 mA		
	2 mA	1.979 mA	2.021 mA		
	-2 mA	-2.021 mA	-1.979 mA		
	-100 mA	-100.054 mA	-99.946 mA		

Voltage Measurement Verification

To verify voltage measurement, compare a set of voltage set points as measured by an external DMM to the measured voltage reported by the NI 4132. Refer to Figure 1 for the necessary connections.

Table 4 lists the voltage set points for each range that you must measure and request with both an external DMM and the NI 4132 to complete verification. For example, the 10 V range requires verification at 10 V, 0 V, and -10 V outputs from the NI 4132, taking measurements using the external DMM and NI 4132 at each point.

To ensure the system has adequate time to settle, wait one second after requesting a new voltage before taking a measurement with the DMM and the NI 4132. The verification limits for voltage

measurement depend on the actual voltage measured with the external DMM, and are expressed as an offset voltage plus percentage of DMM reading in Table 4.

Table 4. NI 4132 Voltage Measurement Verification Points

Range	Test Point	Measured Voltage		Test Limit	Reported Voltage	
		As Found	As Left		As Found	As Left
10 V	10 V			0.02% + 2.0 mV		
	0 V					
	-10 V					
100 V	100 V			0.02% + 5.0 mV		
	75 V					
	50 V					
	25 V					
	0 V					
	-25 V					
	-50 V					
	-75 V					
	-100 V					

Current Measurement Verification

To verify current measurement, compare a set of current set points as measured by an external DMM to the measured current reported by the NI 4132. Refer to Figure 2 for the necessary connections.

Table 5 lists the current set points for each range that you must measure and request with both an external DMM and the NI 4132 to complete verification. For example, the 10 µA range requires verification at 10 µA, 0 µA, and -10 µA outputs from the NI 4132, taking measurements using the external DMM and NI 4132 at each point.

To ensure the system has adequate time to settle, wait one second after requesting a new current before taking a measurement with the DMM and the NI 4132. The verification limits for current measurement depend on the actual current measured with the external DMM, and are expressed as an offset current plus percentage of DMM reading in Table 5.

Note To verify the zero current test points, instead of using an external DMM, disconnect all external equipment from the I/O connector and take a current measurement with the NI 4132. When you verify the zero current test points this way, the measured current is always zero.

Table 5. NI 4132 Current Measurement Verification Points

Range	Test Point	Measured Current		Test Limit	Reported Current	
		As Found	As Left		As Found	As Left
10 µA	10 µA			0.028% + 1.0 nA		
	0 µA					
	-10 µA					
100 µA	100 µA			0.028% + 10 nA		
	0 µA					
	-100 µA					
1 mA	1 mA			0.028% + 0.1 µA		
	750 µA					
	500 µA					
	250 µA					
	0 µA					
	-250 µA					
	-500 µA					
	-750 µA					
	-1 mA					
10 mA	10 mA			0.028% + 1 µA		
	0 µA					
	-10 mA					
100 mA	100 mA			0.020% + 10 µA		
	0 µA					
	-100 mA					

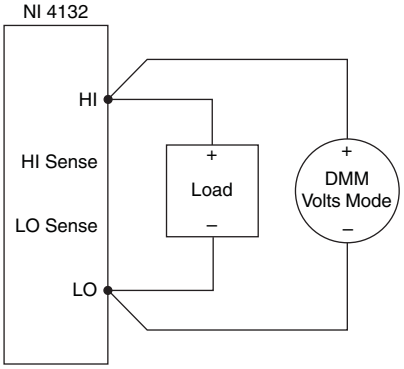
Load Regulation Verification

The load regulation test verifies that the output voltage falls within specified limits when the load current changes, or that the output current falls within specified limits when the load voltage changes. For each test, you need two resistors to vary the load voltage or current. The load regulation test results are dependent upon voltage and current measurement accuracy. A failure of any of the *Voltage Measurement Verification* or *Current Measurement Verification* steps may result in a failure of Load Regulation Verification.

Voltage Load Regulation

To verify voltage load regulation, use the NI 4132 in constant voltage mode and confirm the output voltage change falls within calculated limits while varying the load current using different resistors. Table 6 lists the resistance values and measurements needed to complete verification. Refer to Figure 3 for the necessary connections.

Figure 3. Voltage Load Regulation Verification Connection Diagram



Complete the following steps to verify voltage load regulation:

1. For each test, connect the first specified resistance (R_1) to the NI 4132.
2. While taking a current measurement with the NI 4132 (I_1), use a DMM to measure the voltage across the output of the NI 4132 (V_1).
3. Change the load from R_1 to R_2 and repeat the previous step.
4. Record the voltage and current measurements for both resistances.
5. Calculate the voltage change limit using the following formula, where the current is in mA:

$$Voltage\ Change\ Limit = \pm (I_1 - I_2) \times 0.0005\ \text{V}$$

6. Subtract the two voltage measurements $V_1 - V_2$ to calculate the *Voltage Change*.

The test passes if the *Voltage Change* falls within the calculated *Voltage Change Limit*.

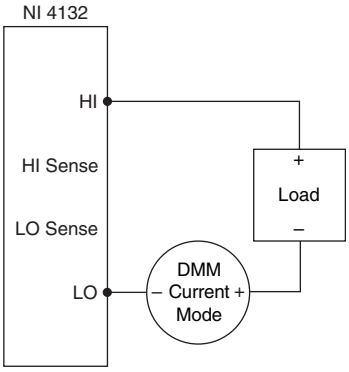
Table 6. NI 4132 Voltage Load Regulation Verification Points

V Range	I Range	I Limit	Test Point	Load R_1	Load R_2	Measured				Voltage Change Limit (V)	Voltage Change (V)
						I_1 (mA)	V_1 (V)	I_2 (mA)	V_2 (V)		
10 V	100 mA	100 mA	10 V	120	1 k						

Current Load Regulation

To verify current load regulation, use the NI 4132 in constant current mode and confirm the output current change falls within calculated limits while varying the load voltage using different resistors. Table 7 lists the resistance values and measurements needed to complete verification. Refer to Figure 4 for the necessary connections.

Figure 4. Current Load Regulation Verification Connection Diagram



Complete the following steps to verify current load regulation:

1. For each test, connect the first specified resistance (R_1) to the NI 4132.
2. While taking a voltage measurement with the NI 4132 (V_1), use a DMM in series to measure the output current (I_1).
3. Change the load from R_1 to R_2 and repeat the previous step.
4. For each test, the units for all current measurements and calculations should be the same as the *I Range* unit. Record the current and voltage measurements for both resistances.
5. Calculate the current change limit using the following formula:
   $Current\ Change\ Limit = \pm 0.0001 \times I\ Range \times (V_1 - V_2)$
6. Subtract the two current measurements $I_1 - I_2$ to calculate the *Current Change*.

The test passes if the *Current Change* falls within the calculated *Current Change Limit*.

Table 7. NI 4132 Current Load Regulation Verification Points

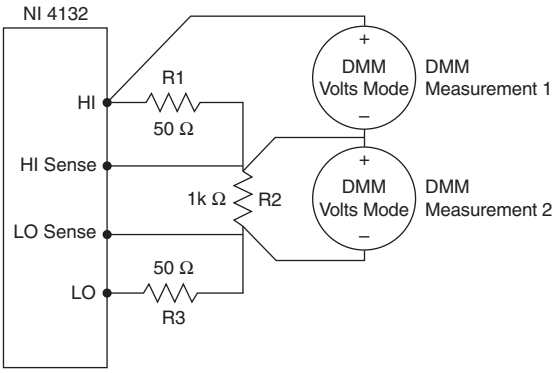
I Range	V Range	V Limit	Test Point	Load R_1	Load R_2	Measured				Current Change Limit (Ω)	Current Change (Ω)
						I_1	V_1 (V)	I_2	V_2 (V)		
10 µA	10 V	10 V	10 µA	100 k	900 k						
100 µA	10 V	10 V	100 µA	10 k	90 k						
1 mA	10 V	10 V	1 mA	1 k	9 k						
10 mA	10 V	10 V	10 mA	100	900						
100 mA	10 V	10 V	100 mA	10	90						

Remote Sense Output Verification

To verify remote sense, complete the following steps using a test circuit of three resistors that simulates the voltage drop between the device and a load.

1. Connect a 50 Ω (R_1), 1 kΩ (R_2), and 50 Ω (R_3) resistor in series, with the 1 kΩ resistor as the center resistor as shown in Figure 5.

Figure 5. Remote Sense Output Verification Connection Diagram



2. Connect the resistors to the HI and LO terminals on the NI 4132 as shown in Figure 5. Connect the remote sense leads directly across the 1 kΩ resistor (R_2).
3. Set remote sense to On, use a current limit of 100 mA, and output 10 V in the 10 V range.
4. Measure the HI Lead Drop with a DMM (*DMM Measurement 1*) from the HI terminal of the NI 4132 to the HI side of the 1 kΩ resistor.
5. Calculate the accuracy limit for the load voltage using the following equation:

$$\textit{Load Voltage Limit} = 10\ \text{V} \pm (0.0055\text{V} + \textit{HI Lead Drop} \times 0.005)$$

6. Measure the load voltage with a DMM (*DMM Measurement 2*) across the 1 kΩ load where the sense leads connect.

The test passes if the *Load Voltage* measurement falls within the calculated *Load Voltage Limit*.

Table 8. NI 4132 Remote Sense Output Verification Points

V Range	I Range	Test Point	Measured		Load Voltage Limit (V)
			HI Lead Drop (V)	Load Voltage (V)	
10 V	100 mA	10 V			

Adjustment

Following the adjustment procedure automatically updates the calibration date and temperature on the NI 4132.

Note National Instruments recommends a complete adjustment of your device to renew the calibration interval. However, if you do not want to perform an adjustment, you can update the calibration date and onboard calibration temperature without making any adjustments by calling only the niDCPower Initialize External Calibration VI or the `niDCPower_InitExtCal` function and the niDCPower Close External Calibration VI or `niDCPower_CloseExtCal` function with the action of **Commit**.

Adjustment corrects the following NI 4132 specifications:

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

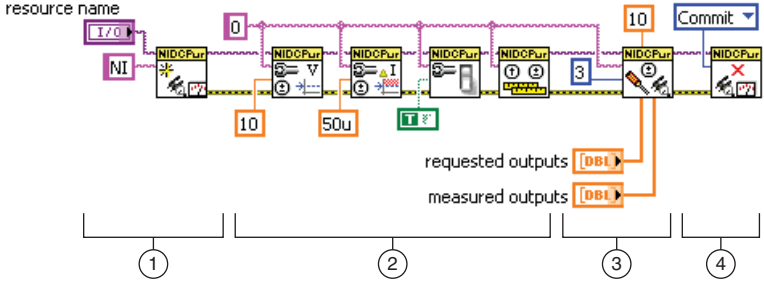
The adjustment components of the NI-DCPower API require the SMU to be programmed using the voltage output function (this is the default configuration). To achieve a negative output current using the voltage function, specify a negative voltage level that ensures the SMU operates in constant current mode, and specify the absolute value of the negative current as the current limit.

You must adjust each range with a separate call to an niDCPower Cal Adjust VI or function. For voltage and current output, adjust positive and negative polarities separately as well.

Considerations

Figure 6 represents the general flow of an application used to adjust a range on the NI 4132.

Figure 6. LabVIEW Block Diagram Illustrating Range Adjustment on the NI 4132



1. **Initialize External Calibration Session**: To adjust the NI 4132, call the niDCPower Initialize External Calibration VI or the `niDCPower_InitExtCal` function to initiate a special type of NI-DCPower session.
2. **Configure the instrument**: Call a series of standard NI-DCPower VIs/functions specific to the adjustment of a particular range. These calls vary depending on the requirements of the range being adjusted. Typical operations in this step include configuring ranges, setting output levels, or taking measurements. Measurements made by external equipment required for adjustment also occur during this step. For assistance configuring the NI 4132 to a particular output or measurement mode, refer to the example programs installed with NI-DCPower, located at **Start»All Programs»National Instruments»NI-DCPower» Examples**.
3. **Call niDCPower Cal Adjust function(s)**: When the measurements required for adjustment of a range are complete, call one of the niDCPower Cal Adjust VIs or functions to calculate new calibration coefficients and store them in memory on the host. Calling these VIs/functions does *not* commit the new coefficients to hardware.
4. **Close session and commit new calibration coefficients**: To complete adjustment of the range, call the niDCPower Close External Calibration VI or `niDCPower_CloseExtCal` function to close the session. To write new calibration coefficients to the hardware, specify an action of **Commit**. At this time, the calibration date and temperature stored on board are also updated.

Note You can adjust any voltage or current range individually by opening a calibration session, adjusting, and then closing the session with an action of **Commit**. To adjust all voltage and current ranges at one time, open a single calibration session, execute multiple adjustment steps, and then close the session with an action of **Commit** to write coefficients for multiple ranges simultaneously.

Adjusting Voltage Output

To adjust voltage output, compare a set of requested voltage set points to measurements of the actual voltage at the output by an external DMM. Refer to Figure 1 for the necessary connections.

Table 9 outlines the voltage set points that you must request and measure for each range. For example, the 10 V range requires the adjustment application to separately request -1 nV, -5 V, and -10 V outputs and 0 V, 5 V, and 10 V outputs from the NI 4132. Take measurements using the external DMM at each voltage set point.

Note Do not use the NI-DCPower Soft Front Panel (SFP) to request set points for adjusting voltage outputs.

To ensure the system has had adequate time to settle, wait one second after requesting a new voltage before taking a measurement with the DMM.

Table 9. NI 4132 Voltage Output Adjustment Points

Voltage Output Range	10 V		100 V	
Polarity	+	—	+	—
Required Set Points	0 V	-1 nV	0 V	-1 nV
	5 V	-5 V	50 V	-50 V
	10 V	-10 V	100 V	-100 V

After you measure all set points for a range, call the niDCPower Cal Adjust Voltage Level VI or the `niDCPower_CalAdjustVoltageLevel` function to calculate updated calibration coefficients. Some notable parameters to this VI/function are specific to adjustment applications and are explained in Table 10. Others are common to many VIs/functions within the NI-DCPower API that are explained in more detail in the *Programming with NI-DCPower* book in the *NI DC Power Supplies and SMUs Help*.

Figure 7. NI-DCPower Cal Adjust Voltage Level VI

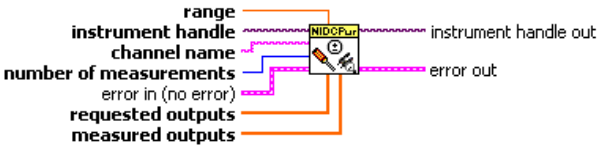


Table 10. NI-DCPower Cal Adjust Voltage Level VI/Function Parameter Descriptions

VI/Function Parameter	Description
range	The range to be adjusted with these settings.
requested outputs	An array of requested voltage set points required for adjustment of a range. For example, the requested outputs for the positive half of the 10 V range are 0, 5, and 10.
measured outputs	An array of measurements made by the external DMM corresponding to *requested outputs*.
number of measurements	The number of elements in *requested outputs* and *measured outputs*.

After you calculate the new coefficients, commit them to the hardware using the process described in the *Considerations* section.

Note Adjust positive and negative current polarities with separate calls to the niDCPower Cal Adjust Voltage Level VI or the `niDCPower_CalAdjustVoltageLevel` function.

Adjusting Current Output

To adjust current output, compare a set of requested current set points to measurements of the actual current at the output by an external DMM. Refer to Figure 2 for the necessary connections.

Table 11 lists the current set points that you must request and measure for each range. For example, the 10 µA range requires the adjustment application to acquire data from ten negative and ten positive set points using an external DMM.

To ensure the system has had adequate time to settle, wait one second after requesting a new current before taking a measurement with the DMM.

Table 11. NI 4132 Current Output Set Points

Current Output Range	10 µA	100 µA	1 mA	10 mA	100 mA
Polarity	±	±	±	±	±
Required Set Points	±0.2 µA	±2 µA	±0.02 mA	±0.2 mA	±2 mA
	±1.289 µA	±12.89 µA	±0.1289 mA	±1.289 mA	±12.890 mA
	±2.378 µA	±23.78 µA	±0.2378 mA	±2.378 mA	±23.78 mA
	±3.467 µA	±34.67 µA	±0.3467 mA	±3.467 mA	±34.67 mA
	±4.556 µA	±45.56 µA	±0.4556 mA	±4.556 mA	±45.56 mA
	±5.644 µA	±56.44 µA	±0.5644 mA	±5.644 mA	±56.44 mA
	±6.733 µA	±67.33 µA	±0.6733 mA	±6.733 mA	±67.33 mA
	±7.822 µA	±78.22 µA	±0.7822 mA	±7.822 mA	±78.22 mA
	±8.911 µA	±89.11 µA	±0.8911 mA	±8.911 mA	±89.11 mA
	±10 µA	±100 µA	±1 mA	±10 mA	±100 mA

After you measure all set points for a range, call the niDCPower Cal Adjust Current Limit VI or the `niDCPower_CalAdjustCurrentLimit` function to calculate updated calibration coefficients. Some parameters to this VI/function are specific to adjustment applications and are explained in Table 12. Others are common to many VIs/functions within the NI-DCPower API that are explained in more detail in the *Programming with NI-DCPower* book in the *NI DC Power Supplies and SMUs Help*.

Note Adjust positive and negative current polarities with separate calls to the niDCPower Cal Adjust Current Limit VI or the `niDCPower_CalAdjustCurrentLimit` function.

Figure 8. NI-DCPower Cal Adjust Current Limit VI

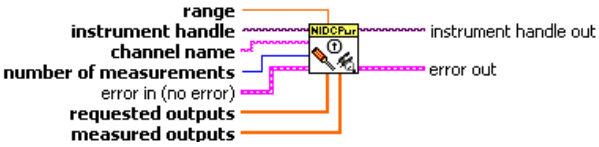


Table 12. NI-DCPower Cal Adjust Current Limit VI/Function Parameter Descriptions

Parameter	Description
range	The range to be adjusted with these settings.
requested outputs	An array of requested currents required for adjustment of a range. For example, the requested output would be the ten set points listed in Table 11 for each range polarity. Requested output currents can not be negative. For negative polarities, calculate the absolute value.
measured outputs	An array of measurements made by the external DMM corresponding to *requested outputs*. Measurements can be entered as positive or negative.
number of measurements	The number of elements in *requested outputs* and *measured outputs*.

After you calculate the new coefficients, commit them to the hardware using the process described in the *Considerations* section.

Adjusting Voltage Measurement

To adjust voltage measurement, compare a set of voltage set points as measured by an external DMM to the measured voltage reported by the NI 4132. Refer to Figure 1 for the necessary connections.

Table 13 lists the voltage set points that you must measure and request with both an external DMM and the NI 4132 to adjust a given range. For example, the 10 V range requires the adjustment application to separately request 10 V, 0 V, and -10 V outputs from the NI 4132. Take measurements using the external DMM and NI 4132 at each point.

To ensure the system has had adequate time to settle, wait one second after requesting a new voltage before taking a measurement with the DMM and the NI 4132.

Table 13. NI 4132 Voltage Measurement Adjustment Points

Voltage Output Range	10 V	100 V
Required Set Points	10 V	100 V
	0 V	0 V
	-10 V	-100 V

After you measure all set points for a range, use the niDCPower Cal Adjust Voltage Measurement VI or the `niDCPower_CalAdjustVoltageMeasurement` function to calculate updated calibration coefficients. Some notable parameters to this VI/function are specific to adjustment applications and are explained in Table 14. Others are common to many VIs/functions within the NI-DCPower API that are explained in more detail in the *Programming with NI-DCPower* book in the *NI DC Power Supplies and SMUs Help*.

Figure 9. NI-DCPower Cal Adjust Voltage Measurement VI

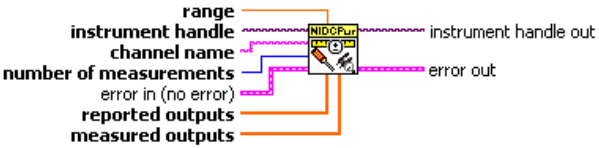


Table 14. NI-DCPower Cal Adjust Voltage Measurement VI/Function Parameter Descriptions

VI/Function Parameter	Description
range	The range to be adjusted with these settings.
reported outputs	An array of measurements taken by the NI 4132 corresponding to required set points in Table 13.
measured outputs	An array of measurements taken by the external DMM corresponding to *requested outputs*.
number of measurements	The number of elements in *requested outputs* and *measured outputs*.

After you calculate the new coefficients, commit them to the hardware using the process described in the *Considerations* section.

Adjusting Current Measurement

To adjust current measurement, compare a set of current set points as measured by an external DMM to the measured current reported by the NI 4132. Refer to Figure 2 for the necessary connections.

Table 15 outlines the current set points that you must measure and request with both an external DMM and the NI 4132 to adjust a given range. For example, the 10 µA range requires the adjustment application to separately request 10 µA, 0 µA, and -10 µA outputs from the NI 4132. Take measurements using the external DMM and NI 4132 at each point.

To ensure the system has had adequate time to settle, wait one second after requesting a new voltage before taking a measurement with the DMM and the NI 4132.

Table 15. NI 4132 Current Output Adjustment Points

Current Output Range	10 µA	100 µA	1 mA	10 mA	100 mA
Required Set Points	10 µA	100 µA	1 mA	10 mA	100 mA
	0 µA	0 µA	0 mA	0 mA	0 mA
	-10 µA	-100 µA	-1 mA	-10 mA	-100 mA

Note When measuring a 0 A set point, remove any connections to the front panel I/O connector to ensure no current is flowing through the output instead of measuring with an external DMM. Any valid current limit can be specified during this process, as the actual output current is always zero.

After you measure all set points for a range, call the niDCPower Cal Adjust Current Measurement VI or the `niDCPower_CalAdjustCurrentMeasurement` function to calculate updated calibration coefficients. Some parameters to this VI/function are specific to adjustment applications and are explained in Table 16. Others are common to many VIs/functions within the NI-DCPower API that are explained in more detail in the *Programming with NI-DCPower* book in the *NI DC Power Supplies and SMUs Help*.

Figure 10. NI-DCPower Cal Adjust Current Measurement VI

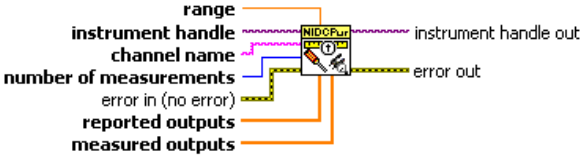


Table 16. NI-DCPower Cal Adjust Current Measurement VI/Function Parameter Descriptions

VI/Function Parameter	Description
range	The range to be adjusted with these settings.
reported outputs	An array of measurements taken by the NI 4132 corresponding to required set points in Table 15.
measured outputs	An array of measurements made by the external DMM corresponding to required set points in Table 15. For zero current set points, a measured output of exactly zero should be entered as all connection to the NI 4132 should be removed to take this measurement.
number of measurements	The number of elements in *reported outputs* and *measured outputs*.

After you calculate the new coefficients, commit them to the hardware using the process described in the *Considerations* section.

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