APEX WAVES

COMPREHENSIVE SERVICES

We offer competitive repair and calibration services, as well as easily accessible documentation and free downloadable resources.

SELL YOUR SURPLUS

We buy new, used, decommissioned, and surplus parts from every NI series. We work out the best solution to suit your individual needs.

〜 Sell For Cash   〜 Get Credit   〜 Receive a Trade-In Deal

OBSOLETE NI HARDWARE IN STOCK & READY TO SHIP

We stock **New, New Surplus, Refurbished,** and **Reconditioned** NI Hardware.

Bridging the gap between the manufacturer and your legacy test system.

📞 1-800-915-6216

🌐 www.apexwaves.com

✉ sales@apexwaves.com

Request a Quote   ✉ CLICK HERE   **PXIe-4154**

CALIBRATION PROCEDURE

NI PXIe-4154

This document contains information for calibrating the NI PXIe-4154 Battery Simulator. For more information about calibration, visit `ni.com/calibration`.

Contents

Software Requirements

Calibrating the NI PXIe-4154 requires installing NI-DCPower version 1.5 or later on a Windows calibration system. You can download the NI-DCPower instrument driver from `ni.com/drivers`. 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 functions appear in the NI-DCPower Calibration palette. For LabWindows™/CVI™ users, the NI-DCPower function panel (`niDCPower.fp`) provides access to available functions. For a list of related files that you may need to calibrate your device, refer to the *NI-DCPower Readme* available from the Start menu.

> **Note**   If you are running Windows 8, you may not have a Start menu. To access National Instruments programs and documentation, open the Start screen, type the name of the file or folder you want to access, and select the appropriate icon from the search results.
>
> For example, to access the *NI DC Power Supplies and SMUs Help*, open the Start screen, type `NI DC Power Supplies and SMUs Help`, and select the appropriate icon from the results. To access device specifications, open the Start screen, type your device number (for example, `4154`), and select the specifications document for your device. Use this method any time the Start menu is referenced in this document.

Documentation Requirements

For information about NI-DCPower and the NI PXIe-4154, you can consult the following documents:

- *NI DC Power Supplies and SMUs Getting Started Guide*—provides instructions for installing and configuring NI power supplies and SMUs.
- *NI DC Power Supplies and SMUs Help*—includes detailed information about the NI PXIe-4154 and NI-DCPower LabVIEW VI and C function programming references.
- *NI PXIe-4154 Specifications*—provides the published specification values for the NI PXIe-4154. Refer to the most recent *NI PXIe-4154 Specifications* at `ni.com/manuals`.

These documents are installed with NI-DCPower. You also can find the latest versions of the documentation at `ni.com/manuals`.

Password

The default password is `NI`.

Calibration Interval

National Instruments recommends a calibration interval of one year for the NI PXIe-4154. 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 PXIe-4154.

Table 1. Recommended Equipment

Equipment	Recommended Model	Parameter Measured	Minimum Requirements
Two Digital Multimeters (DMM)	NI PXI-4071	All Parameters	Voltage: better than ±50 ppm accuracy and better than 30 µV resolution
100 mΩ Precision Current Shunt	Guildline 9230A-15R characterized at 5 W, or Ohm Labs CS10	Current Output and Measurement	±100 ppm tolerance. ±50 ppm stability. ±5 ppm/°C temperature coefficient. Minimum current 10 A. 4-wire kelvin sense.
100 Ω Precision Current Shunt	Vishay Y1453100R000T9L	Current Output and Measurement	±100 ppm tolerance. ±50 ppm stability. ±5 ppm/°C temperature coefficient. Minimum power rating 0.5 W.
External Current Source	Fluke 5500A or Fluke 5520A	Current Measurement	Current output of at least 3 A. Less than 8 µA RMS Normal Mode Current Noise.
Programmable Electronic Load with Dynamic Current Capability	Agilent N3302A	Load Regulation, Transient Response, Output Resistance	Constant Current mode with the ability to sink at least 3 A. Dynamic mode capable of doing a 0.1 A to 1.5 A step with a period of 5 mS and slew rate of at least 200 mA/µS.
Digital Oscilloscope	NI PXI-5124	Transient Response	Sampling rate of at least 200 MS/s. Edge triggering capability.
Two 22.6 Ω Resistors	Vishay PTF22R600FYBF	Remote Sense Output	1% tolerance, ¼ W, ±10 ppm/°C
200 Ω Resistor	Vishay PTF65200R00AZEB	Remote Sense Output	0.05% tolerance, ¼ W, ±10 ppm/°C
Two 3-Foot, 18 AWG Cables	Belden 8760-BEL	Transient Response	18 AWG, twisted-pair
Front Panel Connector	Phoenix Contact Combicon, 5.08 mm, 5 Position Connector and Backshell Kit NI P/N 781627-01	All Parameters	—

Test Conditions

The following setup and environmental conditions are required to ensure NI PXIe-4154 meets published specifications.

- 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/PXI Express 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* at ni.com/manuals.
- Keep relative humidity between 10% and 70%, noncondensing.
- Allow a warm-up time of at least 30 minutes after the NI-DCPower driver is loaded. Unless manually disabled, the NI-DCPower driver automatically loads with the operating system and enables the device. Allow the recommended warm-up time for all additional test equipment.
- Perform all measurements using **Local Sense** unless otherwise noted.
- Perform all measurements with the niDCPower Samples to Average property/attribute set to 20000.
- Use characterized values in all instances where precision shunt resistance is measured.
- Use shielded copper wire for all cable connections to the device. Use twisted-pair wire to eliminate noise and thermal offsets. Use separate twisted-pair wires for Output +, Output -, Sense +, and Sense - pins. Refer to Figure 1 for a connection diagram.

Figure 1. Twisted-Pair Connection
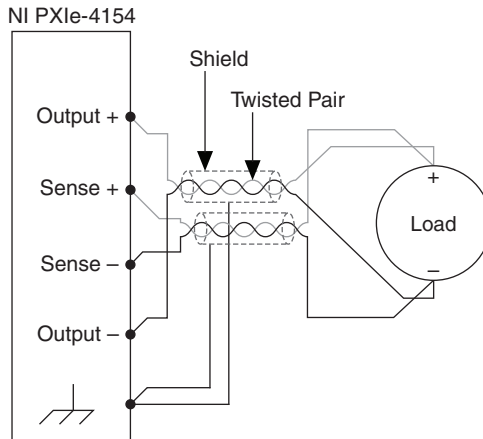
- Plug the chassis and the instrument standard into the same power strip to avoid ground loops.

Calibration Procedures

The calibration process includes the following steps:

1. *Initial Setup*—Install the device and configure it in Measurement & Automation Explorer (MAX).

2. *Verification*—Verify the existing operation of the device. This step confirms whether the device is operating within the published specifications prior to adjustment.

3. *Adjustment*—Adjust the calibration constants of the device. The adjustment procedure automatically updates the calibration constants, date, and temperature in the EEPROM.

4. *Reverification*—Repeat the verification procedure to ensure that the device is operating within the published specifications after adjustment.

Initial Setup

Refer to the *NI DC Power Supplies and SMUs Getting Started Guide* for information about how to install the software and hardware and how to configure the device in MAX.

Verification

This section provides information for verifying the following specifications for the NI PXIe-4154.

Verification tests the following NI PXIe-4154 specifications:

- Voltage output
- Current output
- Voltage measurement
- Current measurement
- Output resistance
- Load regulation
    - Voltage load regulation
    - Current load regulation
- Remote sense accuracy
- Transient response (Channel 0 only)

Verification of the NI PXIe-4154 is complete only after you have successfully completed all tests in this section.

Note Limits in the following tables are based upon the October 2010 edition of the *NI PXIe-4154 Specifications*. Refer to the most recent NI PXIe-4154 specifications online at ni.com/manuals. If a more recent edition of the specifications is available, recalculate the limits based upon the latest specifications.

Verification should be performed under the following conditions:

- Adherence to the guidelines listed in the *Test Conditions* section.
- Ambient temperature is 23 ±5°C.
- Close all calibration sessions before setting the necessary parameters.

Example programs are installed with NI-DCPower or available for download at ni.com/devzone.

Voltage Output Verification

To verify the voltage output of an NI PXIe-4154, compare a range of requested voltage test points to the actual voltage measurements at the output using an external DMM. The external DMM should be zeroed prior to each reading when measuring current output using a 0.1 Ω shunt and voltage output for 0 V level. Refer to Figure 2 for a connection diagram.

Figure 2. Voltage Verification Connection Diagram
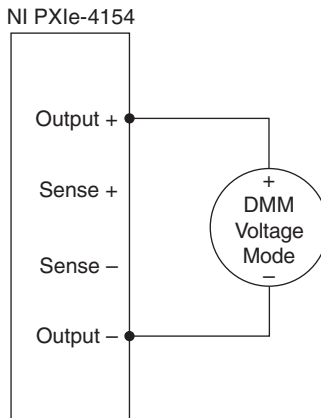
Note Use separate twisted-pair cables for connections from Output + and Output - to the external DMM. Refer to Figure 1 for a connection diagram.

Refer to Table 2 for a list of voltage test points that you must request and measure with an external DMM in voltage mode to complete verification. For example, the 6 V range on Channel 0 requires the verification application to separately request 6 V, 4.5 V, 3 V, 1.5 V, and 0 V outputs from the NI PXIe-4154.

Note After requesting a new voltage, wait one second to take a measurement with an external DMM to ensure the system has adequate time to settle.

Table 2. NI PXIe-4154 Voltage Output Verification Points

Channel	Range	Test Point	Limits of Accuracy		Measured	
			Lower Limit	**Upper Limit**	**As Found**	**As Left**
0	6 V	0 V	-0.005 V	0.005 V		
		1.5 V	1.4944 V	1.5056 V		
		3 V	2.9938 V	3.0062 V		
		4.5 V	4.4932 V	4.5068 V		
		6 V	5.9926 V	6.0074 V		
1	8 V	0 V	-0.006 V	0.006 V		
		2 V	1.9932 V	2.0068 V		
		4 V	3.9924 V	4.0076 V		
		6 V	5.9916 V	6.0084 V		
		8 V	7.9908 V	8.0092 V		

Current Output Verification

To verify the current output of an NI PXIe-4154, compare a range of requested current test points to the measurements of the actual current at the output. Current output is calculated by dividing the voltage measured across the precision shunt by the actual resistance of the precision shunt. Refer to Figure 3 for a connection diagram with a 100 mΩ precision shunt. Refer to Figure 4 for a connection diagram with a 100 Ω precision shunt.

Figure 3. Current Verification Connection Diagram with 100 mΩ Precision Shunt
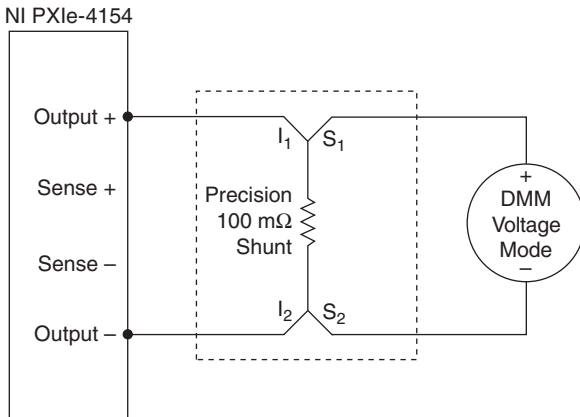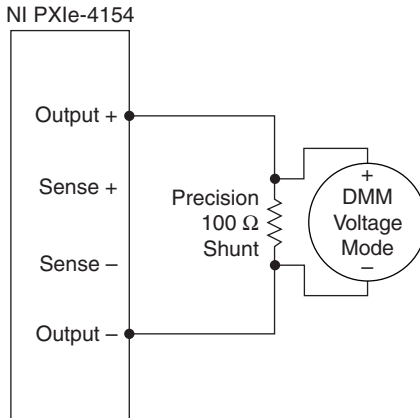
Figure 4. Current Verification Connection Diagram with 100 Ω Precision Shunt

Note Use separate twisted-pair cables for connections from Output + and Output - to the external DMM. Refer to Figure 1 for a connection diagram.

Refer to Table 3 for the current test points that you must request and measure for each range to complete verification. For example, the 30 mA range on Channel 0 requires the verification application to separately request 30 mA, 22.5 mA, 15.0 mA, 7.5 mA, and 0.1 mA outputs from the NI PXIe-4154 while setting the voltage level to its maximum value. Take measurements using the DMM as a voltmeter at each point, dividing by the characterized value of the precision shunt each time.

Note After requesting a new current, wait one second to take a measurement with an external DMM to ensure the system has adequate time to settle.

Note Total output current for both channels combined cannot exceed 3.1 A. Thus, the current test points for each channel—current limits when in Constant Voltage mode or the current levels when in Constant Current mode—must add up to no more than 3.1 A.

Table 3. NI PXIe-4154 Current Output Verification Points

| Channel | Range | Precision Shunt Value | Test Point | Limits of Accuracy | | Measured | |
				Lower Limit	Upper Limit	As Found	As Left
0	30 mA	100 Ω	0.1 mA	0.064880 mA	0.135120 mA		
			7.5 mA	7.456000 mA	7.544000 mA		
			15.0 mA	14.947000 mA	15.053000 mA		
			22.5 mA	22.438000 mA	22.562000 mA		
			30 mA	29.929000 mA	30.071000 mA		
0	3 A	100 mΩ	0.01 A	0.006488 A	0.013512 A		
			0.75 A	0.745600 A	0.754400 A		
			1.50 A	1.494325 A	1.505675 A		
			2.25 A	2.242394 A	2.257606 A		
			3.00 A	2.989900 A	3.010100 A		
1	1.5 A	100 mΩ	0.01 A	0.006484 A	0.013516 A		
			0.35 A	0.345940 A	0.354060 A		
			0.75 A	0.744925 A	0.755075 A		
			1.25 A	1.242625 A	1.257375 A		
			1.50 A	1.491100 A	1.508900 A		

Voltage Measurement Verification

To verify the voltage measurement of an NI PXIe-4154, compare a range of voltage test points measured with an external DMM to the voltage measured with an NI PXIe-4154. The external DMM should be zeroed prior to each reading when measuring current output using a 0.1 Ω shunt and voltage output for 0 V level. Refer to Figure 2 for a connection diagram.

Refer to Table 4 for the list of voltage test points for each range that you must measure and request with both an external DMM and the NI PXIe-4154. For example, in the 6 V range on Channel 0, program the NI PXIe-4154 to output 6 V, 4.5 V, 3 V, 1.5 V, and 0 V. Take voltage measurements at each test point using the DMM. Compare these values to the voltage measurements taken at each test point using the NI PXIe-4154.

✎ **Note** After requesting a new voltage, wait one second to take a measurement with an external DMM and NI PXIe-4154 to ensure the system has adequate time to settle.

The verification limits for voltage measurement depend on the actual voltage measured with an external DMM, and are expressed as a percentage of DMM reading plus offset voltage. Refer to Table 4 for more information.

Table 4. NI PXIe-4154 Voltage Measurement Verification Points

| Channel | Range | Test Point | Measured Voltage | | Test Limit | Reported Voltage | |
			As Found	As Left		As Found	As Left
0	6 V	0 V			0.025% + 2 mV		
		1.5 V					
		3 V					
		4.5 V					
		6 V					
1	8 V	0 V			0.05% + 2.5 mV		
		2 V					
		4 V					
		6 V					
		8 V					

Current Measurement Verification

To verify the current measurement of an NI PXIe-4154, measure a range of current test points with an external DMM and a precision shunt. Divide the voltage across the precision shunt by the actual resistance of the precision shunt. Compare these values to the values of the current measured at the same current test points using the NI PXIe-4154. Refer to Figure 3 or Figure 4 for the configuration to verify current measurements while sourcing. Refer to Figure 5 or Figure 6 for the configuration to verify current measurement while sinking.

Refer to Table 5 for a list of current test points for each range that you must request and measure with an external DMM/precision shunt and the NI PXIe-4154 in order to complete verification.

To verify positive currents, use the NI PXIe-4154 channel as a source. For example, in the 1.5 A range on Channel 1, program the NI PXIe-4154 to output 375 mA, 750 mA, 1.125 A, and 1.5 A while setting the voltage limit to its maximum value. Use an external DMM/precision shunt and the NI PXIe-4154 to take a current measurement at each test point. Compare the measured values against each other.

To verify negative currents, use an external current source to force Channel 0 of the NI PXIe-4154 to sink current. For example, in the 3 A range on Channel 0, program the NI PXIe-4154 channel for 0 V output and program the external current source to output 750 mA, 1.5 A, 2.25 A, and 3 A. Channel 0 will be sinking current, so its measurements will be negative currents. Take a current measurement at each test point using both an external DMM/precision shunt and the NI PXIe-4154. Compare the measured values against each other.

Note The zero current test point is verified only with the measurement returned by the NI PXIe-4154. To ensure no current is flowing while taking this zero current measurement, disconnect all external equipment from the I/O connector and take a current measurement with the NI PXIe-4154. When you verify zero current test points this way, the measured current is always zero.

Note After requesting a new current, wait one second to take a measurement with an external DMM and NI PXIe-4154 to ensure the system has adequate time to settle.

The verification limits for current measurement depend on the actual current measured with an external DMM, and are expressed as a percentage of DMM reading plus offset current. Refer to Table 5 for more information.

Figure 5. Current Measurement Verification Connection Diagram
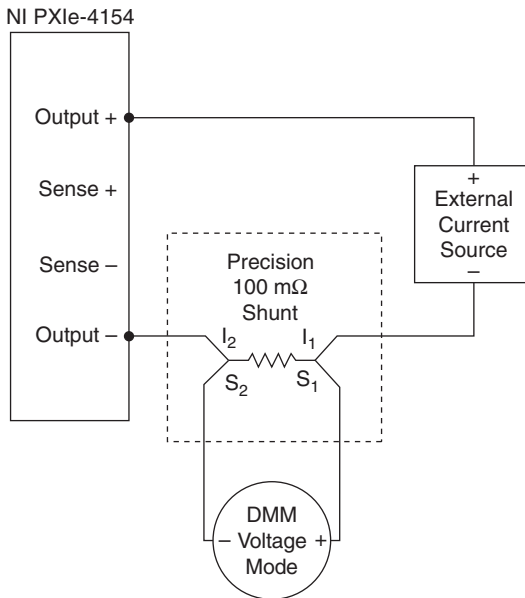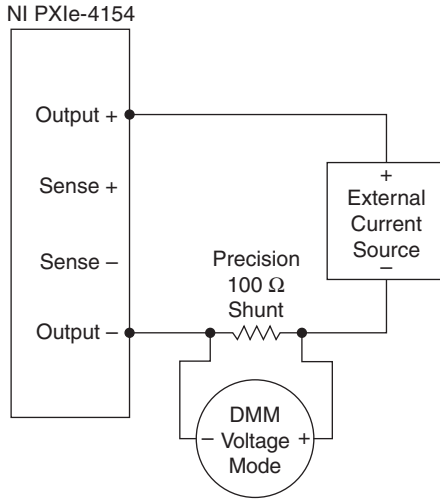Using External Current Source with 100 mΩ Precision Shunt

Figure 6. Current Measurement Verification Connection Diagram
Using External Current Source with 100 Ω Precision Shunt

Note Use separate twisted-pair cables for connections from Output + and Output -
to the external DMM or current source. Refer to Figure 1 for a connection diagram.

Table 5. NI PXIe-4154 Current Measurement Verification Points

| Channel	Range	Precision Shunt Value	Test Point	Measured Current		Test Limit	Reported Current	
				As Found	As Left		As Found	As Left
0	30 mA	100 Ω	-30 mA			0.04% + 7 µA		
			-22.5 mA					
			-15 mA					
			-7.5 mA					
			0 mA					
			7.5 mA					
			15 mA					
			22.5 mA					
			30 mA					

Table 5. NI PXIe-4154 Current Measurement Verification Points (Continued)

Channel	Range	Precision Shunt Value	Test Point	Measured Current As Found	Measured Current As Left	Test Limit	Reported Current As Found	Reported Current As Left
0	3 A	100 mΩ	-3 A			0.14% + 0.7 mA		
			-2.25 A			0.1025% + 0.7 mA		
			-1.5 A			0.065% + 0.7 mA		
			-750 mA			0.04% + 0.7 mA		
			0 A			0.04% + 0.7 mA		
			750 m			0.04% + 0.7 mA		
			1.5 A			0.065% + 0.7 mA		
			2.25 A			0.1025% + 0.7 mA		
			3 A			0.14% + 0.7 mA		
1	1.5 A	100 mΩ	0 A			0.12% + 0.35 mA		
			375 mA			0.12% + 0.35 mA		
			750 mA			0.17% + 0.35 mA		
			1.125 A			0.245% + 0.35 mA		
			1.5 A			0.32% + 0.35 mA		

Output Resistance Verification (Channel 0 Only)

To verify the output resistance of an NI PXIe-4154, compare a range of requested resistance test points to measurements of the actual resistance at output. Calculate using two external DMMs and a 100 mΩ precision shunt. Refer to Figure 7 for a connection diagram.

Figure 7. Output Resistance and Load Regulation Verification
Connection Diagram with 100 mΩ Precision Shunt
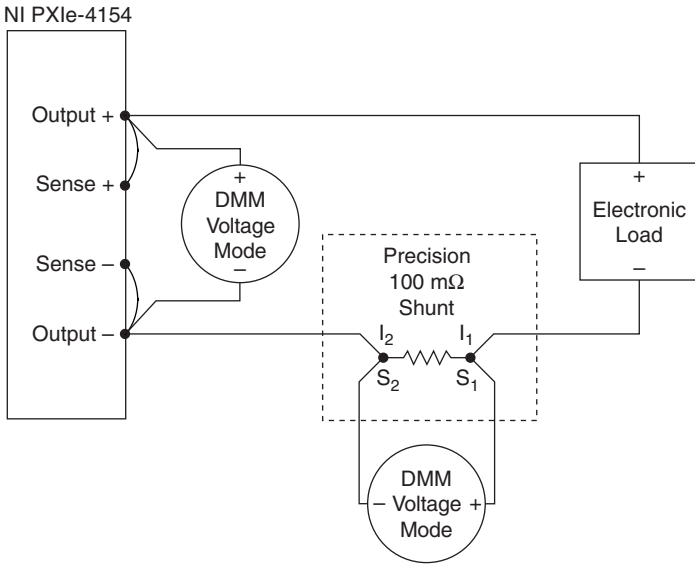
> 📝 **Note** Use twisted-pair cables for connections from Output + and Output - to the electronic load. Refer to Figure 1 for a connection diagram. Use short wires to jumper Sense + to Output +, and Sense - to Output -.

Refer to Table 6 for a list of output resistance test points that you must request and measure with two external DMMs to complete verification. For example, program the verification application to separately request -0.04 Ω, 0 Ω, 0.25 Ω, 0.5 Ω, 0.75 Ω, and 1 Ω outputs from the NI PXIe-4154. Configure the NI PXIe-4154 to output 4 V with a current limit of 3 A.

> 📝 **Note** After requesting a new output resistance, wait one second to take a measurement with the external DMMs to ensure the system has adequate time to settle.

Complete the following steps to calculate the output resistance for each test point.

1. Ensure that **Remote Sense** is *ON*.

1. Set the electronic load for 100 mA constant current.

2. Record the DMM voltage at the Output + and Output - terminals of Channel 0 of the NI PXIe-4154 (V_1).

3. Calculate the current (I_1). Divide the voltage measured across the 100 mΩ precision shunt by the characterized value of the 100 mΩ precision shunt.

4. Increase the electronic load to 1 A constant current.

5. Record the DMM voltage at the Output + and Output - terminals of Channel 0 of the NI PXIe-4154 (V_2).

6. Calculate the current (I_2). Divide the voltage measured across the 100 mΩ precision shunt by the characterized value of the 100 mΩ precision shunt.

7. Calculate the output resistance using the following formula:

$$\textit{Output Resistance } (\Omega) = (V_1 - V_2) / (I_2 - I_1)$$

📝 **Note** Output resistance is requested by the NI DCPower Output Resistance Property Node.

Table 6. NI PXIe-4154 Output Resistance Verification Points

Channel	V Level	I Limit	Test Point	Measured Voltages		Measured Currents		Limits of Accuracy		Calculated Resistance	
				V_1	V_2	I_1	I_2	Lower Limit	Upper Limit	As Found	As Left
0	4 V	3 A	-40 mΩ					-0.04312 Ω	-0.03688 Ω		
			0 Ω					-0.003 Ω	0.003 Ω		
			250 mΩ					0.24625 Ω	0.25375 Ω		
			500 mΩ					0.4955 Ω	0.5045 Ω		
			750 mΩ					0.74475 Ω	0.75525 Ω		
			1 Ω					0.994 Ω	1.006 Ω		

Load Regulation Verification

The load regulation test verifies that the output voltage falls within specified limits when the load current changes, or the output current falls within specified limits when the load voltage changes. For each test, two loads of different values are needed to vary the load voltage or current. Validation of load regulation should be performed after successfully validating the voltage and current measurement accuracy, and the output resistance.

Voltage Load Regulation

To verify the voltage load regulation of an NI PXIe-4154, use the device in Constant Voltage mode. Confirm the output voltage change falls within calculated limits while varying the load current using an electronic load. The external DMM should be zeroed prior to each reading when measuring current output using a 0.1 Ω shunt and voltage output for 0 V level. Refer to Table 7 for a list of load current values and measurements needed to complete verification. Refer to Figure 7 for a connection diagram.

> **Note** For Channel 0 of the NI PXIe-4154, ensure that output resistance is set to 0 Ω during voltage load regulation verification.

Complete the following steps to verify voltage load regulation.

1. Ensure that **Remote Sense** is *ON*.
1. Configure the electronic load in constant current mode and set it to *Load Current 1,* as shown in the following table.

Table 7. NI PXIe-4154 Load Regulation Setup

Channel	V Range	I Range	I Limit	V Level	Load Current 1	Load Current 2
0	6 V	3 A	3 A	6 V	0.03 A	2.7 A
1	8 V	1.5 A	1.5 A	8 V	0.015 A	1.35 A

2. Record the DMM voltage at the Output + and Output - terminals of the NI PXIe-4154 (V_1) in the following table.

Table 8. NI PXIe-4154 Regulation Verification Points

Channel	I_1 (A)	V_1 (V)	I_2 (A)	V_2 (V)	Voltage Change Limit (V)	Voltage Change (V)
0						
1						

3. Calculate the current (I_1). Divide the voltage measured across the 100 mΩ precision shunt by the characterized value of the 100 mΩ precision shunt.
4. Increase the electronic load to *Load Current 2*, as shown in Table 7.

5. Record the DMM voltage at the Output + and Output - terminals of the NI PXIe-4154 (V_2).

6. Calculate the current (I_2). Divide the voltage measured across the 100 mΩ precision shunt by the characterized value of the 100 mΩ precision shunt.

7. Calculate the voltage change limit using the following formulas:

$$Channel\ 0\ Voltage\ Change\ Limit\ (V) = \pm (I_1 - I_2) * 0.003$$

$$Channel\ 1\ Voltage\ Change\ Limit\ (V) = \pm (I_1 - I_2) * 0.001$$

8. Calculate the *Voltage Change.* Subtract V_1 from V_2.

The test passes if the *Voltage Change* is less than or equal to the calculated *Voltage Change Limit*.

Current Load Regulation

To verify the current load regulation of an NI PXIe-4154, use the device in Constant Current mode and confirm the output current change falls within calculated limits while varying the load voltage using an electronic load. Refer to Table 9 for a list of resistance values and measurements to complete verification. Refer to Figure 7 for a connection diagram.

✍ **Note** For each test, the units for all current measurements and calculations should be the same as the *I Range* unit.

Complete the following steps to verify current load regulation.

1. Ensure that **Remote Sense** is *ON*.

1. Configure the electronic load in constant voltage mode and set it to *Load Voltage 1*. Refer to the following table.

Table 9. NI PXIe-4154 Current Load Regulation Verification Points

Channel	V Range	I Range	V Limit	I Level	Precision Shunt Value	Load Voltage 1	Load Voltage 2
0	6 V	3 A	6 V	1.5 A	100 mΩ	5 V	2 V
	6 V	30 mA	6 V	15 mA	100 Ω	4.4 V	2 V
1	8 V	1.5 A	8 V	0.75 A	100 mΩ	7 V	2 V

2. Record the DMM voltage at the Output + and Output - terminals of the NI PXIe-4154 (V_1) in the following table.

Table 10. NI PXIe-4154 Measured Current Load Regulation Verification Points

Channel	I_1 (A)	V_1 (V)	I_2 (A)	V_2 (V)	Current Change Limit (A)	Current Change (A)
0						
1						

3. Calculate the current (I_1). Divide the voltage measured across the 100 mΩ precision shunt by the characterized value of the 100 mΩ precision shunt.

4. Decrease the electronic load to *Load Voltage 2,* as shown in Table 9.

5. Record the DMM voltage at the Output + and Output - terminals of the NI PXIe-4154 (V_2).

6. Calculate the current (I_2). Divide the voltage measured across the 100 mΩ precision shunt by the characterized value of the 100 mΩ precision shunt.

7. Calculate the current change limit using the following formula:

$$\textit{Current Change Limit } (A) = \pm 0.0001 * \textit{I Range} * (V_1 - V_2).$$

8. Calculate the *Current Change.* Subtract I_1 from I_2.

The test passes if the *Current Change* is less than or equal to the calculated *Current Change Limit*.

Remote Sense Accuracy Verification

To verify the remote sense accuracy of an NI PXIe-4154, use a test circuit of three resistors that simulate voltage drop between the device and a load. Channels 0 and 1 should be tested separately, using the same method. Remote sense accuracy validation should be performed only after successfully validating the voltage and current measurement accuracy and the load regulation.

Complete the following steps to verify remote sense.

1. Ensure that **Remote Sense** is *ON*.

2. Connect a 22.6 Ω (R_1), 200 Ω (R_2), and 22.6 Ω (R_3) resistor in series. The 200 Ω resistor is the center resistor, as shown in Figure 8.

Figure 8. Remote Sense Output Verification Connection Diagram
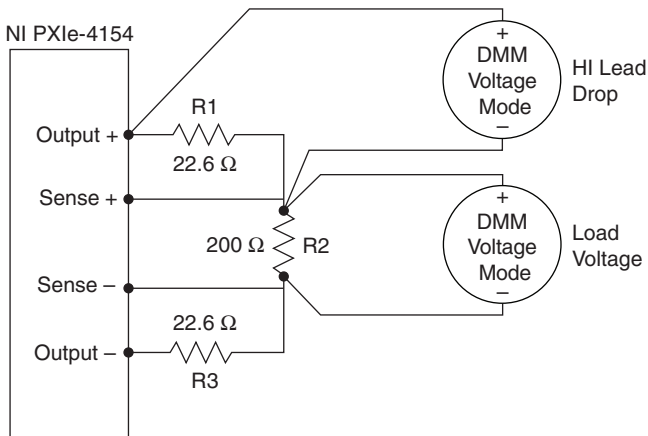
Note Use separate twisted-pair cables for connections from Output + and Output - to the load and from Sense + and Sense - to the load. Refer to Figure 1 for a connection diagram.

3. Connect the resistors to the Output + and Output - terminals on the NI PXIe-4154, as shown in Figure 8. Connect the remote sense leads directly across the 200 Ω resistor (R_2).

4. Set the voltage level and current limit to the values listed in Table 12.

5. Measure the Output + Lead Drop with a DMM (*HI Lead Drop*) from the Output + terminal of the NI PXIe-4154 to the 200 Ω resistor, as shown in Figure 8.

6. Measure the load voltage with a DMM (*Load Voltage*) across the 200 Ω resistor where the sense leads connect, as shown in Figure 8.

7. Calculate the accuracy limit for the load voltage using the following equations and the V Level listed in Table 12, where *V Level* and *HI Lead Drop* are given in volts.

Table 11. Load Voltage Equations

Channel	Equation
Channel 0	*V Level* ± [(*V Level* * 0.04% + 0.005) + (*HI Lead Drop* * 0.002)] V
Channel 1	*V Level* ± [(*V Level* * 0.04% + 0.006) + (*HI Lead Drop* * 0.002)] V

Table 12. NI PXIe-4154 Remote Sense Output Verification Points

Channel	V Range	I Range	V Level	I Limit	Measured HI Lead Drop (V)	Measured Load Voltage (V)	Load Voltage Limit (V)
0	6 V	3 A	6 V	0.1 A			
1	8 V	1.5 A	8 V	0.1 A			

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

Transient Response Verification (Channel 0 Only)

To verify the transient sense of an NI PXIe-4154, use a digital oscilloscope and a programmable electronic load with dynamic current capability. Transient response validation should be performed only after successfully validating the voltage and current measurement accuracy and the load regulation.

Note Use one 3-foot, 18 AWG twisted-pair cable to connect Output + and Output - to the electronic load, and another 3-foot, 18 AWG twisted-pair cable to connect Sense + and Sense - to the electronic load. To ensure signal integrity, the cable shields should be terminated to the ground. Refer to Figure 1 for a connection diagram.

Complete the following steps to verify transient response.

1. Ensure that **Remote Sense** is *ON*.

2. To verify Channel 0 *FAST* transient response, connect a digital oscilloscope and electronic load to an NI PXIe-4154. Refer to the following figure for a connection diagram.

Figure 9. Channel 0 Transient Response Connection Diagram
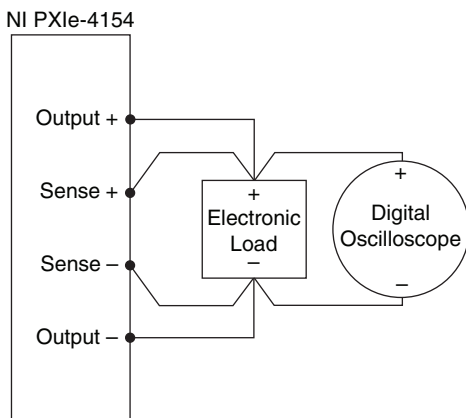
3. Configure the electronic load in current control dynamic mode with the settings listed in the following table.

Table 13. Electronic Load Settings

Load High Current	Load Low Current	Load Period	Load Slew Rate
1.5 A	0.1 A	1 ms	200 mA/µs

4. Configure the oscilloscope to acquire a waveform according to the settings listed in the following table.

Table 14. Oscilloscope Settings

Volts/ Division	Time/ Division	Trigger Slope	Trigger Level	Input Impedance	Input Coupling	Sampling Rate	Trigger
50 mV	20 µS	Negative Edge	-20 mV	1 MΩ	AC	≥200 MS/s	Edge Trigger

5. Configure the NI PXIe-4154 according to the settings listed in the following table.

Table 15. NI PXIe-4154 Settings

V Range	I Range	V Level	I Limit
6 V	3 A	6 V	3 A

6. Repeat steps 3 through 5 to verify Channel 0 *Normal* transient response.

7. Measure the transient response recovery time and transient response dip, as displayed in Figure 10. The transient response recovery time is measured from the time the dip begins until the time at which the waveform crosses above the final voltage minus 20 mV.

Figure 10. Example Transient Response Dip and
Transient Response Recovery Time Waveform
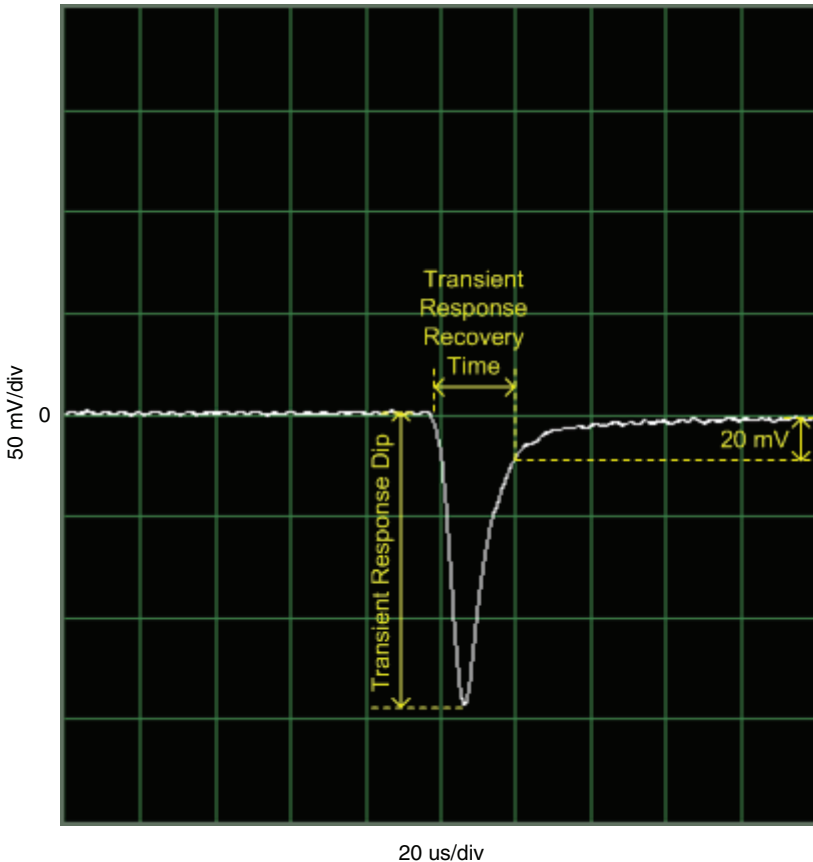
20 us/div

The test passes if the *Transient Response Dip* and *Transient Response Recovery Time* measurements fall within the limits listed on Table 16.

Table 16. NI PXIe-4154 Transient Response Verification Limits

Channel	Transient Response Speed	Measured		Transient Response Dip Limit	Transient Response Recovery Time Limit
		Transient Response Dip	Transient Response Recovery Time		
0	Normal			250 mV	40 μs
0	Fast			70 mV	20 μs

Adjustment

Following the adjustment procedure automatically updates the calibration date and temperature on the NI PXIe-4154.

📝 **Note** National Instruments recommends a complete adjustment of your device to renew the calibration interval. However, if all verification steps were successful and 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 PXIe-4154 specifications:
- Voltage programming accuracy
- Current programming accuracy
- Voltage measurement accuracy
- Current measurement accuracy
- Output resistance accuracy

The adjustment components of the NI-DCPower API require the NI PXIe-4154 be programmed using the voltage output function (this is the default configuration). You must adjust each range with a separate call to an niDCPower Cal Adjust VI or function.

📝 **Note** Do not use the NI-DCPower Soft Front Panel (SFP) to request test points for any adjustment functions.

Adjustment should be performed under the following conditions:
- Adherence to the guidelines listed in the *Test Conditions* section.
- Ambient room temperature should be kept at 23±1°C during adjustment.
- Close all calibration sessions before setting the necessary parameters.

Considerations

Refer to Figure 11 for the general flow of an application used to adjust a range on the NI PXIe-4154.

Figure 11. LabVIEW Block Diagram Illustrating Range Adjustment on the NI PXIe-4154
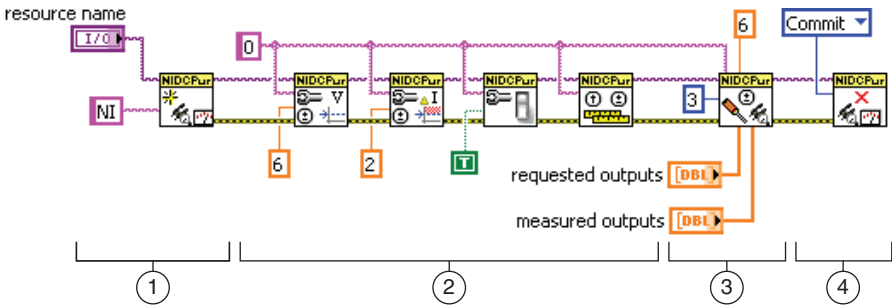
1. **Initialize External Calibration Session**: To adjust the NI PXIe-4154, call the niDCPower Initialize External Calibration VI or the `niDCPower_InitExtCal` function to initiate a special type of NI-DCPower session.

2. **Configure the instrument**: Call a series of standard NI-DCPower VIs 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 PXIe-4154 to a particular output or measurement mode, refer to the example programs installed with NI-DCPower.

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 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 Current Measurement

To adjust the current measurement of a calibrated NI PXIe-4154, compare a range of current test points measured with an external DMM as a voltmeter in conjunction with a precision shunt to the measured current reported by the NI PXIe-4154. Refer to Figure 3 or Figure 4 to adjust current measurement while sourcing. Refer to Figure 5 or Figure 6 to adjust current measurement while sinking.

Refer to Table 17 for the current test points that you must request and measure with an external DMM and the NI PXIe-4154 to adjust a given range. For example, the 30 mA on Channel 0 requires the adjustment application to separately request 27 mA, 0 mA, and -27 mA outputs from the NI PXIe-4154.

For positive currents, the voltage level should be set to the maximum value. Take measurements with the DMM/precision shunt and the NI PXIe-4154 at each test point. To calculate the current value using the DMM/precision shunt, divide the voltage measured with the DMM by the characterized value of the precision shunt.

For negative current adjustment points, an external current source is required to provide the necessary current. The voltage level for the NI PXIe-4154 should be set to 0 V. Refer to Table 1 for external current source equipment recommendations and requirements.

> **Note** After requesting a new voltage, wait 3 ms to take a measurement with the external DMM and NI PXIe-4154 to ensure the system has adequate time to settle while minimizing self-heating effects of the internal measurement circuitry.

Table 17. NI PXIe-4154 Current Measurement Adjustment Points

Channel	I Range	Required Adjustment Points			Precision Shunt Value
0	30 mA	-27 mA	0 mA	27 mA	100 Ω
0	3 A	-2 A	0 A	2 A	100 mΩ
1	1.5 A	0 A	0.75 A	1.35 A	100 mΩ

> **Note** When measuring a 0 A test point, remove any connections to the front panel I/O connector to ensure no current is flowing through the output.

After test points are measured for a range, call the niDCPower Cal Adjust Current Measurement VI or the `niDCPower_CalAdjustCurrentMeasurement` function to calculate updated calibration coefficients. Refer to Table 18 for specific adjustment applications for this VI. Refer to the *NI DC Power Supplies and SMUs Help* for more information about programming references common to many VIs within the NI-DCPower API.

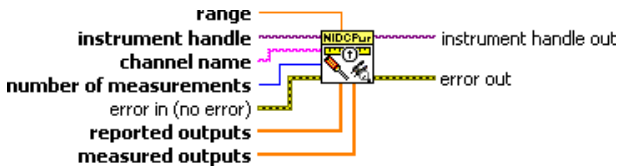**Figure 12.** NI-DCPower Cal Adjust Current Measurement VI Block Diagram

Table 18. NI-DCPower Cal Adjust Current Measurement VI Parameter Descriptions

Parameter	Description
range	The range to be adjusted with these settings.
reported outputs	Array of measurements taken by the NI PXIe-4154 corresponding to required adjustment test points in Table 17.
measured outputs	Array of measurements made by an external DMM corresponding to required adjustment test points in Table 17. For zero current test points, a measured output of exactly zero should be entered as all connections to the NI PXIe-4154 should be removed to take this measurement.
number of measurements	The number of elements in *reported outputs* and *measured outputs*.

When the new coefficients are calculated, commit them to the hardware using the process described in the *Considerations* section.

Adjusting Voltage Output

To adjust the voltage output of a calibrated NI PXIe-4154, compare a range of requested voltage test points to the measurements of the actual voltage at the output by an external DMM. Refer to Figure 2 for a connection diagram.

Refer to Table 19 for an outline of the voltage test points that you must request and measure for each range. For example, the 6 V range on Channel 0 requires the adjustment application to separately request 0.1 V, 3 V, and 6 V outputs from the NI PXIe-4154. Take measurements using the external DMM at each voltage test point.

**Note** Do not use the NI-DCPower SFP to request test points for adjusting voltage outputs.

Note After requesting a new voltage, wait one second to take a measurement with an external DMM to ensure the system has adequate time to settle.

Table 19. NI PXIe-4154 Voltage Output Adjustment Points

Channel	V Range	Required Adjustment Points		
0	6 V	0.1 V	3 V	6 V
1	8 V	0.1 V	4 V	8 V

Figure 13. NI-DCPower Cal Adjust Voltage Level VI Block Diagram
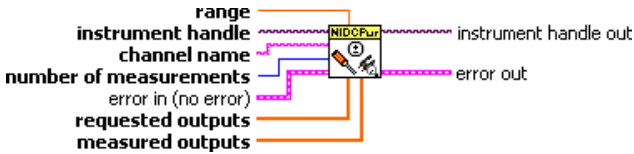
After all test points are measured for a range, call the niDCPower Cal Adjust Voltage Level VI or the `niDCPower_CalAdjustVoltageLevel` function to calculate updated calibration coefficients. Refer to Table 20 for parameters similar to adjustment applications for this VI. Refer to the *NI DC Power Supplies and SMUs Help* for more information about programming references common to many VIs within the NI-DCPower API.

Table 20. NI-DCPower Cal Adjust Voltage Level VI Parameter Descriptions

Parameter	Description
range	The range to be adjusted with these settings.
requested outputs	Array of requested voltage test points required for adjustment of a range. For example, this would be 0, 3, and 6 for the 6 V range on Channel 0.
measured outputs	Array of measurements made by external DMM corresponding to *requested outputs*.
number of measurements	The number of elements in *requested outputs* and *measured outputs*.

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

Adjusting Current Output

To adjust current output of a calibrated NI PXIe-4154, compare a set of requested current test points to measurements of the actual current at the output by a DMM/precision shunt. Refer to Figure 3 for a connection diagram with a 100 mΩ precision shunt. Refer to Figure 4 for a connection diagram with a 100 Ω precision shunt.

Refer to Table 21 for a list of current test points that you must request and measure for each range. For example, the 30 mA range on Channel 0 requires the adjustment application to acquire data from ten test points using an external DMM/precision shunt with the voltage set to maximum value. To calculate the current value using the DMM/precision shunt, divide the voltage measured with the DMM by the characterized value of the precision shunt.

Note After requesting a new current, wait 3 ms to take a measurement with an external DMM to ensure the system has adequate time to settle while minimizing self-heating effects of the internal measurement circuitry.

Table 21. NI PXIe-4154 Current Output Adjustment Points

Channel	I Range	Required Adjustment Points					Precision Shunt Value
0	30 mA	0.3 mA	3.6 mA	6.9 mA	10.2 mA	13.5 mA	100 Ω
		16.8 mA	20.1 mA	23.4 mA	26.7 mA	30 mA	
0	3 A	0.030 A	0.327 A	0.624 A	0.921 A	1.218 A	100 mΩ
		1.515 A	1.812 A	2.109 A	2.406 A	2.7 A	
1	1.5 A	0.015A	0.164 A	0.312 A	0.461 A	0.609 A	100 mΩ
		0.758 A	0.906 A	1.055 A	1.203 A	1.35 A	

After all test points are measured for a range, call the niDCPower Cal Adjust Current Limit VI or the niDCPower_CalAdjustCurrentLimit function to calculate updated calibration coefficients. Refer to Table 22 for some parameters specific to adjustment applications for this VI. Refer to the *NI DC Power Supplies and SMUs Help* for more information about programming references common to VIs within the NI-DCPower API.

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

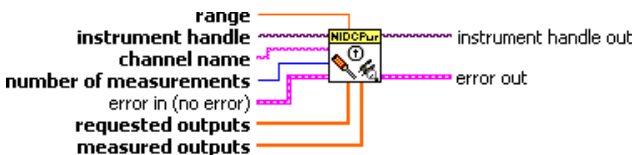**Figure 14.** NI-DCPower Cal Adjust Current Limit VI Block Diagram

Table 22. NI-DCPower Cal Adjust Current Limit VI Parameter Descriptions

Parameter	Description
range	The range to be adjusted with these settings.
requested outputs	Array of requested currents required for adjustment of a range. For example, this would be the ten test points listed in Table 21 for each range.
measured outputs	Array of measurements made by external DMM corresponding to *requested outputs*.
number of measurements	The number of elements in *requested outputs* and *measured outputs*.

After the new coefficients are calculated, commit the new coefficients to the hardware using the process described in the *Considerations* section.

Adjusting Voltage Measurement

To adjust the voltage measurement for a calibrated NI PXIe-4154, compare a set of voltage test points as measured by an external DMM to the measured voltage reported by the NI PXIe-4154. Refer to Figure 2 for a connection diagram.

Refer to Table 23 for a list of the voltage test points that you must request and measure with an external DMM and the NI PXIe-4154 to adjust a given range. For example, the 8 V range on Channel 1 requires the adjustment application to separately request 0.1 V, 4 V, and 8 V outputs from the NI PXIe-4154. Take measurements using an external DMM and NI PXIe-4154 at each test point.

> **Note** After requesting a new voltage, wait one second to take a measurement with an external DMM and NI PXIe-4154 to ensure the system has adequate time to settle.

Table 23. NI PXIe-4154 Voltage Measurement Adjustment Points

Channel	V Range	Required Adjustment Test Points		
0	6 V	0.1 V	3 V	6 V
1	8 V	0.1 V	4 V	8 V

After all test points are measured for a range, use the niDCPower Cal Adjust Voltage Measurement VI or the `niDCPower_CalAdjustVoltageMeasurement` function to calculate updated calibration coefficients. Refer to Table 24 for parameters specific to adjustment applications for this VI. Refer to the *NI DC Power Supplies and SMUs Help* for more information about programming references common to VIs within the NI-DCPower API.

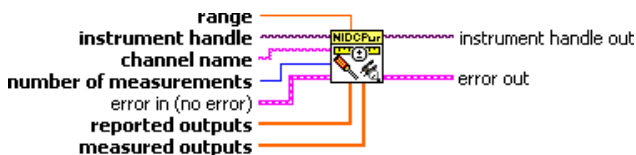**Figure 15.** NI-DCPower Cal Adjust Voltage Measurement VI Block Diagram

Table 24. NI-DCPower Cal Adjust Voltage Measurement VI Parameter Descriptions

Parameter	Description
range	The range to be adjusted with these settings.
reported outputs	Array of measurements taken by the NI PXIe-4154 corresponding to required adjustment test points in Table 23.
measured outputs	Array of measurements taken by an external DMM corresponding to *requested outputs*.
number of measurements	The number of elements in *requested outputs* and *measured outputs*.

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

Adjusting Output Resistance (Channel 0 Only)

To adjust the output resistance of a calibrated NI PXIe-4154, compare a set of requested output resistance test points to measurements of the actual resistance at the output calculated using two external DMMs and a precision shunt. Use an electronic load to control the output current. Refer to Figure 7 for a connection diagram.

Refer to Table 25 for the resistance test points that you must request and measure for each range. For example, Channel 0 requires the adjustment application to separately request $0 \, \Omega$, $0.5 \, \Omega$, and $0.9 \, \Omega$ outputs from the NI PXIe-4154. Take measurements using the external DMMs and precision shunt at each output resistance test point.

> **Note** After requesting a new output, wait one second to take a measurement with the external DMMs to ensure the system has adequate time to settle.

Set the electronic load to an initial constant current of 100 mA. Obtain V_1 and I_1 by measuring the voltage and calculating the current using the external DMMs and precision shunt.

Use the following steps to calculate the output resistance for each test point.

1. Ensure that **Remote Sense** is *ON*.
2. Reconfigure the electronic load to a constant current of 1 A.
3. Obtain V_2 and I_2. Measure the voltage and calculate the current using the external DMMs and precision shunt.
4. Repeat steps 2 and 3 for each output resistance required adjustment point listed in Table 25.
5. Calculate the output resistance at each point using the following formula:

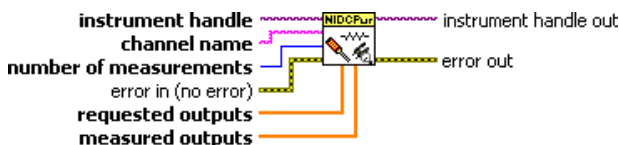$$\textit{Output Resistance } (\Omega) = (V_1 - V_2) / (I_2 - I_1)$$

> **Note** Output resistance is requested on the NI PXIe-4154 using the NI DCPower Property Node.

Table 25. NI PXIe-4154 Output Resistance Adjustment Points

Channel	V Range	V Level	I Limit	Required Adjustment Points		
0	6 V	4 V	3 A	0 Ω	0.5 Ω	0.9 Ω

After all test points are measured for a range, call the niDCPower Cal Adjust Output Resistance VI or the `niDCPower_CalAdjustOutputResistance` function to calculate updated calibration coefficients. Refer to Table 26 for parameters specific to adjustment applications for this VI. Refer to the *NI DC Power Supplies and SMUs Help* for more information about programming references common to VIs within the NI-DCPower API.

Figure 16. Figure 15. NI-DCPower Cal Adjust Output Resistance VI Block Diagram

Table 26. NI-DCPower Cal Adjust Output Resistance VI Parameter Descriptions

Parameter	Description
range	The range to be adjusted with these settings.
requested outputs	Array of requested output resistance test points required for adjustment. For example, this would be -0.04 Ω, 0 Ω, and 1 Ω for Channel 0.
measured outputs	Array of measurements made by external DMMs corresponding to *requested outputs*.
number of measurements	The number of elements in *requested outputs* and *measured output*s.

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

Where to Go for Support

The National Instruments Web site 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.

National Instruments corporate headquarters is located at 11500 North Mopac Expressway, Austin, Texas, 78759-3504. National Instruments also has offices located around the world to help address your support needs. For telephone support in the United States, create your service request at `ni.com/support` and follow the calling instructions or dial 512 795 8248. For telephone support outside the United States, visit the Worldwide Offices section of `ni.com/niglobal` to access the branch office Web sites, which provide up-to-date contact information, support phone numbers, email addresses, and current events.