CALIBRATION PROCEDURE

NI PXI-4110

Triple-output Programmable DC Power Supply

Français	Deutsch	日本語	한국어	简体中文

ni.com/manuals

This document contains information for calibrating the NI PXI-4110 (NI 4110) triple-output programmable DC power supply. For more information about calibration, visit ni.com/calibration.

Contents

NATIONAL INSTRUMENTS™

Software

To calibrate the NI 4110, you must install the NI-DCPower instrument driver version 1.0 or later on the Windows calibration system. You can download NI-DCPower at ni.com/downloads. NI-DCPower supports programming an external calibration in the LabVIEW and C application development environments (ADEs). When you install NI-DCPower, you need to install support only for the application software 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. Refer to Table 1 for file locations.

Table 1. Calibration File Locations (NI-DCPower 1.0 or Later)

File Name and Location	Description
IVI\Bin\nidcpower_32.dll	NI-DCPower driver containing the entire NI-DCPower API, including calibration functions.
IVI\Lib\msc\nidcpower.lib	NI-DCPower library for Microsoft C containing the entire NI-DCPower API, including calibration functions.
<LabVIEW>\instr.lib\niDCPower Calibrate\nidcpower.llb	LabVIEW VI library containing VIs for calling the NI-DCPower calibration API. You can access calibration functions from the NI-DCPower calibration section of the LabVIEW function palette.
IVI\Drivers\niDCPower\nidcpower.fp	LabWindows/CVI function panel file that includes calibration function prototypes and help on using NI-DCPower in the LabWindows/CVI environment.
IVI\Include\nidcpower.h	NI-DCPower header file, which you must include in any C program accessing calibration functions. This file includes the entire NI-DCPower API, including calibration functions.

Related Documentation

Consult the following documents for information about the NI 4110, NI-DCPower, and your application software. All documents are installed with the software and are located at **Start»All Programs»National Instruments»NI-DCPower»Documentation**. You can also download the latest versions of the documentation at `ni.com/manuals`.

NI PXI-4110 Getting Started Guide

Contains instructions for NI 4110 installation, hardware installation, and hardware programming.

NI PXI-4110 Specifications

Contains NI PXI-4110 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 4110.

LabVIEW Help

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

NI-DCPower C Reference Help

Contains reference information for NI-DCPower C functions and NI-DCPower C attributes.

Password

The default calibration password is `NI`.

Calibration Interval

National Instruments recommends that you perform a complete calibration for the NI 4110 at least once a year. You can shorten this calibration interval based on the accuracy demands of your application. Refer to the *Where to Go for Support* section for more information.

Test Equipment

Table 2 lists the equipment required to calibrate the NI 4110. If you do not have the recommended equipment, select a substitute calibration standard using the specifications listed in Table 2.

Table 2. Required Equipment Specifications for NI 4110 Calibration

Required Equipment	Recommended Equipment	Specifications
Digital multimeter (DMM)	NI PXI-4071	Voltage: ≤±50 ppm accuracy, ≤30 μV resolution; Current: ≤±0.04% accuracy, ≤50 nA resolution
External load	Clarostat 240C	Power resistor decade box with a range of 4 Ω to 25,000 Ω, an accuracy of ±10%, and minimum power rating of 40 W per decade
Auxiliary power supply	NI APS-4100	11 V to 15.5 V, 5 A
Twisted pair, shielded cabling wire	—	18 AWG to 22 AWG
Variable power supply	Xantrex HPD 30-10	Variable between 11 V and 15.5 V, 5 A

Test Conditions

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

- Keep cabling wire as short as possible. Long cables and wires act as antennas, picking up extra noise that can affect measurements.
- Verify that all connections, 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 90%, noncondensing.
- Maintain an ambient temperature of 23 °C ± 10 °C for verification procedures and an ambient temperature of 23 °C ± 1 °C for adjustment procedures.
- Allow a warm-up time of at least 15 minutes after the NI-DCPower driver is loaded. Unless manually disabled, NI-DCPower automatically loads with the operating system and enables the device. The warm-up time ensures that the measurement circuitry of the NI 4110 is 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.
- 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 its specified range prior to calibration.
3. *Adjustment*—Perform an external adjustment of the device that adjusts the calibration constants with respect to a known voltage source. The adjustment procedure automatically stores the calibration date on the EEPROM to allow traceability.
4. *Reverification*—Repeat the verification procedure to ensure that the device is operating within its specifications after adjustment.

These steps are described in more detail in the following sections.

Note In some cases, a complete calibration procedure may not be required. Refer to *Where to Go for Support* for more information.

Initial Setup

Refer to the *NI PXI-4110 Getting Started Guide* for information about how to install the software and hardware and how to configure the device in MAX.

Tables 3 and 4 list configuration information for the calibration equipment required for verification.

Table 3. Calibration Equipment Configuration for Voltage Programming and Measurement Verification/Adjustment

NI 4110 Channel(s)	DMM*		
	Function	**Range**†	**Input Impedance**†
0	DC Voltage	10 V	10 GΩ
1, 2		100 V	10 MΩ

* Use the highest resolution available on the DMM.

† Assumes an NI 4071 DMM. For all other DMMs, use the range and input impedance closest to the values listed in this table.

Table 4. Calibration Equipment Configuration for Current Output and Measurement Verification/Adjustment

NI 4110 Channel(s)	DMM*		
	Function	Range	Input Impedance†
0	DC Current	1 A	10 MΩ
1, 2 (20 mA range)		0.1 A	
1, 2 (1 A range)		1 A	

* Use the highest resolution available on the DMM.

† Assumes an NI 4071 DMM. For all other DMMs, use the range and input impedance closest to the values listed in this table.

Verification

The following performance verification procedures describe the sequence of operation and test limits required to check the NI 4110, and assumes that adequate traceable uncertainties are available for the calibration references.

Verification consists of generating and measuring a series of outputs using the NI 4110, verifying the accuracy with the DMM, and comparing the results to the calibration test limits. If the results fall within the test limits, the NI 4110 meets its published specifications, and adjustment is optional. If the results fall outside of the test limits, you must adjust the NI 4110.

Verification tests the following NI 4110 specifications:

- Voltage programming accuracy
- Voltage measurement accuracy
- Current programming accuracy
- Current measurement accuracy
- Voltage load regulation
- Current load regulation
- Voltage line regulation
- Current line regulation

Verification of the NI 4110 is complete only after you successfully complete all tests in this section.

Note If verification fails post-adjustment, confirm that you meet the required *Test Conditions* before you return the NI 4110 to NI for repair.

Verifying Voltage Programming Accuracy

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

Figure 1. Voltage Verification Connection Diagram

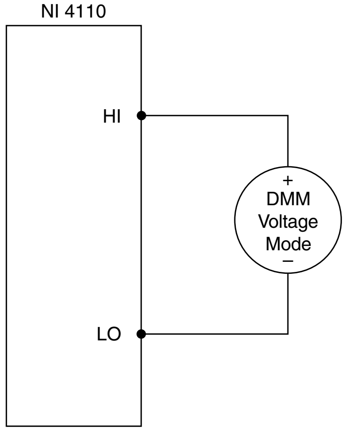


Table 5 lists the voltage output test points that you must request for each channel with the NI 4110 and measure with the DMM to complete verification. Take voltage measurements using the DMM at each voltage test point and compare the reading with the value from the Output column of Table 5. Verify that the measurement error falls between the tolerances listed in the *Test Limit (V)* column for the iteration of channel *x* in Table 5. If the output voltage that you measure is outside the test limit, you must adjust the NI 4110.

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

The voltage measurement test limits in Table 5 are derived from the voltage programming accuracy specifications plus an offset voltage.

Table 5. NI 4110 Output Parameters and Test Limits for Voltage Programming Accuracy Verification

Channel	Iteration	Output (V)	Current Limit (A)	Test Limit (V)
0	1	0	0.5	±0.00400
	2	1.5		±0.00475
	3	3		±0.00550
	4	4.5		±0.00625
	5	6		±0.00700
1	1	0		±0.01000
	2	5		±0.01250
	3	10		±0.01500
	4	15		±0.01750
	5	20		±0.02000
2	1	0		±0.01000
	2	-5		±0.01250
	3	-10		±0.01500
	4	-15		±0.01750
	5	-20		±0.02000

Verifying Voltage Measurement Accuracy

To verify the voltage measurement accuracy of the NI 4110, compare a set of voltage measurements from the NI 4110 to measurements of the actual voltage at the output by a DMM. Refer to Figure 1 for the necessary connections. When taking measurements with the NI 4110, set the Samples to Average property to `300`.

Table 6 lists the voltage test points that you must measure and request for each channel with both the DMM and the NI 4110 to complete verification. Take voltage measurements using the DMM at each test point, and then take voltage measurements using the NI 4110 at each test point. Compare the two values. Verify that the measurement error falls between the tolerances listed in the *Test Limit (V)* column for the iteration of channel *x* in Table 6. If the output voltage that you measure is outside the test limit, you must adjust the NI 4110.

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 4110.

The voltage measurement test limits in Table 6 are derived from the voltage measurement accuracy specifications plus an offset voltage.

Table 6. NI 4110 Output Parameters and Test Limits for Voltage Measurement Accuracy Verification

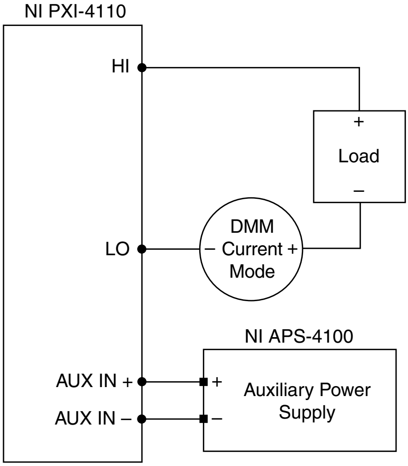
Channel	Iteration	Output (V)	Current Limit (A)	Test Limit (V)
0	1	0	0.5	±0.004000
	2	1.5		±0.004750
	3	3		±0.005500
	4	4.5		±0.006250
	5	6		±0.007000
1	1	0		±0.005000
	2	5		±0.007500
	3	10		±0.010000
	4	15		±0.012500
	5	20		±0.015000
2	1	0		±0.005000
	2	-5		±0.007500
	3	-10		±0.010000
	4	-15		±0.012500
	5	-20		±0.015000

Verifying Current Programming Accuracy

Note Program the NI 4110 in DC Voltage mode for this test.

To verify current programming accuracy, compare a set of requested current test points to measurements of the actual current at the output by the DMM. Connect an NI APS-4100 auxiliary power supply for this verification procedure. Refer to Figure 2 for the necessary connections.

Figure 2. Current Accuracy Verification Test System



Configure the DMM using the configuration settings for channel *x* in Table 4. Table 7 lists the voltage test points and external load settings that you must measure in DC Voltage mode for each current range to complete verification. For example, the 1 A range requires verification at the following outputs from the NI 4110, taking measurements using the external DMM at each point:

- 0.02 A
- 0.25 A
- 0.5 A
- 0.75 A
- 1.0 A

The value in the Output (A) column of Table 7 is the current limit value that you should program for each setpoint.

Note The values in the *Output* (A) column are the settings for the current limit. This column is labeled *Output* because the current limit is the value that the NI 4110 generates.

To ensure the system has had adequate time to settle, wait three seconds after requesting a new current before taking a measurement with the DMM. The current programming test limits in Table 7 are derived from the current programming accuracy specifications.

Table 7. NI 4110 Output Parameters and Test Limits for Current Programming Accuracy Verification

Channel(s)	Output (V)	Current Range	Iteration	Equivalent Resistance (Ω)	Output (A)	Test Limit (A)
0	6	1 A	1	150	0.020000	±0.004030
			2	12	0.250000	±0.004375
			3	6	0.500000	±0.004750
			4	4	0.750000	±0.006063
			5	3	1.000000	±0.008000
1	16	1 A	1	500	0.020000	±0.004030
			2	40	0.250000	±0.004375
			3	20	0.500000	±0.004750
			4	13	0.750000	±0.006063
			5	9	1.000000	±0.008000
1	16	20 mA	1†	25,000	0.000400	±0.000060
			2	2,000	0.005000	±0.000068
			3	1,000	0.010000	±0.000075
			4	670	0.015000	±0.000083
			5	500	0.020000	±0.000090
2	-16	1 A	1	500	0.020000	±0.004030
			2	40	0.250000	±0.004375
			3	20	0.500000	±0.004750
			4	13	0.750000	±0.006063
			5	9	1.000000	±0.008000

Table 7. NI 4110 Output Parameters and Test Limits for Current Programming Accuracy Verification (Continued)

Channel(s)	Output (V)	Current Range	Iteration	Equivalent Resistance (Ω)	Output (A)	Test Limit (A)
2	-16	20 mA	1*	25,000	0.000400	±0.000060
			2	2,000	0.005000	±0.000068
			3	1,000	0.010000	±0.000075
			4	670	0.015000	±0.000083
			5	500	0.020000	±0.000090

* Wait 15 s for the output of the NI 4110 to settle.

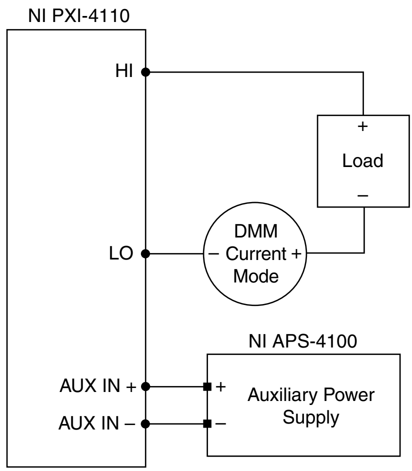
Verifying Current Measurement Accuracy

Note Program the NI 4110 in DC Voltage mode for this test.

Note Set the Current Limit and the Current Limit Range to the values in the *Current Range* column of Table 8.

To verify current measurement accuracy, compare a set of voltage setpoints as measured by an external DMM to the measured voltage reported by the NI 4110. Connect an NI APS-4100 auxiliary power supply for this verification procedure. Refer to the following figure for the necessary connections.

Figure 3. Current Measurement Connection Diagram



Configure the DMM using the configuration settings for channel *x* in Table 4. Table 8 lists the voltage test points and external load settings that you must measure in DC Voltage mode for each current range to complete verification. For example, the 1 A range requires verification at 0.02 A, 0.25 A, 0.5 A, 0.75 A, and 1.0 A outputs from the NI 4110, taking measurements using the external DMM and NI 4110 at each point. When taking measurements with the NI 4110, set the Samples to Average property to `300`.

To ensure the system has had adequate time to settle, wait three seconds after requesting a new current before taking a measurement with the DMM and the NI 4110.

Verify that the measurement error falls between the absolute limits listed in the *Test Limit* for the iteration of channel *x* in Table 8. If the measurement error is outside of the test limit, you must adjust the NI 4110.

Table 8. 4110 Output Parameters and Test Limits for Current Measurement Accuracy Verification

Channel(s)	Current Range	Iteration	Equivalent Resistance (Ω)	Output (V)*	Test Limit (A)	Published Specification (A)
0	1 A	1	open	0†	±0.002000	±0.004
		2	5	1.25	±0.002050	±0.004375
		3	5	2.5	±0.002500	±0.00475
		4	5	3.75	±0.004000	±0.006063
		5	5	5	±0.005500	±0.008000
1, 2	1 A	1	open	0†	±0.002000	±0.004
		2	20	±5	±0.002050	±0.004375
		3	20	±10	±0.002500	±0.00475
		4	20	±15	±0.004000	±0.006063
		5	20	±20	±0.005500	±0.008000

Table 8. 4110 Output Parameters and Test Limits for Current Measurement Accuracy Verification (Continued)

Channel(s)	Current Range	Iteration	Equivalent Resistance (Ω)	Output (V)[*]	Test Limit (A)	Published Specification (A)
1, 2	20 mA	1	open	0[†]	±0.000012	±0.000035
		2	1,000	±5	±0.000020	±0.000043
		3	1,000	±10	±0.000027	±0.000050
		4	1,000	±15	±0.000035	±0.000058
		5	1,000	±20	±0.000042	±0.000065

[*] When verifying channel 1, the *Output* is positive. When verifying channel 2, the *Output* is negative.

[†] To facilitate an accurate measurement using an *Output* value of 0, verify that the DMM and the external load are disconnected from the NI 4110. For all other *Output* values, the DMM and the external load are connected to the NI 4110.

Verifying Load Regulation

Complete the load regulation test to verify that the output voltage falls within specified limits when the load current changes or to verify that the output current falls within specified limits when the load voltage changes. Each test requires two resistors to vary the load voltage or current.

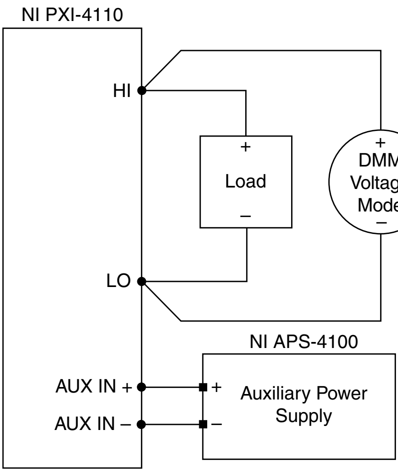
Note Load Voltage Verification results are dependent upon voltage and current measurement accuracy. Any failure of the Voltage Measurement Verification or Current Measurement Verification steps may result in a failure of the Load Regulation Verification steps.

Connect the NI APS-4100 to the Aux Power Input connections for load regulation tests.

Voltage Load Regulation

To verify voltage load regulation, use the NI 4110 in constant voltage mode and confirm that the output voltage change falls within calculated limits while varying the load current using different resistors. Table 10 lists the resistance values and measurements needed to complete verification. Refer to Figure 4 for the necessary connections.

Figure 4. 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 specified channel of the NI 4110.
2. While taking a current measurement with the NI 4110 (I_1), use the DMM to measure the voltage across the output of the NI 4110 (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 formulas in the following table, where the current is in mA.

Table 9. NI 4110 Voltage Load Regulation Voltage Change Limit Formulas

Channels	Voltage Change Limit
0	$\pm (I_1 - I_2) \times 2.52 \times 10^{-5}$
1 and 2	$\pm (I_1 - I_2) \times 2.00 \times 10^{-5}$

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*.

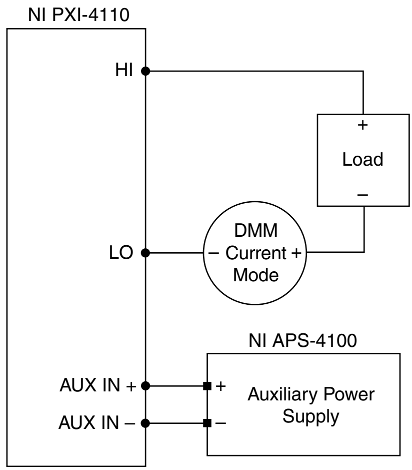
Table 10. NI 4110 Voltage Load Regulation Verification Points

Channel	V Range	I Range	I Limit	V Level	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)		
0	6 V	1 A	1 A	6 V	620 Ω	7 Ω						
1	20 V	1 A	1 A	10 V	1 kΩ	11 Ω						
2	20 V	1 A	1 A	-10 V	1 kΩ	11 Ω						

Current Load Regulation

To verify current load regulation, use the NI 4110 in Constant Current mode and confirm that the output current change falls within calculated limits while varying the load voltage using different resistors. Table 12 lists the resistance values and measurements needed to complete verification. Refer to Figure 5 for the necessary connections.

Figure 5. 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 specified channel of the NI 4110.
2. While taking a voltage measurement with the NI 4110 (V_1), use the 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 formulas shown in the following tables:

Table 11. NI 4110 Current Load Regulation Current Change Limit Formulas

Channels	Current Range	Current Change Limit
0	1 A	$\pm 2.00 \times 10^{-4} \times (V_1 - V_2)$
1 and 2	20 mA	$\pm 6.00 \times 10^{-7} \times (V_1 - V_2)$
1 and 2	1 A	$\pm 7.00 \times 10^{-5} \times (V_1 - V_2)$

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 12. NI 4110 Current Load Regulation Verification Points

Channel	V Range	I Range	V Limit	I Level	Load R_1	Load R_2	Measured				Current Change Limit (A)	Current Change (A)
							I_1 (A)	V_1 (V)	I_2 (A)	V_2 (V)		
0	6 V	1 A	6 V	500 mA	10 Ω	4 Ω						
1	20 V	20 mA	20 V	10 mA	1.8 kΩ	200 Ω						
1	20 V	1 A	20 V	500 mA	36 Ω	4 Ω						
2	20 V	20 mA	20 V	-10 mA	1.8 kΩ	200 Ω						
2	20 V	1 A	20 V	-500 mA	36 Ω	4 Ω						

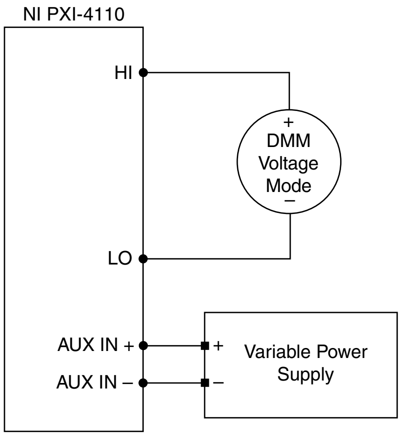
Verifying Line Regulation

Complete the line regulation test to verify that the output voltage falls within specified limits when the line voltage coming from the auxiliary power supply changes or that the output current falls within specified limits when the line voltage changes. Each test requires a variable auxiliary power supply to vary the line voltage or current. An NI APS-4100 is not sufficient for verifying line regulation because the output voltage is fixed. Run this test only after the *Verifying Voltage Measurement Accuracy* and *Verifying Current Measurement Accuracy* tests pass.

Voltage Line Regulation

To verify voltage line regulation, use the NI 4110 in Constant Voltage mode and confirm that the output voltage change falls within calculated limits while varying the line voltage using a variable power supply. Table 14 lists the voltage values and measurements needed to complete verification. Refer to Figure 6 for the necessary connections.

Figure 6. Voltage Line Regulation Verification Connection Diagram



Complete the following steps to verify voltage load regulation:

1. For each test, adjust the external variable power supply to the specified voltage (V_{ext1}) listed in Table 14.
2. Set the NI 4110 to output the voltage specified in Table 14.
3. Use the DMM to measure the voltage across the output of the specified channel of the NI 4110 (V_1).
4. Change the external variable power supply voltage from V_{ext1} to V_{ext2} and repeat the previous step.
5. Record the NI 4110 output voltage measurements for both external voltages.
6. Calculate the *Voltage Change Limit* using the formula shown in the following table:

Table 13. NI 4110 Voltage Line Regulation Voltage Change Limit Formulas

Channel	Voltage Change Limit
1 and 2	$\pm ((V_1 \times 1.00 \times 10^{-4}) + 1.00 \times 10^{-3}) \times (V_{ext1} - V_{ext2})$

7. 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*.

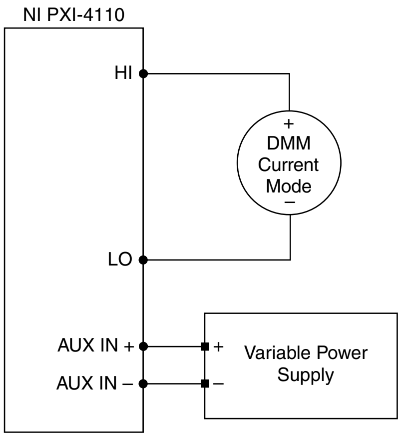
Table 14. NI 4110 Voltage Line Regulation Verification Points

Channel	V Range	I Range	I Limit	V Level	V_{ext1}	V_{ext2}	Measured		Voltage Change Limit (V)	Voltage Change (V)
							V_1 (V)	V_2 (V)		
1	20 V	1 A	100 mA	10 V	15.5 V	11 V				
2	20 V	1 A	100 mA	-10 V	15.5 V	11 V				

Current Line Regulation

To verify current line regulation, use the NI 4110 in constant current mode and confirm the output current change falls within calculated limits while varying the line voltage using a variable power supply. Table 16 lists the voltage values and current measurements needed to complete verification. Refer to the figure below for the necessary connections.

Figure 7. Current Line Regulation Verification Connection Diagram



Complete the following steps to verify current load regulation:

1. For each test, adjust the external variable power supply to the specified voltage (V_{ext1}) listed in Table 15.
2. Set the NI 4110 to output the current specified in Table 15.
3. Use the DMM to measure the current across the output of the specified channel of the NI 4110 (I_1).
4. Change the external variable power supply voltage from V_{ext1} to V_{ext2} and repeat the previous step.
5. Record the NI 4110 output current measurements for both external voltages.
6. Calculate the *Current Change Limit* using the formulas shown in the following table:

Table 15. NI 4110 Current Line Regulation Current Change Limit Formulas

Channels	Current Range	Current Change Limit
1 and 2	20 mA	$\pm ((I_1 \times 1.00 \times 10^{-4}) + 4.00 \times 10^{-6}) \times (V_{ext1} - V_{ext2})$
1 and 2	1 A	$\pm ((I_1 \times 1.00 \times 10^{-4}) + 2.00 \times 10^{-4}) \times (V_{ext1} - V_{ext2})$

7. Subtract the two voltage 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 16. NI 4110 Current Line Regulation Verification Points

Channel	V Range	I Range	V Limit	I Level	V_{ext1}	V_{ext2}	Measured		Current Change Limit (A)	Current Change (A)
							I_1 (A)	I_2 (A)		
1	20 V	20 mA	10 V	20 mA	15.5 V	11 V				
1	20 V	1 A	10 V	1 A	15.5 V	11 V				
2	20 V	20 mA	10 V	-20 mA	15.5 V	11 V				
2	20 V	1 A	10 V	-1 A	15.5 V	11 V				

If the device has successfully passed all verification tests, the NI 4110 is within the published specifications, and adjustment is optional.

Adjustment

Adjustment improves the accuracy of the NI 4110 and updates the calibration date and temperature in the EEPROM. Perform an adjustment once a year or when the accuracy of NI 4110 is outside the calibration test limits.

Adjustment corrects the following NI 4110 specifications:

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

The adjustment components of the NI-DCPower API require that you program the NI 4110 using the voltage output and current output functions. You must adjust each range with a separate call to the appropriate niDCPower Cal Adjust VI or function.

Note If the NI 4110 passes initial verification and is within all calibration test limits, NI recommends, but does not require, an adjustment to guarantee the published specifications for the next year.

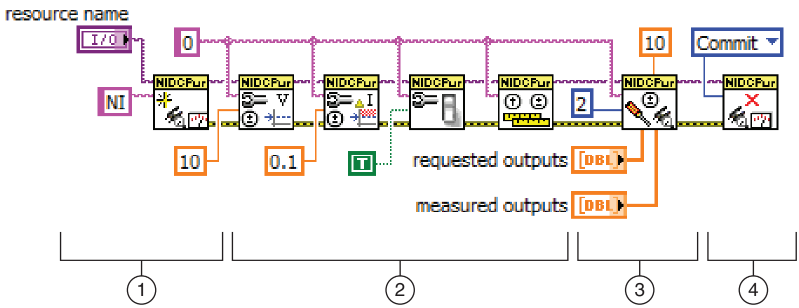
Perform the adjustment under the following conditions:

- Adhere to the guidelines listed in the *Test Conditions* section.
- Perform self-calibration prior to starting the adjustment procedure.
- Ensure that the ambient temperature is 23 °C ± 1 °C.

Considerations

The figure below represents the general flow of an application used to adjust a range on a single channel of the NI 4110.

Figure 8. LabVIEW Block Diagram Illustrating Adjustment on the NI 4110



1. **Initialize external calibration session**: To adjust the NI 4110, call the niDCPower Initialize External Calibration VI (`niDCPower_InitExtCal` function) to initiate a special type of NI-DCPower session. The default calibration password is `NI`.
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 more information about configuring the NI 4110 for 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/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 (`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 onboard 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 simultaneously, 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 Programming Accuracy

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

Table 17 outlines the voltage setpoints that you must request and measure for each range. Take measurements using the external DMM at each voltage set 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.

Use the niDCPower Cal Adjust Voltage Level VI (`niDCPower_CalAdjustVoltageLevel` function) to calculate the new calibration coefficients. Pass the voltage setpoints requested by the NI 4110 to the Requested Outputs input of the VI, and pass the voltage values measured by the DMM to the Measured Outputs input of the VI. Call this VI or function once per range.

Table 17. NI 4110 Output Parameters for Voltage Programming Accuracy Adjustment

Channel	Iteration	Output (V)	Current Limit (A)
0	1	0	0.5
	2	3	
	3	6	
1	1	0	
	2	10	
	3	20	
2	1	0	
	2	-10	
	3	-20	

Adjusting Voltage Measurement Accuracy

To adjust voltage measurement, compare a set of voltage output points as measured by an external DMM to the measured voltage reported by the NI 4110. When taking measurements with the NI 4110, set the Samples to Average property to `300`. Configure the voltage level using the *Output* value for the iteration of channel *x* in Table 18. Refer to Figure 1 for the necessary connections.

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 4110.

Use the niDCPower Cal Adjust Voltage Measurement VI (`niDCPower_CalAdjustVoltageMeasurement` function) to calculate the new calibration coefficients. Pass the voltage values reported by the NI 4110 to the Reported Outputs input of the VI, and pass the voltage values measured by the DMM to the Measured Outputs input of the VI. Call this VI or function once per range.

Table 18. NI 4110 Output Parameters for Voltage Measurement Accuracy Adjustment

Channel	Iteration	Output (V)
0	1	0
	2	3
	3	6
1	1	0
	2	10
	3	20
2	1	0
	2	-10
	3	-20

Adjusting Current Programming Accuracy

To adjust current programming, configure the external load using the *Equivalent Resistance* value for the iteration of channel *x* in Table 19, and then compare the current outputs measured by an external DMM to the values in the *Output* column of Table 19. Refer to Figure 2 for the necessary connections.

Note The values in the *Output* (A) column are the settings for the current limit. This column is labeled *Output* because the current limit is the value that the NI 4110 generates.

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.

Use the niDCPower Cal Adjust Current Limit VI (`niDCPower_CalAdjustCurrentLimit` function) to calculate the new calibration coefficient values. Pass the current setpoints requested by the NI 4110 to the Requested Outputs input of the VI, and pass the current values measured by the DMM to the Measured Outputs input of the VI. Call this VI or function once per range.

Table 19. NI 4110 Output Parameters for Current Programming Accuracy Adjustment

Channel(s)	Current Range	Iteration	Voltage Setpoint (V)	Equivalent Resistance (Ω)	Output (A)
0	1 A	1	5	80	0.050
		2		12	0.375
		3		5	0.750
1	1 A	1	16	180	0.050
		2		24	0.375
		3		12	0.750
	20 mA	1		9,600	0.001
		2		900	0.010
		3		480	0.020
2	1 A	1	-16	180	0.050
		2		24	0.375
		3		12	0.750
	20 mA	1		9,600	0.001
		2		900	0.010
		3		480	0.020

Adjusting Current Measurement Accuracy

To adjust current measurement, program the NI 4110 to the values in the *Output* column and configure the external load using the *Equivalent Resistance* value for the iteration of channel *x* in Table 20, and then compare the current outputs measured by an external DMM to the measured current reported by the NI 4110. Refer to Figure 3 for the necessary connections. When taking measurements with the NI 4110, set the Samples to Average property to `300`.

Note To facilitate an accurate measurement using an *Output* value of 0, verify that the DMM and the external load are disconnected from the NI 4110. For all other *Output* values, the DMM and the external load are connected to the NI 4110.

Use the niDCPower Cal Adjust Current Measurement VI (`niDCPower_CalAdjustCurrentMeasurement` function) to calculate the new calibration coefficients. Pass the current values reported by the NI 4110 to the Reported Outputs input of the VI, and pass the voltage values measured by the DMM to the Measured Outputs input of the VI. Call this VI or function once per range.

Table 20. NI 4110 Output Parameters for Current Measurement Accuracy Adjustment

Channel(s)	Current Range	Iteration	Equivalent Resistance (Ω)	Output (V)*
0	1 A	1	open	0†
		2	5	1.875
		3	5	3.75
1, 2	1 A	1	open	0†
		2	20	±7.5
		3	20	±15
1, 2	20 mA	1	open	0†
		2	1,000	±10
		3	1,000	±20

* When adjusting channel 1, the *Output* is positive. When adjusting channel 2, the *Output* is negative.

† To facilitate an accurate measurement using an *Output* value of 0, verify that the DMM and the external load are disconnected from the NI 4110. For all other *Output* values, the DMM and the external load are connected to the NI 4110.

After you successfully complete all adjustment tests, close the calibration session by setting **action** to **Commit** on the niDCPower Close External Calibration VI (`niDCPower_Close_External_Calibration` function). Adjustment of the NI 4110 is now complete. Repeat the *Verification* section to reverify the performance of the NI 4110 post-adjustment. After re-verification, update the verification date and temperature by opening a calibration session, and then closing the calibration session with **action** set to **Commit**. If the NI 4110 successfully passes all verification tests, calibration is complete.

Where to Go for Support

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.

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Visit `ni.com/register` to register your National Instruments product. Product registration facilitates technical support and ensures that you receive important information updates from NI.

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