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NI PXI-4110 Calibration Procedure Addendum

This document is an addendum to the *NI PXI-4110 Calibration Procedure*, part number 371701F-01, available at `ni.com/manuals`. This document contains instructions for running tests to verify load regulation and line regulation as part of writing a manual calibration procedure for the NI PXI-4110 programmable DC power supply.

Test Equipment

Table 1 lists the equipment required to calibrate the NI PXI-4110. If you do not have the recommended equipment, select a substitute calibration standard using the specifications listed in Table 1.

Table 1. Required Equipment Specifications for NI PXI-4110 Calibration

Required Equipment	Recommended Equipment	Specifications
Digital multimeter (DMM)	NI 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 3 to 25,000 Ω and 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

NATIONAL INSTRUMENTS

Verifying Load Regulation

Complete the load regulation test to verify 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. Each test requires an external load to vary the load voltage or current. Run this test only after verifying the voltage measurement accuracy and current measurement accuracy tests have passed.

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

Refer to the *Verifying Voltage Measurement Accuracy* section and the *Verifying Current Measurement Accuracy* section of the *NI PXI-4110 Calibration Procedure* for instructions on running these measurement accuracy tests.

Voltage Load Regulation

To verify voltage load regulation, use the NI PXI-4110 in constant voltage mode and confirm the output voltage change falls within calculated limits while varying the load current using an external load. Table 3 lists the resistance values and measurements needed to complete verification. Refer to Figure 1 for the necessary connections.
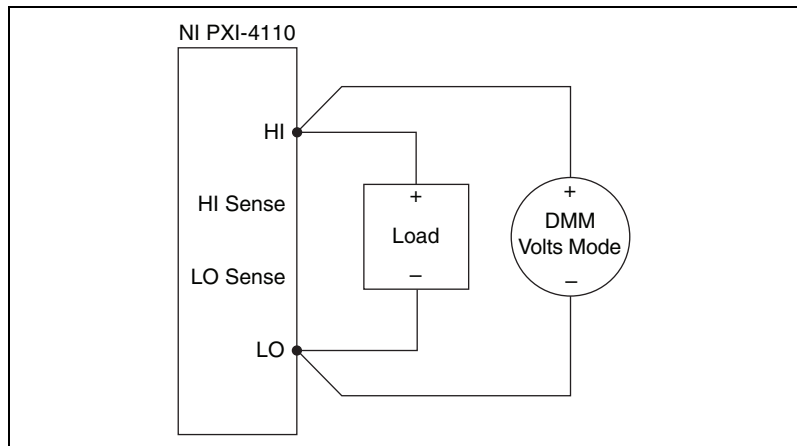

Figure 1. Voltage Load Regulation Verification Connection Diagram

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 PXI-4110.

2. While taking a current measurement with the NI PXI-4110 (I_1), use a DMM to measure the voltage across the output of the NI PXI-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 Table 2, where the current is in amps.

Table 2. NI PXI-4110 Voltage Load Regulation Voltage Change Limit Formulas

Channels	Voltage Change Limit
0	$\pm (I_1 - I_2) \times 0.0252$
1 and 2	$\pm (I_1 - I_2) \times 0.02$

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 3. NI PXI-4110 Voltage Load Regulation Verification Points

Channel	V Range	V Level	I Range	I Limit	Load R_1	Load R_2	Measured I_1 (A)	V_1 (V)	I_2 (A)	V_2 (V)	Voltage Change Limit (V)	Voltage Change (V)
0	6 V	6 V	1 A	1 A	620 Ω	7 Ω						
1	20 V	10 V	1 A	1 A	1 kΩ	11 Ω						
2	20 V	10 V	1 A	1 A	1 kΩ	11 Ω						

Current Load Regulation

To verify current load regulation, use the NI PXI-4110 in constant current mode and confirm the output current change falls within calculated limits while varying the load voltage using an external load. Table 5 lists the resistance values and measurements needed to complete verification. Refer to Figure 2 for the necessary connections.
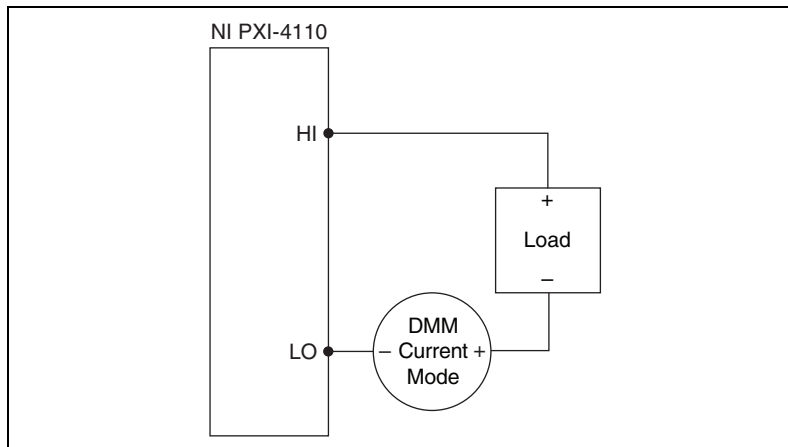

Figure 2. Current Load Regulation Verification Connection Diagram

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 PXI-4110.

2. While taking a voltage measurement with the NI PXI-4110 (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 formulas in Table 4.

Table 4. NI PXI-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 5. NI PXI-4110 Current Load Regulation Verification Points

Channel	V Range	V Limit	I Range	I Level	Load R_1	Load R_2	Measured I_1 (A)	V_1 (V)	I_2 (A)	V_2 (V)	Current Change Limit (A)	Current Change (A)
0	6 V	6 V	1 A	500 mA	10 Ω	4 Ω						
1	20 V	20 V	20 mA	10 mA	1.8 kΩ	200 Ω						
1	20 V	20 V	1 A	500 mA	36 Ω	4 Ω						
2	20 V	–20 V	20 mA	10 mA	1.8 kΩ	200 Ω						
2	20 V	–20 V	1 A	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 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 the voltage measurement accuracy and verifying the current measurement accuracy test have passed.

Refer to the *Verifying Voltage Measurement Accuracy* and *Verifying Current Measurement Accuracy* sections of the *NI PXI-4110 Calibration Procedure* for instructions on running these measurement accuracy tests.

Voltage Line Regulation

To verify voltage line regulation, use the NI PXI-4110 in constant voltage mode and confirm the output voltage change falls within calculated limits while varying the line voltage using a variable power supply. Table 7 lists the voltage values and measurements needed to complete verification. Refer to Figure 3 for the necessary connections.
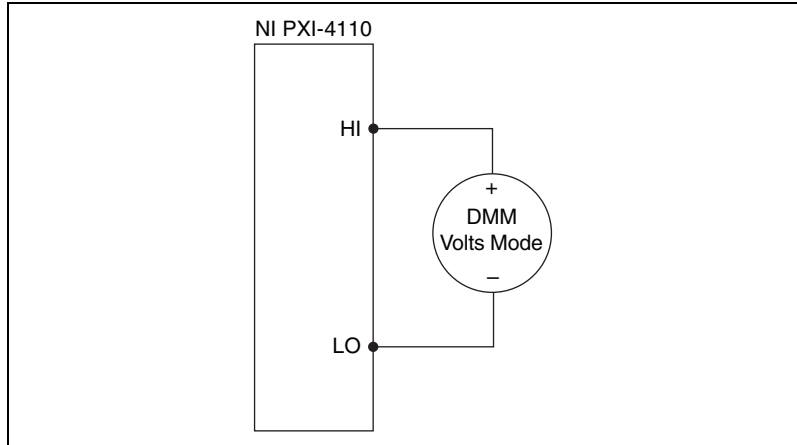

Figure 3. Voltage Line Regulation Verification Connection Diagram

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 7.

2. Set the NI PXI-4110 to output the voltage specified in Table 7.

3. Use a DMM to measure the voltage across the output of the specified channel of the NI PXI-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 PXI-4110 output voltage measurements for both external voltages.

6. Calculate the *Voltage Change Limit* using the formula in Table 6.

Table 6. NI PXI-4110 Voltage Line Regulation Voltage Change Limit Formulas

Channels	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 7. NI PXI-4110 Voltage Line Regulation Verification Points

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

Current Line Regulation

To verify current line regulation, use the NI PXI-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 9 lists the voltage values and current measurements needed to complete verification. Refer to Figure 4 for the necessary connections.
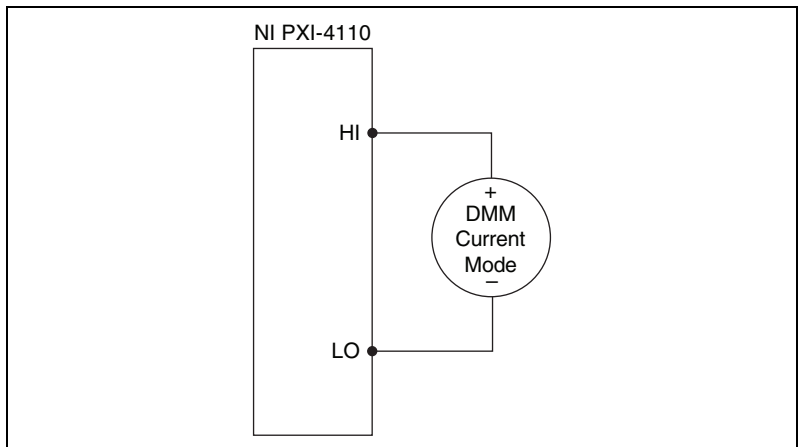

Figure 4. Current Line Regulation Verification Connection Diagram

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 9.

2. Set the NI PXI-4110 to output the current specified in Table 9.

3. Use a DMM to measure the current across the output of the specified channel of the NI PXI-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 PXI-4110 output current measurements for both external voltages.

6. Calculate the *Current Change Limit* using the formulas in Table 8.

Table 8. NI PXI-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 9. NI PXI-4110 Current Line Regulation Verification Points

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