

NOTE TO USERS

NI PXI-4130 Calibration Procedure Addendum

This document is an addendum to the *NI PXI-4130 Calibration Procedure*, part number 374753B-01. This document contains instructions for running tests to verify load regulation, line regulation, and remote sense output as part of writing a manual calibration procedure for the NI PXI-4130 programmable, high-power source measure unit (SMU).

Test Equipment

Table 1 lists the equipment required to calibrate the NI PXI-4130. 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-4130 Calibration

Required Equipment	Recommended Equipment	Specifications
Digital multimeter (DMM)	NI 4071	Voltage: better than ± 50 ppm accuracy, better than $30 \mu\text{V}$ resolution; Current: better than $\pm 0.04\%$ accuracy, better than $1 \mu\text{A}$ resolution
Variable power supply	Xantrex HPD 30-10	Variable between 11 V and 15.5 V, 5 A
External load	Clarostat 240C	Power resistor decade box with a range of 4 to 48,000 Ω and an accuracy of $\pm 10\%$
Resistors	—	Two 50 Ω , 1/4 W $\pm 10\%$ resistors, and one 1 k Ω , 1/4 W $\pm 10\%$ resistor

Table 1. Required Equipment Specifications for NI PXI-4130 Calibration (Continued)

Required Equipment	Recommended Equipment	Specifications
Auxiliary power supply	NI APS-4100	11 V to 15.5 V, 5 A
Twisted pair, shielded cabling wire	Belden 83319E 009100	18 AWG to 22 AWG

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 the verifying the voltage measurement accuracy and verifying the current measurement accuracy test 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-4130 Calibration Procedure* for instructions on running these measurement accuracy tests.

Voltage Load Regulation

To verify voltage load regulation, use the NI PXI-4130 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.

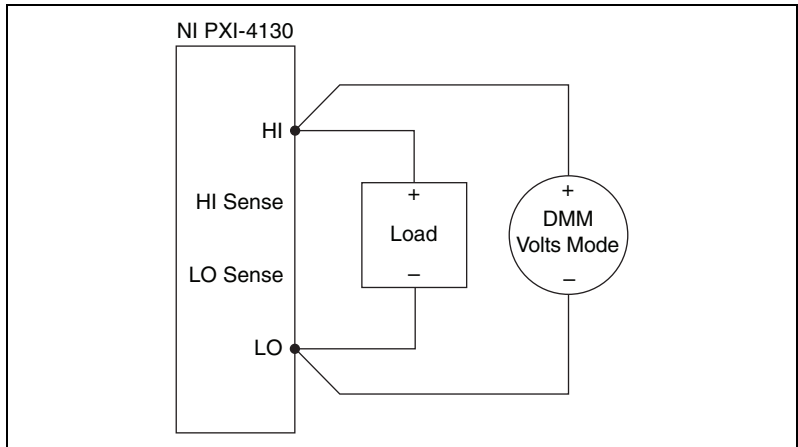


Figure 1. Voltage Load Regulation Verification Connection Diagram

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-4130.
2. While taking a current measurement with the NI PXI-4130 (I_1), use a DMM to measure the voltage across the output of the NI PXI-4130 (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-4130 Voltage Load Regulation Voltage Change Limit Formulas

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

- 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-4130 Voltage Load Regulation Verification Points

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

Current Load Regulation

To verify current load regulation, use the NI PXI-4130 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.

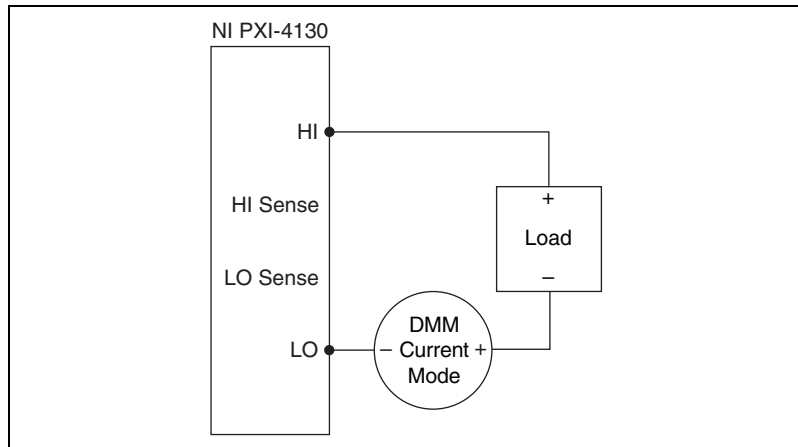


Figure 2. Current Load Regulation Verification Connection Diagram

Complete the following steps to verify current load regulation:

- For each test, connect the first specified resistance (R_1) to the specified channel of the NI PXI-4130.
- While taking a voltage measurement with the NI PXI-4130 (V_1), use a DMM in series to measure the output current (I_1).
- 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-4130 Current Load Regulation Current Change Limit Formulas

Channel	Current Range	Current Change Limit
0	1 A	$\pm 2.00 \times 10^{-4} \times (V_1 - V_2)$
1	200 μ A	$\pm 2.00 \times 10^{-8} \times (V_1 - V_2)$
1	2 mA	$\pm 2.00 \times 10^{-7} \times (V_1 - V_2)$
1	20 mA	$\pm 2.00 \times 10^{-6} \times (V_1 - V_2)$
1	200 mA	$\pm 2.00 \times 10^{-5} \times (V_1 - V_2)$
1	2 A	$\pm 2.00 \times 10^{-4} \times (V_1 - V_2)$

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-4130 Current Load Regulation Verification Points

Channel	V Range	V Limit	I Range	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	6 V	1 A	500 mA	10 Ω	4 Ω						
1	20 V	20 V	200 μ A	100 μ A	180 k Ω	20 k Ω						
1	20 V	20 V	2 mA	1 mA	18 k Ω	2 k Ω						
1	20 V	20 V	20 mA	10 mA	1.8 k Ω	200 Ω						
1	20 V	20 V	200 mA	100 mA	180 Ω	20 Ω						
1	20 V	20 V	2 A	1 A	18 Ω	2 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 current measurement accuracy tests have passed.

Refer to the *Verifying Voltage Measurement Accuracy* section and the *Verifying Current Measurement Accuracy* section of the *NI PXI-4130 Calibration Procedure* for instructions about running these measurement accuracy tests.

Voltage Line Regulation

To verify voltage line regulation, use the NI PXI-4130 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.

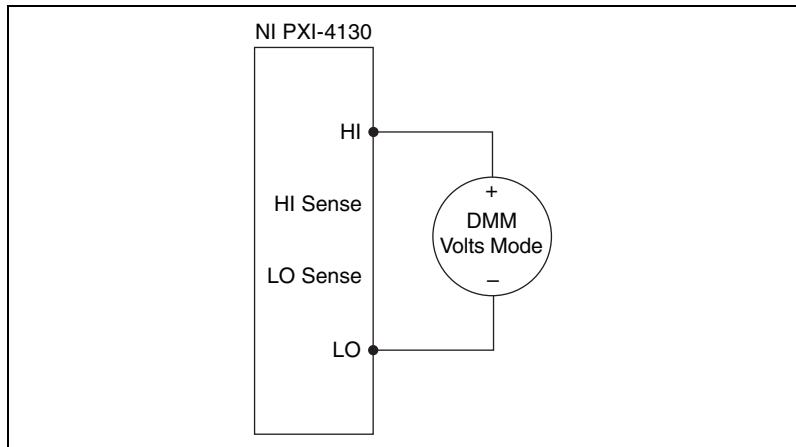


Figure 3. Voltage Line Regulation Verification Connection Diagram

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-4130 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-4130 (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-4130 output voltage measurements for both external voltages.

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

Table 6. NI PXI-4130 Voltage Line Regulation Voltage Change Limit Formulas

Channel	Voltage Change Limit
1	$\pm ((V_1 \times 1.00 \times 10^{-4}) + 0.001) \times (V_{\text{ext1}} - V_{\text{ext2}})$

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-4130 Voltage Line Regulation Verification Points

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

Current Line Regulation

To verify current line regulation, use the NI PXI-4130 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.

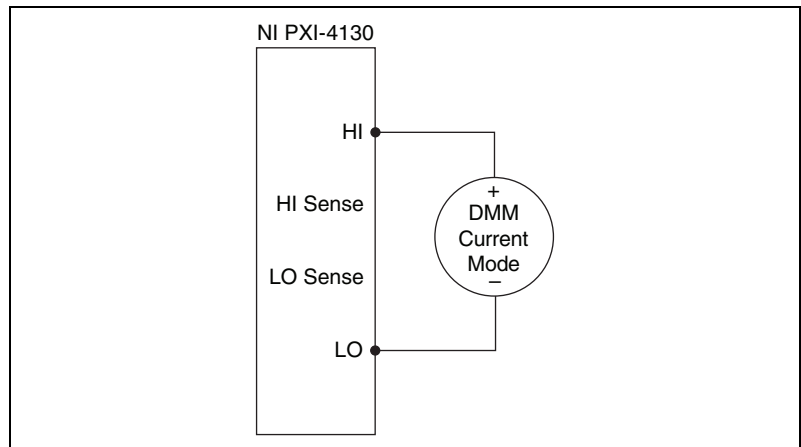


Figure 4. Current Line Regulation Verification Connection Diagram

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-4130 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-4130 (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-4130 output current measurements for both external voltages.
6. Calculate the current change limit using the formulas in Table 8.

Table 8. NI PXI-4130 Current Line Regulation Current Change Limit Formulas

Channel	Current Range	Current Change Limit
1	200 μ A	$\pm ((I_1 \times 1.00 \times 10^{-4}) + 4.00 \times 10^{-8}) \times (V_{ext1} - V_{ext2})$
1	2 mA	$\pm ((I_1 \times 1.00 \times 10^{-4}) + 4.00 \times 10^{-7}) \times (V_{ext1} - V_{ext2})$
1	20 mA	$\pm ((I_1 \times 1.00 \times 10^{-4}) + 4.00 \times 10^{-6}) \times (V_{ext1} - V_{ext2})$
1	200 mA	$\pm ((I_1 \times 1.00 \times 10^{-4}) + 4.00 \times 10^{-5}) \times (V_{ext1} - V_{ext2})$
1	2 A	$\pm ((I_1 \times 1.00 \times 10^{-4}) + 4.00 \times 10^{-4}) \times (V_{ext1} - V_{ext2})$

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-4130 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	200 μ A	10 V	200 μ A	15.5 V	11 V				
1	20 V	2 mA	10 V	2 mA	15.5 V	11 V				
1	20 V	20 mA	10 V	20 mA	15.5 V	11 V				
1	20 V	200 mA	10 V	200 mA	15.5 V	11 V				
1	20 V	2 A	10 V	2 A	15.5 V	11 V				

Verifying Remote Sense Output

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

1. Connect the $50\ \Omega$ (R_1), $1\ \text{k}\Omega$ (R_2), and $50\ \Omega$ (R_3) resistors in series, with the $1\ \text{k}\Omega$ resistor being the center resistor as shown in Figure 5.

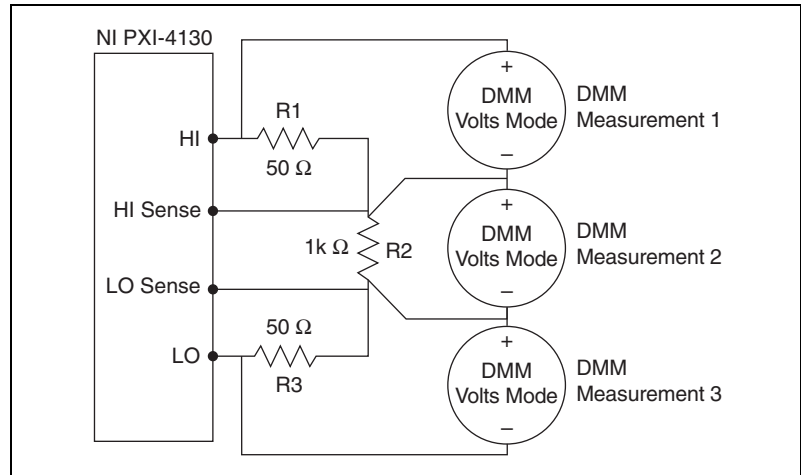


Figure 5. Remote Sense Output Verification Connection Diagram

2. Connect the resistors to the HI and LO terminals on the NI PXI-4130 as shown in Figure 5. Connect the remote sense leads directly across the $1\ \text{k}\Omega$ resistor (R_2).
3. With remote sense On and a current limit of 100 mA, output 10 V in the 20 V range as shown in Table 10.
4. Measure the *HI Lead Drop* with a DMM (*DMM Measurement 1*) from the HI terminal of the NI PXI-4130 to the HI side of the $1\ \text{k}\Omega$ resistor.
5. Measure the *LO Lead Drop* with a DMM (*DMM Measurement 3*) from the LO side of the $1\ \text{k}\Omega$ resistor to the LO terminal of the NI PXI-4130.
6. Calculate the accuracy limit for the load voltage using the following equation:

$$\text{Load Voltage Limit} = 10\ \text{V} \pm (0.0052\ \text{V} + (0.000120\ \text{V} \times (\text{HI Lead Drop} + \text{LO Lead Drop})))$$

7. Measure the load voltage with a DMM (*DMM Measurement 2*) across the 1 k Ω load where the sense leads connect. The test passes if the *Load Voltage* measurement falls within the calculated *Load Voltage Limit*.

Table 10. NI PXI-4130 Remote Sense Output Verification Points

V Range	V Level	I Range	I Limit	Measured Load Voltage (V)	Measured HI Lead Drop (V)	Measured LO Lead Drop (V)	Load Voltage Upper Limit (V)	Load Voltage Lower Limit (V)
20 V	10 V	200 mA	100 mA					

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