Calibration Procedure

PXIe-4162/4163 Calibration Procedure

October 2024

376739C-01

This document contains the verification and adjustment procedures for the PXIe-4162/4163. Use the procedures in this document to automate calibration or to conduct manual calibration. Review and become familiar with the entire procedure before beginning the calibration process.

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Contents

PXIe-4162/4163 Calibration Procedure

This document contains the performance verification procedures, adjustment procedures, and switch fixture assembly performance test for the PXIe-4162/4163. Refer to ni.com/calibration for more information about calibration solutions.

Review and become familiar with the entire procedure before beginning the calibration process.

Required Software

Calibrating the PXIe-4162/4163 requires you to install the following software on the calibration system:

- NI-DCPower 22.5 or later
- Supported application development environment (ADE)—LabVIEW or LabWindows™/CVI™
- Supported operating system—Windows

You can download all required software from ni.com/downloads.

Related Documentation

For additional information, refer to the following documents as you perform the calibration procedure:

- **PXIe-4162 Getting Started Guide**
- **PXIe-4163 Getting Started Guide**
- **NI DC Power Supplies and SMUs Help**
- **PXIe-4162 Specifications**
- **PXIe-4163 Specifications**
- **NI-DCPower Readme**
- **LabVIEW Help**

Visit ni.com/docs for the latest versions of these documents.

Password

The default password for password-protected operations is NI.

Calibration Interval

Recommended calibration interval	1 year

Test Equipment

The following table lists the necessary equipment for the switch fixture assembly performance test, performance verification procedures, and adjustment procedures. If the recommended equipment is not available, select a substitute that meets the minimum required specifications listed in the table.

Table 1. Required Equipment

Required Equipment	Recommended Model	Parameter Measured	Minimum Requirements
PXIe-4162/4163 Calibration Accessories Kit	NI part number 787490-01 kit includes: CAL-4162/63 Calibration Switch Fixture SHDB62M-DB62M-LL, 62-Pin D-SUB Cable for SMUs, Low Leakage, 1 M Type LV4-BAN4 Cable Assembly, 1 M Male-to-Male Triax Cable Assembly, 300 V Isolation, Low Noise, Low Leakage, 1 M PXIe-4162/4163 Output Shorting Assembly	All parameters	Thermal EMF: ±20 µV 2-Wire path resistance: ≤ 5 Ω 4-Wire path resistance: ≤1 Ω 3 kΩ resistor: ±3 Ω 1 MΩ measurement path (functional verification): ±300 Ω (IET Labs SRL-1M/1 Triax value) Leakage verification (functional verification): >5 GΩ
Digital Multimeter (DMM)	PXIe-4081	All parameters except load regulation verification and remote sense accuracy	Voltage accuracy: 50 ppm of reading + 500 µV Voltage resolution: 100 µV Current accuracy: 100 µA to 10 mA range: 200 ppm of reading + 40 ppm of range

Required Equipment	Recommended Model	Parameter Measured	Minimum Requirements
Digital Multimeter (DMM) *(cont.)*			100 µA to 10 mA range: 200 ppm of reading + 40 ppm of range 100 mA range: 200 ppm of reading + 20 ppm of range Current resolution: 1 ppm of range
PXI Relay Module	PXI-2520	All parameters	You must use the PXI-2520.
PXI Express Chassis	PXIe-1092 or PXIe-1095		If these chassis are unavailable, use a PXI Express Chassis with ≥ 58 W slot cooling capacity.
1 MΩ current shunt	IET Labs SRL-1M/Triax	1 µA/10 µA current accuracy	Accuracy: ±150 ppm Tempco: 10 ppm/°C
Low thermal test leads	Fluke 5440	1 µA/10 µA current accuracy	Shielded, twisted pair copper cables with copper or gold-plated copper banana plugs
Banana plug patch cord	Pomona B-4-0	1 µA/10 µA current accuracy	—

Switch Fixture Assembly Maintenance

To ensure proper operation of the CAL-4162/63 and its connection to the PXI-2520, you must periodically test its performance. Consider the conditions specific to your test setup, including how often the relays are used, to determine how frequently to execute the switch fixture assembly performance test.

Test Conditions

Follow the setup and environmental information below to ensure the CAL-4162/63 Switch Fixture Assembly meets the test limits in the CAL-4162/63 Switch Fixture Assembly Test Limits table.

- Keep cabling as short as possible. Long cables act as antennas, picking up extra noise that can affect measurements.
- Verify that all connections to the CAL-4162/63, including front panel connections and screws, are secure.
- Maintain an ambient temperature of 23 °C ±5 °C. The temperature of the module will be greater than the ambient temperature.
- Keep relative humidity between 10% and 70%, noncondensing.

Test Limit Equations

The tests performed in the CAL-4162/63 Switch Fixture Assembly Performance Test do not validate the full performance of the CAL-4162/63 switch fixture assembly. The parameters and limits used in the tests are based on the measurement requirements of the procedure.

Table 2. CAL-4162/63 Switch Fixture Assembly Test Limits

Measurement	Limit
Thermal EMF	±20 µV
2-Wire path resistance	≤ 5 Ω
4-Wire path resistance	≤1 Ω
3 kΩ resistor	±3 Ω
1 MΩ measurement path (functional verification)	IET Labs SRL-1M/1Triax value: ±300 Ω
Leakage verification (functional verification)	>5 GΩ

Relay Configurations by Channel for Switch Fixture Assembly Performance Test

Use the following table to configure the relays as described in the CAL-4162/63 Switch Fixture Assembly Performance Test.

Table 3. Relay Configurations by Channel

Channel	HI (4 W)	Sense HI (2 W)
CH0	k11, k6, k69, k1, k4	k10, k5, k75
CH1	k13, k8, k74, k3, k4	k12, k7, k77
CH2	k16, k6, k69, k1, k4	k15, k5, k75

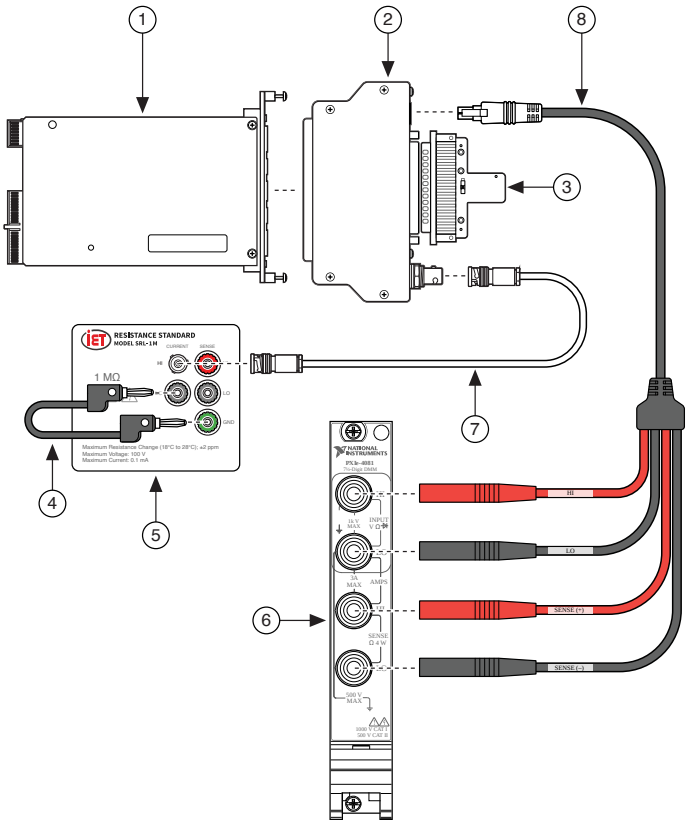
Channel	HI (4 W)	Sense HI (2 W)
CH3	k18, k8, k74, k3, k4	k17, k7, k77
CH4	k21, k6, k69, k1, k4	k20, k5, k75
CH5	k23, k8, k74, k3, k4	k22, k7, k77
CH6	k26, k6, k69, k1, k4	k25, k5, k75
CH7	k28, k8, k74, k3, k4	k27, k7, k77
CH8	k31, k6, k69, k1, k4	k30, k5, k75
CH9	k33, k8, k74, k3, k4	k32, k7, k77
CH10	k36, k6, k69, k1, k4	k35, k5, k75
CH11	k38, k8, k74, k3, k4	k37, k7, k77
CH12	k41, k6, k69, k1, k4	k40, k5, k75
CH13	k43, k8, k74, k3, k4	k42, k7, k77
CH14	k46, k6, k69, k1, k4	k45, k5, k75
CH15	k48, k8, k74, k3, k4	k47, k7, k77
CH16	k51, k6, k69, k1, k4	k50, k5, k75
CH17	k53, k8, k74, k3, k4	k52, k7, k77
CH18	k56, k6, k69, k1, k4	k55, k5, k75
CH19	k58, k8, k74, k3, k4	k57, k7, k77
CH20	k61, k6, k69, k1, k4	k60, k5, k75
CH21	k63, k8, k74, k3, k4	k62, k7, k77
CH22	k66, k6, k69, k1, k4	k65, k5, k75
CH23	k68, k8, k74, k3, k4	k67, k7, k77

CAL-4162/63 Switch Fixture Assembly Performance Test

1. Connect the CAL-4162/63 to the test equipment as shown in the following diagram.

> **Note** NI recommends keeping the PXI-2520 and the calibration kit accessories connected to the CAL-4162/63 after executing the switch fixture assembly performance test. If you disconnect this equipment, you should execute the switch fixture assembly performance test again to ensure accuracy.

Figure 1. Switch Fixture Assembly Performance Test Connections

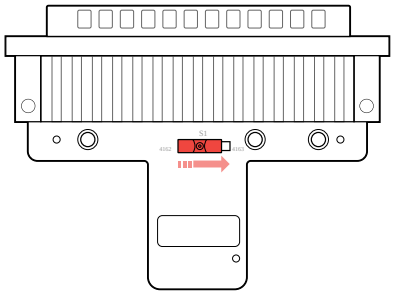


- 1. PXI-2520
- 2. CAL-4162/63
- 3. Output Shorting Assembly
- 4. Banana Plug Patch Cord
- 5. 1 MΩ Current Shunt
- 6. PXIe-4081
- 7. Triax Cable
- 8. DMM Cable

2. Set the switch on the output shorting assembly to **4163**.

> **Note** Despite the module under calibration, the output shorting assembly must be set to **4163** for the switch fixture assembly performance test.

Figure 2. Output Shorting Assembly Switch



3. Verify the HI relays:
   a. Ensure all relays are open, then locate the **HI (4 W)** column in the Relay Configurations by Channel for Switch Fixture Assembly Performance Test table, and close the relays for channel CH0.
   b. Use the following table to configure the PXIe-4081.

Measurement	Range	Aperture	Offset Compensated Ohms (OCO)	ADC Calibration
4-Wire resistance	100 Ω	≥100 ms	On	On

   c. Acquire a measurement for channel CH0, and compare the result to the **4-Wire Path Resistance** limit in the CAL-4162/63 Switch Fixture Assembly Test Limits table.
   d. Repeat step a through step c for channels CH1 through CH23.
   e. Ensure all relays are open, then locate the **HI (4W)** column in the Relay Configurations by Channel for Switch Fixture Assembly Performance Test table, and close the relays for channel CH0.
   f. Use the following table to configure the PXIe-4081.

Measurement	Range	Auto Zero	ADC Calibration
DC voltage	100 mV	On	On

   g. Acquire a measurement for channel CH0, and compare the result to the **Thermal EMF** limit in the CAL-4162/63 Switch Fixture Assembly Test Limits table.
   h. Repeat step e through step g for channels CH1 through CH23.

4. Verify the Sense HI relays:
   a. Ensure all relays are open, then locate the **Sense HI (2 W)** column in the Relay Configurations by Channel for Switch Fixture Assembly Performance Test table, and close the relays for channel CH0.
   b. Use the following table to configure the PXIe-4081.

Measurement	Range	Aperture	Offset Compensated Ohms (OCO)	ADC Calibration
2-Wire resistance	100 Ω	≥100 ms	On	On

   c. Acquire a measurement for channel CH0, and compare the result to the **2-Wire Path Resistance** limit in the CAL-4162/63 Switch Fixture Assembly Test Limits table.
   d. Repeat step a through step c for channels CH1 through CH23.
   e. Ensure all relays are open, then locate the **Sense HI (2 W)** column in the Relay Configurations by Channel for Switch Fixture Assembly Performance Test table, and close the relays for channel CH0.
   f. Use the following table to configure the PXIe-4081.

Measurement	Range	Auto Zero	ADC Calibration
DC voltage	100 mV	On	On

   g. Acquire a measurement for channel CH0, and compare the result to the **Thermal EMF** limit in the CAL-4162/63 Switch Fixture Assembly Test Limits table.
   h. Repeat step e through step g for channels CH1 through CH23.
5. Verify shared Sense LO switching:
   a. Ensure all relays are open, then refer to the following table to close the relays listed for channels **CH0 through CH5 Sense LO**.

Table 4. Shared Sense LO Switch Configuration

Channels	Relays
CH0 through CH5 Sense LO	k7, k29, k19

Channels	Relays
CH6 through CH11 Sense LO	k7, k29, k34
CH12 through CH17 Sense LO	k7, k29, k49
CH18 through CH23 Sense LO	k7, k29, k64

b. Use the following table to configure the PXIe-4081.

Measurement	Range	Aperture	Offset Compensated Ohms (OCO)	ADC Calibration
2-Wire resistance	100 Ω	≥100 ms	On	On

c. Acquire a measurement for channel CH0, and compare the result to the **2-Wire Path Resistance** limit in the CAL-4162/63 Switch Fixture Assembly Test Limits table.

d. Repeat step a through step c for the remaining configurations in the Shared Sense LO Switch Configuration table.

e. Ensure all relays are open, then refer to the Shared Sense LO Switch Configuration table to close the relays listed for channels **CH0 through CH5 Sense LO**.

f. Use the following table to configure the PXIe-4081.

Measurement	Range	Auto Zero	ADC Calibration
DC voltage	100 mV	On	On

g. Acquire a measurement for channel CH0, and compare the result to the **Thermal EMF** limit in the CAL-4162/63 Switch Fixture Assembly Test Limits table.

h. Repeat step a through step c for the remaining configurations in the Shared Sense LO Switch Configuration table.

6. Verify the calibration pin relay:

a. Ensure all relays are open, then close relays k44, k14, k24, k4, k1, and k6.

b. Use the following table to configure the PXIe-4081.

Measurement	Range	Aperture	Offset Compensated Ohms (OCO)	ADC Calibration
4-Wire resistance	100 Ω	≥100 ms	On	On

c. Acquire a measurement for the calibration pin, and compare the result to the **4-Wire Path Resistance** limit in the CAL-4162/63 Switch Fixture Assembly Test Limits table.

d. Use the following table to configure the PXIe-4081.

Measurement	Range	Auto Zero	ADC Calibration
DC voltage	100 mV	On	On

e. Acquire a measurement for the calibration pin, and compare the result to the **Thermal EMF** limit in the CAL-4162/63 Switch Fixture Assembly Test Limits table.

7. Verify remote sense verification resistance:

a. Ensure all relays are open, then close relays k44, k39, k4, k1, k8, k71, and k73.

b. Use the following table to configure the PXIe-4081.

Measurement	Range	Aperture	Offset Compensated Ohms (OCO)	ADC Calibration
4-Wire resistance	10 kΩ	≥100 ms	On	On

c. Acquire a measurement for the remote sense resistor, and compare the result to the **3 kΩ resistor** limit in the CAL-4162/63 Switch Fixture Assembly Test Limits table.

8. Verify path to 1 MΩ (functional verification):

a. Ensure all relays are open, then close relays k44, k39, k4, k1, k8, k78, and k76.

b. Use the following table to configure the PXIe-4081.

Measurement	Range	Aperture	Auto Zero	ADC Calibration
4-Wire resistance	1 MΩ	≥100 ms	On	On

c. Acquire a measurement for the 1 MΩ path, and compare the result to the **1 MΩ measurement path (functional verification)** limit in the CAL-4162/63 Switch Fixture Assembly Test Limits table.

9. Verify leakage (functional verification):

a. Ensure all relays are open, then close relays k5, k6, k7, k8, and k29.

b. Use the following table to configure the PXIe-4081.

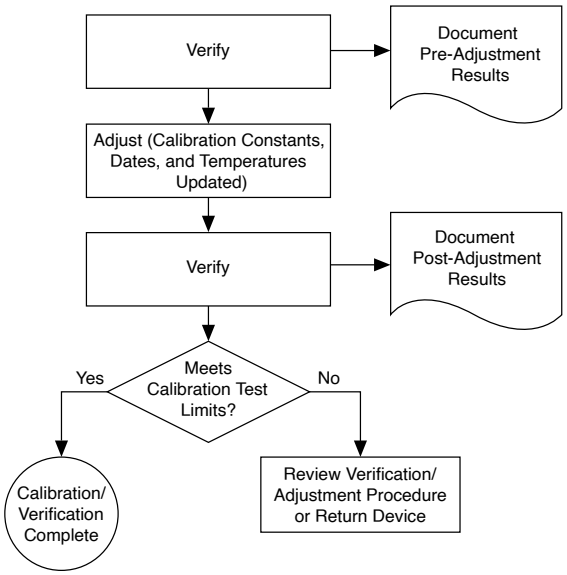
Measurement	Range	Aperture	Auto Zero	ADC Calibration
2-Wire resistance	5 G Ω	≥100 ms	On	On

c. Acquire a measurement for leakage verification, and compare the result to the **Leakage verification (functional verification)** limit in the CAL-4162/63 Switch Fixture Assembly Test Limits table.

Calibration Procedure Overview

Calibration includes the steps shown in the following figure.

Figure 3. Calibration Overview



1. Initial setup—Install the PXIe-4162/4163 and configure it in Measurement & Automation Explorer (MAX).
2. Verification—Verify the existing operation of the PXIe-4162/4163 to confirm whether the PXIe-4162/4163 is operating within the published specifications prior to adjustment.
3. Adjustment—Adjust the calibration constants of the PXIe-4162/4163.
4. Reverification—Repeat the Verification procedure to ensure that the PXIe-4162/4163 is operating within the published specifications after adjustment.

Test Conditions

Follow the setup and environmental information below to ensure the PXIe-4162/4163 meets the published specifications.

- Keep cabling as short as possible. Long cables act as antennas, picking up extra noise that can affect measurements.
- Verify that all connections to the PXIe-4162/4163, including front panel connections and screws, are secure.
- Ensure that the PXI chassis fan filters, if present, are clean, and that the empty slots contain filler panels.
- Allow a warm-up time of at least 30 minutes after the chassis is powered on and NI-DCPower is loaded and recognizes the PXIe-4162/4163. The warm-up time ensures that the PXIe-4162/4163 and test instrumentation are at a stable operating temperature.
- Use shielded copper wire for all cable connections to the module. Use twisted-pair wire to eliminate noise and thermal offsets.
- To ensure the system has had adequate time to settle, wait one second after requesting a new current or voltage or after changing a load before taking a measurement.
- When making measurements, configure the following aperture time-related settings:

- Set the niDCPower Aperture Time property or NIDCPOWER_ATTR_APERTURE_TIME attribute to 2 power-line cycles (PLCs) on the module.
- Set the niDCPower Aperture Time Units property or NIDCPOWER_ATTR_APERTURE_TIME_UNITS to power line cycles.
- Set the niDCPower Configure Power Line Frequency property or the NIDCPOWER_ATTR_POWER_LINE_FREQUENCY attribute to either 50 or 60 depending on the frequency of the AC power line in your location.

- Ensure that properties or attributes for the module that are not specified in calibration procedures are set to their default values.
- When making measurements, configure any specified digital multimeters (DMMs) with the best available ranges and measurement settings for each specified test point.
- Keep relative humidity between 10% and 70%, noncondensing.
- For verification procedures, maintain an ambient temperature of 23 °C ± 5 °C. Maintain an internal device temperature range of T_{cal} ± 1 °C.[1]
- For adjustment procedures, maintain an ambient temperature of 23 °C ± 1 °C. The PXIe-4162/4163 internal temperature is greater than the ambient temperature.

As-Found and As-Left Limits

The **as-found limits** are the published specifications for the device. NI uses these limits to determine whether the device meets the device specifications when it is received for calibration.

The **as-left limits** are equal to the published NI specifications for the device, less guard bands for measurement uncertainty, temperature drift, and drift over time. NI uses these limits to determine whether the device will meet the device specifications over its calibration interval.

Relay Configurations by Channel for Verification and Adjustment Procedures

[1] T_{cal} is the internal device temperature recorded by the PXIe-4162/4163 at the completion of the last self-calibration. Call the niDCPower Get Self Cal Last Temp VI to query T_{cal} from the PXIe-4162/4163.

Use the following table to configure the relays as described in the verification and adjustment procedures.

Table 5. Relay Configurations by Channel for PXIe-4162

PXIe-4162 Channel	Verify Voltage	Verify Remote Sense	1 µA and 10 µA	100 µA to 60 mA
CH0	k11, k10, k19, k6, k5, k0, k44, k12, k29	k11, k10, k12, k19, k44, k40, k0, k29, k6, k5	k11, k76, k39, k13, k59	k11, k1, k44
CH1	k16, k15, k19, k6, k5, k0, k44, k17, k29	k16, k15, k19, k71, k70, k29, k44, k17, k0	k16, k76, k39, k18, k59	k16, k1, k44
CH2	k21, k20, k19, k6, k5, k0, k44, k22, k29	k21, k20, k19, k71, k70, k29, k44, k22, k0	k21, k76, k39, k23, k59	k21, k1, k44
CH3	k26, k25, k34, k6, k5, k0, k44, k27, k29	k26, k25, k34, k71, k70, k29, k44, k27, k0	k26, k76, k39, k28, k59	k26, k1, k44
CH4	k31, k30, k34, k6, k5, k0, k44, k32, k29	k31, k30, k34, k71, k70, k29, k44, k32, k0	k31, k76, k39, k33, k59	k31, k1, k44
CH5	k36, k35, k34, k6, k5, k0, k44, k37, k29	k36, k35, k34, k71, k70, k29, k44, k37, k29, k0	k36, k76, k39, k38, k59	k36, k1, k44
CH6	k41, k40, k49, k6, k5, k0, k44, k42, k29	k41, k40, k49, k71, k70, k29, k44, k42, k0	k41, k76, k39, k43, k59	k41, k1, k44
CH7	k46, k45, k49, k6,k5, k0, k44, k47, k29	k46, k45, k49, k71, k70, k29, k44, k47, k0	k46, k76, k39, k48, k59	k46, k1, k44
CH8	k51, k50, k49, k6, k5, k0, k44, k52, k29	k51, k50, k49, k71, k70, k29, k44, k0, k52	k51, k76, k39, k53, k59	k51, k1, k44
CH9	k56, k55, k64, k6, k5, k0, k44, k57, k29	k56, k55, k64, k71, k70, k29, k44, k57, k0	k56, k76, k39, k58, k59	k56, k1, k44

PXIe-4162 Channel	Verify Voltage	Verify Remote Sense	1 µA and 10 µA	100 µA to 60 mA
CH10	k61, k60, k64, k6, k5, k0, k44, k29, k62	k61, k60, k64, k71, k70, k29, k44, k62, k0	k61, k76, k39, k63, k59	k61, k1, k44
CH11	k66, k65, k64, k6, k5, k0, k44, k67, k29	k66, k65, k64, k71, k70, k29, k44, k0, k67	k66, k76, k39, k68, k59	k66, k1, k44

Table 6. Relay Configurations by Channel for PXIe-4163

PXIe-4163 Channel	Verify Voltage	Verify Remote Sense	1 µA and 10 µA	100 µA to 60 mA
CH0	k11, k10, k19, k6, k5, k0, k44	k11, k10, k19, k44, k0, k29, k71, k70	k11, k76, k39, k13, k59	k11, k1, k44
CH1	k13, k12, k19, k8, k7, k0, k44	k13, k12, k19, k73, k72, k44, k0	k13, k78, k39, k11, k54	k13, k3, k44
CH2	k16, k15, k19, k6, k5, k0, k44	k16, k15, k19, k71, k70, k29, k44, k0	k16, k76, k39, k18, k59	k16, k1, k44
CH3	k18, k17, k19, k8, k7, k0, k44	k18, k17, k19, k73, k72, k44, k0	k18, k78, k39, k16, k54	k18, k3, k44
CH4	k21, k20, k19, k6, k5, k0, k44	k21, k20, k19, k71, k70, k29, k44, k0	k21, k76, k39, k23, k59	k21, k1, k44
CH5	k23, k22, k19, k8, k7, k0, k44	k23, k22, k19, k73, k72, k0, k44, k0	k23, k78, k39, k21, k54	k23, k3, k44
CH6	k26, k25, k34, k6, k5, k0, k44	k26, k25, k34, k71, k70, k29, k44, k0	k26, k76, k39, k28, k59	k26, k1, k44
CH7	k28, k27, k34, k8, k7, k0, k44	k28, k27, k34, k73, k72, k44, k0	k28, k78, k39, k26, k54	k28, k3, k44
CH8	k31, k30, k34, k6, k5, k0, k44	k31, k30, k34, k71, k70, k29, k44, k0	k31, k76, k39, k33, k59	k31, k1, k44
CH9	k33, k32, k34, k8, k7, k0, k44	k33, k32, k34, k73, k72, k44, k0	k33, k78, k39, k31, k54	k33, k3, k44
CH10	k36, k35, k34, k6, k5, k0, k44	k36, k35, k34, k71, k70, k29, k44, k0	k36, k76, k39, k38, k59	k36, k1, k44
CH11	k38, k37, k34, k8, k7, k0, k44	k38, k37, k34, k73, k72, k0, k44, k0	k38, k78, k39, k36, k54	k38, k3, k44

PXIe-4163 Channel	Verify Voltage	Verify Remote Sense	1 µA and 10 µA	100 µA to 60 mA
CH12	k41, k40, k49, k6, k5, k0, k44	k41, k40, k49, k71, k70, k44, k0	k41, k76, k39, k43, k59	k41, k1, k44
CH13	k43, k42, k49, k8, k7, k0, k44	k43, k42, k49, k73, k72, k44, k0	k43, k78, k39, k41, k54	k43, k3, k44
CH14	k46, k45, k49, k6,k5, k0, k44	k46, k45, k49, k71, k70, k29, k44, k0	k46, k76, k39, k48, k59	k46, k1, k44
CH15	k48, k47, k49, k8, k7, k0, k44	k48, k47, k49, k73, k72, k44, k0	k48, k78, k39, k46, k54	k48, k3, k44
CH16	k51, k50, k49, k6, k5, k0, k44	k51, k50, k49, k71, k70, k29, k44, k0	k51, k76, k39, k53, k59	k51, k1, k44
CH17	k53, k52, k49, k8, k7, k0, k44	k53, k52, k49, k73, k72, k44, k0	k53, k78, k39, k51, k54	k53, k3, k44
CH18	k56, k55, k64, k6, k5, k0, k44	k56, k55, k64, k71, k70, k29, k44, k0	k56, k76, k39, k58, k59	k56, k1, k44
CH19	k58, k57, k64, k8, k7, k0, k44	k58, k57, k64, k73, k72, k44, k0	k58, k78, k39, k56, k54	k58, k3, k44
CH20	k61, k60, k64, k6, k5, k0, k44	k61, k60, k64, k71, k70, k29, k44, k0	k61, k76, k39, k63, k59	k61, k1, k44
CH21	k63, k62, k64, k8, k7, k0, k44	k63, k62, k64, k73, k72, k44, k0	k63, k78, k39, k61, k54	k63, k3, k44
CH22	k66, k65, k64, k6, k5, k0, k44	k66, k65, k64, k71, k70, k29, k44, k0	k66, k76, k39, k68, k59	k66, k1, k44
CH23	k68, k67, k64, k8, k7, k0, k44	k68, k67, k64, k73, k72, k44, k0	k68, k78, k39, k66, k54	k68, k3, k44

Verification Procedure

This section provides instructions for verifying the PXIe-4162/4163 specifications.

Note The performance verification procedures assume that adequate traceable uncertainties are available for the calibration references.

Self-Calibrating the PXIe-4162/4163

1. Disconnect or disable all connections to the PXIe-4162/4163.

2. Allow the PXIe-4162/4163 30 minutes to warm up.
3. Initialize an NI-DCPower session.
4. Call the self-calibration function.

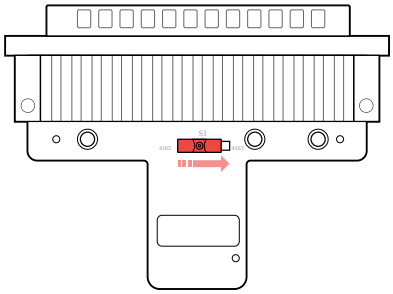
> **Note** After self-calibration completes, maintain the device temperature within ±1 °C of the self-calibration temperature.

5. Close the NI-DCPower session.

Preparing the Output Shorting Assembly

Set the switch on the output shorting assembly to match the SMU under calibration: **PXIe-4162** or **PXIe-4163**.

Figure 4. Output Shorting Assembly Switch



> **Note** For the remainder of the calibration tests, the switch on the output shorting assembly must be set to the SMU under calibration.

Verifying Current Measurement and Output Offset for 0 A Test Points

Verify current offset performance of the PXIe-4162/4163 by sourcing voltage with an open circuit and measuring current in each range.

> **Note** Complete this procedure only after successfully completing all previous verification tests.

Complete the following steps before performing this verification.

1. Disconnect all equipment from the outputs of the PXIe-4162/4163.

2. Set the DUT to output 0 V on the current channel to test.
3. Set the DUT to the current range and limit as specified in the table for the current channel to test.
4. Check the measured output current on the DUT.
5. Repeat steps 2 through 4 for each channel on the PXIe-4162/4163

Refer to the following tables as you complete this verification.

Table 7. 0 A Test Point Current Measurement and Output Verification for PXIe-4162/4163 100 pA Variant

Limit Range	Voltage Level Range	Test Point	As-Found Measurement Test Limit		As-Left Measurement Test Limit	
			Lower	Upper	Lower	Upper
10 µA	24 V	0 V	-0.005 µA	0.005 µA	-0.002 µA	0.002 µA
100 µA	24 V	0 V	-0.05 µA	0.05 µA	-0.02 µA	0.02 µA
1 mA	24 V	0 V	-0.0005 mA	0.0005 mA	-0.0002 mA	0.0002 mA
10 mA	24 V	0 V	-0.005 mA	0.005 mA	-0.002 mA	0.002 mA
50 mA (PXIe-4163 only)	24 V	0 V	-0.025 mA	0.025 mA	-0.01 mA	0.01 mA
100 mA (PXIe-4162 only)	24 V	0 V	-0.05 mA	0.05 mA	-0.02 mA	0.02 mA

Table 8. 0 A Test Point Current Measurement and Output Verification for PXIe-4162/4163 10 pA Variant

Limit Range	Voltage Level Range	Test Point	As-Found Measurement Test Limit		As-Left Measurement Test Limit	
			Lower	Upper	Lower	Upper
1 µA	24 V	0 V	-0.0001 µA	0.0001 µA	-0.000071 µA	0.000071 µA
10 µA	24 V	0 V	-0.001 µA	0.001 µA	-0.000847 µA	0.000847 µA
100 µA	24 V	0 V	-0.01 µA	0.01 µA	-0.0087 µA	0.0087 µA
1 mA	24 V	0 V	-0.0001 mA	0.0001 mA	-0.000089 mA	0.000089 mA
10 mA	24 V	0 V	-0.001 mA	0.001 mA	-0.000884 mA	0.000884 mA

Limit Range	Voltage Level Range	Test Point	As-Found Measurement Test Limit		As-Left Measurement Test Limit	
			Lower	Upper	Lower	Upper
50 mA (PXIe-4163 only)	24 V	0 V	-0.005 mA	0.005 mA	-0.00445 mA	0.00445 mA
100 mA (PXIe-4162 only)	24 V	0 V	-0.01 mA	0.01 mA	-0.0089 mA	0.0089 mA

Verifying Voltage Measurement and Output

Compare a set of voltages measured by a DMM to the voltage test points requested by the PXIe-4162/4163.

Refer to the following table as you complete this verification.

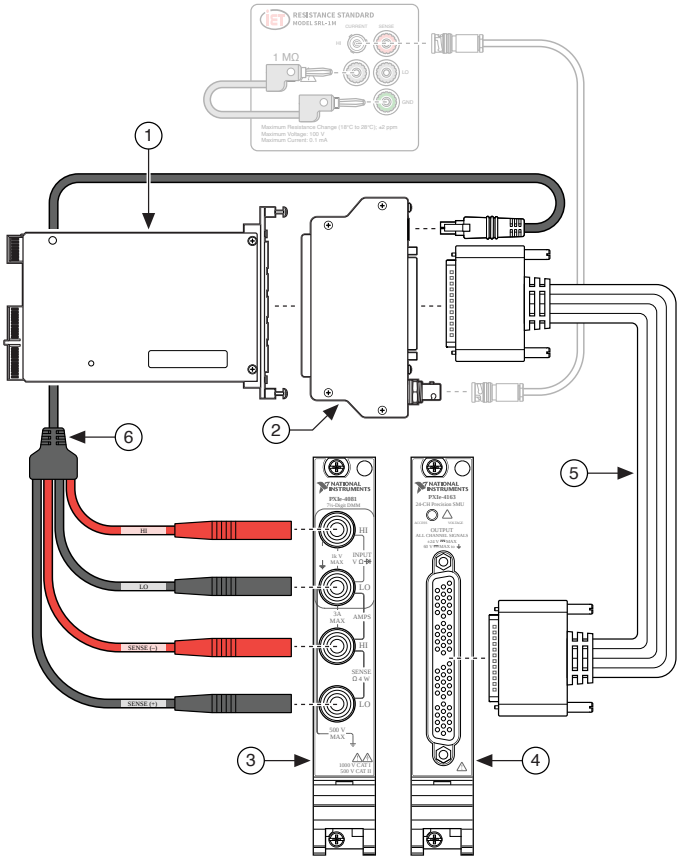
Table 9. PXIe-4162/4163 Voltage Measurement and Output Verification

Level Range	Limit Range and Limit	Test Point	As-Found Measurement Test Limit ±(% of Voltage + Offset	As-Left Measurement Test Limit ±(% of Voltage + Offset
24 V	1 mA	-24V	0.05% + 5 mV	0.02% + 2.4 mV
		0 mV		
		24 V		

1. Measure the internal device temperature. If the device temperature changes ±1 °C from the self-calibration temperature, perform self-calibration.
2. Make the necessary connections for this procedure, as shown in the following figure:

Note The 1 MΩ current shunt, triax cable, and banana plug patch cord are not necessary for this test but may remain connected.

Figure 5. Voltage Verification Connections



- 1. PXI-2520
- 2. CAL-4162/63
- 3. PXIe-4081
- 4. PXIe-4162 or PXIe-4163
- 5. DSUB-DSUB Cable
- 6. DMM Cable

3. Set the niDCPower Output Function property or NIDCPOWER_OUTPUT_FUNCTION attribute to DC Voltage for the PXIe-4162/4163.
4. Ensure all relays are open, then locate the **Verify Voltage** column in the Relay Configurations by Channel for Verification and Adjustment table and close the relays for channel CH0.

5. Refer to the PXIe-4162/4163 Voltage Measurement and Output Verification table to set the first specified level range, limit range, and limit on the PXIe-4162/4163.
6. Set the niDCPower Sense property or NIDCPOWER_ATTR_SENSE attribute to Local.
7. Configure the PXIe-4162/4163 to output the first specified test point in the PXIe-4162/4163 Voltage Measurement and Output Verification table.
8. Compare a DMM voltage measurement to the voltage measurement test limits.
    a. Take a voltage measurement using the DMM.
    b. Calculate the lower and upper voltage measurement test limits using the following formula:
    Voltage Measurement Test Limits = **Test Point** ± (|**Test Point**| * **% of Voltage** + **Offset**)
    c. Verify the DMM measurement falls within the test limits.
9. Repeat step 5 through step 8 for each test point.
10. Repeat step 4 through step 9 for each channel.
11. Ensure all relays are open, then locate the **Verify Voltage** column in the Relay Configurations by Channel for Verification and Adjustment table and close the relays for channel CH0.
12. Refer to the PXIe-4162/4163 Voltage Measurement and Output Verification table to set the first specified level range, limit range, and limit on the PXIe-4162/4163.
13. Set the niDCPower Sense property or NIDCPOWER_ATTR_SENSE attribute to Remote.
14. Configure the PXIe-4162/4163 to output the first specified test point in the PXIe-4162/4163 Voltage Measurement and Output Verification table.
15. Compare a DMM voltage measurement to a remote sense voltage measurement from the PXIe-4162/4163.
    a. Take a voltage measurement using the DMM.
    b. Calculate the lower and upper voltage measurement test limits using the following formula:

Voltage Measurement Test Limits= **DMM Measured Voltage** ± (|**DMM Measured Voltage**| * **% of Voltage** + **Offset**)

c. Take a voltage measurement using the PXIe-4162/4163. Verify the measurement falls within the test limits.

16. Repeat step 12 through step 15 for each test point.
17. Repeat step 11 through step 16 for each channel.

Verifying Voltage Remote Sense

Use the PXIe-4162/4163 in constant current mode with a test circuit to simulate the voltage drop between the device and a load.

Refer to the following table as you complete this verification.

Table 10. Remote Sense Voltage Output Verification

Level Range	Limit Range and Limit	Test Point	Load	As-Found Measurement Test Limit	As-Left Measurement Test Limit
1 mA	24 V	1 mA	3 kΩ	±5 mV	±2.4 mV

1. Measure the internal device temperature. If the device temperature changes ±1 °C from the self-calibration temperature, perform self-calibration.
2. Set the niDCPower Output Function property or NIDCPOWER_OUTPUT_FUNCTION attribute to DC Current for the PXIe-4162/4163.
3. Ensure all relays are open, then locate the **Verify Remote Sense** column in the Relay Configurations by Channel for Verification and Adjustment table and close the relays for channel CH0.
4. Set the niDCPower Sense property or NIDCPOWER_ATTR_SENSE attribute to Remote.
5. Refer to the Remote Sense Voltage Output Verification table to set the first specified level range, limit range, and limit on the PXIe-4162/4163.
6. Set the level on the PXIe-4162/4163 to the specified test point and enable the output.
7. Take a voltage measurement using the PXIe-4162/4163.

8. Record the voltage from the previous step.
9. Verify that the recorded value falls within the test limits.
10. Repeat step 3 through step 9 for each channel.

Verifying 1 µA and 10 µA Current Measurement and Output

Compare a set of measured currents reported by the PXIe-4162/4163 to the currents measured by a voltmeter and current shunt.

Note Complete this procedure only after successfully completing all previous verification tests.

Refer to the following table as you complete this verification.

Table 11. 1 µA and 10 µA Current Measurement and Output Verification for PXIe-4162/4163 10 pA Variant

Level Range	Limit Range and Limit	Shunt	Test Point	As-Found Measurement Test Limit (µA)		As-Left Measurement Test Limit (µA)	
				Lower	Upper	Lower	Upper
1 µA	24 V	1 MΩ	-1 µA	-1.0011	-0.9989	-1.000371	-0.999629
			1 µA	0.9989	1.0011	0.999629	1.000371
10 µA	24 V	1 MΩ	-10 µA	-10.011	-9.989	-10.008347	-9.991653
			10 µA	9.989	10.011	9.991653	10.008347

Table 12. 10 µA Current Measurement and Output Verification for PXIe-4162/4163 100 pA Variant

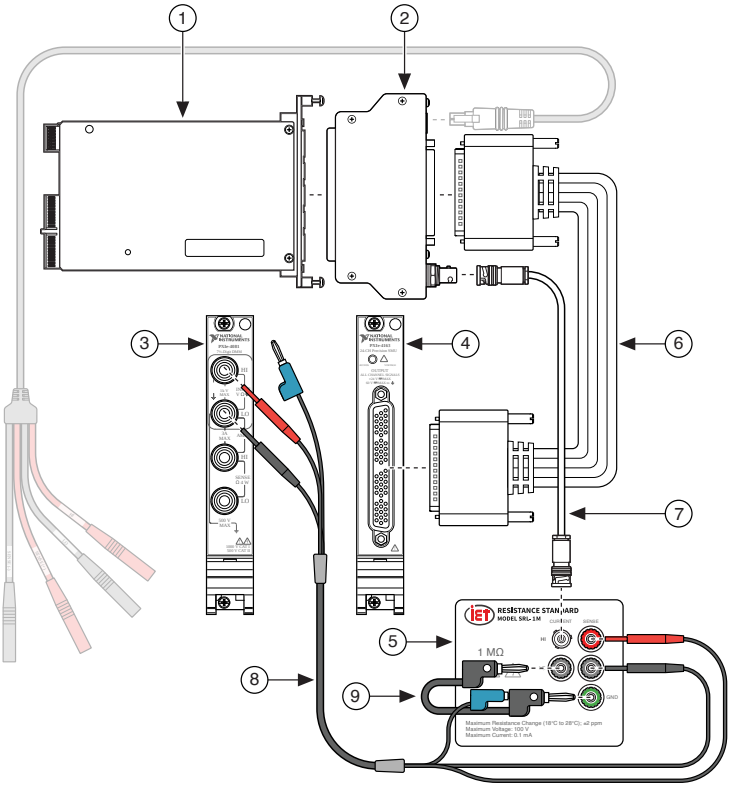
Level Range	Limit Range and Limit	Shunt	Test Point	As-Found Measurement Test Limit (µA)		As-Left Measurement Test Limit (µA)	
				Lower	Upper	Lower	Upper
10 µA	24 V	1 MΩ	-10 µA	-10.015	-9.985	-10.0095	-9.9905
			10 µA	9.985	10.015	9.9905	10.0095

1. Measure the internal device temperature. If the device temperature changes ±1 °C from the self-calibration temperature, perform self-calibration.

2. Make the necessary connections for this procedure, as shown in the following figure:

> **Note** The DMM cable is not necessary for this test but may remain connected to the CAL-4162/63.

Figure 6. 1 µA and 10 µA Current Verification Connections



- 1. PXI-2520
- 2. CAL-4162/63
- 3. PXIe-4081
- 4. PXIe-4162 or PXIe-4163
- 5. 1 MΩ Current Shunt
- 6. DSUB-DSUB Cable
- 7. Triax Cable
- 8. Low Thermal Test Leads
- 9. Banana Plug Patch Cord

3. Set the niDCPower Output Function property or NIDCPOWER_OUTPUT_FUNCTION attribute to DC Current for the PXIe-4162/4163.
4. Ensure all relays are open, then locate the **1 µA and 10 µA** column in the Relay Configurations by Channel for Verification and Adjustment table and close the relays for channel CH0.
5. If you are calibrating the PXIe-4163, configure the adjacent channel to source a voltage equal to the nominal voltage of the channel under test, with a 10 mA limit.
   Calculate the nominal voltage as
   (current test point (A) * shunt resistance (Ω)).
   For the verification test, the nominal voltages will be -10 V and 10 V for the 10 µA range, and -1 V and 1 V for the 1 µA range.

   Note "Adjacent channel" refers to paired even/odd channels. For example, the adjacent channel for CH0 is CH1, and the adjacent channel for CH1 is CH0.

6. Refer to the 1µ and 10 µA Current Measurement and Output Verification table to set the first specified level range, limit range, and limit on the PXIe-4162/4163.
7. Set the level on the PXIe-4162/4163 to the first specified test point.
8. Calculate the current through the shunt by completing the following steps.
   a. Configure the DMM for voltage measurements and >10 GΩ input impedance.
   b. Take a voltage measurement across the shunt using the DMM.
   c. Divide the voltage measurement by the calibrated value of the shunt.
   d. Record the calculated value as **DMM Measured Current**.
9. Verify that the calculated **DMM Measured Current** value falls within the test limits listed in the 1 µA and 10 µA Current Measurement and Output Verification table.
10. Repeat step 6 through step 9 for each test point.
11. Repeat step 4 through step 10 for each channel.

Verifying 100 µA to 100 mA Current Measurement and Output

Compare a set of currents measured by a DMM to the current test points requested by the PXIe-4162/4163.

Note Complete this procedure only after successfully completing all previous verification procedures.

Refer to the following table as you complete this verification.

Note Verify level ranges in the order listed in the table.

Table 13. 100 µA to 100 mA Current Measurement and Output Verification for the PXIe-4162/4163 10 pA Variant

Level Range	Limit Range and Limit	Test Point	As-Found Measurement Test Limit		As-Left Measurement Test Limit	
			Lower	Upper	Lower	Upper
100 µA	24 V	-100 µA	-100.11 µA	-99.89 µA	-100.0837 µA	-99.9163 µA
		100 µA	99.89 µA	100.11 µA	99.9163 µA	100.0837 µA
1 mA	24 V	-1 mA	-1.0011 mA	-0.9989 mA	-1.000839 mA	-0.999161 mA
		1 mA	0.9989 mA	1.0011 mA	0.999161 mA	1.000839 mA
10 mA	24 V	-10 mA	-10.011 mA	-9.989 mA	-10.008384 mA	-9.991616 mA
		10 mA	9.989 mA	10.011 mA	9.991616 mA	10.008384 mA
50 mA (PXIe-4163 only)	24 V	-50 mA	-50.055 mA	-49.945 mA	-50.04195 mA	-49.95805 mA
		50 mA	49.945 mA	50.055 mA	49.95805 mA	50.04195 mA
100 mA (PXIe-4162 only)	24 V	-100 mA	-100.11 mA	-99.89 mA	-100.0839 mA	-99.9161 mA
		100 mA	99.89 mA	100.11 mA	99.9161 mA	100.0839 mA

Table 14. 100 µA to 100 mA Current Measurement and Output Verification for the PXIe-4162/4163 100 pA Variant

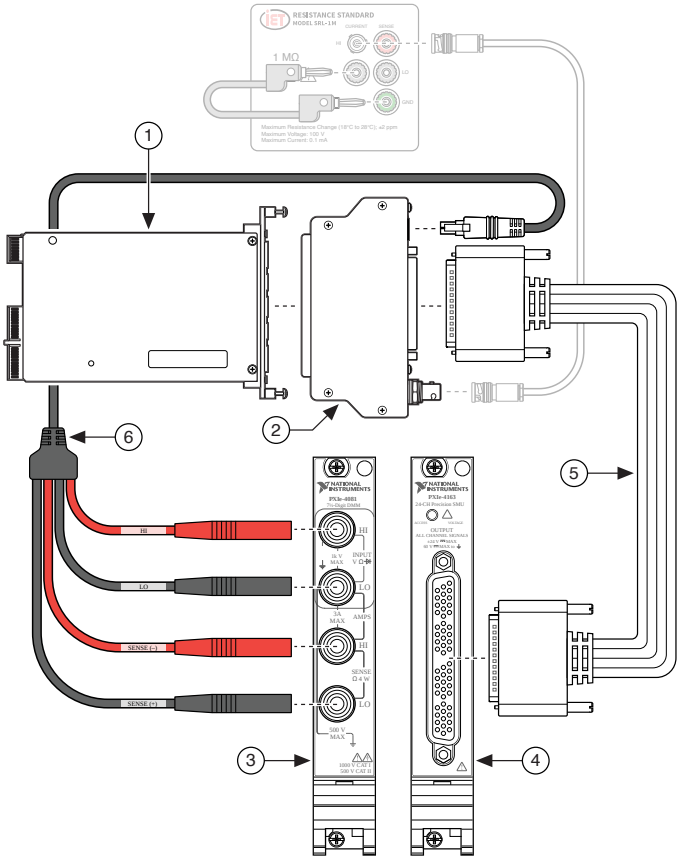
Level Range	Limit Range and Limit	Test Point	As-Found Measurement Test Limit		As-Left Measurement Test Limit	
			Lower	Upper	Lower	Upper
100 µA	24 V	-100 µA	-100.15 µA	-99.85 µA	-100.10 µA	-99.90 µA

Level Range	Limit Range and Limit	Test Point	As-Found Measurement Test Limit		As-Left Measurement Test Limit	
			Lower	Upper	Lower	Upper
		100 µA	99.85 µA	100.15 µA	99.90 µA	100.10 µA
1 mA	24 V	-1 mA	-1.0015 mA	-0.9985 mA	-1.00095 mA	-0.99905 mA
		1 mA	0.9985 mA	1.0015 mA	0.99905 mA	1.00095 mA
10 mA	24 V	-10 mA	-10.015 mA	-9.985 mA	-10.0095 mA	-9.9905 mA
		10 mA	9.985 mA	10.015 mA	9.9905 mA	10.0095 mA
50 mA (PXIe-4163 only)	24 V	-50 mA	-50.075 mA	-49.925 mA	-50.0475 mA	-49.9525 mA
		50 mA	49.925 mA	50.075 mA	49.9525 mA	50.0475 mA
100 mA (PXIe-4162 only)	24 V	- 100 mA	-100.15 mA	-99.85 mA	-100.095 mA	-99.905 mA
		100 mA	99.85 mA	100.15 mA	99.905 mA	100.095 mA

1. Measure the internal device temperature. If the device temperature changes ±1 °C from the self-calibration temperature, perform self-calibration.
2. Make the necessary connections for this procedure, as shown in the following figure:

Note The 1 MΩ current shunt, triax cable, and banana plug patch cord are not necessary for this test but may remain connected.

Figure 7. 100 µA to 100 mA Current Verification Connections



- 1. PXI-2520
- 2. CAL-4162/63
- 3. PXIe-4081
- 4. PXIe-4162 or PXIe-4163
- 5. DSUB-DSUB Cable
- 6. DMM Cable

3. Set the niDCPower Output Function property or NIDCPOWER_OUTPUT_FUNCTION attribute to DC Current for the PXIe-4162/4163.
4. Ensure all relays are open, then locate the **100 µA to 100 mA** column in the Relay Configurations by Channel for Verification and Adjustment Tests table and close the relays for channel CH0.

5. Refer to the 100 µA to 100 mA Current Measurement and Output Verification table to set the first specified level range, limit range, and limit on the PXIe-4162/4163.
6. Set the level on the PXIe-4162/4163 to the first specified test point.
7. Compare a DMM current measurement to the current measurement test limits.
    a. Take a current measurement using the DMM.
    b. Verify the DMM measurement falls within the test limits in the 100 µA to 100 mA Current Measurement and Output Verification table.
8. Repeat step 5 through step 7 for each test point.
9. Repeat step 4 through step 8 for each channel.

Verifying Load Regulation (Functional Test)

Note Although load regulation is listed as a typical specification for the PXIe-4162/4163, verification is required. If the PXIe-4162/4163 fails the load regulation verification procedure, discontinue use of the device, and contact an authorized NI service representative to request a Return Material Authorization (RMA).

Refer to the following table as you complete this verification.

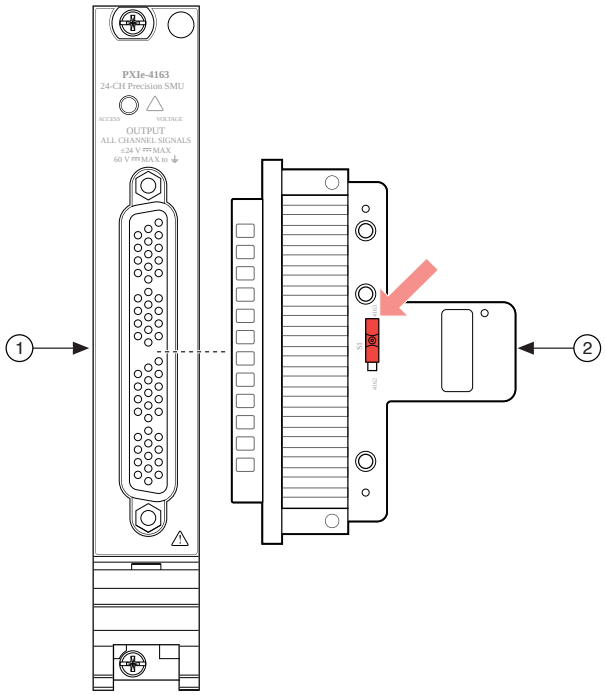
Table 15. Load Regulation Verification

Level Range	Limit Range and Limit	Test Point	As-Found/As-Left Limit
10 mA	24 V	0 mA	±1.5 mV
		10 mA	

1. Measure the internal device temperature. If the device temperature changes ±1 °C from the self-calibration temperature, perform self-calibration.
2. Set the niDCPower Output Function property or NIDCPOWER_OUTPUT_FUNCTION attribute to DC Current for the PXIe-4162/4163.

3. Set the niDCPower Sense property or NIDCPOWER_ATTR_SENSE attribute to Local.
4. Disconnect all equipment from the output of the PXIe-4162/4163 and insert the output shorting assembly onto the front panel connector as shown in the following figure.

Figure 8. Load Regulation Verification Connection



- 1. PXIe-4162 or PXIe-4163
- 2. Output Shorting Assembly

5. Ensure the switch on the output shorting assembly is set to match the SMU under calibration: **PXIe-4162** or **PXIe-4163**.
6. Set all channels to source 0 A in the 10 mA range with a 24 V limit.
7. Set the channel under test on the PXIe-4162/4163 to the level range, limit range, and limit specified in the Load Regulation Verification table.
8. Set the specified level range, limit range, and limit on the PXIe-4162/4163.
9. Configure the PXIe-4162/4163 to output the first specified test point in the Load Regulation Verification table.

10. Take a voltage measurement using the PXIe-4162/4163. Record the value as **V1**.
11. Repeat step 9 and step 10 for the other test point specified in the level range. Record the value as **V2**
12. Calculate the load regulation error using the following formula, and then record the value.
    Load Regulation Error = V2 - V1
13. Verify that the recorded value falls within the test limits in the **Load Regulation Verification** table.
14. Repeat step 7 through step 13 for each channel.

Adjustment Procedure

This section provides instructions for adjusting the PXIe-4162/4163 to meet published specifications.

Adjusted Specifications

Adjustment corrects the following specifications for the PXIe-4162/4163:

- Voltage measurement/output accuracy
- Current measurement/output accuracy

Following the adjustment procedures automatically updates the calibration date and temperature on the device.

Note You do not need to separately adjust both measurement and output. The architecture of the PXIe-4162/4163 ensures that if measurement is accurate, then output is as well, and vice versa.

Initiating the Adjustment Session

Initiate an external calibration session (a specific type of NI-DCPower session) by calling the niDCPower Initialize External Calibration VI or niDCPower_InitExtCal function.

Note Keep the calibration session open until you complete all adjustment procedures. Complete all adjustment procedures in the

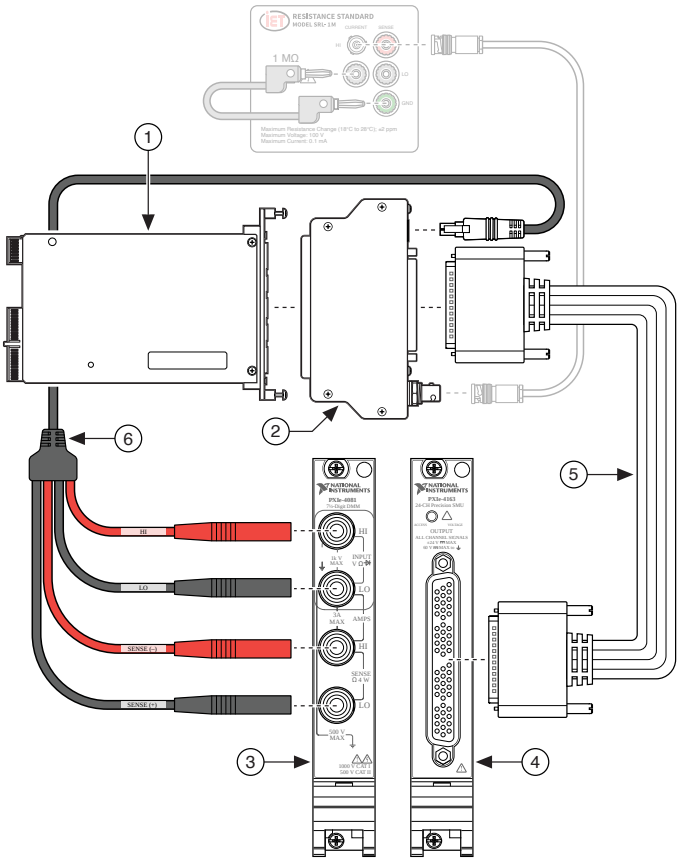
specified order. Do not self-calibrate the device except as specified in a procedure.

Connecting Equipment for Resistor Reference and Voltage Adjustment

Make the necessary connections for this procedure, as shown in the following figure:

Note The 1 MΩ current shunt, triax cable, and banana plug patch cord are not necessary for this test but may remain connected.

Figure 9. Resistor Reference and Voltage Adjustment Connections



- 1. PXI-2520
- 2. CAL-4162/63
- 3. PXIe-4081

- 4. PXIe-4162 or PXIe-4163
- 5. DSUB-DSUB Cable
- 6. DMM Cable

Adjusting Resistor Reference

Compare resistance measurements and a ground measurement from a DMM.

1. Use the niDCPower Connect Internal Reference VI or niDCPower_ConnectInternalReference function to set internal reference to ground.
2. Configure the DMM to take 2-Wire resistance measurements in the 100 kΩ range.
3. Close relays k44 and k14. Ensure all other relays are open.
4. Take a 2-Wire resistance measurement using the DMM to determine the ground reference measurement (R_{GND}).
5. Use the niDCPower Connect Internal Reference VI or niDCPower_ConnectInternalReference function to set internal reference to 100 kΩ.
6. Take a 2-Wire resistance measurement using the DMM to determine the resistance reference measurement (R_{REF}).
7. Use the niDCPower Connect Internal Reference VI or niDCPower_ConnectInternalReference function to set internal reference to none.
8. Configure the DMM to take 2-Wire resistance measurements in the 10 MΩ range.
9. Take a 2-Wire resistance measurement using the DMM to determine the resistance measurement in the 10 MΩ range ($R_{10\ M\ \Omega}$).
10. Calculate the new value for resistor reference (R) using the following formula:

    $$R = \left(\frac{1}{\left(\frac{1}{R_{REF}} - \frac{1}{R_{10M\Omega}}\right)}\right) - R_{GND}$$

    where R_{GND} is the resistance measured in step 3, R_{REF} is the resistance measured in step 5, and $R_{10\ M\Omega}$ is the resistance measured in step 8.

11. To program the new internal reference value to the PXIe-4162/4163, call the niDCPower Adjust Internal Reference VI or niDCPower_AdjustInternalReference function with the internal reference set to 100 kΩ and the adjusted internal reference value set to the new value for the resistor reference (R).

Adjusting Voltage Measurement and Output

Compare a voltage measurement and a ground measurement from a DMM.

1. Use the niDCPower Connect Internal Reference VI or niDCPower_ConnectInternalReference function to set internal reference to ground.
2. Configure the DMM to take voltage measurements in the smallest range.
3. Take a voltage measurement using the DMM to determine the ground reference measurement (V_{GND}).
4. Use the niDCPower Connect Internal Reference VI or niDCPower_ConnectInternalReference function to set internal reference to 5 V.
5. Configure the DMM to take voltage measurements in the 10 V range.
6. Take a voltage measurement using the DMM to determine the voltage reference measurement (V_{REF}).
7. Use the niDCPower Connect Internal Reference VI or niDCPower_ConnectInternalReference function to set internal reference to none.
8. Calculate the new value for voltage reference (V) using the following formula:
   $$V = V_{REF} * (1 + \frac{20\ k\Omega}{R_{10M\Omega}}) - V_{GND}$$
   where V_{GND} is the voltage measured in step 3, V_{REF} is the voltage measured in step 6, and $R_{10\ M\ \Omega}$ is the resistance measured in step 8 of the Adjusting Resistor Reference section.
9. To program the new internal reference value to the PXIe-4162/4163, call the niDCPower Adjust Internal Reference VI or niDCPower_AdjustInternalReference function with the internal reference set

to 5 V and the adjusted internal reference value set to the new value for the voltage reference (V).

Self-Calibrating the PXIe-4162/4163

1. Disconnect or disable all connections to the PXIe-4162/4163.
2. Call the self-calibration function with all channels.

Adjusting 1 µA and 10 µA Current Measurement and Output

Compare a set of currents measured by an external DMM and current shunt to the current test points requested by the PXIe-4162/4163.

Refer to the following table as you complete this adjustment.

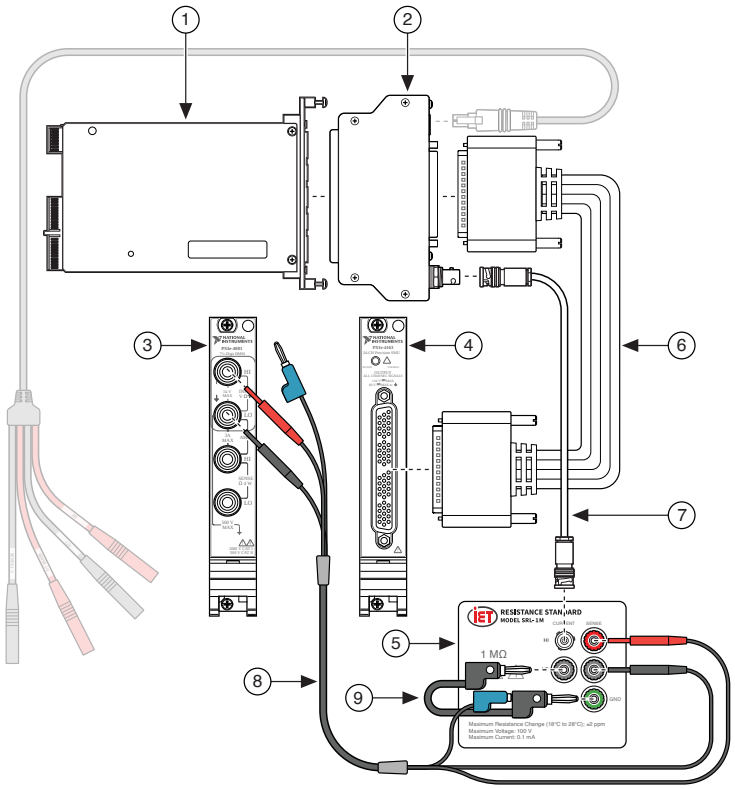
Table 16. 1 µA and 10 µA Current Measurement and Output Adjustment

Level Range	Limit Range and Limit	Test Point
1 µA (10 pA variant only)	24 V	-0.9 µA
		0.9 µA
10 µA	24 V	-9 µA
		9 µA

1. Make the necessary connections for this procedure, as shown in the following figure:

Note The DMM cable is not necessary for this test but may remain connected to the CAL-4162/63.

Figure 10. 1 µA and 10 µA Current Adjustment Connections



- 1. PXI-2520
- 2. CAL-4162/63
- 3. PXIe-4081
- 4. PXIe-4162 or PXIe-4163
- 5. 1 MΩ Current Shunt
- 6. DSUB-DSUB Cable
- 7. Triax Cable
- 8. Low Thermal Test Leads
- 9. Banana Plug Patch Cord

2. Set the first specified level range, limit range, and limit on the PXIe-4162/4163.
3. Configure the DMM to measure current in the specified level range.
4. Ensure all relays are open, then locate the **1 µA and 10 µA** column in the Relay Configurations by Channel for Verification and Adjustment table and close the relays for channel CH0.

5. If you are calibrating the PXIe-4163, configure the adjacent channel to source a voltage equal to the nominal voltage of the channel under test, with a 10 mA limit.
   Calculate the nominal voltage as
   (current test point (A) * shunt resistance (Ω)).
   For the adjustment test, the nominal voltages will be -0.9 V and 0.9 V for the 1 µA variant and -9 V and 9 V for the 10 µA variant.

   > **Note** "Adjacent channel" refers to paired even/odd channels. For example, the adjacent channel for CH0 is CH1, and the adjacent channel for CH1 is CH0.

6. Refer to the 1 µA and 10 µA Current Measurement and Output Adjustment table to set the level on the PXIe-4162/4163 to the first specified test point.
7. Allow one second to settle.
8. Take a voltage measurement using the DMM and convert to current using the shunt resistance value. Complete the following steps to caluculate this value.
   a. Configure the DMM for voltage measurements and >10 GΩ input impedance.
   b. Take a voltage measurement across the shunt using the DMM.
   c. Divide the voltage measurement by the calibrated value of the shunt.
   d. Record the calculated value as **DMM Measured Current**.
9. Store the value from the previous step to use as an input for the niDCPower Cal Adjust VI or niDCPower_CalAdjustCurrentLimit function called in the following steps.
10. Repeat step 6 through step 9 for each test point.
11. Update the output calibration constants by configuring and calling the niDCPower Cal Adjust Current Limit VI or niDCPower_CalAdjustCurrentLimit function.
    a. Input the DMM measurements as the measured outputs.
    b. Input the test points as the requested outputs.
    c. Input the specified level range as the range.

12. Repeat step 4 through step 11 for each channel.

Adjusting 100 µA to 60 mA Current Measurement and Output

Compare a set of currents measured by an external DMM to the current test points requested by the PXIe-4162/4163.

Refer to the following table as you complete this adjustment.

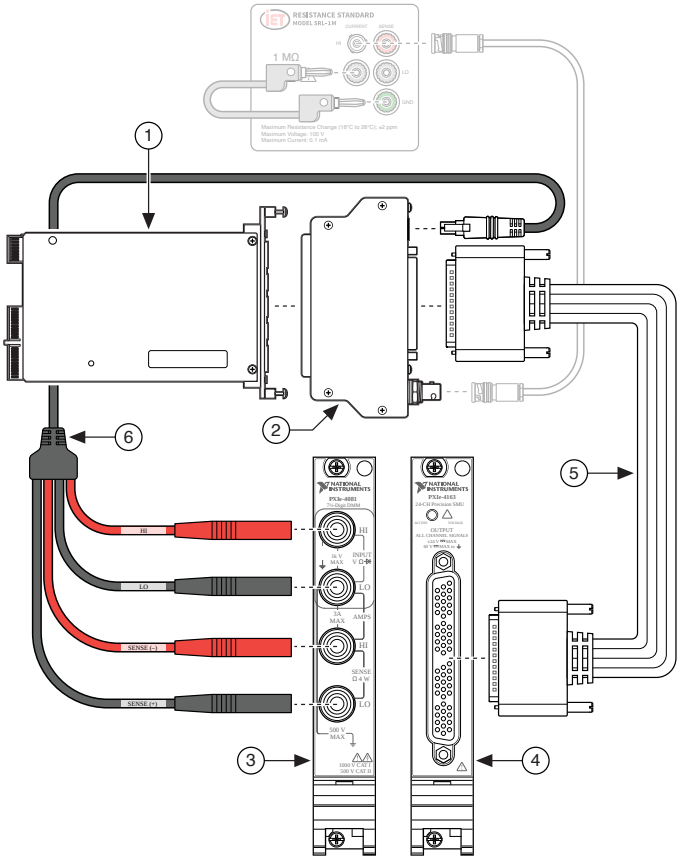
Table 17. 100 µA to 100 mA Current Measurement and Output Adjustment

Level Range	Limit Range and Limit	Test Point
100 µA	24 V	-90 µA
		90 µA
1 mA	24 V	-0.9 mA
		0.9 mA
10 mA	24 V	-9 mA
		9 mA
30 mA (PXIe-4163 only)	24 V	-27 mA
		27 mA
60 mA (PXIe-4162 only)	24 V	-54 mA
		54 mA

1. Make the necessary connections for this procedure, as shown in the following figure:

Note The 1 MΩ current shunt, triax cable, and banana plug patch cord are not necessary for this test but may remain connected.

Figure 11. 100 µA to 60 mA Current Adjustment Connections



- 1. PXI-2520
- 2. CAL-4162/63
- 3. PXIe-4081
- 4. PXIe-4162 or PXIe-4163
- 5. DSUB-DSUB Cable
- 6. DMM Cable

2. Set the first specified level range, limit range, and limit on the PXIe-4162/4163.
3. Configure the DMM to measure current in the specified level range.
4. Ensure all relays are open, then locate the **100 µA to 60 mA** column in the Relay Configurations by Channel for Verification and Adjustment table and close the relays for channel CH0.
5. Refer to the 100 µA to 60 mA Current Measurement and Output Adjustment table to set the level on the PXIe-4162/4163 to the first specified test point.

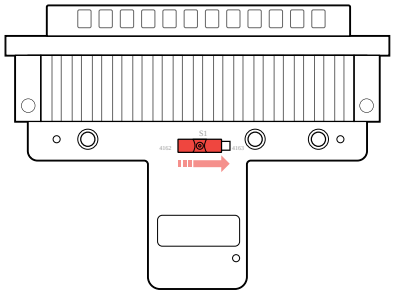
6. Allow one second to settle.
7. Take a current measurement using the DMM.
8. Store the value from step 7 to use as an input for the niDCPower Cal Adjust VI or niDCPower_CalAdjustCurrentLimit function called in the following steps.
9. Repeat step 5 through step 8 for each test point.
10. Update the output calibration constants by configuring and calling the niDCPower Cal Adjust Current Limit VI or niDCPower_CalAdjustCurrentLimit function.
    a. Input the DMM measurements as the measured outputs.
    b. Input the test points as the requested outputs.
    c. Input the specified level range as the range.
11. Repeat step 10 for each level range.
12. Repeat step 4 through step 11 for each channel.

Self-Calibrating the PXIe-4162/4163

1. Disconnect or disable all connections to the PXIe-4162/4163.
2. Call the self-calibration function with all channels.

Adjusting Residual Voltage Offset

1. Disconnect all equipment from the output of the PXIe-4162/4163 and insert the output shorting assembly onto the front panel connector.
2. Ensure the switch on the output shorting assembly is set to match the SMU under calibration: **PXIe-4162** or **PXIe-4163**.



3. With the Output HI, Sense HI, Output LO, and Sense LO terminals shorted, eliminate residual voltage offset at 0 V by configuring and calling the niDCPower Cal Adjust Residual Voltage Offset VI or niDCPower_CalAdjustResidualVoltageOffset function.
4. Repeat step 3 for each channel on the PXIe-4162/4163.

Adjusting Residual Current Offset

1. Disconnect all equipment from the output of the PXIe-4162/4163.
2. With terminals open, eliminate current offset at 0 A by configuring and calling the niDCPower Cal Adjust Residual Current Offset VI or niDCPower_CalAdjustResidualCurrentOffset function.
3. Repeat step 2 for each channel on the PXIe-4162/4163.

Closing the Adjustment Session

Close the session and commit the new constants to hardware by calling the niDCPower Close External Calibration VI or niDCPower_CloseExtCal function and specifying Commit as the **calibration close action**.

Alternative to Performing Adjustment Procedures

If your device passes all as-found limits in the verification procedures successfully and you want to skip updating the calibration constants, you can update solely the calibration date by completing the following steps.

Note NI recommends following all adjustment procedures to update the calibration constants and renew the device calibration interval.

1. Call either the niDCPower Initialize External Calibration VI or the niDCPower_InitExtCal function.
2. Call either the niDCPower Close External Calibration VI or the niDCPower_CloseExtCal function, specifying Commit in **calibration close action**.

Reverification

Note If any test fails reverification after performing an adjustment, verify that you have met the test conditions before returning your PXIe-4162/4163 to NI. Refer to the NI Services section for information about support resources or service requests.

1. After completing the adjustment procedure, wait a minimum of five minutes for the internal device temperature to stabilize.
2. Repeat the Verification Procedure to determine the as-left status of the PXIe-4162/4163.

Setting the Calibration Due Date

Use either Measurement & Automation Explorer (MAX) or NI System Configuration API to set or clear a calibration due date for your device. NI suggests a minimum calibration due date of the date of external calibration plus the external calibration interval for the device.

1. In MAX, navigate to the External Calibration section of the Settings tab to update the **Calibration Due Date** entry.
2. Alternatively, use the Update Calibration VI in the NI System Configuration API to set the calibration due date for either a specific date or an interval in months.

Revision History

Part Number	Edition Date	Section	Changes
376739B-01	December 2020	Test Equipment	Replaced individual equipment with the Calibration Kit.
		Switch Fixture Assembly Maintenance	Added switch fixture assembly performance test.

Part Number	Edition Date	Section	Changes
		Test Conditions	Removed obsolete statement: "Do not use the NI DCPower Soft Front Panel (SFP) to request test points for any adjustment functions because you cannot set aperture time using the SFP."
		Self-Calibrating the PXIe-4162/4163	Added **step 6**.
		Verification Procedure and Adjustment Procedure	Updated connection diagrams.
		Verifying Voltage Remote Sense	Removed connection diagram.
376739C-01	August 2023	Required Software	Updated required NI-DCPower version to 22.5.
		Relay Configurations by Channel for Verification and Adjustment Procedures	Added a column for 1µA variant relay configurations.
		Verifying 10µA Current Measurement and Output	Updated title to reflect new 1µA variant and added new values.
		Adjusting 10µA Current Measurement and Output	Updated title to reflect new 1µA variant and added new values.
		Verifying Current Measurement and Output Offset for 0 µA Test Points	Methodology for verifying 0 A test points changed.

Part Number	Edition Date	Section	Changes
		Verifying Current Measurement and Output Offset for 0 µA Test Points	Updated values.
		Adjusting 1µA to 10 µA Current Measurement and Output	Updated title to reflect new 1µA variant and added new values.
		CAL-4162/63 Switch Fixture Assembly Performance Test	Updated configuration relay numbers in step 5a (k49 to k64) and 7a (k7 to k71).
		Relay Configurations by Channel for Verification and Adjustment Procedures	Created separate table for PXIe-4162 and PXIe-4163. Updated multiple relay configurations.
		Misc.	Changed 30 mA to 50 mA, and 60 mA to 100 mA throughout the document.

NI Services

Visit ni.com/support to find support resources including documentation, downloads, and troubleshooting and application development self-help such as tutorials and examples.

Visit ni.com/services to learn about NI service offerings such as calibration options, repair, and replacement.

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

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