CALIBRATION PROCEDURE
NI 9219

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ni.com/manuals

This document contains information for calibrating the National Instruments 9219. For more information on calibration, visit ni.com/calibration.

Contents

Software Requirements

Calibrating the NI 9219 requires installing NI-DAQmx 9.3 or later on the calibration system. You can download NI-DAQmx from ni.com/downloads. NI-DAQmx supports a number of programming languages, including LabVIEW, LabWindows/CVI, C/C++, C#, and Visual Basic .NET. When you install NI-DAQmx you only need to install support for the ADE that you intend to use.

Documentation Requirements

For information about NI-DAQmx and the NI 9219, you can consult the following documents:

- *NI 9219 Operating Instructions and Specifications*—This document includes detailed information about the NI 9219 and provides the published specification values for the NI 9219. Visit `ni.com/info` and enter `cseriesdoc` for the most recent *NI 9219 Operating Instructions and Specifications*.

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

- *DAQ Getting Started* guides—These guides provide instructions for installing and configuring NI-DAQ devices.
- *NI DAQmx Help*—This help file contains general information about measurement concepts, key NI-DAQmx concepts, and common applications that apply to all programming environments.
- *NI-DAQmx C Reference Help*—This help file contains C reference and general information about measurement concepts.

Calibration Interval

National Instruments recommends a calibration interval of one year for the NI 9219. You should adjust the recommended calibration interval based on the measurement accuracy demands of your application.

Test Equipment

National Instruments recommends that you use the equipment in Table 1 for calibrating the NI 9219.

Table 1. Recommended Equipment

Equipment	Recommended Model	Parameter Measured	Minimum Requirements
Source	Fluke 5700A	Voltage Accuracy, Thermocouple Accuracy	If this instrument is unavailable, use a device that can source voltages as high as 48 V and meets the following specifications: Noise: ≤5 mV_{pkpk} 0.1 Hz–10 Hz at 48 V ≤500 μV_{pkpk} 0.1 Hz–10 Hz at 12 V ≤500 μV_{pkpk} 0.1 Hz–10 Hz at 3.2 V ≤50 μV_{pkpk} 0.1 Hz–10 Hz at 0.8 V ≤5 μV_{pkpk} 0.1 Hz–10 Hz at 0.1 V
		Current Accuracy	If this instrument is unavailable, use a current source with noise ≤500 nA_{pkpk} 0.1 Hz–10 Hz.
		Half-Bridge Accuracy, Full-Bridge Accuracy	If this instrument is unavailable, use a voltage source with noise ≤500 μV_{pkpk} 0.1 Hz–10 Hz at 3 V.

Table 1. Recommended Equipment (Continued)

Equipment	Recommended Model	Parameter Measured	Minimum Requirements
DMM (x2)	NI 4071	Voltage Accuracy, Thermocouple Accuracy	If this instrument is unavailable, use a DMM with ≤30 ppm uncertainty for voltage, and ≤0.8 μV offset error in smallest range.
		Resistance Accuracy, RTD Accuracy, Quarter-Bridge Accuracy	If this instrument is unavailable, use a DMM with ≤60 ppm uncertainty for resistance, and ≤0.01 Ω offset error in smallest range.
		Half-Bridge Accuracy, Full-Bridge Accuracy	**(DMM1)** If this instrument is unavailable, use one DMM with ≤15 ppm uncertainty for voltages under 3 V.
			(DMM2) If this instrument is unavailable, use a second DMM with ≤20 ppm for uncertainty voltages under 1 V and ≤0.8 μV offset error in smallest range.
		Current Accuracy	≤270 ppm uncertainty for current, ≤2 nA offset error in smallest range
Discrete Resistors	—	RTD Accuracy	TCR: ≤10 ppm/°C Resistor values: 4020 Ω ± 1%, 402 Ω ± 1%, 20 Ω ± 5%, 4.99 Ω ± 5%
		Resistance Accuracy	TCR: ≤10 ppm/°C Resistor values: 8450 Ω ± 1%, 845 Ω ± 1%, 20 Ω ± 5%
		Quarter-Bridge Accuracy	TCR: ≤10 ppm/°C Resistor values: 309 Ω ± 1%, 121 Ω ± 1%, 4.99 Ω ± 5%
		Half-Bridge Accuracy	TCR: ≤10 ppm/°C Resistor values: 1 kΩ ± 1% (x2)
		Full-Bridge Accuracy	TCR: ≤10 ppm/°C Resistor values: 10 kΩ ± 1% (x2)
cDAQ Chassis	NI cDAQ-9178	All	—
Connection Accessory	NI 9972	All	—

Test Conditions

The following setup and environmental conditions are required to ensure the NI 9219 meets published specifications.

- Keep connections to the device as short as possible. Long cables and wires act as antennae, picking up extra noise that can affect measurements.
- Verify that all connections to the device are secure.
- Use shielded copper wire for all cable connections to the device. Use twisted-pairs wire to eliminate noise and thermal offsets.
- Maintain an ambient temperature of 23 ±5 °C. The device temperature will be greater than the ambient temperature.
- Keep relative humidity below 80%.
- Allow a warm-up time of at least 10 minutes to ensure that the NI 9219 measurement circuitry is at a stable operating temperature.

Calibration Procedures

The calibration process includes the following steps:

1. *Initial Setup*—Install the device and configure it in Measurement & Automation Explorer (MAX).
2. *Verification*—Verify the existing operation of the device. This step confirms whether the device is operating within the published specifications prior to adjustment.
3. *Adjustment*—Adjust the calibration constants of the device. The adjustment procedure automatically updates the calibration date and temperature in the EEPROM.
4. *Reverification*—Repeat the verification procedure to ensure that the device is operating within the published specifications after adjustment.

Initial Setup

Complete the following steps to set up the NI 9219.

1. Install the NI-DAQmx driver software.
2. Install the NI 9219 in slot 8 of the NI cDAQ-9178 chassis. Leave slots 1 through 7 of the NI cDAQ-9178 chassis empty.
3. Launch Measurement & Automation Explorer (MAX).
4. Right-click the device name and select **Self-Test** to ensure that the device is working properly.

Verification

This section provides instructions for verifying the NI 9219 specifications. Refer to Figure 1, Table 2, and Table 3 for the channel assignments, signal names, and terminal assignments of the NI 9219.

Caution The analog inputs on the NI 9219 are not grounded (floating). Ensure that a single point in the test system is connected to ground to prevent the entire system from floating.

Note The test limits listed in Tables 5, 7, 9, 11, 13, 15, 17, 19, 21, are derived using the values in Table 24.

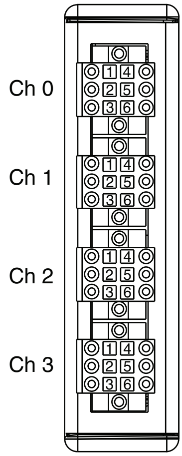


Figure 1. NI 9219 Channel and Terminal Assignments

Table 2. NI 9219 Signal Name

Terminal	Signal Name	Signal Description
1	T+	TEDS Data
2	T–	TEDS COM
3	EX+/HI*	Positive excitation or input signal
4	HI	Positive input signal
5	EX–/LO*	Negative excitation or input signal
6	LO	Negative input signal

* Depending on the mode, terminals 3 and 5 are either the excitation signals or the input signals.

Table 3. NI 9219 Terminal Assignments by Mode

Mode	Terminal					
	1	2	3	4	5	6
Voltage	T+	T–	—	HI	LO	—
Current	T+	T–	HI	—	LO	—
4-Wire Resistance	T+	T–	EX+	HI	EX–	LO
2-Wire Resistance	T+	T–	HI	—	LO	—
Thermocouple	T+	T–	—	HI	LO	—
4-Wire RTD	T+	T–	EX+	HI	EX–	LO
3-Wire RTD	T+	T–	EX+	—	EX–	LO
Quarter-Bridge	T+	T–	HI	—	LO	—
Half-Bridge	T+	T–	EX+	HI	EX–	—
Full-Bridge	T+	T–	EX+	HI	EX–	LO
Digital In	T+	T–	—	HI	LO	—
Open Contact	T+	T–	HI	—	LO	—

Voltage Accuracy Verification

Complete the following steps to verify the voltage accuracy of an NI 9219.

1. Connect the NI 9219 to the DMM and source as shown in Figure 2.

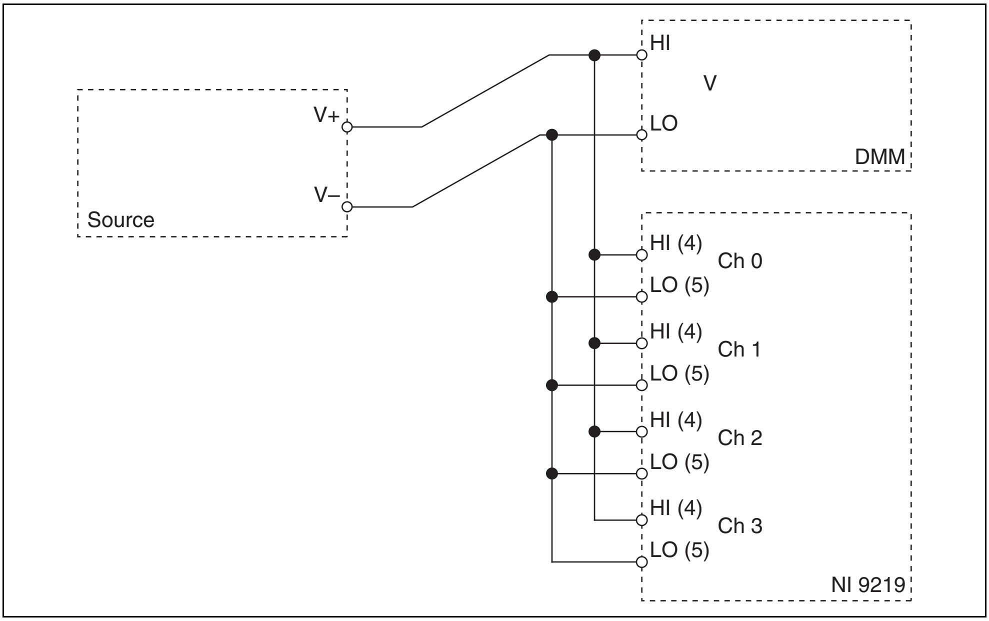


Figure 2. Voltage Accuracy Verification Connections to the NI 9219

2. Set the source to the appropriate test point value indicated in Table 5. Use the smallest available range needed to source each test point. Using a range larger than necessary creates unwanted additional noise.
3. Configure the DMM for a voltage measurement in the lowest appropriate range according to the test point from Table 5.
4. Enable Auto Zero on the DMM.
5. Acquire a voltage reading with the DMM. Record this measurement as V_{ref}.
6. Create an AI voltage channel on the NI 9219. Configure the channel according to Table 4.

Table 4. NI 9219 Configuration for Voltage Accuracy Verification

Measurement Type	Min (V)	Max (V)	ADC Timing Mode	Sample Timing Type
Voltage	–60	60	High Resolution	On Demand
	–15	15		
	–4	4		
	–1	1		
	–0.125	0.125		

7. Acquire 20 voltage readings with the NI 9219. Record the average of the readings as $V_{channel}$.
8. Perform the following calculation using the recorded V_{ref} and $V_{channel}$ values.

$$Accuracy = V_{channel} - V_{ref}$$

9. Compare the calculation result to the Upper Limit and Lower Limit values in Table 5.

Table 5. NI 9219 Verification Test Limits for Voltage Accuracy

Range		Test Point		1–Year Limits	
Minimum (V)	Maximum (V)	Location	Value (V)	Lower Limit (V)	Upper Limit (V)
–60	60	Max	48	–0.03670	0.03670
		Mid	0.0	–0.00100	0.00100
		Min	–48	–0.03670	0.03670
–15	15	Max	12	–0.00980	0.00980
		Mid	0.0	–0.00080	0.00080
		Min	–12	–0.00980	0.00980
–4	4	Max	3.2	–0.00300	0.00300
		Mid	0.0	–0.00060	0.00060
		Min	–3.2	–0.00300	0.00300

Table 5. NI 9219 Verification Test Limits for Voltage Accuracy (Continued)

Range		Test Point		1–Year Limits	
Minimum (V)	Maximum (V)	Location	Value (V)	Lower Limit (V)	Upper Limit (V)
–1	1	Max	0.80	–0.000260	0.000260
		Mid	0.00	–0.000014	0.000014
		Min	–0.80	–0.000260	0.000260
–0.125	0.125	Max	0.10	–0.000041	0.000041
		Mid	0.00	–0.000010	0.000010
		Min	–0.10	–0.000041	0.000041

10. Set the source output to zero and clear the acquisition.
11. Repeat steps 2 through 10 for all test points and all channels on the NI 9219. NI recommends that you verify the values for all the iterations listed in Table 5 for each channel, but you can save time by verifying only the ranges, values, and channels used in your application.
12. Disconnect the source and the DMM from the device.

Thermocouple Accuracy Verification

Complete the following steps to verify the thermocouple accuracy of an NI 9219.

1. Connect the NI 9219 to the DMM and source as shown in Figure 3.

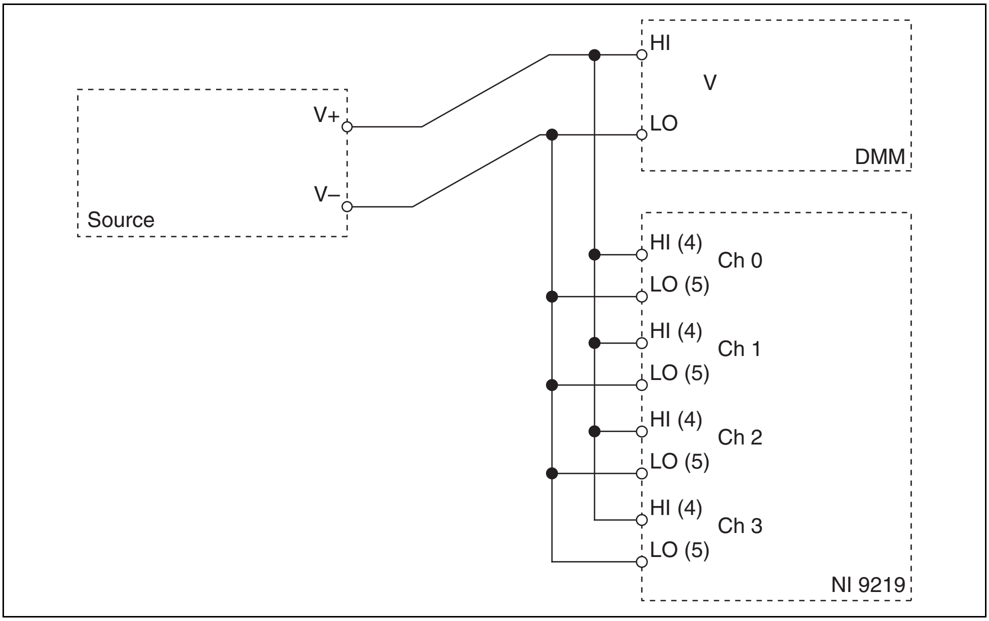


Figure 3. Thermocouple Accuracy Verification Connections to the NI 9219

2. Set the source to the appropriate test point value indicated in Table 7. Use the smallest available range needed to source each test point. Using a range larger than necessary creates unwanted additional noise.
3. Configure the DMM for a voltage measurement in the lowest appropriate range according to the test point from Table 7.
4. Enable Auto Zero on the DMM.
5. Acquire a voltage reading with the DMM. Record the measurement as V_{ref}.
6. Create an AI thermocouple channel on the NI 9219. Configure the channel according to Table 6.

Table 6. NI 9219 Configuration for Thermocouple Accuracy Verification

Measurement Type	Min (°C)	Max (°C)	ADC Timing Mode	Sample Timing Type
Thermocouple	0	100	High Resolution	On Demand

7. Acquire 20 unscaled I32 readings with the NI 9219. Record the average of the readings as $data_{unscaled}$.
8. Scale the data by using the formula below to change the unscaled data into volts.

$$V_{channel} = \frac{data_{unscaled}}{2^{23}} \times range_{max}$$

where $range_{max}$ is the maximum value (mV) in Table 7.

9. Perform the following calculation using the recorded V_{ref} and $V_{channel}$ values.

$$Accuracy = V_{channel} - V_{ref}$$

10. Compare the calculation result to the Upper Limit and Lower Limit values in Table 7.

Table 7. NI 9219 Verification Test Limits for Thermocouple Accuracy

Range		Test Point		1–Year Limits	
Minimum (mV)	**Maximum (mV)**	**Location**	**Value (V)**	**Lower Limit (V)**	**Upper Limit (V)**
–125	125	Max	0.10	–0.000041	0.000041
		Min	0.00	–0.000010	0.000010

11. Set the source output to zero and clear the acquisition.
12. Repeat steps 2 through 11 for all test points and all channels on the NI 9219. NI recommends that you verify the values for all the iterations listed in Table 7 for each channel, but you can save time by verifying only the values and channels used in your application.
13. Disconnect the source and the DMM from the device.

Current Accuracy Verification

Complete the following steps to verify the current accuracy of an NI 9219.

1. Connect the NI 9219 to the DMM and source as shown in Figure 4.

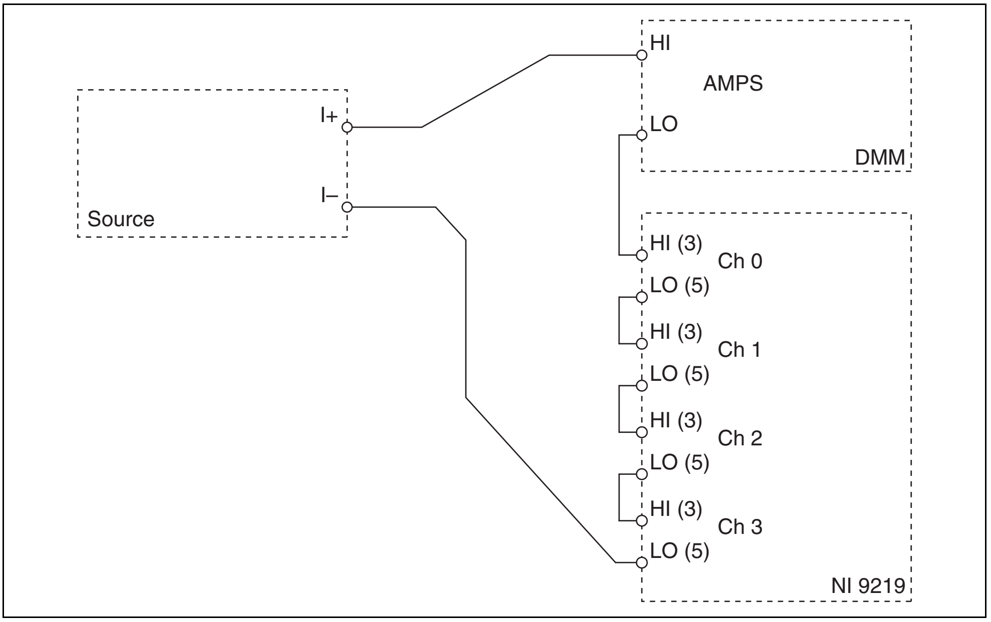


Figure 4. Current Accuracy Verification Connections to the NI 9219

2. Set the current source to the appropriate test point value indicated in Table 9. Use the smallest available range needed to source each test point. Using a range larger than necessary creates unwanted additional noise.
3. Configure the DMM for a current measurement in the lowest appropriate range according to the test point from Table 9.
4. Enable Auto Zero on the DMM.
5. Create an AI current channel on the NI 9219. Configure the channel according to Table 8.

Table 8. NI 9219 Configuration for Current Accuracy Verification

Measurement Type	Physical Channels	Min (A)	Max (A)	ADC Timing Mode	Sample Timing Type
Current	ai0:3	–0.025	0.025	High Resolution	On Demand

6. Commit the task.
7. Acquire a current reading with the DMM. Record this measurement as I_{ref}.
8. Acquire 20 current readings per channel on the NI 9219.

Note Perform the DMM measurements and the NI 9219 measurements as simultaneously as possible in order to reduce error from drift in the current source.

9. Record the average of the readings for the channel you want to verify as $I_{channel}$.

10. Perform the following calculation using the recorded I_{ref} and $I_{channel}$ values.

$$Accuracy = I_{channel} - I_{ref}$$

11. Compare the calculation result to the Upper Limit and Lower Limit values in Table 9.

Table 9. NI 9219 Verification Test Limits for Current Accuracy

Range		Test Point		1–Year Limits	
Minimum (mA)	**Maximum (mA)**	**Location**	**Value (mA)**	**Lower Limit (mA)**	**Upper Limit (mA)**
–25	25	Max	19.0	–0.02089	0.02089
		Mid	0.0	–0.00061	0.00061
		Min	–19.0	–0.02089	0.02089

12. Repeat steps 9 through 11 for each channel you want to verify. NI recommends that you verify each channel, but you can save time by verifying only the channels used in your application.
13. Set the source to zero and clear the acquisition.
14. Repeat steps 2 through 13 for all test points listed in Table 9. NI recommends that you verify the values for all the iterations listed in Table 9, but you can save time by verifying only the values used in your application.
15. Disconnect the source and the DMM from the device.

2-Wire Resistance Accuracy Verification

Complete the following steps to verify the 2-wire resistance accuracy of an NI 9219.

1. Connect the NI 9219 to the resistor and the DMM as shown in Figure 5. Connect the leads of the DMM as close as possible to the terminals on the NI 9219 to ensure that the DMM reference measurements include the same lead wire resistance as the NI 9219 2-wire measurement.

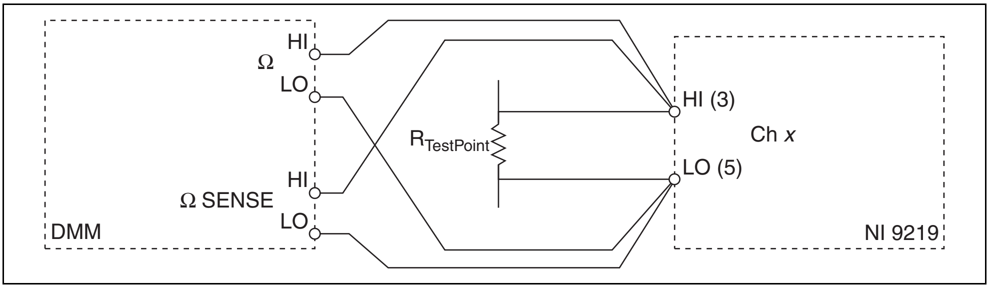


Figure 5. 2-Wire Resistance Accuracy Verification Connections to the NI 9219

2. Create an AI voltage channel in the 1 V range on the NI 9219.
3. Commit the task to place the NI 9219 in voltage mode. This prevents the module from interfering with the resistance measurements of the DMM.
4. Configure the DMM for a 4-wire resistance measurement in the appropriate range according to the appropriate test point from Table 11.
5. Enable Auto Zero on the DMM.
6. Acquire a resistance reading with the DMM. Record this measurement as Ω_{ref}.

7. Disconnect the DMM from the resistor to ensure that the terminals on the DMM do not interfere with the resistor while the NI 9219 makes measurements.
8. Clear the task.
9. Create an AI resistance channel on the NI 9219. Configure the channel according to Table 10.

Table 10. NI 9219 Configuration for 2-Wire Resistance Accuracy Verification

Measurement Type	Min (Ω)	Max (Ω)	Excitation Source	Excitation Value	ADC Timing Mode	Sample Timing Type
2-Wire Resistance 1 kΩ	0	1000	Internal	0.0005	High Resolution	On Demand
2-Wire Resistance 10 kΩ		10000				

10. Acquire 20 2-wire resistance readings with the NI 9219. Record the average of the readings as $\Omega_{channel}$.
11. Perform the following calculation using the recorded Ω_{ref} and $\Omega_{channel}$ values.

$$Accuracy = \Omega_{channel} - \Omega_{ref}$$

12. Compare the calculation result to the Upper Limit and Lower Limit values in Table 11.

Table 11. NI 9219 Verification Test Limits for 2-Wire Resistance Accuracy

Mode	Range		Test Point		1–Year Limits	
	Min (Ω)	Max (kΩ)	Location	Value	Lower Limit (Ω)	Upper Limit (Ω)
2-Wire Resistance 1 kΩ	0	1.05	Max	845 Ω ±1%	–1.15	1.15
			Min	20 Ω ±5%	–0.50	0.50
2-Wire Resistance 10 kΩ	0	10.5	Max	8450 Ω ±1%	–7.20	7.20
			Min	20 Ω ±5%	–0.64	0.64

13. Clear the acquisition.
14. Disconnect the resistor from the device.
15. Repeat steps 1 through 14 for all test points and channels on the NI 9219. NI recommends that you verify the values for all the iterations listed in Table 11 for each channel, but you can save time by verifying only the values and channels used in your application.

Quarter-Bridge Accuracy Verification

Complete the following steps to verify the quarter-bridge accuracy of an NI 9219.

1. Connect the NI 9219 to the resistor and the DMM as shown in Figure 6. Observe the following conditions when connecting the equipment to the NI 9219.
   - Connect the leads of the DMM as close as possible to the terminals on the NI 9219 to ensure that the DMM reference measurements include the same lead wire resistance as the NI 9219 quarter-bridge measurement.
   - Secure the spring-terminal connectors to the NI 9219 using the captive screws.

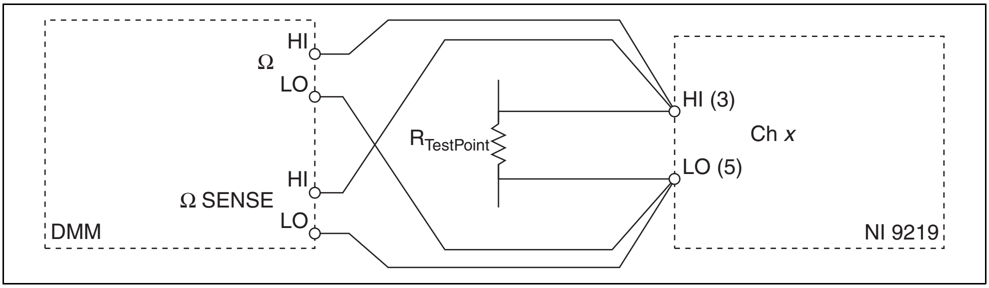


Figure 6. Quarter-Bridge Accuracy Verification Connections to the NI 9219

2. Create an AI voltage channel in the 1 V range on the NI 9219.
3. Commit the task to place the NI 9219 in voltage mode. This prevents the module from interfering with the resistance measurements of the DMM.
4. Configure the DMM for a 4-wire resistance measurement in the appropriate range according to the test point from Table 13.
5. Enable Auto Zero on the DMM.
6. Acquire a resistance reading with the DMM. Record this measurement as Ω_{ref}.
7. Disconnect the DMM from the resistor to ensure that the terminals on the DMM do not interfere with the resistor while the NI 9219 makes measurements.
8. Clear the task.
9. Create an AI bridge (V/V) channel on the NI 9219. Configure the channel according to Table 12.

Table 12. NI 9219 Configuration for Quarter-Bridge Accuracy Verification

Measurement Type	Minimum (V/V)	Maximum (V/V)	Strain Config	Nominal Gage Resistance	ADC Timing Mode	Sample Timing Type
Quarter-Bridge 350 Ω	–0.025	0.025	Quarter-Bridge	350	High Resolution	On Demand
Quarter-Bridge 120 Ω				120		

10. Acquire 20 unscaled I32 quarter-bridge readings with the NI 9219. Record the average of the readings as $data_{unscaled}$.
11. Scale the data by using the formula below to change the unscaled data into Ω.

$$\Omega_{channel} = \frac{data_{unscaled}}{2^{24}} \times range_{max}$$

where $range_{max}$ is the maximum value for the selected range in Table 13.

12. Perform the following calculation using the recorded Ω_{ref} and $\Omega_{channel}$ values.

$$Accuracy = \Omega_{channel} - \Omega_{ref}$$

13. Compare the calculation result to the Upper Limit and Lower Limit values in Table 13.

Table 13. NI 9219 Verification Test Limits for Quarter-Bridge Accuracy

Mode	Range		Test Point		1–Year Limits	
	Min (Ω)	Max (Ω)	Location	Value	Lower Limit (Ω)	Upper Limit (Ω)
Quarter-Bridge 350 Ω	0	390	Max	309 Ω ±1%	–0.61	0.61
			Min	4.99 Ω ±5%	–0.37	0.37
Quarter-Bridge 120 Ω	0	150	Max	121 Ω ±1%	–0.33	0.33
			Min	4.99 Ω ±5%	–0.24	0.24

14. Clear the acquisition.
15. Disconnect the resistor from the device.
16. Repeat steps 1 through 15 for all test points and channels on the NI 9219. NI recommends that you verify the values for all the iterations listed in Table 13 for each channel, but you can save time by verifying only the values and channels used in your application.

4-Wire Resistance Accuracy Verification

Complete the following steps to verify the 4-wire resistance accuracy of an NI 9219.

1. Connect the NI 9219 to the resistor and the DMM as shown in Figure 7. Connect the sense leads of the DMM as close as possible to the same point that the sense leads of the NI 9219 (HI and LO) connect to the resistor to ensure that the DMM reference measurements include the same lead wire resistance as the NI 9219 4-wire measurements.

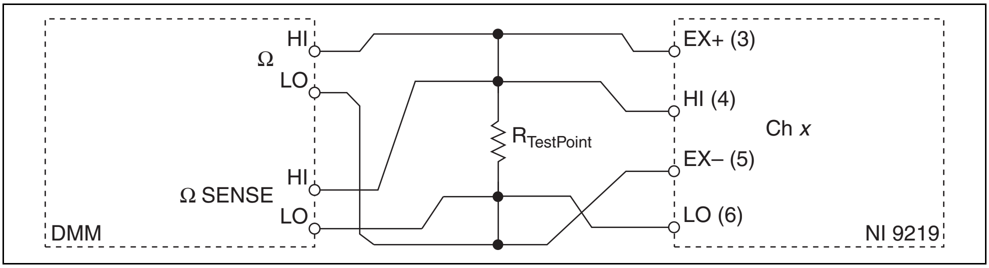


Figure 7. 4-Wire Resistance Accuracy Verification Connections to the NI 9219

2. Create an AI voltage channel in the 1 V range on the NI 9219.
3. Commit the task to place the NI 9219 in voltage mode. This prevents the module from interfering with the resistance measurement of the DMM.
4. Configure the DMM for a 4-wire resistance measurement in the appropriate range according to the test point from Table 15.
5. Enable Auto Zero on the DMM.
6. Acquire a resistance reading with the DMM. Record this measurement as Ω_{ref}.
7. Disconnect the DMM from the resistor to ensure that the terminals on the DMM do not interfere with the resistor while the NI 9219 makes measurements.
8. Clear the task.

9. Create an AI resistance channel on the NI 9219. Configure the channel according to Table 14.

Table 14. NI 9219 Configuration for 4-Wire Resistance Accuracy Verification

Measurement Type	Min (Ω)	Max (Ω)	Excitation Source	Excitation Value	Resistance Config	ADC Timing Mode	Sample Timing Type
4-Wire Resistance 1 kΩ	0	1000	Internal	0.0005	4-Wire	High Resolution	On Demand
4-Wire Resistance 10 kΩ		10000					

10. Acquire 20 4-wire resistance readings with the NI 9219. Record the average of the readings as $\Omega_{channel}$.
11. Perform the following calculation using the recorded Ω_{ref} and $\Omega_{channel}$ values.

$$Accuracy = \Omega_{channel} - \Omega_{ref}$$

12. Compare the calculation result to the Upper Limit and Lower Limit values in Table 15.

Table 15. NI 9219 Verification Test Limits for 4-Wire Resistance Accuracy

Mode	Range		Test Point		1–Year Limits	
	Min (Ω)	Max (kΩ)	Location	Value	Lower Limit (Ω)	Upper Limit (Ω)
4-Wire Resistance 1 kΩ	0	1.05	Max	845 Ω ±1%	–1.15	1.15
			Min	20 Ω ±5%	–0.50	0.50
4-Wire Resistance 10 kΩ	0	10.5	Max	8450 Ω ±1%	–7.20	7.20
			Min	20 Ω ±5%	–0.64	0.64

13. Clear the acquisition.
14. Disconnect the resistor from the device.
15. Repeat steps 1 through 14 for all test points and channels on the NI 9219. NI recommends that you verify the values for all the iterations listed in Table 15 for each channel, but you can save time by verifying only the values and channels used in your application.

4-Wire RTD Accuracy Verification

Complete the following steps to verify the 4-wire RTD accuracy of an NI 9219.

1. Connect the NI 9219 to the resistor and the DMM as shown in Figure 8. Connect the sense leads of the DMM as close as possible to the same point that the sense leads of the NI 9219 (HI and LO) connect to the resistor to ensure that the DMM reference measurements include the same lead wire resistance as the NI 9219 4-wire measurements.

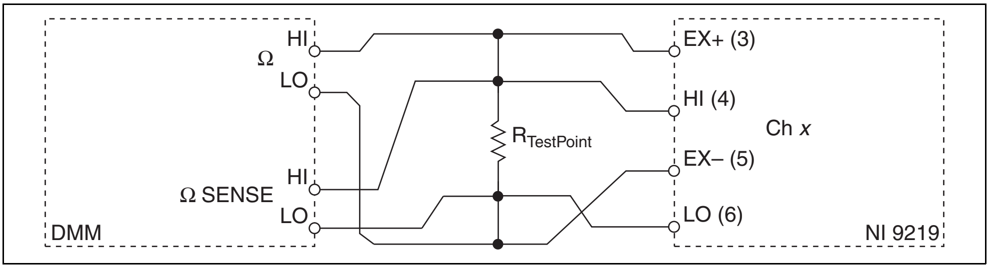


Figure 8. 4-Wire RTD Accuracy Verification Connections to the NI 9219

2. Create an AI voltage channel in the 1 V range on the NI 9219.
3. Commit the task to place the NI 9219 in voltage mode. This prevents the module from interfering with the resistance measurements of the DMM.
4. Configure the DMM for a 4-wire resistance measurement in the appropriate range according to the test point from Table 17.
5. Enable Auto Zero on the DMM.
6. Acquire a resistance reading with the DMM. Record this measurement as Ω_{ref}.
7. Disconnect the DMM from the resistor to ensure that the terminals on the DMM do not interfere with the resistor while the NI 9219 makes measurements.
8. Clear the task.
9. Create an AI RTD channel on the NI 9219. Configure the channel according to Table 16.

Table 16. NI 9219 Configuration for 4-Wire RTD Accuracy Verification

Measurement Type	Min (°C)	Max (°C)	Excitation Source	Excitation Value	Resistance Config	r0*	ADC Timing Mode	Sample Timing Type
4-Wire RTD Pt1000	0	800	Internal	0.0005	4-Wire	1000	High Resolution	On Demand
4-Wire RTD Pt100						100		

* RTD nominal resistance at 0 °C.

10. Acquire 20 unscaled I32 4-wire readings with the NI 9219. Record the average of the readings as $data_{unscaled}$.
11. Scale the data by using the formula below to change the unscaled data into Ω.

$$\Omega_{channel} = \frac{data_{unscaled}}{2^{24}} \times range_{max}$$

where $range_{max}$ is the maximum value for the selected range in Table 17.

12. Perform the following calculation using the recorded Ω_{ref} and $\Omega_{channel}$ values.

$$Accuracy = \Omega_{channel} - \Omega_{ref}$$

13. Compare the calculation result to the Upper Limit and Lower Limit values in Table 17.

Table 17. NI 9219 Verification Test Limits for 4-Wire RTD Accuracy

Mode	Range		Test Point		1–Year Limits	
	Min (Ω)	Max (Ω)	Location	Value	Lower Limit (Ω)	Upper Limit (Ω)
4–Wire RTD Pt1000	0	5050	Max	4020 Ω ±1%	–3.73	3.73
			Min	20 Ω ±5%	–0.61	0.61
4–Wire RTD Pt100	0	505	Max	402 Ω ±1%	–0.79	0.79
			Min	4.99 Ω ±5%	–0.48	0.48

14. Clear the acquisition.
15. Disconnect the resistor from the device.
16. Repeat steps 1 through 15 for all test points and channels on the NI 9219. NI recommends that you verify the values for all the iterations listed in Table 17 for each channel, but you can save time by verifying only the values and channels used in your application.

3-Wire RTD Accuracy Verification

Complete the following steps to verify the 3-Wire RTD accuracy of an NI 9219.

1. Connect the NI 9219 to the resistor and the DMM as shown in Figure 9. Connect the Ω_{HI} and $\Omega_{senseHI}$ leads of the DMM directly to the spring-terminal connector of the NI 9219 and the Ω_{LO} and the $\Omega_{senseLO}$ leads of the DMM as close as possible to the same point where the LO lead from the NI 9219 connects to the resistor to ensure that the DMM reference measurements include the same lead wire resistance as the NI 9219 3-wire measurements.

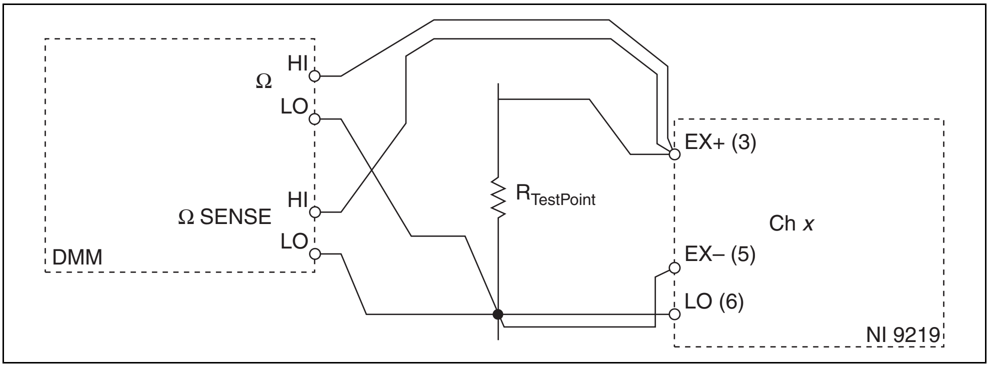


Figure 9. 3-Wire RTD Accuracy Verification Connections to the NI 9219

2. Create an AI voltage channel in the 1 V range on the NI 9219.
3. Commit the task to place the NI 9219 in voltage mode. This prevents the module from interfering with the resistance measurements of the DMM.
4. Configure the DMM for a 4-wire resistance measurement in the appropriate range according to the test point from Table 19.
5. Enable Auto Zero on the DMM.
6. Acquire a resistance reading with the DMM. Record this measurement as $\Omega_{TopHalfDMM}$.

7. Reconnect the DMM as shown in Figure 10. To minimize mismatch between the NI 9219 and the DMM, connect the Ω_{HI} and $\Omega_{senseHI}$ leads of the DMM as close as possible to the same point where the LO lead from the NI 9219 connects to the resistor and the Ω_{LO} and the $\Omega_{senseLO}$ leads of the DMM directly to the spring-terminal connector of the NI 9219.

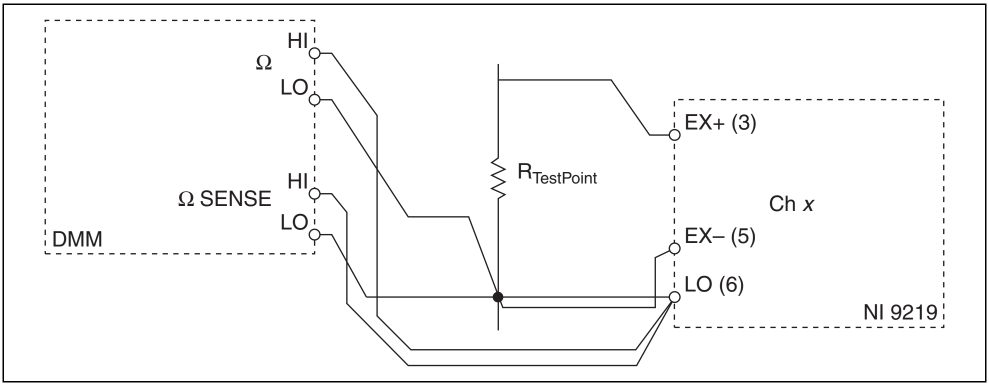


Figure 10. 3-Wire RTD Accuracy Verification Connections to the NI 9219

8. Configure the DMM for a 4-wire resistance measurement in the 100 Ω range or the smallest range available.
9. Enable Auto Zero on the DMM.
10. Acquire a resistance reading with the DMM. Record this measurement as $\Omega_{BottomHalfDMM}$.
11. Disconnect the DMM from the resistor and the NI 9219.
12. Calculate the DMM measurement of the 3-wire system from the following equation.

$$\Omega_{ref} = (\Omega_{TopHalfDMM} - 2 \times \Omega_{BottomHalfDMM})$$

13. Clear the task.
14. Create an AI RTD channel on the NI 9219. Configure the channel according to Table 18.

Table 18. NI 9219 Configuration for 3-Wire RTD Accuracy Verification

Measurement Type	Min (°C)	Max (°C)	Excitation Source	Excitation Value	Resistance Config	r0*	ADC Timing Mode	Sample Timing Type
3-Wire RTD Pt1000	0	800	Internal	0.0005	3-Wire	1000	High Resolution	On Demand
3-Wire RTD Pt100						100		
* RTD nominal resistance at 0 °C.								

15. Acquire 20 unscaled I32 3-wire readings with the NI 9219. Record the average of the readings as $data_{unscaled}$.

16. Scale the data by using the formula below to change the unscaled data into Ω.

$$\Omega_{channel} = \frac{data_{unscaled}}{2^{24}} \times range_{max}$$

where $range_{max}$ is the maximum value for the selected range in Table 19.

17. Perform the following calculation using the recorded Ω_{ref} and $\Omega_{channel}$ values.

$$Accuracy = \Omega_{channel} - \Omega_{ref}$$

18. Compare the calculation result to the Upper Limit and Lower Limit values in Table 19.

Table 19. NI 9219 Verification Test Limits for 3-Wire RTD Accuracy

Mode	Range		Test Point		1–Year Limits	
	Min (Ω)	Max (Ω)	Location	Value	Lower Limit (Ω)	Upper Limit (Ω)
3-Wire RTD Pt1000	0	5050	Max	4020 Ω ±1%	–3.86	3.86
			Min	20 Ω ±5%	–0.62	0.62
3-Wire RTD Pt100	0	505	Max	402 Ω ±1%	–0.80	0.80
			Min	4.99 Ω ±5%	–0.48	0.48

19. Clear the acquisition.
20. Disconnect the resistor from the device.
21. Repeat steps 1 through 20 for all test points and channels on the NI 9219. NI recommends that you verify the values for all the iterations listed in Table 19 for each channel, but you can save time by verifying only the values and channels used in your application.

Half-Bridge Accuracy Verification

Complete the following steps to verify the half-bridge accuracy of an NI 9219.

1. Connect the NI 9219 to DMM1 as shown in Figure 11.

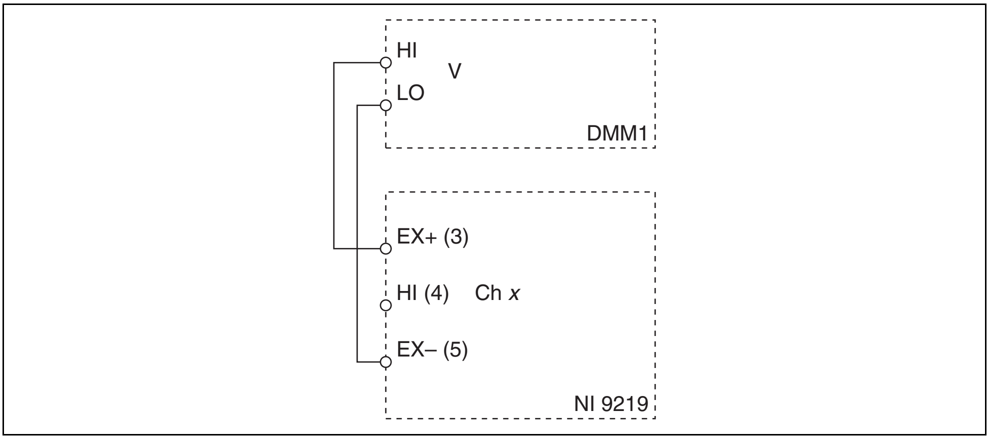


Figure 11. Half-Bridge Accuracy Verification Connections to the NI 9219 (Configuration 1)

2. Create an AI bridge V/V channel on the NI 9219. Configure the channel according to Table 20.

Table 20. NI 9219 Configuration for Half-Bridge Accuracy Verification

Measurement Type	Min (V)	Max (V)	Excitation Source	Excitation Value	Bridge Config	ADC Timing Mode	Sample Timing Type
Half-Bridge 500 mV/V	–0.5	0.5	Internal	2.5	Half-Bridge	High Resolution	On Demand

3. Commit the task.
4. Configure DMM1 for a voltage measurement in the 10 V range.
5. Enable Auto Zero on DMM1.
6. Use DMM1 to measure the excitation voltage from the NI 9219. Record this measurement as $V_{ExcitationModule}$.

Note The excitation voltage on the NI 9219 may be off if the module is not configured correctly. The excitation value on the NI 9219 should be at least 2.5 V.

7. Set the voltage source to $V_{ExcitationModule}$. Use the smallest available range needed to source $V_{ExcitationModule}$. Using a range larger than necessary creates unwanted additional noise.
8. Connect the NI 9219 to DMM1, DMM2, and the voltage source as shown in Figures 12, 13, or 14 for the appropriate test point value indicated in Table 21. Observe the following conditions when connecting the equipment to the NI 9219.
   - Connect the leads of DMM1 as close as possible to the terminals on the NI 9219.
   - Connect the HI lead of DMM2 as close as possible to the same point that the HI lead of the NI 9219 connects to the resistor network.
   - Connect the LO lead of DMM2 as close as possible to the EX– terminal of the NI 9219.

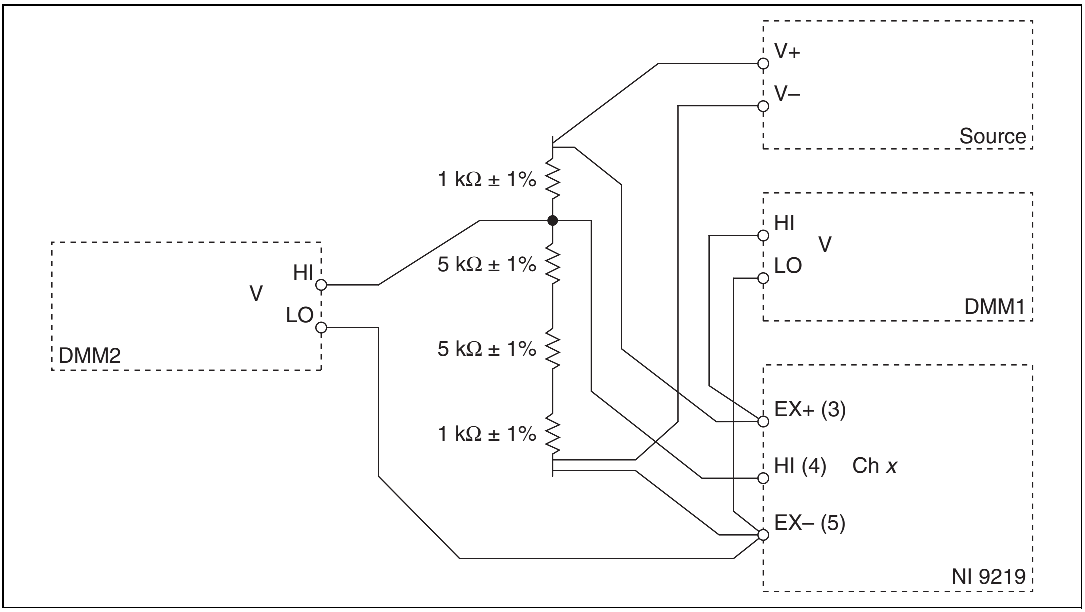


Figure 12. Half-Bridge Accuracy Verification Connections to the NI 9219 (Configuration 2)

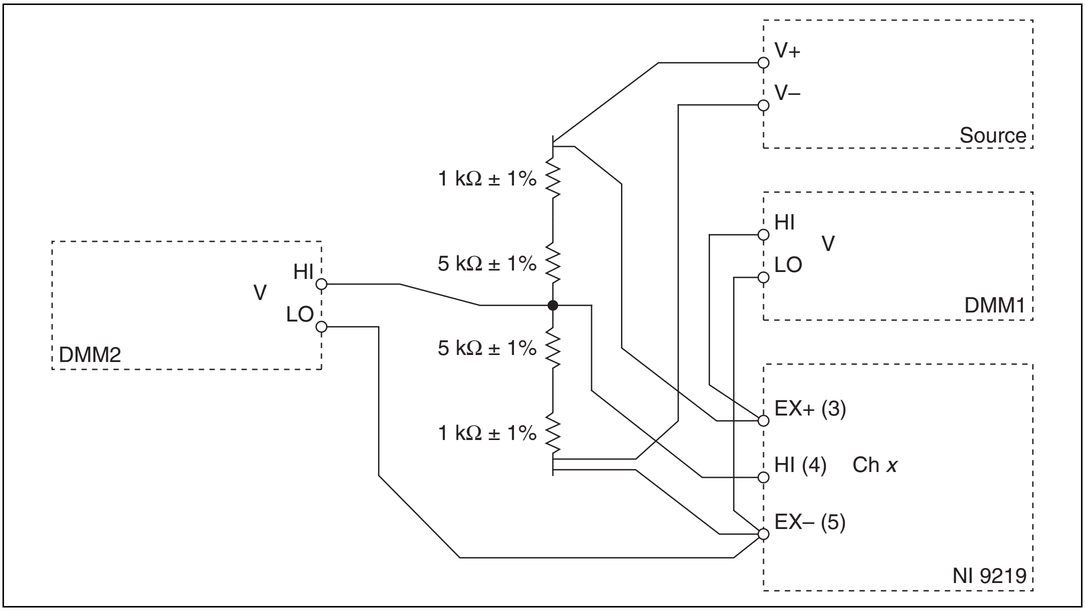


Figure 13. Half-Bridge Accuracy Verification Connections to the NI 9219 (Configuration 3)

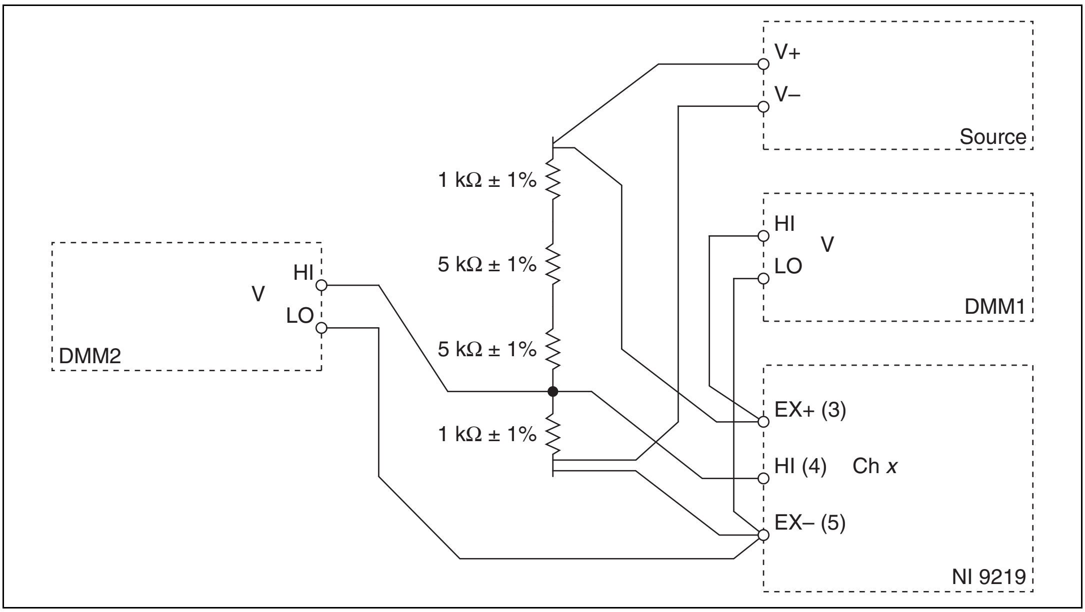


Figure 14. Half-Bridge Accuracy Verification Connections to the NI 9219 (Configuration 4)

9. Configure DMM1 for a voltage measurement in the 10 V range.
10. Enable Auto Zero on DMM1.
11. Configure DMM2 for a voltage measurement in the 10 V range.
12. Enable Auto Zero on DMM2.

13. Acquire voltage measurements with both DMMs. Perform the following calculation using the two DMM measurements.

$$Ratio_{ref} = \frac{V_{DMM2}}{V_{DMM1}}$$

14. Acquire 20 bridge readings with the NI 9219. Record the average of the readings as $\text{Ratio}_{\text{channel}}$.

Note Perform the DMM measurements and the NI 9219 measurements as simultaneously as possible in order to reduce error from drift in the resistors.

15. Perform the following calculation using the recorded $\text{Ratio}_{\text{ref}}$ and $\text{Ratio}_{\text{channel}}$ values.

$$Accuracy = \left(Ratio_{channel} + \frac{1}{2}\right) - Ratio_{ref}$$

16. Compare the calculation result to the Upper Limit and Lower Limit values in Table 21.

Table 21. NI 9219 Verification Test Limits for Half-Bridge Accuracy

Mode	Range		Test Point			1–Year Limits	
	Min (mV/V)	Max (mV/V)	Location	Value	Ratio	Lower Limit (mV/V)	Upper Limit (mV/V)
Half-Bridge 500 mV/V	–500	500	Max	Configuration 2	0.916	–0.29	0.29
			Mid	Configuration 3	0.500	–0.20	0.20
			Min	Configuration 4	0.083	–0.29	0.29

17. Clear the acquisition.
18. Repeat steps 8 through 17 for all test points.
19. Repeat steps 1 through 18 for all channels on the NI 9219. NI recommends that you verify each channel, but you can save time by verifying only the channels used in your application.
20. Disconnect the DMMs and the resistors from the device.

Full-Bridge Accuracy Verification

Complete the following steps to verify the full-bridge accuracy of an NI 9219.

1. Connect the NI 9219 to DMM1 as shown in Figure 15.

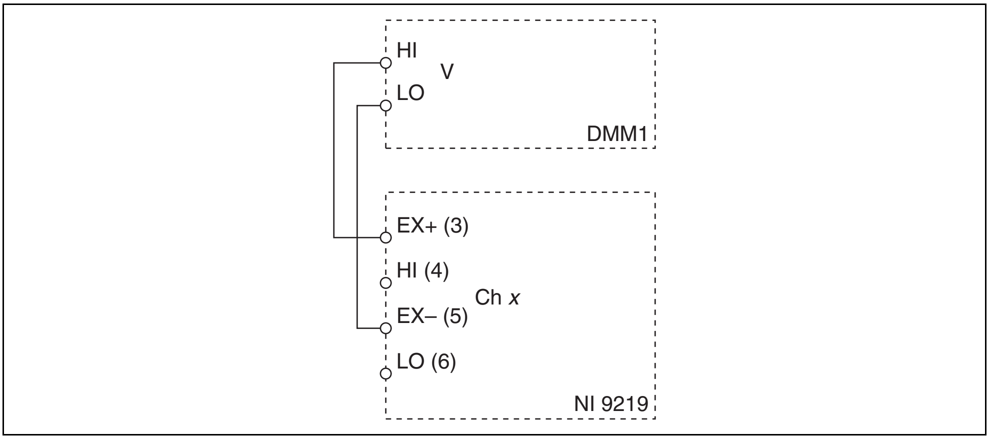


Figure 15. Full-Bridge Accuracy Verification Connections to the NI 9219 (Configuration 1)

2. Create an AI bridge V/V channel on the NI 9219. Configure the channel according to Table 22.

Table 22. NI 9219 Configuration for Full-Bridge Accuracy Verification

Measurement Type	Min (V)	Max (V)	Excitation Source	Excitation Value	Bridge Config	ADC Timing Mode	Sample Timing Type
Full-Bridge 62.5 mV/V	–0.0625	0.0625	Internal	2.5	Full-Bridge	High Resolution	On Demand
Full-Bridge 7.8 mV/V	–0.0078125	0.0078125					

3. Commit the task.
4. Configure DMM1 for a voltage measurement in the 10 V range.
5. Enable Auto Zero on DMM1.
6. Use DMM1 to measure the excitation voltage from the NI 9219. Record this measurement as $V_{ExcitationModule}$.

Note The excitation voltage on the NI 9219 may be off if the module is not configured correctly. The excitation value on the NI 9219 should be at least 2.5 V.

7. Set the voltage source to $V_{ExcitationModule}$. Use the smallest available range needed to source $V_{ExcitationModule}$. Using a range larger than necessary creates unwanted additional noise.
8. Connect the NI 9219 to DMM1, DMM2, and the source as shown in Figures 16 or 17 for the appropriate test point value indicated in Table . Observe the following conditions when connecting the equipment to the NI 9219.
   - Connect the leads of DMM1 as close as possible to the terminals on the NI 9219.
   - Connect the HI lead of DMM2 as close as possible to the same point that the HI lead of the NI 9219 connects to the resistor network.

- Connect the LO lead of DMM2 as close as possible to the same point that the LO lead of the NI 9219 connects to the resistor network.

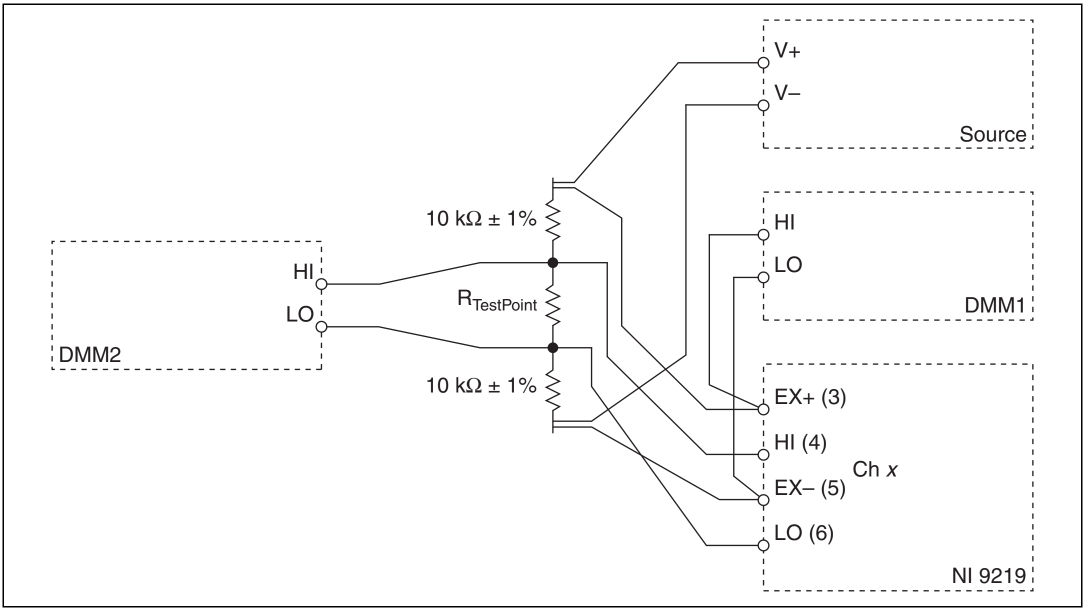


Figure 16. Full-Bridge Accuracy Verification Connections to the NI 9219 (Configuration 2)

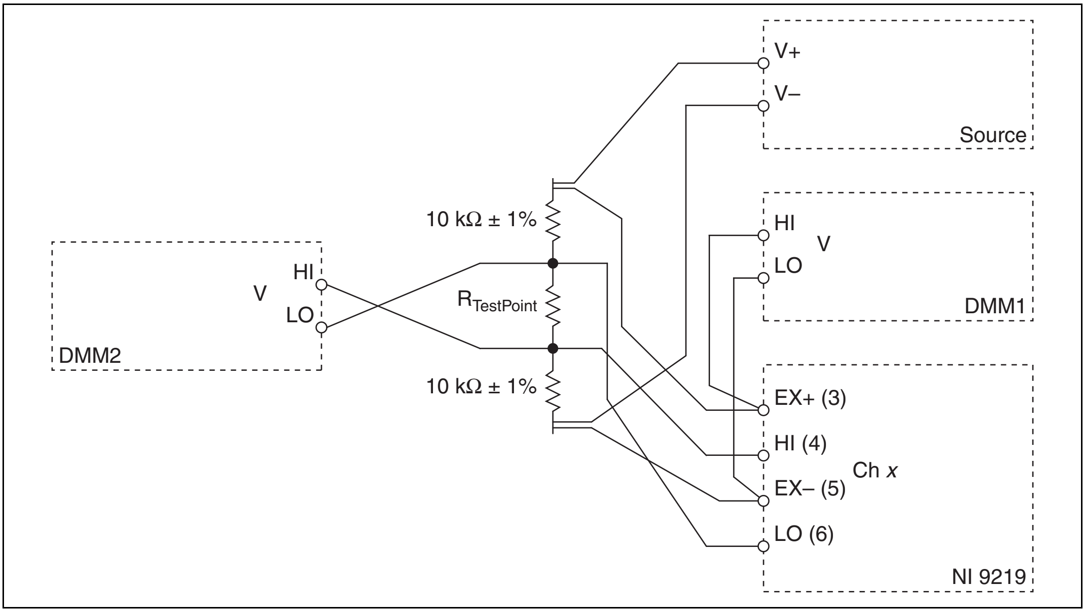


Figure 17. Full-Bridge Accuracy Verification Connections to the NI 9219 (Configuration 3)

9. Configure DMM1 for a voltage measurement in the 10 V range.
10. Enable Auto Zero on DMM1.

11. Configure DMM2 for a voltage measurement in the 1 V range.
12. Enable Auto Zero on DMM2.
13. Acquire voltage measurements with both DMMs. Perform the following calculation using the two DMM measurements.

$$Ratio_{ref} = \frac{V_{DMM2}}{V_{DMM1}}$$

14. Acquire 20 bridge readings with the NI 9219. Record the average of the readings as $\text{Ratio}_{\text{channel}}$.
15. Perform the following calculation using the recorded $\text{Ratio}_{\text{ref}}$ and $\text{Ratio}_{\text{channel}}$ values.

$$Accuracy = Ratio_{channel} - Ratio_{ref}$$

16. Compare the calculation result to the Upper Limit and Lower Limit values in Table .

Table 23. NI 9219 Verification Test Limits for Full-Bridge Accuracy

Mode	Range		Test Point			1–Year Limits	
	Min (mV/V)	**Max (mV/V)**	**Location**	**Value**	**Configuration**	**Lower Limit (µV/V)**	**Upper Limit (µV/V)**
Full-Bridge 62.5 mV/V	–62.5	62.5	Max	1 kΩ ±5%	Configuration 2	–17.6	17.6
			Mid	0 Ω	Configuration 2	–12.3	12.3
			Min	1 kΩ ±5%	Configuration 3	–17.6	17.6
Full-Bridge 7.8 mV/V	–7.8125	7.8125	Max	120 Ω ±5%	Configuration 2	–12.6	12.6
			Mid	0 Ω	Configuration 2	–11.9	11.9
			Min	120 Ω ±5%	Configuration 3	–12.6	12.6

17. Clear the acquisition.
18. Repeat steps 8 through 17 for all test points.
19. Repeat steps 1 through 18 for all channels on the NI 9219. NI recommends that you verify each channel, but you can save time by verifying only the channels used in your application.
20. Disconnect the DMMs and the resistors from the device.

Adjustment

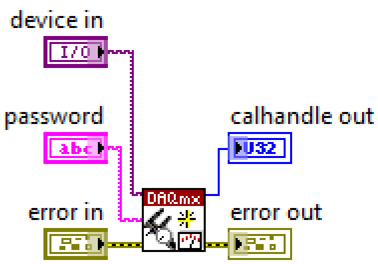
Following the adjustment procedure automatically updates the calibration date and temperature in the EEPROM of the NI 9219.

Note National Instruments recommends a complete adjustment of your device to renew the calibration interval. However, if you do not want to perform an adjustment, you can update the calibration date and onboard calibration temperature without making any adjustments by calling only DAQmx Initialize External Calibration VI, DAQmx Set Temperature C Series Calibration, and DAQmx Close External Calibration VI.

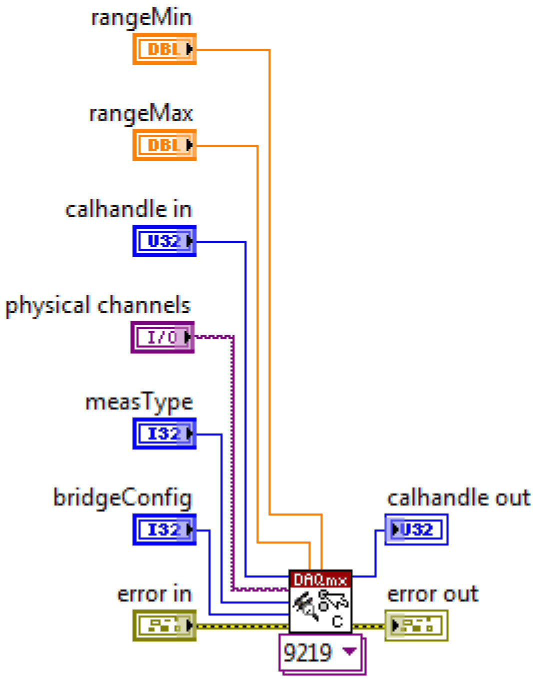
Voltage and Thermocouple Accuracy Adjustment

Complete the following steps to adjust the voltage accuracy and thermocouple accuracy of the NI 9219.

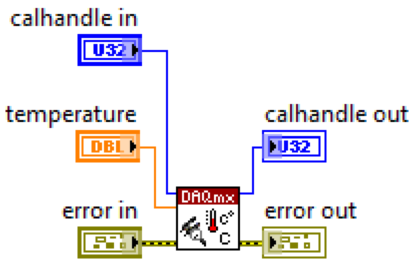
1. Connect the NI 9219 to the DMM and source as shown in Figure 2.
2. Open a calibration session to your device using the DAQmx Initialize External Calibration VI. The default password is `NI`.

LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxInitExtCal` with the following parameters: **deviceName**: The name of the device you want to calibrate. This name can be found under Devices and Interfaces in Measurements & Automation Explorer. **password**: `NI` **calHandle**: `&calHandle`

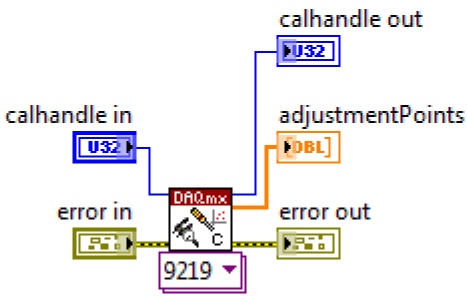
3. Set up the signal acquisition using the NI 9219 instance of the DAQmx Setup C Series Calibration VI.

LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxSetup9219Cal` with the following parameters: **rangeMin**: `-60, -15, -4, -1`, or `-0.125` **rangeMax**: `60, 15, 4, 1`, or `0.125` **calHandle**: `calHandle` **channelNames**: `cDAQ1Mod8/ai`*x** **measType**: `DAQmx_Val_Voltage` **bridgeConfig**: `DAQmx_Val_NoBridge`
* *x* refers to the channel number	

4. Input the external temperature using the DAQmx Set Temperature C Series Calibration VI.

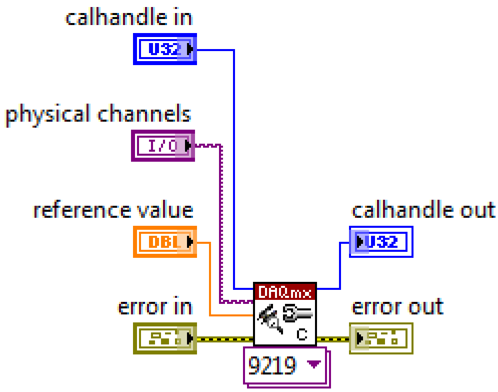
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxCSeriesSetCalTemp` with the following parameters: **calHandle**: `calHandle` **temperature**: The external temperature value in degrees Celsius.

5. Obtain an array of the recommended calibration voltages for your device using the NI 9219 instance of the DAQmx Get C Series Calibration Adjustment Points VI.

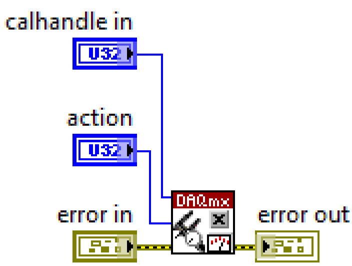
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxGet9219CalAdjustPoints` with the following parameters: **calHandle**: `calHandle` **adjustmentPoints**: An array of reference values for the DAQmx Adjust Calibration VI. **bufferSize**: The size of the **adjustmentPoints** array in elements.

6. Set the source to a reference value determined by the array of adjustment points.
7. Configure the DMM for a voltage measurement.
8. Enable Auto Zero on the DMM.
9. Acquire a voltage reading with the DMM.

10. Acquire a voltage reading with the NI 9219 using the NI 9219 instance of the DAQmx Adjust C Series Calibration VI.

LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxAdjust9219Cal` with the following parameters: **calHandle**: `calHandle` **channelName**: `cDAQ1Mod8/ai`*x*** **value**: The DMM reading.
**x* refers to the channel number	

11. Repeat steps 6 through 10 for every value in the array.
12. Compute and save the adjustment to the EEPROM using the DAQmx Close External Calibration VI. This VI also saves the date, time, and temperature of the adjustment to the EEPROM.

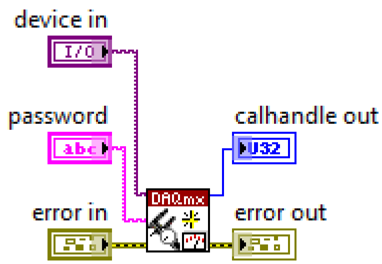
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxCloseExtCal` with the following parameters: **calHandle**: `calHandle` **action**: `DAQmx_Val_Action_Commit`

13. Repeat steps 3 through 12 for each voltage range on the NI 9219 channel.
14. Repeat steps 3 through 13 for each channel on the NI 9219.
15. Disconnect the source and the DMM from the device.

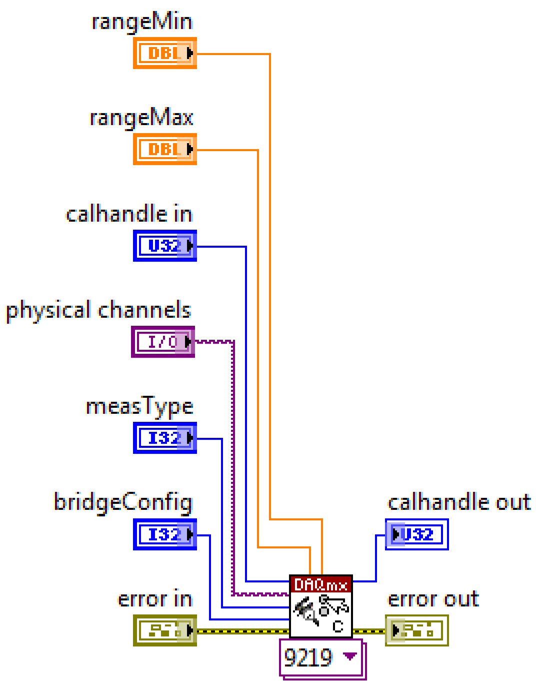
Current Accuracy Adjustment

Complete the following steps to adjust the current accuracy of the NI 9219.

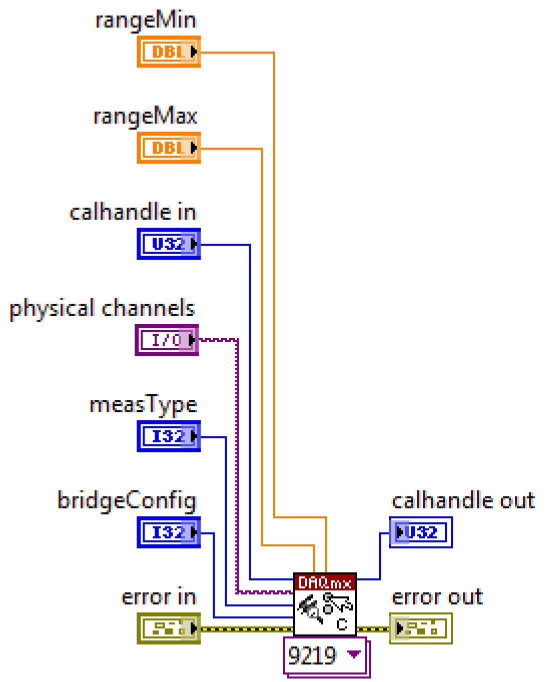
1. Connect the NI 9219 to the DMM and source as shown in Figure 4.
2. Open a calibration session to your device using the DAQmx Initialize External Calibration VI. The default password is `NI`.

LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxInitExtCal` with the following parameters: **deviceName**: The name of the device you want to calibrate. This name can be found under Devices and Interfaces in Measurements & Automation Explorer. **password**: `NI` **calHandle**: `&calHandle`

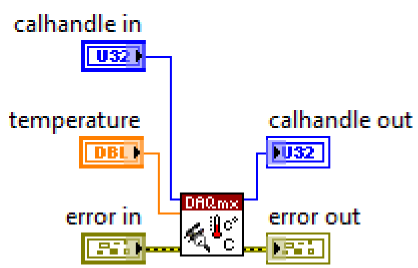
3. Place all channels on the NI 9219 in current mode using the NI 9219 instance of the DAQmx Setup C Series Calibration VI.

LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxSetup9219Cal` with the following parameters: **rangeMin**: `-0.025` **rangeMax**: `0.025` **calHandle**: `calHandle` **channelName**: `cDAQ1Mod8/ai0:3` **measType**: `DAQmx_Val_Current` **bridgeConfig**: `DAQmx_Val_NoBridge`

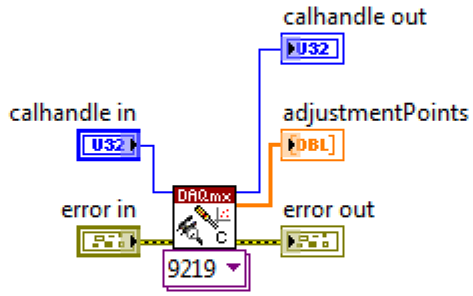
4. Set up the signal acquisition using the NI 9219 instance of the DAQmx Setup C Series Calibration VI.

LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxSetup9219Cal` with the following parameters: **rangeMin**: `-0.025` **rangeMax**: `0.025` **calHandle**: `calHandle` **channelName**: `cDAQ1Mod8/aix`* **measType**: `DAQmx_Val_Current` **bridgeConfig**: `DAQmx_Val_NoBridge`
* *x* refers to the channel number	

5. Input the external temperature using the DAQmx Set Temperature C Series Calibration VI.

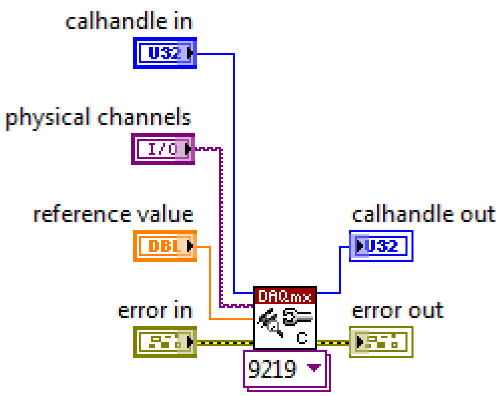
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxCSeriesSetCalTemp` with the following parameters: **calHandle**: `calHandle` **temperature**: The external temperature value in degrees Celsius.

6. Obtain an array of the recommended calibration currents for your device using the NI 9219 instance of the DAQmx Get C Series Calibration Adjustment Points VI.

<table>
<tr><th>LabVIEW Block Diagram</th><th>NI-DAQmx Function Call</th></tr>
<tr><td>
</td><td>Call <code>DAQmxGet9219CalAdjustPoints</code> with the following parameters:

calHandle: <code>calHandle</code>
adjustmentPoints: An array of reference values for the DAQmx Adjust Calibration VI.
bufferSize: The size of the adjustmentPoints array in elements.</td></tr>
</table>

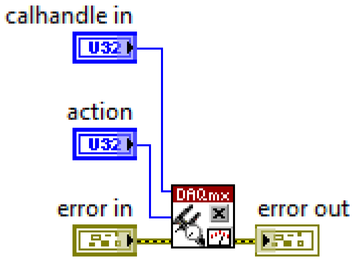
7. Set the source to a reference value determined by the array of adjustment points.
8. Configure the DMM for a current measurement.
9. Enable Auto Zero on the DMM.
10. Acquire a current reading with the DMM.
11. Acquire a current reading with the NI 9219 using the NI 9219 instance of the DAQmx Adjust C Series Calibration VI.

<table>
<tr><th>LabVIEW Block Diagram</th><th>NI-DAQmx Function Call</th></tr>
<tr><td>
</td><td>Call <code>DAQmxAdjust9219Cal</code> with the following parameters:

calHandle: <code>calHandle</code>
channelName: <code>cDAQ1Mod8/aix</code>*
value: The DMM reading.</td></tr>
<tr><td colspan="2">*x refers to the channel number</td></tr>
</table>

12. Repeat steps 7 through 11 for every value in the array.

13. Compute and save the adjustment to the EEPROM using the DAQmx Close External Calibration VI. This VI also saves the date, time, and temperature of the adjustment to the EEPROM.

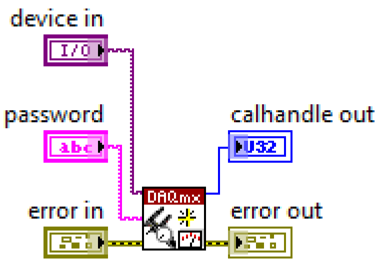
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxCloseExtCal` with the following parameters: **calHandle**: `calHandle` **action**: `DAQmx_Val_Action_Commit`

14. Repeat steps 3 through 13 for each channel on the NI 9219.
15. Disconnect the source and the DMM from the device.

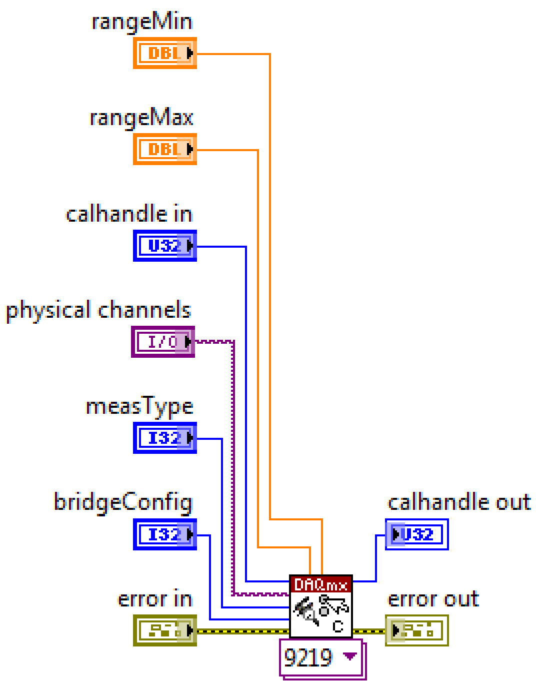
4-Wire and 2-Wire Resistance Accuracy Adjustment

Complete the following steps to adjust the 4-wire resistance accuracy and 2-wire resistance accuracy of the NI 9219.

1. Connect the NI 9219 to the resistor and the DMM as shown in Figure 7. Connect the sense leads of the DMM as close as possible to the same point that the sense leads of the NI 9219 (HI and LO) connect to the resistor to ensure that the DMM reference measurements include the same lead wire resistance as the NI 9219 4-wire measurements.
2. Open a calibration session to your device using the DAQmx Initialize External Calibration VI. The default password is `NI`.

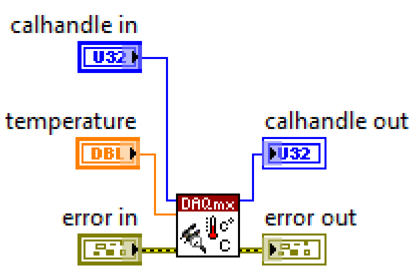
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxInitExtCal` with the following parameters: **deviceName**: The name of the device you want to calibrate. This name can be found under Devices and Interfaces in Measurement & Automation Explorer. **password**: `NI` **calHandle**: `&calHandle`

3. Place the NI 9219 channel in resistance mode using the NI 9219 instance of the DAQmx Setup C Series Calibration VI.

<table>
<tr><th>LabVIEW Block Diagram</th><th>NI-DAQmx Function Call</th></tr>
<tr><td>
</td><td>Call <code>DAQmxSetup9219Cal</code> with the following parameters:

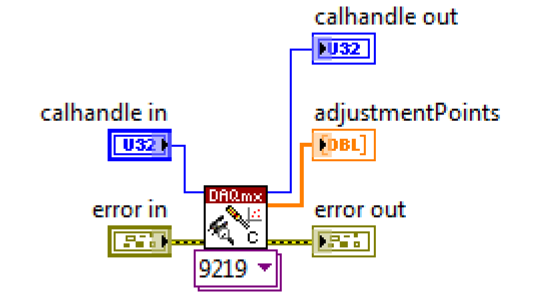
rangeMin: <code>0</code>
rangeMax: <code>1050, 10500</code>
calHandle: <code>calHandle</code>
channelName: <code>cDAQ1Mod8/aix</code>*
measType: <code>DAQmx_Val_Resistance</code>
bridgeConfig: <code>DAQmx_Val_NoBridge</code></td></tr>
<tr><td colspan="2">* x refers to the channel number</td></tr>
</table>

4. Input the external temperature using the DAQmx Set Temperature C Series Calibration VI.

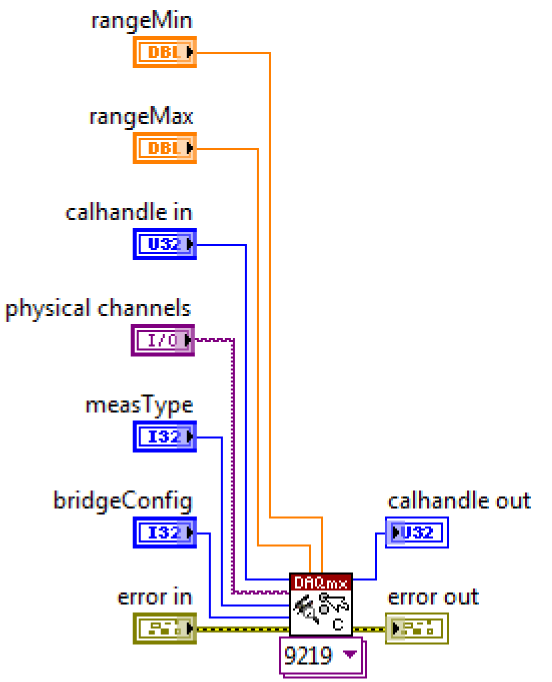
<table>
<tr><th>LabVIEW Block Diagram</th><th>NI-DAQmx Function Call</th></tr>
<tr><td>
</td><td>Call <code>DAQmxCSeriesSetCalTemp</code> with the following parameters:

calHandle: <code>calHandle</code>
temperature: The external temperature value in degrees Celsius.</td></tr>
</table>

5. Obtain an array of the recommended calibration resistances for your device using the NI 9219 instance of the DAQmx Get C Series Calibration Adjustment Points VI.

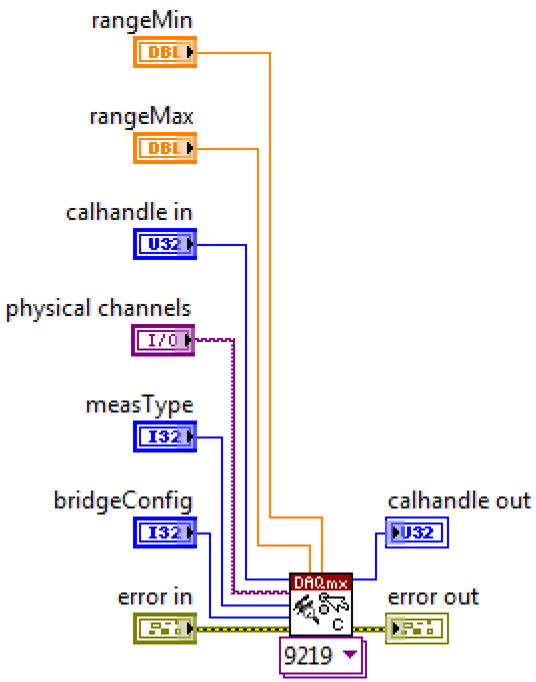
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxGet9219CalAdjustPoints` with the following parameters: **calHandle**: `calHandle` **adjustmentPoints**: An array of reference values for the DAQmx Adjust Calibration VI. **bufferSize**: The size of the **adjustmentPoints** array in elements.

6. Place the NI 9219 channel in voltage mode using the NI 9219 instance of the DAQmx Setup C Series Calibration VI.

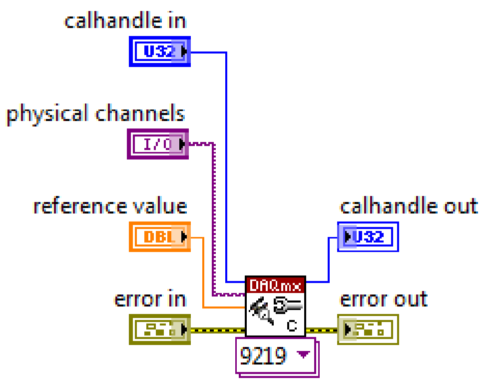
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxSetup9219Cal` with the following parameters: **rangeMin**: `-1` **rangeMax**: `1` **calHandle**: `calHandle` **channelNames**: `cDAQ1Mod8/aix`* **measType**: `DAQmx_Val_Voltage` **bridgeConfig**: `DAQmx_Val_NoBridge`
* *x* refers to the channel number	

7. Configure the DMM for a 4-wire resistance measurement.
8. Enable Auto Zero on the DMM.

9. Acquire a resistance reading with the DMM.
10. Disconnect the DMM from the resistors and NI 9219.
11. Set up the signal acquisition using the NI 9219 instance of the DAQmx Setup C Series Calibration VI.

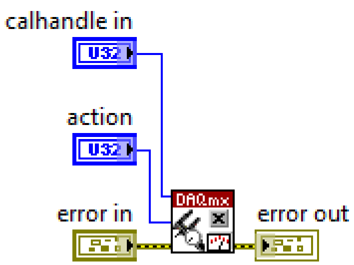
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxSetup9219Cal` with the following parameters: **rangeMin**: `0` **rangeMax**: `1050, 10500` **calHandle**: `calHandle` **channelName**: `cDAQ1Mod8/aix`* **measType**: `DAQmx_Val_Resistance` **bridgeConfig**: `DAQmx_Val_NoBridge`
* *x* refers to the channel number	

12. Acquire a 4-wire resistance reading with the NI 9219 using the NI 9219 instance of the DAQmx Adjust C Series Calibration VI.

LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxAdjust9219Cal` with the following parameters: **calHandle**: `calHandle` **channelName**: `cDAQ1Mod8/aix`* **value**: The DMM reading.

* *x* refers to the channel number

13. Reconnect the DMM as shown in Figure 7.
14. Repeat steps 6 through 13 for every value in the array.
15. Compute and save the adjustment to the EEPROM using the DAQmx Close External Calibration VI. This VI also saves the date, time, and temperature of the adjustment to the EEPROM.

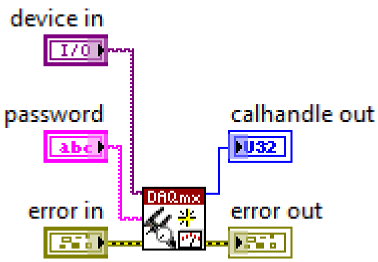
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxCloseExtCal` with the following parameters: **calHandle**: `calHandle` **action**: `DAQmx_Val_Action_Commit`

16. Repeat steps 2 through 15 for each 4-wire resistance mode on the NI 9219.
17. Disconnect the DMM and the resistor from the device.
18. Repeat steps 1 through 17 for each channel on the NI 9219.

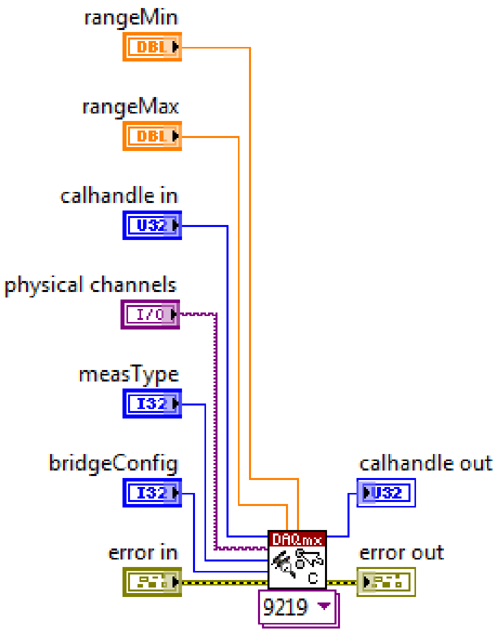
4-Wire RTD, 3-Wire RTD, and Quarter-Bridge Accuracy Adjustment

Complete the following steps to adjust the 4-wire RTD accuracy, 3-wire RTD accuracy, and quarter-bridge accuracy of the NI 9219.

1. Connect the NI 9219 to the resistor and the DMM as shown in Figure 8. Connect the sense leads of the DMM as close as possible to the same point that the sense leads of the NI 9219 (HI and LO) connect to the resistor to ensure that the DMM reference measurements include the same lead wire resistance as the NI 9219 4-wire measurements.
2. Open a calibration session to your device using the DAQmx Initialize External Calibration VI. The default password is `NI`.

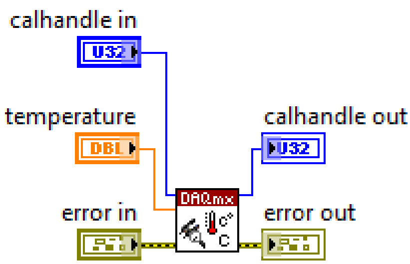
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxInitExtCal` with the following parameters: **deviceName**: The name of the device you want to calibrate. This name can be found under Devices and Interfaces in Measurements & Automation Explorer. **password**: `NI` **calHandle**: `&calHandle`

3. Place the NI 9219 channel in RTD mode using the NI 9219 instance of the DAQmx Setup C Series Calibration VI.

<table>
<tr><th>LabVIEW Block Diagram</th><th>NI-DAQmx Function Call</th></tr>
<tr><td>
</td><td>Call <code>DAQmxSetup9219Cal</code> with the following parameters:

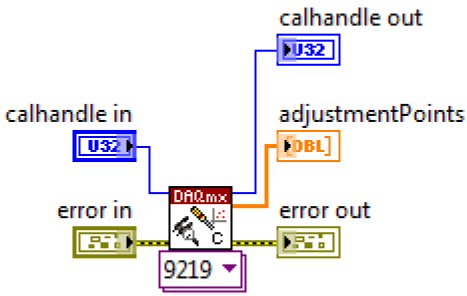
rangeMin: <code>0</code>
rangeMax: <code>505, 5050</code>
calHandle: <code>calHandle</code>
channelName: <code>cDAQ1Mod8/aix</code>*
measType: <code>DAQmx_Val_Temp_RTD</code>
bridgeConfig: <code>DAQmx_Val_NoBridge</code></td></tr>
<tr><td colspan="2">* x refers to the channel number</td></tr>
</table>

4. Input the external temperature using the DAQmx Set Temperature C Series Calibration VI.

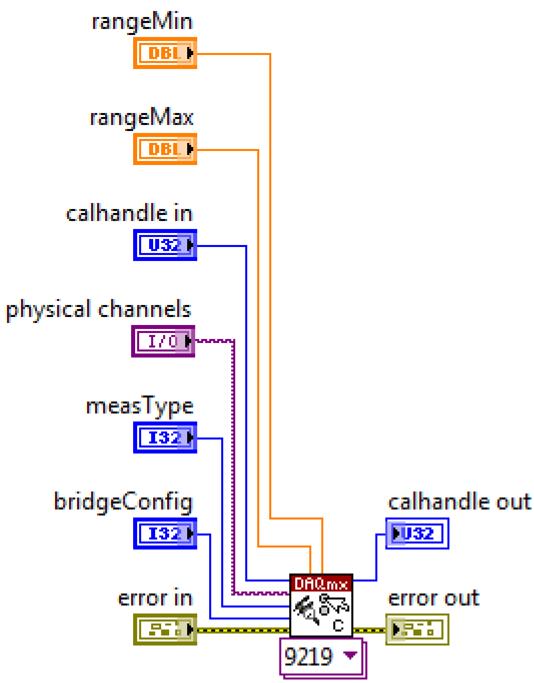
<table>
<tr><th>LabVIEW Block Diagram</th><th>NI-DAQmx Function Call</th></tr>
<tr><td>
</td><td>Call <code>DAQmxCSeriesSetCalTemp</code> with the following parameters:

calHandle: <code>calHandle</code>
temperature: The external temperature value in degrees Celsius.</td></tr>
</table>

5. Obtain an array of the recommended calibration resistances for your device using the NI 9219 instance of the DAQmx Get C Series Calibration Adjustment Points VI

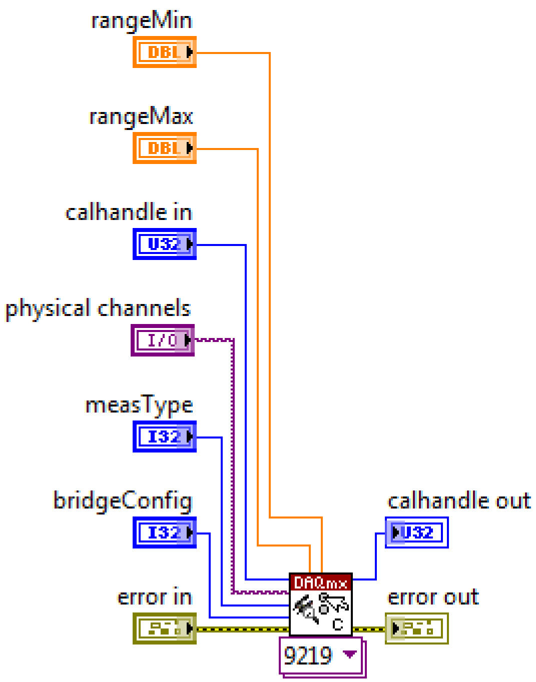
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxGet9219CalAdjustPoints` with the following parameters: **calHandle**: `calHandle` **adjustmentPoints**: An array of reference values for the DAQmx Adjust Calibration VI. **bufferSize**: The size of the **adjustmentPoints** array in elements.

6. Place the NI 9219 channel in voltage mode using the NI 9219 instance of the DAQmx Setup C Series Calibration VI.

LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxSetup9219Cal` with the following parameters: **rangeMin**: `-1` **rangeMax**: `1` **calHandle**: `calHandle` **channelNames**: `cDAQ1Mod8/aix`* **measType**: `DAQmx_Val_Voltage` **bridgeConfig**: `DAQmx_Val_NoBridge`
* *x* refers to the channel number	

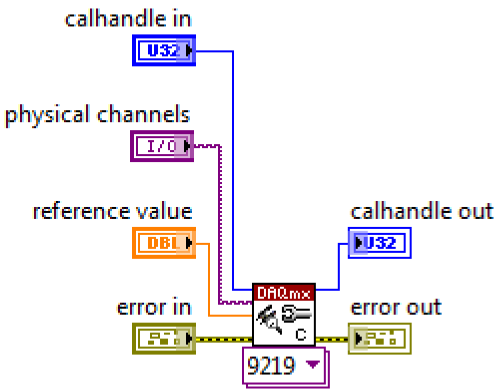
7. Configure the DMM for a 4-wire resistance measurement.

8. Enable Auto Zero on the DMM.
9. Acquire a resistance reading with the DMM.
10. Disconnect the DMM from the resistors and NI 9219.
11. Set up the signal acquisition using the NI 9219 instance of the DAQmx Setup C Series Calibration VI.

LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxSetup9219Cal` with the following parameters: **rangeMin**: `0` **rangeMax**: `505, 5050` **calHandle**: `calHandle` **channelName**: `cDAQ1Mod8/aix`* **measType**: `DAQmx_Val_Temp_RTD` **bridgeConfig**: `DAQmx_Val_NoBridge`

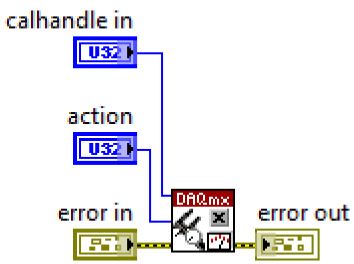
* *x* refers to the channel number

12. Acquire a 4-wire reading with the NI 9219 using the NI 9219 instance of the DAQmx Adjust C Series Calibration VI.

<table>
<tr><th>LabVIEW Block Diagram</th><th>NI-DAQmx Function Call</th></tr>
<tr><td>
</td><td>Call <code>DAQmxAdjust9219Cal</code> with the following parameters:

calHandle: <code>calHandle</code>
channelName: <code>cDAQ1Mod8/aix</code>*
value: The DMM reading.</td></tr>
<tr><td colspan="2">* x refers to the channel number</td></tr>
</table>

13. Reconnect the DMM as shown in Figure 8.
14. Repeat steps 6 through 13 for every value in the array.
15. Compute and save the adjustment to the EEPROM using the DAQmx Close External Calibration VI. This VI also saves the date, time, and temperature of the adjustment to the EEPROM.

<table>
<tr><th>LabVIEW Block Diagram</th><th>NI-DAQmx Function Call</th></tr>
<tr><td>
</td><td>Call <code>DAQmxCloseExtCal</code> with the following parameters:

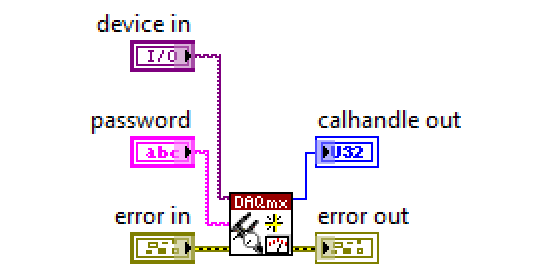
calHandle: <code>calHandle</code>
action: <code>DAQmx_Val_Action_Commit</code></td></tr>
</table>

16. Disconnect the resistor and the DMM from the device.
17. Repeat steps 1 through 16 for each channel on the NI 9219.

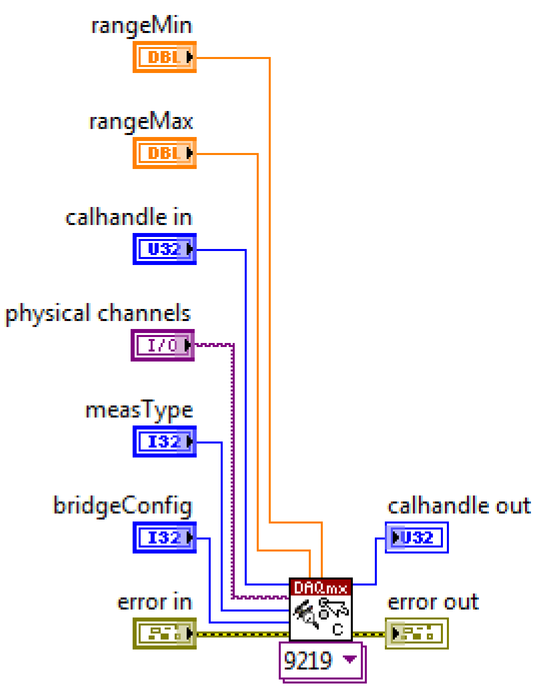
Half-Bridge Accuracy Adjustment

Complete the following steps to adjust the half-bridge accuracy of the NI 9219.

1. Connect the NI 9219 to DMM1 as shown in Figure 11.
2. Open a calibration session to your device using the DAQmx Initialize External Calibration VI. The default password is `NI`.

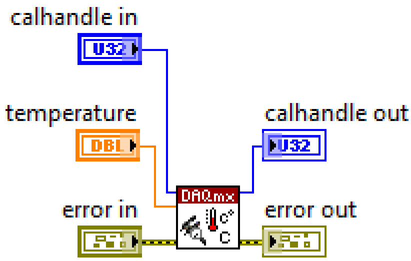
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxInitExtCal` with the following parameters: **deviceName**: The name of the device you want to calibrate. This name can be found under Devices and Interfaces in Measurements & Automation Explorer. **password**: `NI` **calHandle**: `&calHandle`

3. Set up the signal acquisition using the NI 9219 instance of the DAQmx Setup C Series Calibration VI.

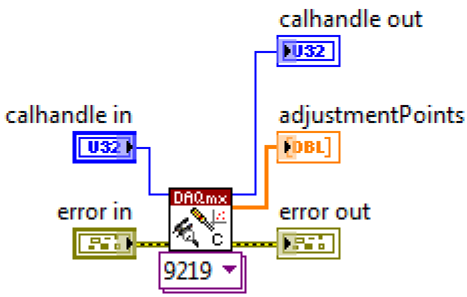
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxSetup9219Cal` with the following parameters: **rangeMin**: `-0.5` **rangeMax**: `0.5` **calHandle**: `calHandle` **channelName**: `cDAQ1Mod8/aix`* **measType**: `DAQmx_Val_Bridge` **bridgeConfig**: `DAQmx_Val_HalfBridge`

* *x* refers to the channel number

4. Input the external temperature using the DAQmx Set Temperature C Series Calibration VI.

LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxCSeriesSetCalTemp` with the following parameters: **calHandle**: `calHandle` **temperature**: The external temperature value in degrees Celsius.

5. Obtain an array of the recommended calibration voltages for your device using the NI 9219 instance of the DAQmx Get C Series Calibration Adjustment Points VI.

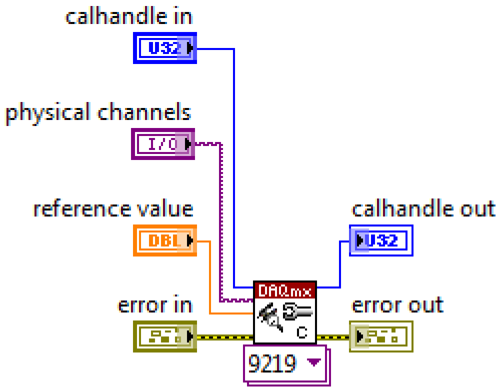
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxGet9219CalAdjustPoints` with the following parameters: **calHandle**: `calHandle` **adjustmentPoints**: An array of reference values. **bufferSize**: The size of the **adjustmentPoints** array in elements.

6. Configure DMM1 for a voltage measurement in the 10 V range.
7. Enable Auto Zero on DMM1.
8. Acquire a voltage reading with DMM1. Record this value as $V_{ExcitationModule}$.
9. Set the voltage source to $V_{ExcitationModule}$.
10. Connect the NI 9219 to DMM1, DMM2, and the voltage source as shown in Figures 12, 13, or 14 for the appropriate test point value indicated in Table 21. Observe the following conditions when connecting the equipment to the NI 9219.
    - Connect the leads of DMM1 as close as possible to the terminals on the NI 9219.
    - Connect the HI lead of DMM2 as close as possible to the same point that the HI lead of the NI 9219 connects to the resistor network.
    - Connect the LO lead of DMM2 as close as possible to the EX– terminal of the NI 9219.
11. Configure DMM1 for a voltage measurement in the 10 V range.
12. Enable Auto Zero on DMM1.
13. Configure DMM2 for a voltage measurement in the 10 V range.
14. Enable Auto Zero on DMM2.

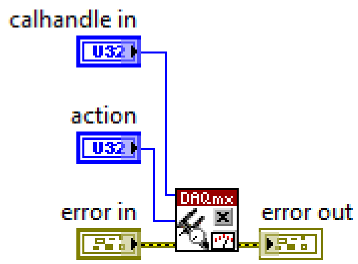
15. Acquire voltage measurements with both DMMs. Perform the following calculation using the two DMM measurements.

$$Ratio_{ref} = \frac{V_{DMM2}}{V_{DMM1}}$$

16. Acquire a bridge reading with the NI 9219 using the NI 9219 instance of the DAQmx Adjust C Series Calibration VI.

LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxAdjust9219Cal` with the following parameters: **calHandle**: `calHandle` **channelName**: `cDAQMod8/aix`* **value**: $Ratio_{ref}$.
* *x* refers to the channel number	

17. Repeat steps 10 through 16 for every value in the array.
18. Compute and save the adjustment to the EEPROM using the DAQmx Close External Calibration VI. This VI also saves the date, time, and temperature of the adjustment to the EEPROM.

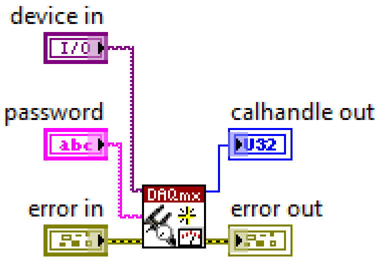
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxCloseExtCal` with the following parameters: **calHandle**: `calHandle` **action**: `DAQmx_Val_Action_Commit`

19. Disconnect the DMMs and the resistors from the device.
20. Repeat steps 1 through 19 for each channel on the NI 9219.

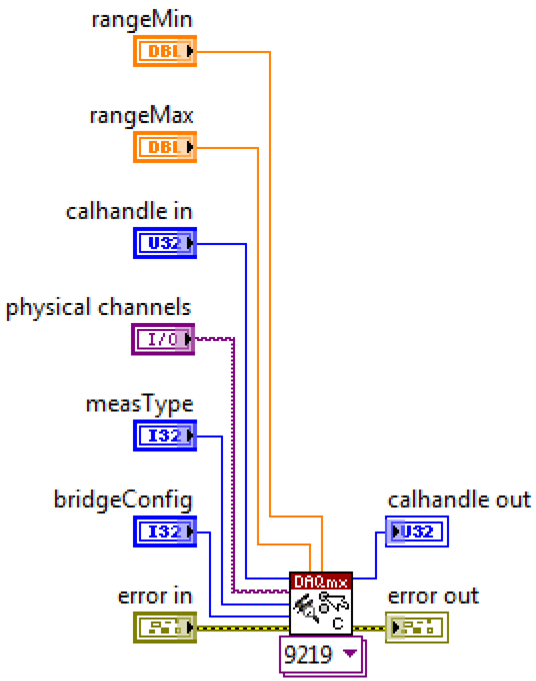
Full-Bridge Accuracy Adjustment

Complete the following steps to adjust the full-bridge accuracy of the NI 9219.

1. Connect the NI 9219 to DMM1 as shown in Figure 15.
2. Open a calibration session to your device using the DAQmx Initialize External Calibration VI. The default password is `NI`.

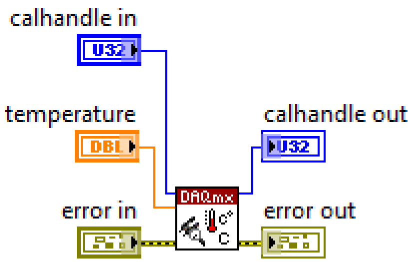
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxInitExtCal` with the following parameters: **deviceName**: The name of the device you want to calibrate. This name can be found under Devices and Interfaces in Measurements & Automation Explorer. **password**: `NI` **calHandle**: `&calHandle`

3. Set up the signal acquisition using the NI 9219 instance of the DAQmx Setup C Series Calibration VI.

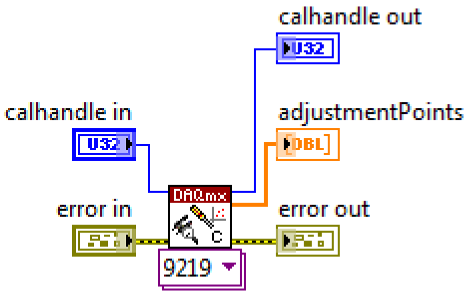
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxSetup9219Cal` with the following parameters: **rangeMin**: `-0.0078125, -0.0625` **rangeMax**: `0.0078125, 0.0625` **calHandle**: `calHandle` **channelName**: `cDAQ1Mod8/aix`* **measType**: `DAQmx_Val_Bridge` **bridgeConfig**: `DAQmx_Val_FullBridge`

* *x* refers to the channel number

4. Input the external temperature using the DAQmx Set Temperature C Series Calibration VI.

LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxCSeriesSetCalTemp` with the following parameters: **calHandle**: `calHandle` **temperature**: The external temperature value in degrees Celsius.

5. Obtain an array of the recommended calibration voltages for your device using the NI 9219 instance of the DAQmx Get C Series Calibration Adjustment Points VI.

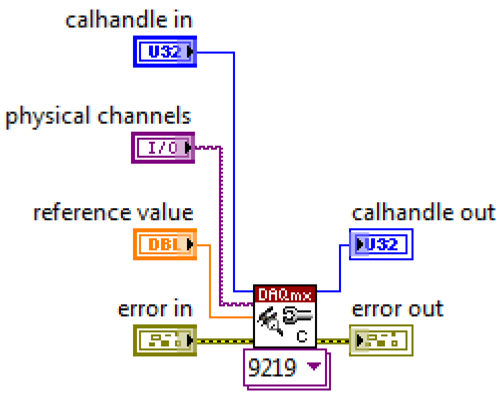
LabVIEW Block Diagram	NI-DAQmx Function Call
	Call `DAQmxGet9219CalAdjustPoints` with the following parameters: **calHandle**: `calHandle` **adjustmentPoints**: An array of reference values. **bufferSize**: The size of the **adjustmentPoints** array in elements.

6. Configure DMM1 for a voltage measurement in the 10 V range.
7. Enable Auto Zero on DMM1.
8. Acquire a voltage reading with DMM1. Record this value as $V_{ExcitationModule}$.
9. Set the voltage source to $V_{ExcitationModule}$.
10. Connect the NI 9219 to DMM1, DMM2, and the voltage source as shown in Figures 16 or 17 for the appropriate test point value indicated in Table . Observe the following conditions when connecting the equipment to the NI 9219.
    - Connect the leads of DMM1 as close as possible to the terminals on the NI 9219.
    - Connect the HI lead of DMM2 as close as possible to the same point that the HI lead of the NI 9219 connects to the resistor network.
    - Connect the LO lead of DMM2 as close as possible to the same point that the LO lead of the NI 9219 connects to the resistor network.
11. Configure DMM1 for a voltage measurement in the 10 V range.
12. Enable Auto Zero on DMM1.
13. Configure DMM2 for a voltage measurement in the 1 V range.

14. Enable Auto Zero on DMM2.
15. Acquire voltage measurements with both DMMs. Perform the following calculation using the two DMM measurements.

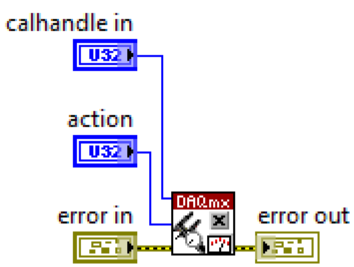
$$Ratio_{ref} = \frac{V_{DMM2}}{V_{DMM1}}$$

16. Acquire a bridge reading with the NI 9219 using the NI 9219 instance of the DAQmx Adjust C Series Calibration VI.

<table>
<tr><th>LabVIEW Block Diagram</th><th>NI-DAQmx Function Call</th></tr>
<tr><td>
</td><td>Call DAQmxAdjust9219Cal with the following parameters:

calHandle: calHandle
channelName: cDAQMod8/aix*
value: $Ratio_{ref}$.</td></tr>
<tr><td colspan="2">* x refers to the channel number</td></tr>
</table>

17. Repeat steps 10 through 16 for every value in the array.
18. Compute and save the adjustment to the EEPROM using the DAQmx Close External Calibration VI. This VI also saves the date, time, and temperature of the adjustment to the EEPROM.

<table>
<tr><th>LabVIEW Block Diagram</th><th>NI-DAQmx Function Call</th></tr>
<tr><td>
</td><td>Call DAQmxCloseExtCal with the following parameters:

calHandle: calHandle
action: DAQmx_Val_Action_Commit</td></tr>
</table>

19. Repeat steps 10 through 18 for each full-bridge mode on the NI 9219.
20. Disconnect the DMMs and the resistors from the device.
21. Repeat steps 1 through 20 for each channel on the NI 9219.

The NI 9219 is now calibrated with respect to your external source. After performing the *Adjustment* Procedure, repeat the *Verification* Procedure to re-verify the accuracy of the module.

Accuracy Under Calibration Conditions

The following accuracy table is valid for calibration under the following conditions:

- Ambient temperature of 23 ±5 °C
- NI 9219 installed in slot 8 of an NI cDAQ-9178 chassis
- Slots 1 through 7 of the NI cDAQ-9178 chassis are empty

Note The test limits listed in Tables 5, 7, 9, 11, 13, 15, 17, 19, 21, are derived using the values in Table 24.

Table 24. NI 9219 Accuracy Under Calibration Conditions

Mode	Range		PPM of Reading	PPM of Range
	Minimum	Maximum		
Voltage ±60 V	–60 V	60 V	744	17
Voltage ±15 V	–15 V	15 V	745	55
Voltage ±4 V	–4 V	4 V	740	147
Voltage ±1 V	–1 V	1 V	308	14
Voltage ±125 mV	–125 mV	125 mV	308	82
Thermocouple	–125 mV	125 mV	308	82
Current	–25 mA	25 mA	1067	24
4-Wire Resistance 10 kΩ	0 Ω	10.5 kΩ	776	61
4-Wire Resistance 1 kΩ	0 Ω	1.05 kΩ	771	474
4-Wire RTD Pt1000	0 Ω	5.05 kΩ	774	122
4-Wire RTD Pt100	0 Ω	505 Ω	764	947
3-Wire RTD Pt1000	0 Ω	5.05 kΩ	807	122
3-Wire RTD Pt100	0 Ω	505 Ω	797	951
2-Wire Resistance 10 kΩ	0 Ω	10.5 kΩ	776	61
2-Wire Resistance 1 kΩ	0 Ω	1.05 kΩ	771	475
Quarter-Bridge 350 Ω	0 Ω	390 Ω	760	956
Quarter-Bridge 120 Ω	0 Ω	150 Ω	734	1612
Half-Bridge 500 mV/V	–500 mV/V	500 mV/V	93	205
Full-Bridge 62.5 mV/V	–62.5 mV/V	62.5 mV/V	111	197
Full-Bridge 7.8 mV/V	–7.8125 mV/V	7.8125 mV/V	120	1526

Note For operational specifications, refer to the most recent *NI 9219 Operating Instructions and Specifications* online at `ni.com/manuals`.

Where to Go for Support

The National Instruments Web site is your complete resource for technical support. At `ni.com/support` you have access to everything from troubleshooting and application development self-help resources to email and phone assistance from NI Application Engineers.

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

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