
NI-9237

Getting Started

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Contents

NI-9237 Getting Started..... 3

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NI-9237 Nomenclature

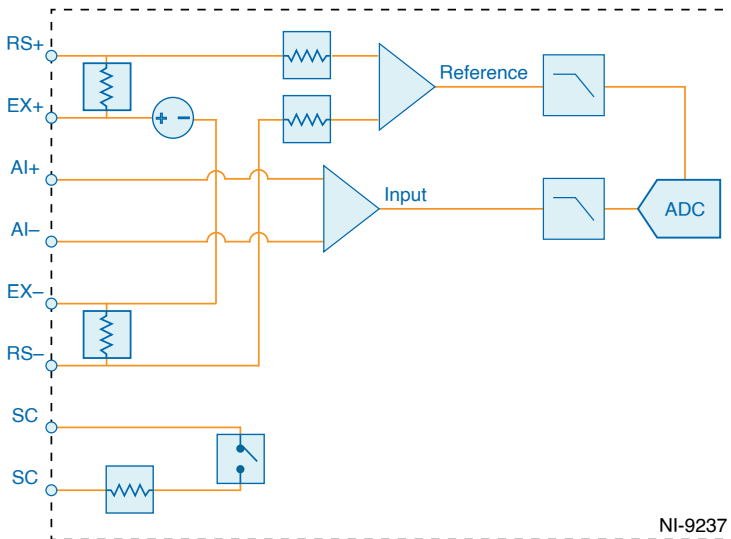
In this article, the NI-9237 with RJ-50 and NI-9237 with DSUB are referred to inclusively as the NI-9237.

NI-9237 Block Diagram

Each channel on the NI-9237 has an independent 24-bit ADC and an input amplifier that enable you to sample signals from all four channels simultaneously.

The NI-9237 is isolated from earth ground. However, the individual channels are not isolated from each other. The EX+, EX-, and T- signals are common among all channels. You can connect the NI-9237 to a device that is biased at any voltage within the NI-9237 rejection range of earth ground.

Figure 1. Input Circuitry for One Channel of the NI-9237



Connection Options to Correct for Resistance Errors

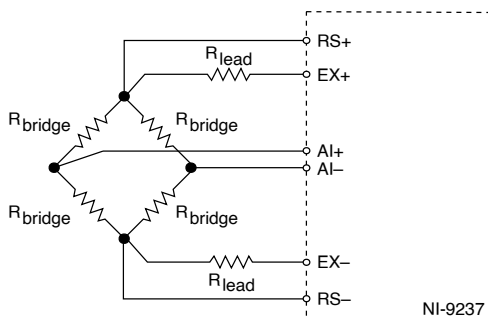
Wiring resistance can create errors in bridge circuits. The NI-9237 provides two mechanisms to correct for these errors: remote sensing and shunt calibration.

Remote Sensing

Remote sensing continuously and automatically corrects for errors in excitation leads, and generally is most appropriate for half- and full-bridge sensors.

Long wire and small gauge wire have greater resistance, which can result in gain error. The resistance in the wires that connect the excitation voltage to the bridge causes a voltage drop, which is a source of gain error. The NI-9237 includes remote sensing to compensate for this gain error. Connect remote sense wires to the points where the excitation voltage wires connect to the bridge circuit. Refer to the following figure for an illustration of how to connect remote sense wires to the NI-9237.

Figure 2. Connecting Remote Sense Wires to the NI-9237



The actual bridge excitation voltage is smaller than the voltage at the EX+ and EX- leads. If you do not use remote sensing of the actual bridge voltage, the resulting gain error is:

$\frac{R_{\text{lead}}}{R_{\text{bridge}}}$ for half-bridge sensors and $\frac{2 R_{\text{lead}}}{R_{\text{bridge}}}$ for full-bridge sensors.

If you connect the remote sense signals directly to the bridge resistors, the NI-9237 senses the actual bridge voltage and eliminates the gain errors caused by the resistance of the EX+ and EX- leads.

Shunt Calibration

Shunt calibration can correct for errors from the resistance of both the excitation wiring and wiring in the individual resistors of the bridge. Remote sensing corrects for resistances from the EX pins on the NI-9237 to the sensor, and shunt calibration corrects for these errors and for errors caused by wire resistance within an arm of

the bridge. Shunt calibration is most useful with quarter-bridge sensors because there may be significant resistance in the wiring to the active resistor in the bridge.

The NI-9237 shunt calibration circuitry consists of a precision resistor and a software-controlled switch. Refer to the software help for information about enabling the shunt calibration switch for the NI-9237.

Shunt calibration involves simulating the input of strain by changing the resistance of an arm in the bridge by some known amount. This is accomplished by shunting, or connecting, a large resistor of known value across one arm of the bridge, creating a known strain-induced change in resistance. You can then measure the output of the bridge and compare it to the expected voltage value. You can use the results to correct gain errors in the entire measurement path, or to simply verify general operation to gain confidence in the setup.

Use a stable signal, which is typically the unloaded state of the sensor, first with the shunt calibration switch off and then again with the switch on. The difference in these two measurements provides an indication of the gain errors from wiring resistances. You can design the software application to correct subsequent readings for this gain error.

Excitation Voltages

You can program the NI-9237 to supply 2.5 V, 3.3 V, 5 V, or 10 V of excitation voltage. The maximum excitation power for internal excitation is 150 mW.



Note Unless you supply external excitation voltage, NI recommends that you set the excitation voltage to a value that keeps the total power below 150 mW. The NI-9237 automatically reduces internal excitation voltages as needed to stay below 150 mW total power.

Use the following equation to calculate the power of a single bridge:

$$P = \frac{V_{\text{ex}}^2}{R}$$

where R is the total resistance of the bridge.

For a quarter or half bridge, R is equal to two times the resistance of each element. For a full bridge, R is equal to the resistance of each element.

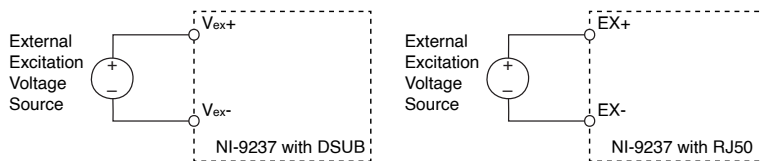
The 150 mW limit allows you to power half and full bridges as follows:

- Four 350 Ω half bridges at 5.0 V
- Four 350 Ω full bridges at 3.3 V
- Four 120 Ω half bridges at 2.5 V

External Excitation

You can connect an external excitation voltage source to the NI-9237 if you need an excitation voltage that causes more than 150 mW to dissipate across all the bridges.

Figure 3. Connecting an External Excitation Voltage Source to the NI-9237



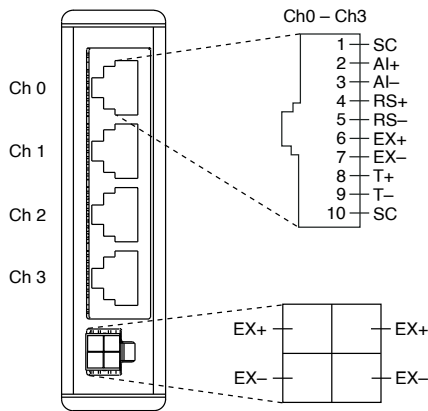
Note For the NI-9237 with RJ-50, use the two EX+ and EX- terminals on the four-terminal external excitation voltage connector to connect one external excitation source.

You can use the additional EX+ and EX- terminals on the connector to wire multiple NI-9237 modules together in a daisy chain.

NI-9237 Pinout

The NI-9237 provides connections for four half or full bridges, and an external excitation voltage source.

NI-9237 with RJ-50 Pinout



Caution Do not use RJ-45 cables with the NI-9237 with RJ-50. RJ-45 cables damage the RJ-50 connector, permanently disabling the shunt calibration, regardless of which connector you use.

Table 1. NI-9237 with RJ-50 Signal Descriptions

| Signal Name | Description |
|-------------|---|
| AI+ | Positive analog input signal connection |
| AI- | Negative analog input signal connection |
| RS+ | Positive remote sensing connection |
| RS- | Negative remote sensing connection |
| EX+ | Positive sensor excitation connection |
| EX- | Negative sensor excitation connection |
| T+ | TEDS data connection |
| T- | TEDS return connection |
| SC | Shunt calibration connection |

NI-9237 with DSUB Pinout

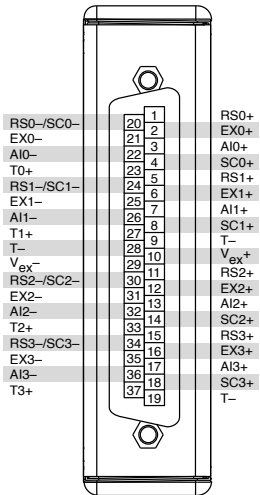


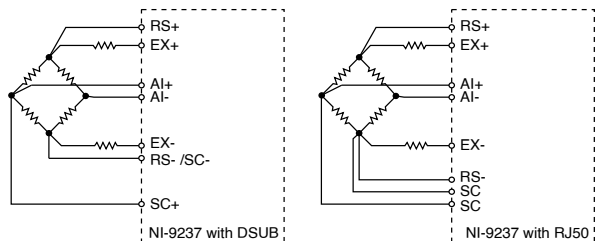
Table 2. NI-9237 with DSUB Signal Descriptions

| Signal Name | Description |
|-------------|---|
| AI+ | Positive analog input signal connection |
| AI- | Negative analog input signal connection |
| RS+ | Positive remote sensing connection |
| RS- | Negative remote sensing connection |
| EX+ | Positive sensor excitation connection |
| EX- | Negative sensor excitation connection |
| T+ | TEDS data connection |
| T- | TEDS return connection |
| SC | Shunt calibration connection |

Connecting a Full Bridge

You can connect a full bridge to the NI-9237.

Figure 4. Connecting a Full Bridge to the NI-9237

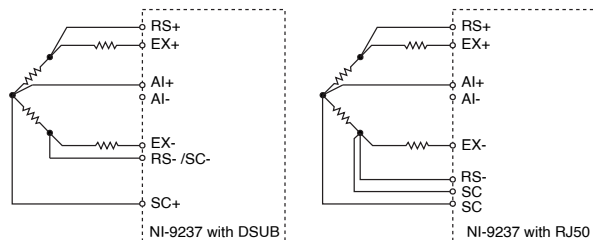


You also can connect floating signals to the NI-9237. If you connect floating signals to the NI-9237, NI recommends connecting the EX- signal to the earth ground or shield for better noise rejection.

Connecting a Half Bridge

You can connect a half bridge to the NI-9237.

Figure 5. Connecting a Half Bridge to the NI-9237



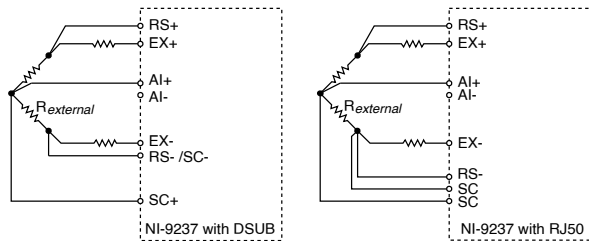
You also can connect floating signals to the NI-9237. If you connect floating signals to the NI-9237, NI recommends connecting the EX- signal to the earth ground or shield for better noise rejection.

Bridge Calibration

When you insert or remove a new sensor from the NI-9237, slight changes in the excitation voltages can cause a mismatch between the internal half-bridge completion resistors and the half-bridge sensors, which results in a change in the measurement offsets. NI recommends performing bridge calibrations of quarter- or half-bridge sensors after connecting all sensors to the NI-9237 and after removing or attaching any additional sensor. For more information about changes in voltage offsets in the NI-9237, visit ni.com/info and enter the Info Code rdw9237.

Connecting a Quarter Bridge

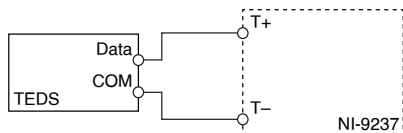
You can connect a quarter bridge to the NI-9237 by adding a resistor externally to create a half bridge.

Figure 6. Connecting a Quarter Bridge to the NI-9237

You also can use a quarter bridge with the NI-9237 with RJ-50 if you use the NI 9944 or NI 9945 Quarter Bridge Completion Accessory.

Connecting TEDS Sensors

You can connect TEDS sensors to the NI-9237.

Figure 7. Connecting TEDS Sensors to the NI-9237

Ensure that neither the TEDS data (T+) nor the TEDS return (T-) signal is tied in common to any AI signals on the NI-9237. The NI-9237 connects all the T- signals together internally. The NI-9237 with DSUB has only three T- pins. To connect four TEDS sensors to the NI-9237 with DSUB, wire the TEDS return signals of two of the sensors to one of the T- pins.

Filtering

The NI-9237 uses a combination of analog and digital filtering to provide an accurate representation of in-band signals and reject out-of-band signals. The filters discriminate between signals based on the frequency range, or bandwidth, of the signal. The three important bandwidths to consider are the passband, the stopband, and the anti-imaging bandwidth.

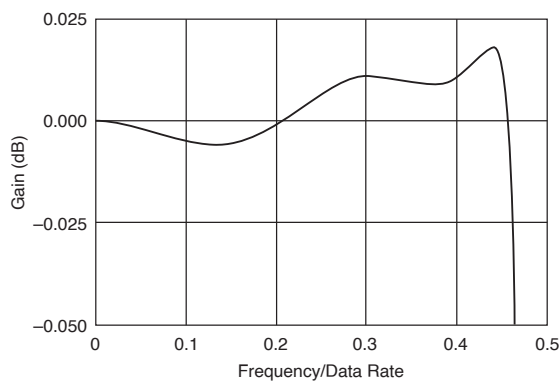
The NI-9237 represents signals within the passband, as quantified primarily by passband ripple and phase nonlinearity. All signals that appear in the alias-free

bandwidth are either unaliased signals or signals that have been filtered by at least the amount of the stopband rejection.

Passband

The signals within the passband have frequency-dependent gain or attenuation. The small amount of variation in gain with respect to frequency is called the passband flatness. The digital filters of the NI-9237 adjust the frequency range of the passband to match the data rate. Therefore, the amount of gain or attenuation at a given frequency depends on the data rate.

Figure 8. Typical Passband Flatness for the NI-9237



Stopband

The filter significantly attenuates all signals above the stopband frequency. The primary goal of the filter is to prevent aliasing. Therefore, the stopband frequency scales precisely with the data rate. The stopband rejection is the minimum amount of attenuation applied by the filter to all signals with frequencies within the stopband.

Alias-Free Bandwidth

Any signals that appear in the alias-free bandwidth are not aliased artifacts of signals at a higher frequency. The alias-free bandwidth is defined by the ability of the filter to reject frequencies above the stopband frequency. The alias-free bandwidth is equal to the data rate minus the stopband frequency.

Data Rates

The frequency of a master timebase (f_M) controls the data rate (f_s) of the NI-9237. The NI-9237 includes an internal master timebase with a frequency of 12.8 MHz, but the module also can accept an external master timebase or export its own master timebase. To synchronize the data rate of an NI-9237 with other modules that use master timebases to control sampling, all of the modules must share a single master timebase source.

The following equation provides the available data rates of the NI-9237:

$$f_s = \frac{f_M \div 256}{n}$$

where n is any integer from 1 to 31.

However, the data rate must remain within the appropriate data rate range. When using the internal master timebase of 12.8 MHz, the result is data rates of 50 kS/s, 25 kS/s, 16.667 kS/s, and so on down to 1.613 kS/s depending on the value of n . When using an external timebase with a frequency other than 12.8 MHz, the NI-9237 has a different set of data rates.



Note The NI 9151 R Series Expansion chassis does not support sharing timebases between modules.