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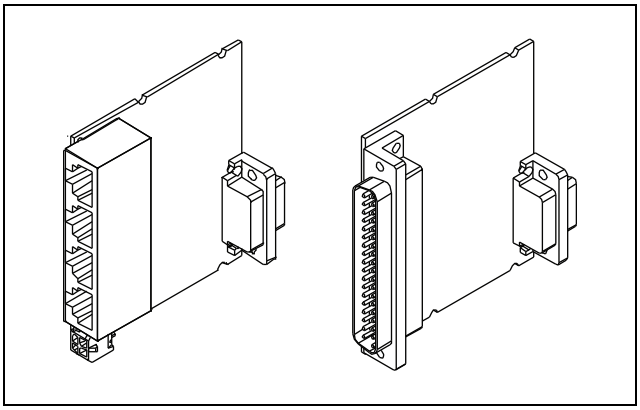
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Find the *National Instruments sbRIO-9237* at our website: *Click HERE*

OPERATING INSTRUCTIONS AND SPECIFICATIONS

NI 9237E

4-Channel, 24-Bit Half/Full-Bridge Analog Input Module



NATIONAL INSTRUMENTS

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This document describes how to use the National Instruments 9237E and includes dimensions, pin assignments, and specifications for the NI 9237E. In this document, the NI 9237E with RJ-50 connectors and the NI 9237E with DSUB are referred to inclusively as the NI 9237E. Visit `ni.com/info` and enter `rdsoftwareversion` to determine which software you need for the modules you are using. For information about installing, configuring, and programming the system, refer to the system documentation. Visit `ni.com/info` and enter `cseriesdoc` for information about C Series documentation.

Caution National Instruments makes no electromagnetic compatibility (EMC) or CE marking compliance claims for the NI 9237E. The end-product supplier is responsible for conformity to any and all compliance requirements.

Caution The NI 9237E must be installed inside a suitable enclosure prior to use. Hazardous voltages may be present.

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NI 9237E Dimensions

The following figure shows the dimensions of the NI 9237E.

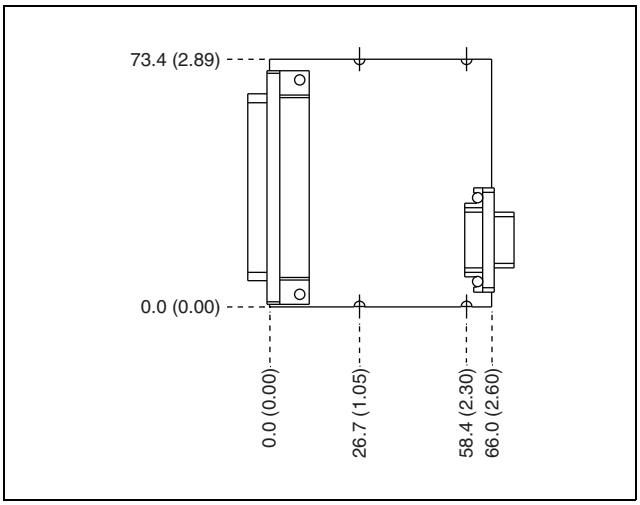


Figure 1. NI 9237E Dimensions in Millimeters (Inches)

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Connecting the NI 9237E

The NI 9237E has four RJ-50 receptacles or a 37-pin DSUB connector that provides connections for four half or full bridges, and an external excitation voltage source.

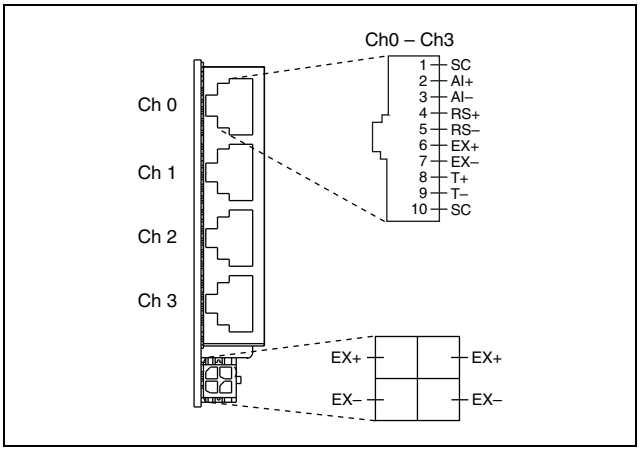


Figure 2. NI 9237E with RJ-50 Pin Assignments

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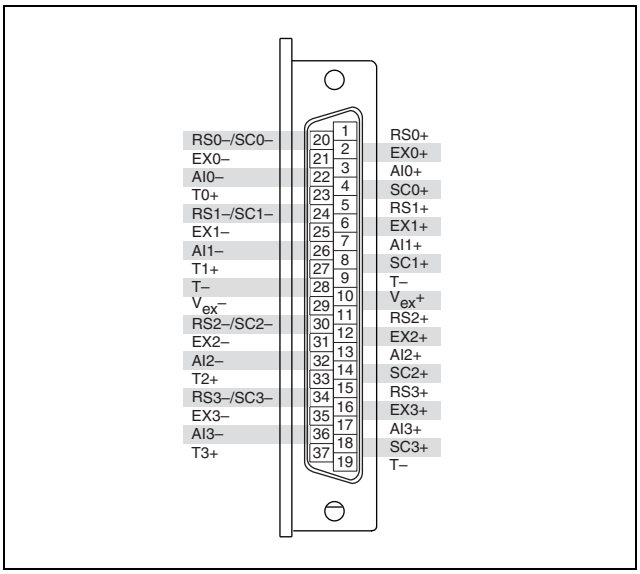


Figure 3. NI 9237E with DSUB Pin Assignments

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When you connect a half bridge to the NI 9237E, you must connect the AI+, EX+ and EX–, and RS+ and RS– signals, but you do not need to connect the AI– signal because it is connected internally. When you connect a full bridge, you must connect the AI+ and AI–, EX+ and EX–, and RS+ and RS– signals. Refer to Figure 4 for an illustration of how to connect half and full bridges to the NI 9237E.

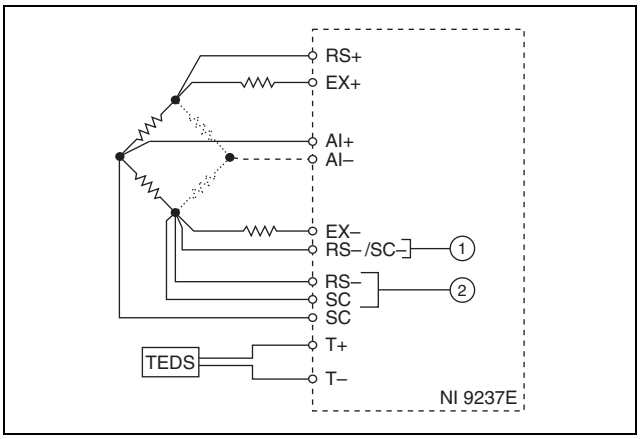
Note You can use a quarter bridge with the NI 9237E if you add a resistor externally to create a half bridge. You also can use a quarter bridge with the NI 9237E with RJ-50 if you use the NI 9944 or NI 9945 Quarter Bridge Completion Accessory. Visit `ni.com` and search for the NI 9944 and NI 9945 Quarter Bridge Completion Accessories for more information about these accessories and how to purchase them.

Note National Instruments does not recommend using an RJ-45 cable with the NI 9237E with RJ-50 because it can physically damage pins 1 and 10 on the device, and thus permanently disable shunt calibration no matter what connector you use.

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Note When you insert or remove a new sensor from the NI 9237E, 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. National Instruments recommends performing bridge calibrations of quarter- or half-bridge sensors after connecting all sensors to the NI 9237E and after removing or attaching any additional sensor. Visit `ni.com/info` and enter the info code `rdw9237` for more information about changes in voltage offsets in the NI 9237E.

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1 NI 9237E with DSUB only 2 NI 9237E with RJ-50 only

Figure 4. Connecting a Half or Full Bridge to the NI 9237E

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

The NI 9237E 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 9237E to a device that is biased at any voltage within the NI 9237E rejection range of earth ground. Refer to the *Specifications* section for more information about the common-mode rejection ratio (CMRR).

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

The NI 9237E also includes filters to prevent aliasing. The filters on the NI 9237E filter according to the data rate. Refer to the *Understanding NI 9237E Filtering* section for more information about filtering.

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Wiring TEDS Channels

Ensure that neither the TEDS data (T+) nor the TEDS return (T–) signal is tied in common to any AI signals on the NI 9237E. The NI 9237E connects all the T– signals together internally. The NI 9237E with DSUB has only three T– pins. To connect four TEDS sensors to the NI 9237E with DSUB, wire the TEDS return signals of two of the sensors to one of the T– pins. Visit `ni.com/info` and enter the info code `rdteds` for more information about TEDS sensors.

Connection Options to Correct for Resistance Errors

Wiring resistance can create errors in bridge circuits. The NI 9237E 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

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source of gain error. The NI 9237E 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 Figure 5 for an illustration of how to connect remote sense wires to the NI 9237E.

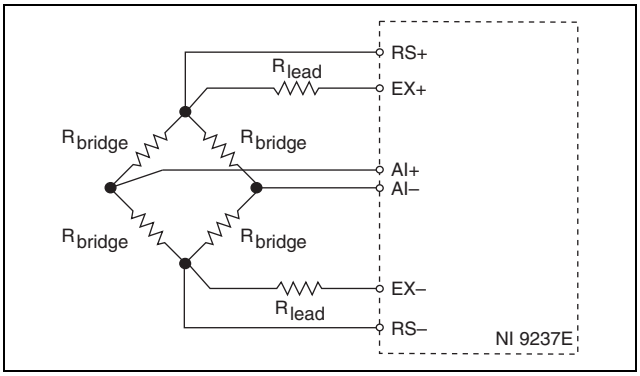


Figure 5. Connecting Remote Sense Wires to the NI 9237E

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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:

$\frac{R_{lead}}{R_{bridge}}$ for half-bridge sensors and

$\frac{2 \cdot R_{lead}}{R_{bridge}}$ for full-bridge sensors.

If you connect the remote sense signals directly to the bridge resistors, the NI 9237E 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 9237E 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

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sensors because there may be significant resistance in the wiring to the active resistor in the bridge.

The NI 9237E 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 9237E. Visit `ni.com/info` and enter `cseriesdoc` for information about C Series documentation.

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.

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Excitation Voltages

Although the sensor industry does not recognize a single standard excitation voltage level, excitation voltage levels of between 2.5 V and 10 V are common. You can program the NI 9237E to supply 2.5 V, 3.3 V, 5 V, or 10 V of excitation voltage, and the module can provide up to 150 mW of excitation power. Unless you supply external excitation voltage, National Instruments recommends that you set the excitation voltage to a value that keeps the total power below 150 mW. The NI 9237E automatically reduces internal excitation voltages as needed to stay below 150 mW total power.

The power consumed by a single bridge is $\frac{V_{ex}^2}{R}$ 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.

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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

If you need an excitation voltage that causes more than 150 mW to dissipate across all the bridges, connect an external excitation voltage source to the NI 9237E. For the NI 9237E with DSUB, use the two V_{ex} pins to connect the external excitation source. For the NI 9237E 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 9237E modules together in a daisy chain.

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Understanding NI 9237E Filtering

The NI 9237E uses a combination of analog and digital filtering to provide an accurate representation of in-band signals while rejecting 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 alias-free bandwidth.

The NI 9237E represents signals within the passband, as quantified primarily by passband flatness 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 9237E 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 6 shows typical passband flatness for the NI 9237E.

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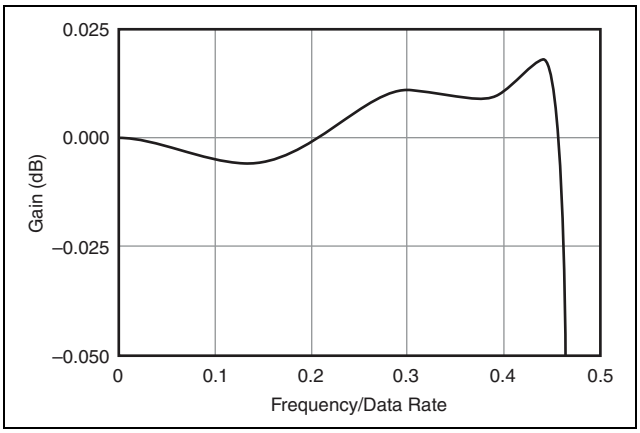


Figure 6. Typical Passband Flatness for the NI 9237E

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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 signal that appears in the alias-free bandwidth of the NI 9237E is not an aliased artifact 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, and it is equal to the data rate minus the stopband frequency.

Understanding NI 9237E Data Rates

The frequency of a master timebase (f_M) controls the data rate (f_s) of the NI 9237E. The NI 9237E 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 9237E with other modules that use master timebases to control sampling, all of the

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modules must share a single master timebase source. Refer to the software help for information about configuring the master timebase source for the NI 9237E. Visit `ni.com/info` and enter `cseriesdoc` for information about C Series documentation.

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

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

where n is any integer from 1 to 31.

However, the data rate must remain within the appropriate data rate range. Refer to the *Specifications* section for more information about the 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, 16.67 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 9237E has a different set of data rates.

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

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Sleep Mode

This module supports a low-power sleep mode. Support for sleep mode at the system level depends on the chassis that the module is plugged into. Refer to the chassis manual for information about support for sleep mode. If the chassis supports sleep mode, refer to the software help for information about enabling sleep mode. Visit `ni.com/info` and enter `cseriesdoc` for information about C Series documentation.

Typically, when a system is in sleep mode, you cannot communicate with the modules. In sleep mode, the system consumes minimal power and may dissipate less heat than it does in normal mode. Refer to the *Specifications* section for more information about power consumption and thermal dissipation.

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Specifications

The following specifications are typical for the range –40 to 85 °C internal to any enclosures unless otherwise noted.

Input Characteristics

Number of channels ..... 4 analog input channels

Bridge completion

- Half and Full ..... Internal
- Quarter ..... External

ADC resolution ..... 24 bits

Type of ADC ..... Delta-Sigma (with analog prefiltering)

Sampling mode ..... Simultaneous

Internal master timebase (f_M)

- Frequency ..... 12.8 MHz
- Accuracy ..... ±100 ppm max

Data rate range (f_s) using internal master timebase

- Minimum ..... 1.613 kS/s
- Maximum ..... 50 kS/s

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Data rate range (f_s) using external master timebase

Minimum ..... 391 S/s

Maximum ..... 51.36 kS/s

Data rates[1] (f_s) ..... $\frac{f_M \div 256}{n}$, n = 1, 2, …, 31

Typical input range ..... ±25 mV/V

Scaling coefficient ..... 2.9802 nV/V per LSB

Overvoltage protection
between any two pins..... ±30 V

[1] The data rate must remain within the appropriate data rate range. Refer to the *Understanding NI 9237E Data Rates* section for more information.

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Accuracy

Measurement Conditions*	Percent of Reading† (Gain Error)	Percent of Range‡ (Offset Error)
Calibrated typ (25 °C, ±5 °C)	0.05%	0.05%
Calibrated max (–40 to 85 °C)	0.20%	0.25%
Uncalibrated typ (25 °C, ±5 °C)	0.20%	0.10%
Uncalibrated max (–40 to 85 °C)	0.55%	0.35%

* Before offset null or shunt calibration.

† Applies at a data rate of 50 kS/s. Lower data rates can have up to 0.20% of reading additional gain error.

‡ Range equals 25 mV/V.

Gain drift.....10 ppm/°C max

Offset drift

- 2.5 V excitation .....0.6 µV/V per °C
- 3.3 V excitation .....0.5 µV/V per °C
- 5 V excitation .....0.3 µV/V per °C
- 10 V excitation .....0.2 µV/V per °C

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Half-bridge completion

Tolerance ..... ±1200 µV/V max

Drift ..... 1.5 µV/V per °C

Channel-to-channel matching (calibrated)

Input Signal Frequency (f_{in})	Gain		Phase
	Typical	Maximum	Maximum
0 to 1 kHz	0.15%	0.3%	0.125°/kHz · f_{in}
1 to 20 kHz	0.4%	1.1%	

Phase nonlinearity

f_{in} = 0 to 1 kHz..... <0.001°

f_{in} = 0 to 20 kHz..... ±0.1°

Input delay ..... $38.4/f_s + 4.8$ µs

Passband

Frequency ..... 0.45 · f_s

Flatness..... 0.1 dB max

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Stopband

Frequency ..... 0.55 · f_s

Rejection..... 100 dB

Alias-free bandwidth ..... 0.45 · f_s

Oversample rate ..... 64 · f_s

Rejection at oversample rate[1]

f_s = 10 kS/s..... 60 dB @ 640 kHz

f_s = 50 kS/s..... 90 dB @ 3.2 MHz

Common-mode voltage,
all signals to earth ground..... ±60 VDC

[1] Rejection by analog prefilter of signal frequencies at oversample rate.

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CMRR

Relative to earth ground[1]
(f_{in} = 0 to 60 Hz) ..... 140 dB

Relative to EX–
(f_{in} = 0 to 1 kHz) ..... 85 dB

SFDR (1 kHz, –60 dBFS) ..... 115 dB

Total Harmonic Distortion (THD)

1 kHz, –20 dBFS ..... –95 dB

8 kHz, –20 dBFS ..... –95 dB

[1] Measured with a balanced cable on the NI 9237E with RJ-50 and with no cable on the NI 9237E with DSUB. Shielded cables that are not twisted-pair may be significantly unbalanced, which can impact CMRR performance. To improve the balance of shielded cables, NI recommends twisting together the AI+/AI– pair, the RS+/RS– pair, and the EX+/EX– pair.

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Input noise

Excitation Voltage	Density (nV/V_{rms} per $\sqrt{1 Hz}$)	Total, f_{in} = 0 to 1 kHz (nV/V_{rms})	Total, f_{in} = 0 to 25 kHz ($\mu V/V_{rms}$)	
	Full Bridge	Full Bridge	Full Bridge	Half Bridge
2.5 V	8	250	1.3	1.6
3.3 V	6	190	1.0	1.2
5 V	4	130	0.6	0.8
10 V	2	65	0.3	0.5

Excitation noise ..... 100 μV_{rms}

Crosstalk (not including cable effects)

f_{in} = 1 kHz..... 110 dB

f_{in} = 10 kHz..... 100 dB

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Excitation

- Internal voltage ..... 2.5 V, 3.3 V, 5.0 V, 10.0 V
- Internal power ..... 150 mW max
- External voltage ..... 2 V to 10 V

Shunt calibration

- Resistance ..... 100 kΩ
- Resistor accuracy
  - 25 °C ..... ±110 Ω
  - –40 to 85 °C ..... ±200 Ω

MTBF

- NI 9237E with RJ-50 ..... 603,359 hours at 25 °C; Bellcore Issue 2, Method 1, Case 3, Limited Part Stress Method
- NI 9237E with DSUB ..... 704,148 hours at 25 °C; Bellcore Issue 2, Method 1, Case 3, Limited Part Stress Method

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Note Contact NI for Bellcore MTBF specifications at other temperatures or for MIL-HDBK-217F specifications.

Power Requirements

Power consumption from chassis

Active mode ..... 740 mW max

Sleep mode ..... 25 µW max

Thermal dissipation (at 85 °C)

Active mode ..... 740 mW max

Sleep mode ..... 25 µW max

Physical Characteristics

Use a dry, low-velocity stream of air to clean the module. If needed, use a soft-bristle brush for cleaning around components.

Note For two-dimensional drawings and three-dimensional models of the C Series module and connectors, visit `ni.com/dimensions` and search by module number.

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Weight

NI 9237E with RJ-50 ..... 53 g (1.9 oz)

NI 9237E with DSUB ..... 49 g (1.7 oz)

Safety

Safety Voltages

Connect only voltages that are within the following limits.

Between any two pins ..... ±30 V max

Isolation

Channel-to-channel ..... None

Channel-to-earth ground

Continuous ..... 60 VDC, Measurement Category I, (Double insulation)

Withstand ..... 1,000 V_{rms}, verified by a 5 s dielectric withstand test

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Measurement Category I is for measurements performed on circuits not directly connected to the electrical distribution system referred to as *MAINS* voltage. MAINS is a hazardous live electrical supply system that powers equipment. This category is for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.

Caution Do *not* connect the NI 9237E to signals or use for measurements within Measurement Categories II, III, or IV.

Safety Standards

This product meets the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use when installed in a suitable enclosure:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA 61010-1

Note For UL and other safety certifications, refer to the product label or the *Online Product Certification* section.

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Online Product Certification

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for this product, visit `ni.com/certification`, search by module number or product line, and click the appropriate link in the Certification column.

Environmental

National Instruments C Series modules are intended for indoor use only but may be used outdoors if installed in a suitable enclosure. Refer to the manual for the chassis you are using for more information about meeting these specifications.

Operating temperature
(IEC 60068-2-1, IEC 60068-2-2) ..... –40 to 85 °C

Storage temperature
(IEC 60068-2-1, IEC 60068-2-2) ..... –40 to 85 °C

Operating humidity
(IEC 60068-2-56)..... 10 to 90% RH, noncondensing

Storage humidity
(IEC 60068-2-56)..... 5 to 95% RH, noncondensing

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Maximum altitude..... 2,000 m

Pollution Degree 2

Environmental Management

National Instruments is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial to the environment and to NI customers.

For additional environmental information, refer to the *NI and the Environment* Web page at `ni.com/environment`. This page contains the environmental regulations and directives with which NI complies, as well as other environmental information not included in this document.

Waste Electrical and Electronic Equipment (WEEE)



EU Customers At the end of the life cycle, all products *must* be sent to a WEEE recycling center. For more information about WEEE recycling centers and National Instruments WEEE initiatives, visit `ni.com/environment/weee`.

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电子信息产品污染控制管理办法 （中国 RoHS）



中国客户 National Instruments 符合中国电子信息产品中限制使用某些有害物质指令 (RoHS)。关于 National Instruments 中国 RoHS 合规性信息，请登录 `ni.com/environment/rohs_china`。 (For information about China RoHS compliance, go to `ni.com/environment/rohs_china`.)

Calibration

You can obtain the calibration certificate and information about calibration services for the NI 9237E at `ni.com/calibration`.

Calibration interval ..... 1 year

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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, contact your local branch office:

Australia 1800 300 800, Austria 43 662 457990-0,
Belgium 32 (0) 2 757 0020, Brazil 55 11 3262 3599,
Canada 800 433 3488, China 86 21 5050 9800,
Czech Republic 420 224 235 774, Denmark 45 45 76 26 00,
Finland 358 (0) 9 725 72511, France 01 57 66 24 24,
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