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DEVICE SPECIFICATIONS

NI 6238

M Series Data Acquisition: 16-Bit, 250 kS/s, 8 AI, 2 AO, 24 DIO Sourcing, Current Input/Output Bank Isolation

The following specifications are typical at 25 °C, unless otherwise noted. For more information about the NI 6238, refer to the *NI 6238/6239 User Manual* available from *ni.com/manuals*.

Analog Input

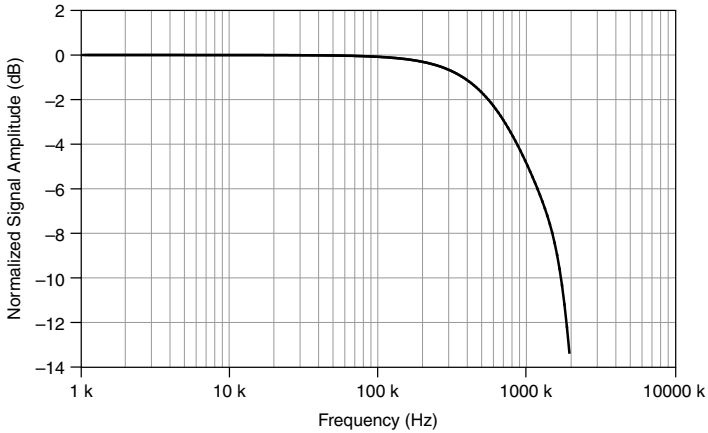
Number of channels	8 differential current inputs
Ground reference	AI GND
ADC resolution	16 bits
DNL	No missing codes guaranteed
INL	Refer to the *AI Absolute Accuracy* section
Sample rate	
Maximum	250 kS/s
Minimum	No minimum
Timing accuracy	50 ppm of sample rate
Timing resolution	50 ns
Input coupling	DC
Input range	±20 mA
Maximum working voltage for analog inputs	Refer to the *Maximum Working Voltage* section
Input impedance (AI+ to AI-)	92 Ω ±10% in parallel with 100 pF
Maximum input impedance	100 Ω (at 55 °C)
Input bias current	±100 pA
Small signal bandwidth (-3 dB)	700 kHz
Input FIFO size	4,095 samples
Scan list memory	4,095 entries

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Data transfers	DMA (scatter-gather), interrupts, programmed I/O
Input current during overvoltage condition	±20 mA maximum/AI pin
Overcurrent protection	±40 mA maximum[1]
Overvoltage protection (AI *x*+ or AI *x*- with respect to AI GND)[2]	
Device on	±25 V for up to two AI pins
Device off	±15 V for up to two AI pins

Typical Performance Graphs

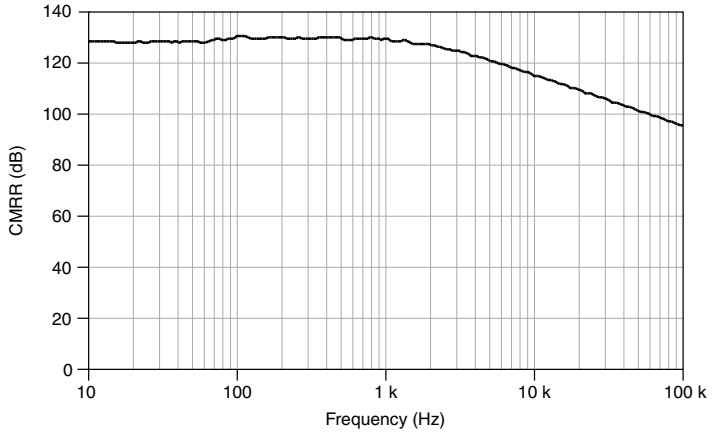
Figure 1. AI Small Signal Bandwidth



[1] Any voltage applied resulting in current flowing above 40 mA can damage the device permanently.
[2] This overvoltage protection triggers after the overcurrent protection is in effect.

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Figure 2. AI CMRR to Earth Ground



AI Absolute Accuracy

Note Accuracies listed are valid for up to one year from the device external calibration.

Table 1. AI Absolute Accuracy

Nominal Range Positive Full Scale	Nominal Range Negative Full Scale	Residual Gain Error (ppm of Reading)	Residual Offset Error (ppm of Range)	Offset Tempco (ppm of Range/°C)	Random Noise, σ (µArms)	Absolute Accuracy at Full Scale (µA)	Sensitivity (µA)
0.02	-0.02	595	100	79	0.6	18.9	0.24

Note Sensitivity is the smallest current change that can be detected. It is a function of noise.

Gain tempco	35 ppm/°C
Reference tempco	5 ppm/°C
INL error	76 ppm of range

AI Absolute Accuracy Equation

$$AbsoluteAccuracy = Reading \cdot (GainError) + Range \cdot (OffsetError) + NoiseUncertainty$$

$$GainError = ResidualAIGainError + GainTempco \cdot (TempChangeFromLastInternalCal) + ReferenceTempco \cdot (TempChangeFromLastExternalCal)$$

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$OffsetError = ResidualAIOffsetError + OffsetTempco \cdot (TempChangeFromLastInternalCal) + INLError$

$NoiseUncertainty = \frac{\text{Random Noise} \cdot 3}{\sqrt{100}}$ for a coverage factor of 3 σ and averaging 100 points.

AI Absolute Accuracy Example

Absolute accuracy at full scale on the analog input channels is determined using the following assumptions:

- TempChangeFromLastExternalCal = 10 °C
- TempChangeFromLastInternalCal = 1 °C
- number_of_readings = 100
- CoverageFactor = 3 σ

For example, on the 20 mA range, the absolute accuracy at full scale is as follows:

GainError = 595 ppm + 35 ppm · 1 + 5 ppm · 10 = 680 ppm

OffsetError = 100 ppm + 79 ppm · 1 + 76 ppm = 255 ppm

$NoiseUncertainty = \frac{.6\ \mu A \cdot 3}{\sqrt{100}} = .18\ \mu A$

AbsoluteAccuracy = 20 mA · (GainError) + 20 mA · (OffsetError) + NoiseUncertainty = 18.9 µA

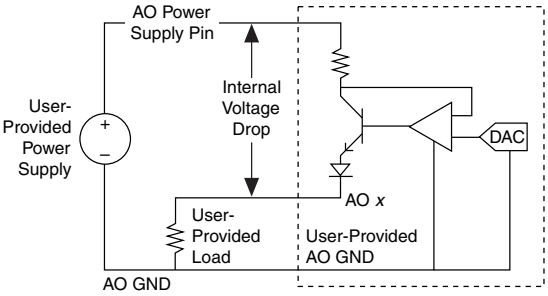
Analog Output

Number of channels	2 current outputs
Ground reference	AO GND
DAC resolution	16 bits
Maximum update rate	
1 channel	500 kS/s
2 channels	450 kS/s per channel
Timing accuracy	50 ppm of sample rate
Timing resolution	50 ns
Output range	0 mA to 20 mA
Output coupling	DC
Power-on state	0 mA
Power-on glitch	None
Output FIFO size	8,191 samples shared among channels used

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Data transfers	DMA (scatter-gather), interrupts, programmed I/O
AO waveform modes	Non-periodic waveform, periodic waveform regeneration mode from onboard FIFO, periodic waveform regeneration from host buffer including dynamic update
External power supply	10 VDC to 30 VDC, refer to the figure
External power supply consumption	50 mA maximum, refer to the figure
Internal voltage drop	3 V maximum, refer to the figure
Maximum resistive load	Up to 1 kΩ with 24 V power supply connected; refer to the figure

Figure 3. Analog Output



Protection	Open and short circuit
Slew rate	0.1 mA/µS

AO Absolute Accuracy

Absolute accuracy at full-scale numbers is valid immediately following internal calibration and assumes the device is operating within 10 °C of the last external calibration.

Note Accuracies listed are valid for up to one year from the device external calibration.

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Table 2. AO Absolute Accuracy

Nominal Range Positive Full Scale (A)	Nominal Range Negative Full Scale (A)	Residual Gain Error (% of Reading)	Gain Tempco (ppm/°C)	Residual Offset Error (ppm of Range)	Offset Tempco (ppm of Range/°C)	Absolute Accuracy at Full Scale (µA)
0.02	0	0.1570	20	0.0537	8	52.3

Reference tempco	5 ppm/°C
INL error	128 ppm of range
Random noise	2 µA

AO Absolute Accuracy Equation

$AbsoluteAccuracy = OutputValue \cdot (GainError) + Range \cdot (OffsetError)$

$GainError = ResidualGainError + GainTempco \cdot (TempChangeFromLastInternalCal) + ReferenceTempco \cdot (TempChangeFromLastExternalCal)$

$OffsetError = ResidualOffsetError + AOOffsetTempco \cdot (TempChangeFromLastInternalCal) + INLError$

Digital I/O/PFI

Static Characteristics

Number of channels	10 total
Number of input channels	6 (PFI <0..5>/P0.<0..5>)
Number of output channels	4 (PFI <6..9>/P1.<0..3>)
Direction control	Fixed, lines are unidirectional

PFI/Port 0/Port 1 Functionality

PFI <0..5>/P0.<0..5>	Static digital input, timing input
PFI <6..9>/P1.<0..3>	Static digital output, timing output
Timing output sources	Many AI, AO, counter timing signals
Debounce filter settings	125 ns, 6.425 µs, 2.56 ms, disable; high and low transitions; selectable per input

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Digital Input (Port 0)

Number of channels	6
Ground reference	P0.GND
Input voltage range	0 V to 30 V
Minimum pulse width for timing signal	0.5 µs
Logic "0" level	0 V to 4 V
Logic "1" level	10 V to 30 V
Minimum input impedance	3.3 kΩ
Typical input current	7 mA at 24 V input, 2.5 mA at 8 V input
Maximum input current	9 mA
Propagation delay	
Low to high	150 ns, typical
High to low	100 ns, typical

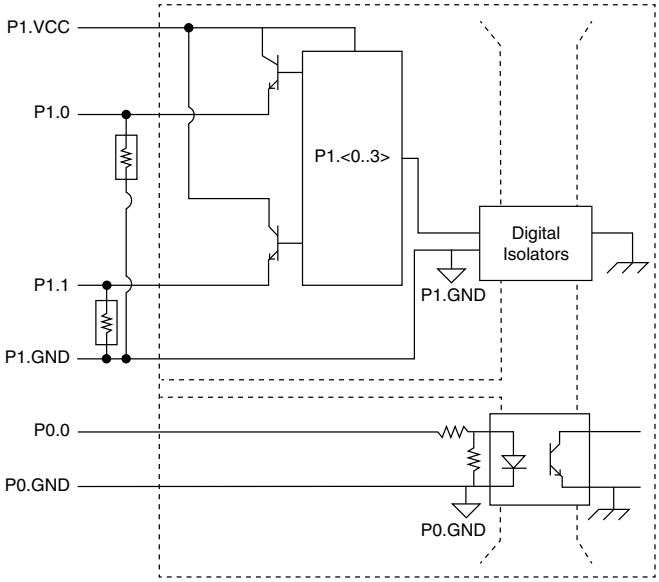
Digital Output (Port 1)

Number of channels	4
Ground reference	P1.GND
Device output type	DO source

The following figure shows PO.<0..5> and PI.<0..3> on the NI 6238 device.

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Figure 4. NI 6238 Digital I/O Connections



Maximum external supply voltage (P1.VCC)	30 V
On state saturation voltage	1.6 V maximum at 350 mA
Off state leakage	50 µA
Maximum current	100 mA for each line for simultaneous usage, 350 mA for single line usage
Minimum pulse width for timing signal (source output)	5 µs
Propagation delay (source output)	
Open to close	0.45 µs
Close to open	2.15 µs

General-Purpose Counters/Timers

Number of counter/timers	2
Resolution	32 bits
Counter measurements	Edge counting, pulse, semi-period, period, two-edge separation

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Position measurements	X1, X2, X4 quadrature encoding with Channel Z reloading; two-pulse encoding
Output applications	Pulse, pulse train with dynamic updates, frequency division, equivalent time sampling
Internal base clocks	80 MHz, 20 MHz, 0.1 MHz
External base clock frequency	0 MHz to 20 MHz
Base clock accuracy	50 ppm
Inputs	Gate, Source, HW_Arm, Aux, A, B, Z, Up_Down
Routing options for inputs	Any input PFI, RTSI, PXI_TRIG, PXI_STAR, many internal signals
FIFO	2 samples
Data transfers	Dedicated scatter-gather DMA controller for each counter/timer; interrupts; programmed I/O

Frequency Generator

Number of channels	1
Base clocks	10 MHz, 100 kHz
Divisors	1 to 16
Base clock accuracy	50 ppm

Output can be available on any output PFI or RTSI terminal.

Phase-Locked Loop (PLL)

Number of PLLs	1
Reference signal	PXI_STAR, PXI_CLK10, RTSI <0..7>
Output of PLL	80 MHz Timebase; other signals derived from 80 MHz Timebase including 20 MHz and 100 kHz Timebases

External Digital Triggers

Source	Any PFI, RTSI, PXI_TRIG, PXI_STAR
Polarity	Software-selectable for most signals

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Analog input function	Start Trigger, Reference Trigger, Pause Trigger, Sample Clock, Convert Clock, Sample Clock Timebase
Analog output function	Start Trigger, Pause Trigger, Sample Clock, Sample Clock Timebase
Counter/timer function	Gate, Source, HW_Arm, Aux, A, B, Z, Up_Down

Device-to-Device Trigger Bus

PCI	RTSI <0..7>[3]
PXI	PXI_TRIG <0..7>, PXI_STAR
Output selections	10 MHz Reference Clock, frequency generator output, many internal signals
Debounce filter settings	125 ns, 6.425 µs, 2.56 ms, disable; high and low transitions; selectable per input

Bus Interface

PCI/PXI	3.3 V or 5 V signal environment

The PXI device can be installed in PXI slots or PXI Express hybrid slots.

DMA channels	4, analog input, analog output, counter/timer 0, counter/timer 1

Power Requirements

Current draw from bus during no-load condition	
+5 V	0.7 A
+12 V	20 mA
Current draw from bus during AI and AO overvoltage condition	
+5 V	0.95 A
+12 V	20 mA

[3] In other sections of this document, RTSI refers to RTSI <0..7> for the PCI devices or PXI_TRIG <0..7> for PXI devices.

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Physical Characteristics

Dimensions	
PCI printed circuit board	9.7 cm × 15.5 cm (3.8 in. × 6.1 in.)
PXI printed circuit board	Standard 3U PXI
Weight	
PCI	103 g (3.6 oz)
PXI	144 g (5.1 oz)
I/O connector	37-pin D-SUB

Calibration

Recommended warm-up time	15 minutes
Calibration interval	1 year

Maximum Working Voltage

Maximum working voltage refers to the signal voltage plus the common-mode voltage.

Channel-to-earth ground[4]	
Continuous	≤30 Vrms/60 VDC Measurement Category I
Withstand	≤840 Vrms/1,200 VDC, verified by a 5 s dielectric withstand test
Channel-to-bus[5]	
Continuous	≤30 Vrms/60 VDC Measurement Category I
Withstand	≤1,400 Vrms/1,950 VDC, verified by a 5 s dielectric withstand test
Analog channel-to-AI GND or AO GND (in the following figure, $\|V_a - V_b\|$)	≤11 V, Measurement Category I
Digital channel-to-P1.GND or P0.GND (in the following figure, $\|V_c - V_d\|$ or $\|V_e - V_f\|$)	≤30 V, Measurement Category I

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

[4] In the figure, $|V_a - V_h|$, $|V_c - V_h|$, and $|V_e - V_h|$.
[5] In the figure, $|V_a - V_g|$, $|V_c - V_g|$, and $|V_e - V_g|$.

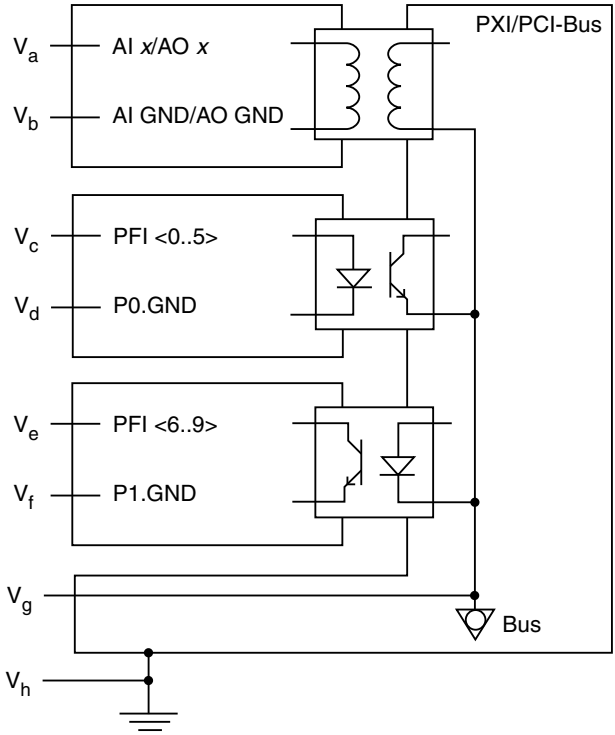
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from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.

Caution This device is rated for Measurement Category I and the voltage across the isolation barrier is limited to no greater than 30 Vrms/60 VDC/42.4 V_{pk} continuous. These test and measurement circuits are not intended for direct connection to the MAINS building installations of Measurement Categories CAT II, CAT III, or CAT IV.

The following figure illustrates the maximum working voltage specifications.

Figure 5. NI 6238 Maximum Working Voltage



Environmental

Operating temperature	0 ºC to 55 ºC
Storage temperature	-20 ºC to 70 ºC

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Humidity	10% RH to 90% RH, noncondensing
Maximum altitude	2,000 m
Pollution Degree (indoor use only)	2

Indoor use only.

Shock and Vibration (PXI Only)

Operational shock	30 g peak, half-sine, 11 ms pulse (Tested in accordance with IEC 60068-2-27. Test profile developed in accordance with MIL-PRF-28800F.)
Random vibration	
Operating	5 Hz to 500 Hz, 0.3 g_{rms}
Nonoperating	5 Hz to 500 Hz, 2.4 g_{rms} (Tested in accordance with IEC 60068-2-64. Nonoperating test profile exceeds the requirements of MIL-PRF-28800F, Class 3.)

Safety

This product is designed to meet the requirements of the following electrical equipment safety standards for measurement, control, and laboratory use:

- 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.

Electromagnetic Compatibility

This product meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use:

- EN 61326-1 (IEC 61326-1): Class A emissions; Basic immunity
- EN 55011 (CISPR 11): Group 1, Class A emissions
- EN 55022 (CISPR 22): Class A emissions
- EN 55024 (CISPR 24): Immunity
- AS/NZS CISPR 11: Group 1, Class A emissions
- AS/NZS CISPR 22: Class A emissions

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- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions

Note In the United States (per FCC 47 CFR), Class A equipment is intended for use in commercial, light-industrial, and heavy-industrial locations. In Europe, Canada, Australia and New Zealand (per CISPR 11) Class A equipment is intended for use only in heavy-industrial locations.

Note Group 1 equipment (per CISPR 11) is any industrial, scientific, or medical equipment that does not intentionally generate radio frequency energy for the treatment of material or inspection/analysis purposes.

Note For EMC declarations and certifications, and additional information, refer to the *Online Product Certification* section.

CE Compliance CE

This product meets the essential requirements of applicable European Directives, as follows:

- 2014/35/EU; Low-Voltage Directive (safety)
- 2014/30/EU; Electromagnetic Compatibility Directive (EMC)
- 2011/65/EU; Restriction of Hazardous Substances (RoHS)

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 model number or product line, and click the appropriate link in the Certification column.

Environmental Management

NI 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 *Minimize Our Environmental Impact* 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.

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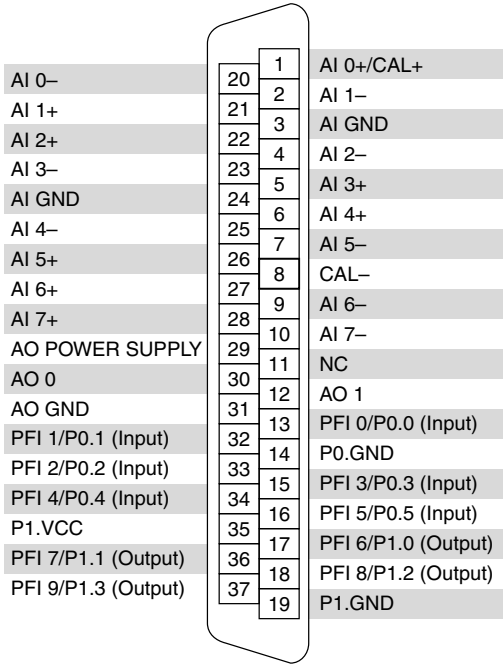
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Device Pinout

Figure 6. NI PCI/PXI-6238 Pinout



NC = No Connect

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