PCI-6221 37 Pin Specifications

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Analog Input

Number of channels	8 differential or 16 single ended
ADC resolution	16 bits
DNL	No missing codes guaranteed
INL	Refer to the AI Absolute Accuracy section
Sample rate Single channel maximum Multichannel maximum (aggregate) Minimum	 250 kS/s 250 kS/s No minimum
Timing accuracy	50 ppm of sample rate
Timing resolution	50 ns
Input coupling	DC
Input range	±0.2 V, ±1 V, ±5 V, ±10 V
Maximum working voltage for analog inputs (signal + common mode)	±11 V of AI GND

CMRR (DC to 60 Hz)	92 dB
Input impedance **Device on** AI+ to AI GND AI- to AI GND **Device off** AI+ to AI GND AI- to AI GND	 >10 GΩ in parallel with 100 pF >10 GΩ in parallel with 100 pF 820 Ω 820 Ω
Input bias current	±100 pA
Crosstalk (at 100 kHz) Adjacent channels Non-adjacent channels	 -75 dB -90 dB
Small signal bandwidth (-3 dB)	700 kHz
Input FIFO size	4,095 samples
Scan list memory	4,095 entries
Data transfers	DMA (scatter-gather), interrupts, programmed I/O
Overvoltage protection for all analog input and sense channels	

Device on	±25 V for up to two AI pins
Device off	±15 V for up to two AI pins
Input current during overvoltage condition	±20 mA maximum/AI pin

Settling Time for Multichannel Measurements

Accuracy, full-scale step, all ranges	
±90 ppm of step (±6 LSB)	4 µs convert interval
±30 ppm of step (±2 LSB)	5 µs convert interval
±15 ppm of step (±1 LSB)	7 µs convert interval

Typical Performance Graphs

Figure 1. Settling Error versus Time for Different Source Impedances

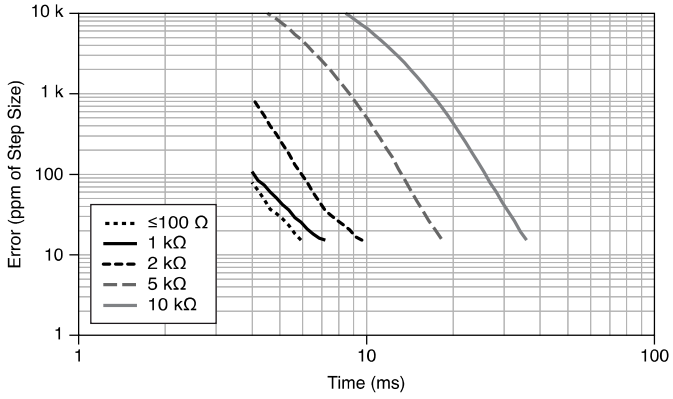


Figure 2. AI Small Signal Bandwidth

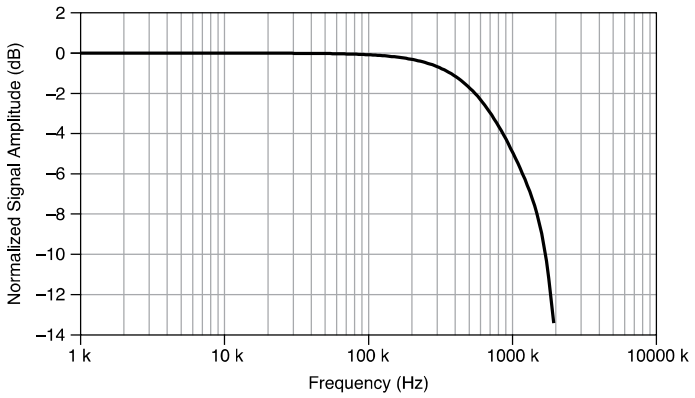
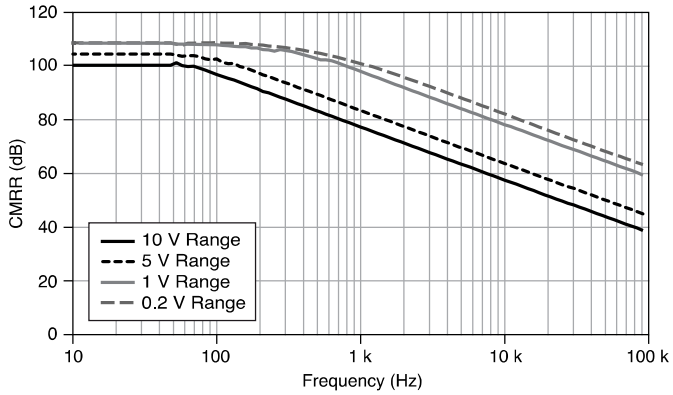


Figure 3. AI CMRR



AI Absolute Accuracy

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

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 (µVrms)	Absolute Accuracy at Full Scale (µV)	Sensitivity (µV)
10	-10	75	20	57	244	3,100	97.6
5	-5	85	20	60	122	1,620	48.8
1	-1	95	25	79	30	360	12.0

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 (µVrms)	Absolute Accuracy at Full Scale (µV)	Sensitivity (µV)
0.2	-0.2	135	80	175	13	112	5.2

Table 3. AI Absolute Accuracy

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

Gain tempco	25 ppm/°C
Reference tempco	5 ppm/°C
INL error	76 ppm of range

AI Absolute Accuracy Equation

AbsoluteAccuracy = **Reading** · **(GainError)** + **Range** · **(OffsetError)** + **NoiseUncertainty**

- **GainError** = **ResidualAIGainError** + **GainTempco** · **(TempChangeFromLastInternalCal)** + **ReferenceTempco** · **(TempChangeFromLastExternalCal)**
- **OffsetError** = **ResidualAIOffsetError** + **OffsetTempco** · **(TempChangeFromLastInternalCal)** + **INLError**
- **NoiseUncertainty** = $\frac{\text{Random Noise} \quad 3}{\sqrt{100}}$ 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 10 V range, the absolute accuracy at full scale is as follows:

- GainError = 75 ppm + 25 ppm · 1 + 5 ppm · 10 = 150 ppm
- OffsetError = 20 ppm + 57 ppm · 1 + 76 ppm = 153 ppm
- NoiseUncertainty = $\frac{244\ \mu V \quad 3}{\sqrt{100}}$ = 73 µV
- AbsoluteAccuracy = 10 V · (GainError) + 10 V · (OffsetError) + NoiseUncertainty = 3,100 µV

Analog Output

Number of channels	2
DAC resolution	16 bits
DNL	±1 LSB
Monotonicity	16 bit guaranteed
Maximum update rate	
1 channel	833 kS/s

2 channels	740 kS/s per channel
Timing accuracy	50 ppm of sample rate
Timing resolution	50 ns
Output range	±10 V
Output coupling	DC
Output impedance	0.2 Ω
Output current drive	±5 mA
Overdrive protection	±25 V
Overdrive current	10 mA
Power-on state	±20 mV
Power-off glitch	400 mV for 200 ms
Output FIFO size	8,191 samples shared among channels used
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
Settling time, full-scale step, 15 ppm (1 LSB)	6 µs

Slew rate	15 V/µs
Glitch energy	
Magnitude	100 mV
Duration	2.6 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.

Nominal Range Positive Full Scale	Nominal Range Negative Full Scale	Residual Gain Error (ppm of Reading)	Gain Tempco (ppm/°C)	Residual Offset Error (ppm of Range)	Offset Tempco (ppm of Range/°C)	Absolute Accuracy at Full Scale (µV)
10	-10	90	10	40	5	3,230

Table 2. AO Absolute Accuracy

Reference tempco	5 ppm/°C
INL error	128 ppm of range

AO Absolute Accuracy Equation

AbsoluteAccuracy = **OutputValue** · **(GainError)** + **Range** · (**OffsetError**)

- **GainError** = **ResidualGainError** + **GainTempco** · (**TempChangeFromLastInternalCal**) + **ReferenceTempco** · (**TempChangeFromLastExternalCal**)
- **OffsetError** = **ResidualOffsetError** + **AOOffsetTempco** · **(TempChangeFromLastInternalCal)** + **INLError**

Digital I/O/PFI

Static Characteristics

Number of channels	10 total, 2 (P0.<0, 1>), 8 (PFI <0..7>/P1)
Ground reference	D GND
Direction control	Each terminal individually programmable as input or output
Pull-down resistor	50 kΩ typical, 20 kΩ minimum
Input voltage protection	±20 V on up to two pins[1]

Waveform Characteristics (Port 0 Only)

Terminals used	Port 0 (P0.<0,1>)
Port/sample size	Up to 2 bits
Waveform generation (DO) FIFO	2,047 samples
Waveform acquisition (DI) FIFO	2,047 samples
DI or DO Sample Clock frequency	0 MHz to 1 MHz, system and bus activity dependent

Data transfers	DMA (scatter-gather), interrupts, programmed I/O
DI or DO Sample Clock source[2]	Any PFI, RTSI, AI Sample or Convert Clock, AO Sample Clock, Ctr **n** Internal Output, and many other signals

PFI/Port 1 Functionality

Functionality	Static digital input, static digital output, timing input, timing output
Timing output sources	Many AI, AO, counter, DI, DO timing signals
Debounce filter settings	125 ns, 6.425 µs, 2.56 ms, disable; high and low transitions; selectable per input

Recommended Operating Conditions

Level	Minimum	Maximum
Input high voltage (V_{IH})	2.2 V	5.25 V
Input low voltage (V_{IL})	0 V	0.8 V
Output high current (I_{OH}) P0.<0,1>	-	-24 mA
Output high current (I_{OH}) PFI <0..7>/P1	-	-16 mA
Output low current (I_{OL}) P0.<0,1>	-	24 mA
Output low current (I_{OL}) PFI <0..7>/P1	-	16 mA

Electrical Characteristics

Level	Minimum	Maximum
Positive-going threshold (VT+)	—	2.2 V
Negative-going threshold (VT-)	0.8 V	—
Delta VT hystersis (VT+ - VT-)	0.2 V	—
I_{IL} input low current (V_{in} = 0 V)	—	-10 µA

Level	Minimum	Maximum
I_{IH} input high current (V_{in} = 5 V)	—	250 µA

Digital I/O Characteristics

Figure 4. P0.<0,1>: I_{oh} versus V_{oh}

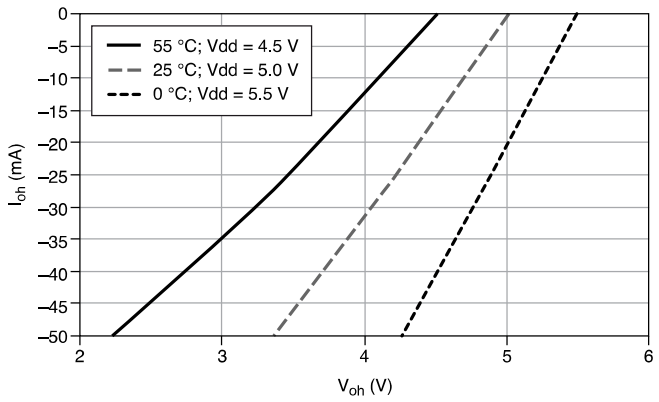


Figure 5. PFI <0..7>/P1: I_{oh} versus V_{oh}

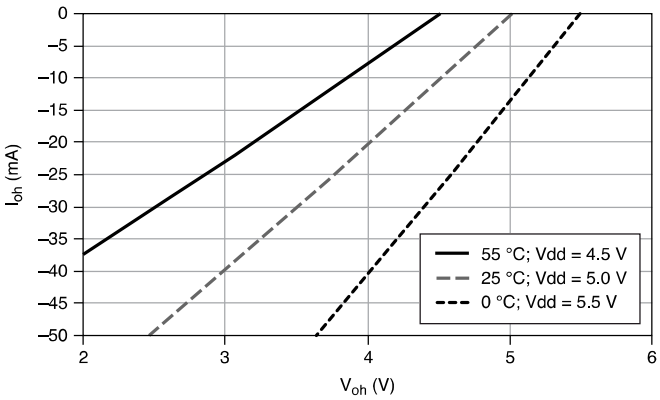


Figure 6. P0.<0,1>: I_{ol} versus V_{ol}

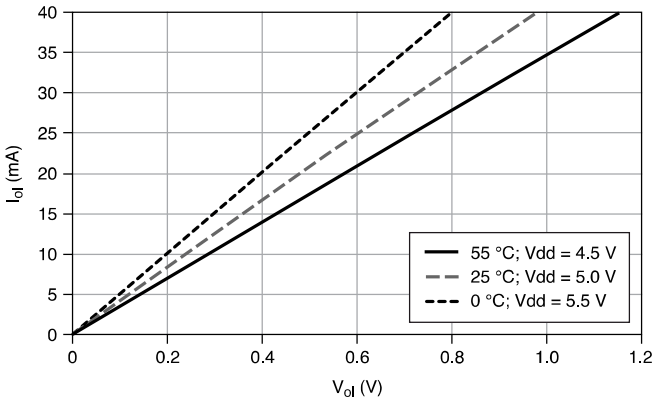
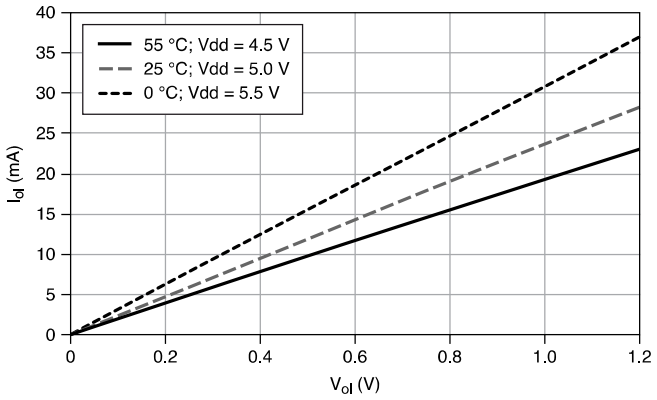


Figure 7. PFI <0..7>/P1: I_{ol} versus V_{ol}



General-Purpose Counters/Timers

Number of counter/timers	2
Resolution	32 bits
Counter measurements	Edge counting, pulse, semi-period, period, two-edge separation
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 PFI, RTSI, PXI_TRIG, PXI_STAR, analog trigger, many internal signals
Routing options for inputs	Any PFI, RTSI, analog trigger, 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	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
Polarity	Software-selectable for most signals
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
Digital waveform generation (DO) function	Sample Clock
Digital waveform acquisition (DI) function	Sample Clock

Device-to-Device Trigger Bus

Trigger bus	RTSI <0..7>
Output selections	10 MHz 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

Bus interface	3.3 V or 5 V signal environment
DMA channels	6, can be used for analog input, analog output, digital input, digital output, counter/timer 0, counter/timer 1

Power Requirements

Current draw from bus during no-load condition[3]	
+5 V	0.27 A
+12 V	0.15 A
Current draw from bus during AI and AO overvoltage condition[3]	
+5 V	0.27 A
+12 V	0.25 A

Physical Characteristics

Dimensions	10.6 cm × 15.5 cm(4.2 in. × 6.1 in.)
Weight	95 g (3.3 oz)
I/O connector	37-pin D-SUB

Calibration

Recommended warm-up time	15 minutes
Calibration interval	1 year

Maximum Working Voltage

Connect only voltages that are below these limits.

Channel-to-earth	11 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 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 use for measurements within Categories II, III, or IV.

> **Note** Measurement Categories CAT I and CAT O (Other) are equivalent. 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.

Environmental

Operating temperature	0 °C to 55 °C
Storage temperature	-20 °C to 70 °C
Humidity	10% RH to 90% RH, noncondensing
Maximum altitude	2,000 m
Pollution Degree (indoor use only)	2

Indoor use only.

Safety Compliance Standards

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 C22.2 No. 61010-1

> **Note** For safety certifications, refer to the product label or the Product Certifications and Declarations section.

Electromagnetic Compatibility

CE Compliance CE

- 2011/65/EU; Restriction of Hazardous Substances (RoHS)

Product Certifications and Declarations

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for NI products, visit ni.com/product-certifications, search by model number, and click the appropriate link.

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 **Engineering a Healthy Planet** 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.

EU and UK Customers

- **Waste Electrical and Electronic Equipment (WEEE)**—At the end of the product life cycle, all NI products must be disposed of according to local laws and regulations. For more information about how to recycle NI products in your region, visit ni.com/environment/weee.

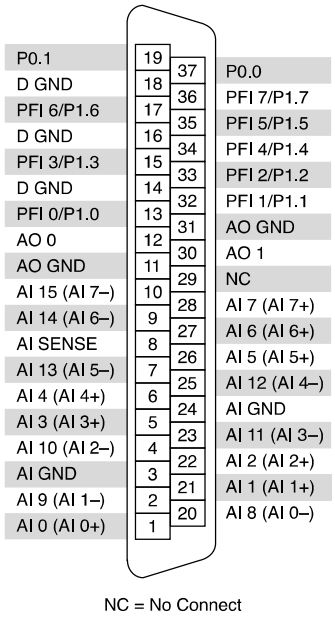
电子信息产品污染控制管理办法（中国 RoHS）

- **中国 RoHS**— NI 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 NI 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.)

Device Pinout

Figure 8. NI PCI-6221 (37-Pin) Pinout



NC = No Connect

[1] Stresses beyond those listed under **Input voltage protection** may cause permanent damage to the device.

[2] The digital subsystem does not have its own dedicated internal timing engine. Therefore, a sample clock must be provided from another subsystem on the device or an external source.

[3] Does not include P0/PFI/P1 terminals.