PCIe-6321 Specifications

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Contents

PCIe-6321 Specifications

Definitions

Warranted specifications describe the performance of a model under stated operating conditions and are covered by the model warranty.

Characteristics describe values that are relevant to the use of the model under stated operating conditions but are not covered by the model warranty.

- ***Typical*** specifications describe the performance met by a majority of models.
- ***Nominal*** specifications describe an attribute that is based on design, conformance testing, or supplemental testing.

Specifications are ***Typical*** unless otherwise noted.

Conditions

Specifications are valid at 25 °C unless otherwise noted.

Analog Input

Number of channels	16 single ended or 8 differential
ADC resolution	16 bits
DNL	No missing codes guaranteed
INL	Refer to AI Absolute Accuracy.

Sample rate	
Single channel maximum	250 kSample/s
Multichannel maximum (aggregate)	250 kSample/s
Minimum	No minimum
Timing resolution	10 ns
Timing accuracy	50 ppm of sample rate
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)	100 dB
Input impedance	
Device on	
AI+ to AI GND	>10 GΩ in parallel with 100 pF
AI- to AI GND	>10 GΩ in parallel with 100 pF
Device off	

AI+ to AI GND	1,200 Ω
AI- to AI GND	1,200 Ω
Input bias current	±100 pA
Crosstalk (at 100 kHz)	
Adjacent channels	-75 dB
Non-adjacent channels	-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), 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

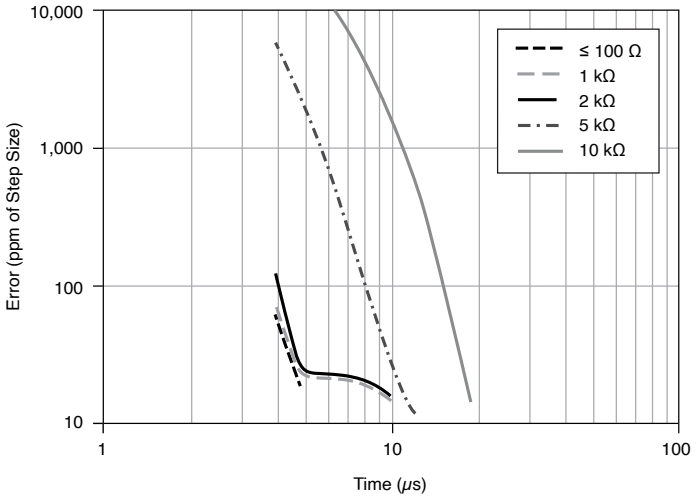
Input current during overvoltage condition	±20 mA maximum/AI pin

Settling Time for Multichannel Measurements

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 Graph

Figure 1. Settling Error versus Time for Different Source Impedances



AI Absolute Accuracy (Warranted)

Table 1. AI Absolute Accuracy

Nominal Range Positive Full Scale (V)	Nominal Range Negative Full Scale (V)	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)
10	-10	65	13	24	229	2,200
5	-5	72	13	25	118	1,140
1	-1	78	17	37	26	257
0.2	-0.2	105	27	93	12	69

Note ***Absolute Accuracy at Full Scale*** is determined using the following assumptions:

- TempChangeFromLastExternalCal = 10 °C
- TempChangeFromLastInternalCal = 1 °C
- NumberOfReadings = 10,000
- CoverageFactor = 3 σ

For more information about absolute accuracy at full scale, refer to the ***AI Absolute Accuracy*** section.

Note Accuracies listed are valid for up to two years from the device external calibration.

Gain tempco	7.3 ppm/°C
Reference tempco	5 ppm/°C

INL error	60 ppm of range

AI Absolute Accuracy Equation

$$\textbf{\textit{AbsoluteAccuracy}} = \textbf{\textit{Reading}} \cdot \textbf{\textit{(GainError)}} + \textbf{\textit{Range}} \cdot \textbf{\textit{(OffsetError)}} + \textbf{\textit{NoiseUncertainty}}$$

- $\textbf{\textit{GainError}} = \textbf{\textit{ResidualGainError}} + \textbf{\textit{GainTempco}} \cdot \textbf{\textit{(TempChangeFromLastInternalCal)}} + \textbf{\textit{ReferenceTempco}} \cdot \textbf{\textit{(TempChangeFromLastExternalCal)}}$
- $\textbf{\textit{OffsetError}} = \textbf{\textit{ResidualOffsetError}} + \textbf{\textit{OffsetTempco}} \cdot \textbf{\textit{(TempChangeFromLastInternalCal)}} + \textbf{\textit{INLError}}$
- $\textbf{\textit{NoiseUncertainty}} = \frac{\text{Random Noise} \cdot 3}{\sqrt{10,\,000}}$
  for a coverage factor of 3 σ and averaging 10,000 points.

AI Absolute Accuracy Example

For example, on the 10 V range, the absolute accuracy at full scale is as follows:

- $\textbf{\textit{GainError}}$: 65 ppm + 7.3 ppm · 1 + 5 ppm · 10 = 122 ppm
- $\textbf{\textit{OffsetError}}$: 13 ppm + 24 ppm · 1 + 60 ppm = 97 ppm
- $\textbf{\textit{NoiseUncertainty}}$: $\frac{229\ \mu V \cdot 3}{\sqrt{10,\,000}}$ = 6.9 µV
- $\textbf{\textit{AbsoluteAccuracy}}$: 10 V · ($\textbf{\textit{GainError}}$) + 10 V · ($\textbf{\textit{OffsetError}}$) + $\textbf{\textit{NoiseUncertainty}}$ = 2,220 µV

Analog Output

Number of channels	2

DAC resolution	16 bits
DNL	±1 LSB
Monotonicity	16 bit guaranteed
Maximum update rate	
1 channel	900 kSample/s
2 channels	840 kSample/s per channel
Timing accuracy	50 ppm of sample rate
Timing resolution	10 ns
Output range	±10 V
Output coupling	DC
Output impedance	0.2 Ω
Output current drive	±5 mA
Overdrive protection	±15 V

Overdrive current	15 mA
Power-on state	±20 mV
Power-on/off glitch	2 V for 500 ms
Output FIFO size	8,191 samples shared among channels used
Data transfers	DMA (scatter-gather), 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

Table 2. AO Absolute Accuracy

Nominal Range Positive Full Scale	Nominal Range Negative Full Scale	Residual Gain Error (ppm of Reading)	Gain Tempco (ppm/°C)	Reference Tempco (ppm/°C)	Residual Offset Error (ppm of Range)	Offset Tempco (ppm of Range/°C)	INL Error (ppm of Range)	Absolute Accuracy at Full Scale (µV)
10	-10	80	11.3	5	53	4.8	128	3,271

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

Note Accuracies listed are valid for up to two years from the device external calibration.

AO Absolute Accuracy Equation

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

- $GainError = ResidualGainError + GainTempco \cdot (TempChangeFromLastInternalCal) + ReferenceTempco \cdot (TempChangeFromLastExternalCal)$
- $OffsetError = ResidualOffsetError + OffsetTempco \cdot (TempChangeFromLastInternalCal) + INLError$

Digital I/O/PFI

Static Characteristics

Number of channels	24 total, 8 (P0.<0..7>), 16 (PFI <0..7>/P1, PFI <8..15>/P2)

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

Caution Stresses beyond those listed under the ***Input voltage protection*** specification may cause permanent damage to the device.

Waveform Characteristics (Port 0 Only)

Terminals used	Port 0 (P0.<0..7>)
Port/sample size	Up to 8 bits
Waveform generation (DO) FIFO	2,047 samples
Waveform acquisition (DI) FIFO	255 samples
DO or DI Sample Clock frequency	0 to 1 MHz, system and bus activity dependent
Data transfers	DMA (scatter-gather), programmed I/O

Digital line filter settings	160 ns, 10.24 µs, 5.12 ms, disable

PFI/Port 1/Port 2 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	90 ns, 5.12 µs, 2.56 ms, custom interval, disable; programmable high and low transitions; selectable per input

Recommended Operating Conditions

Input high voltage (V_{IH})	
Minimum	2.2 V
Maximum	5.25 V
Input low voltage (V_{IL})	
Minimum	0 V
Maximum	0.8 V
Output high current (I_{OH})	
P0.<0..7>	-24 mA maximum

PFI <0..15>/P1/P2	-16 mA maximum
Output low current (I_{OL})	
P0.<0..7>	24 mA maximum
PFI <0..15>/P1/P2	16 mA maximum

Digital I/O Characteristics

Positive-going threshold (VT+)	2.2 V maximum
Negative-going threshold (VT-)	0.8 V minimum
Delta VT hysteresis (VT+ - VT-)	0.2 V minimum
I_{IL} input low current (V_{IN} = 0 V)	-10 µA maximum
I_{IH} input high current (V_{IN} = 5 V)	250 µA maximum

Figure 2. P0.<0..7>: I_{OH} versus V_{OH}

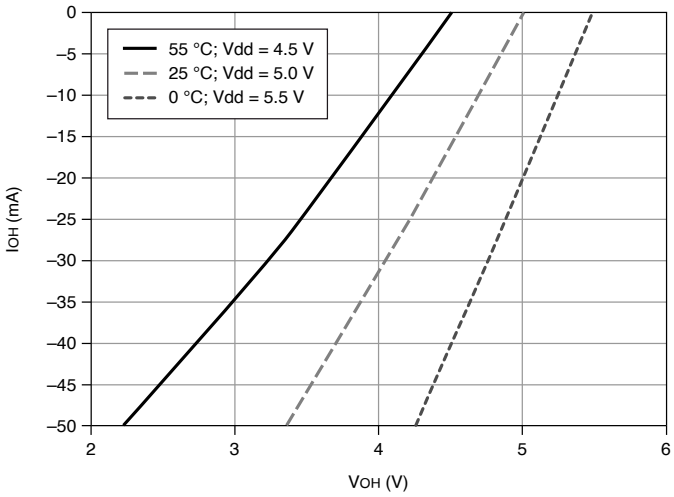


Figure 3. P0.<0..7>: I_{OL} versus V_{OL}

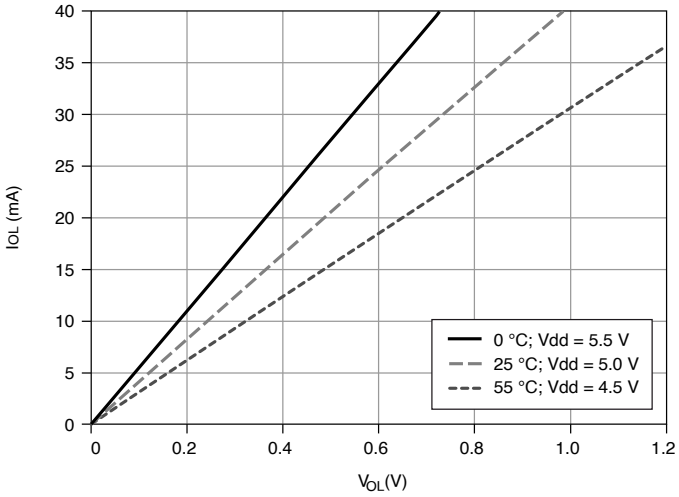


Figure 4. PFI <0..15>/P1/P2: I_{OH} versus V_{OH}

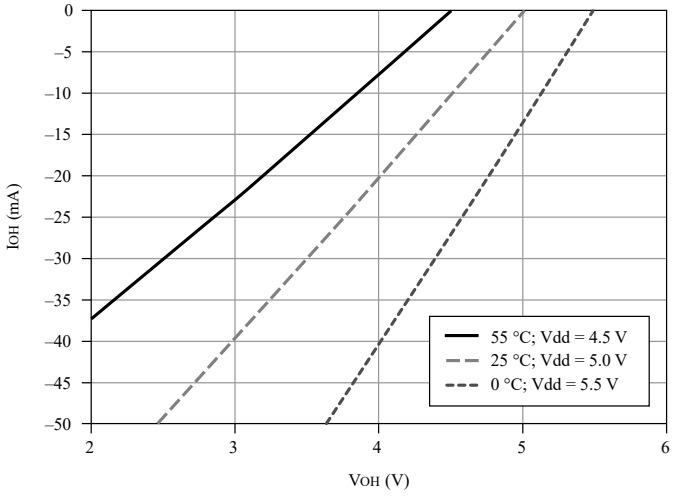
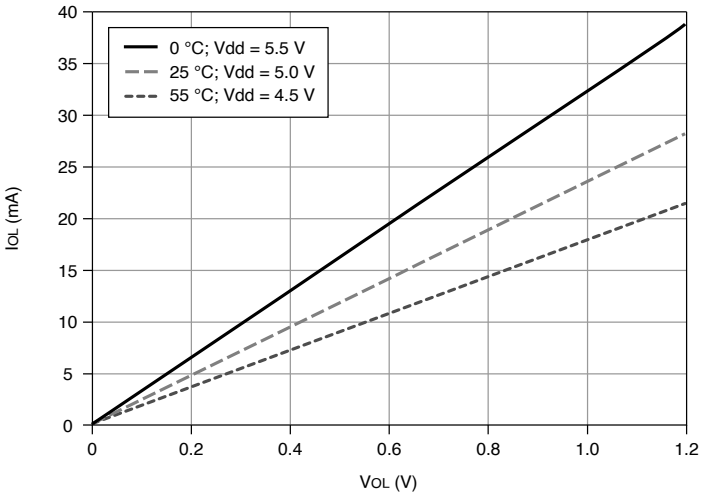


Figure 5. PFI <0..15>/P1/P2: I_{OL} versus V_{OL}



General-Purpose Counters

Number of counter/ timers	4
Resolution	32 bits
Counter measurements	Edge counting, pulse, pulse width, 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	100 MHz, 20 MHz, 100 kHz
External base clock	0 MHz to 25 MHz

frequency	
Base clock accuracy	50 ppm
Inputs	Gate, Source, HW_Arm, Aux, A, B, Z, Up_Down, Sample Clock
Routing options for inputs	Any PFI, RTSI, many internal signals
FIFO	127 samples per counter
Data transfers	Dedicated scatter-gather DMA controller for each counter/timer, programmed I/O

Frequency Generator

Number of channels	1
Base clocks	20 MHz, 10 MHz, 100 kHz
Divisors	1 to 16
Base clock accuracy	50 ppm

Output can be available on any PFI or RTSI terminal.

Phased-Locked Loop (PLL)

Number of PLLs	1

Table 3. Reference Clock Locking Frequencies

Reference Signal	Locking Input Frequency (MHz)
RTSI <0..7>	10, 20
PFI <0..15>	10, 20

Output of PLL	100 MHz Timebase; other signals derived from 100 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 functions	Gate, Source, HW_Arm, Aux, A, B, Z, Up_Down, Sample Clock
Digital waveform generation	Start Trigger, Pause Trigger, Sample Clock, Sample Clock Timebase

(DO) function	
Digital waveform acquisition (DI) function	Start Trigger, Reference Trigger, Pause Trigger, Sample Clock, Sample Clock Timebase

Device-to-Device Trigger Bus

Input source	RTSI <0..7>
Output destination	RTSI <0..7>
Output selections	10 MHz Clock, frequency generator output, many internal signals
Debounce filter settings	90 ns, 5.12 µs, 2.56 ms, custom interval, disable; programmable high and low transitions; selectable per input

Bus Interface

Form factor	x1 PCI Express, specification v1.1 compliant
Slot compatibility	x1, x4, x8, and x16 PCI Express slots [1]
DMA channels	8, can be used for analog input, analog output, digital input, digital output, counter/timer 0, counter/timer 1, counter/timer 2, counter/timer 3

Power Requirements

Caution The protection provided by the device can be impaired if the device is used in a manner not described in the ***X Series User Manual***.

Without disk drive power connector installed	
+3.3 V	1.4 W
+12 V	8.6 W
With disk drive power connector installed	
+3.3 V	1.4 W
+12 V	3 W
+5 V	15 W

Current Limits

Caution Exceeding the current limits may cause unpredictable device behavior.

Without disk drive power connector installed	
P0/PFI/P1/P2 and +5 V terminals combined	1 A max
With disk drive power connector installed	
+5 V terminal (connector 0)	1 A max

P0/PFI/P1/P2 combined	1 A max

Physical Characteristics

Printed circuit board dimensions	9.9 cm × 16.8 cm (3.9 in. × 6.6 in.) (half-length)
Weight	104 g (3.6 oz)
I/O connectors	
Device connector	68-Pos Right Angle Dual Stack PCB-Mount VHDCI (Receptacle)
Cable connector	68-Pos Offset IDC Cable Connector (Plug)(SHC68-*)

Note For more information about the connectors used for DAQ devices, refer to the document, ***NI DAQ Device Custom Cables, Replacement Connectors, and Screws***, by going to ni.com/info and entering the Info Code `rdspmb`.

Disk drive power connector	Standard ATX peripheral connector (not serial ATA)

Calibration

Recommended warm-up time	15 minutes
Calibration interval	2 years

Maximum Working Voltage

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

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 connect the system to signals or use for measurements within Measurement Categories II, III, or IV.

Note Measurement Categories CAT I and CAT O are equivalent. These test and measurement circuits are for other circuits not intended for direct connection to the MAINS building installations of Measurement Categories CAT II, CAT III, or CAT IV.

Environmental

Temperature	
Operating	0 °C to 50 °C
Storage	-40 °C to 70 °C
Humidity	

Operating	10% to 90% RH, noncondensing
Storage	5% to 95% RH, noncondensing
Pollution Degree	2
Maximum altitude	2,000 m

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 Standards

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
- AS/NZS CISPR 11: Group 1, Class A emissions
- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions

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 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.

Notice For EMC declarations and certifications, and additional information, refer to the Product Certifications and Declarations 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)

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`.)