

## SPECIFICATIONS

# NI PCIe-7846

R Series Digital I/O Module for PCI Express, 8 AI, 8 AO, 48 DIO, 500 kS/s AI, Kintex-7 160T FPGA

The following specifications are typical at 25 °C unless otherwise noted.



**Caution** Observe all instructions and cautions in the user documentation. Using the model in a manner not specified can damage the model and compromise the built-in safety protection. Return damaged models to NI for repair.



**Attention** Suivez toutes les instructions et respectez toutes les mises en garde de la documentation utilisateur. L'utilisation d'un modèle de toute autre façon que celle spécifiée risque de l'endommager et de compromettre la protection de sécurité intégrée. Renvoyez les modèles endommagés à NI pour réparation.

## Analog Input

Number of channels	8
Input modes (software-selectable; selection applies to all channels)	DIFF, NRSE, RSE
Type of ADC	Successive approximation register (SAR)
Resolution	16 bits
Conversion time	2 $\mu$ s
Maximum sampling rate (per channel)	500 kS/s
Input impedance	
Powered on	1.25 G $\Omega$    2 pF
Powered off/overload	4 k $\Omega$ minimum
Input signal range (software-selectable)	$\pm 1$ V, $\pm 2$ V, $\pm 5$ V, $\pm 10$ V
Input bias current	$\pm 5$ nA
Input offset current	$\pm 5$ nA
Input coupling	DC

Overvoltage protection

Powered on	±42 V maximum
Powered off	±35 V maximum

**Table 1.** AI Operating Voltage Ranges Over Temperature

Range (V)	Measurement Voltage, AI+ to AI-			Maximum Working Voltage (Signal + Common Mode)
	Minimum (V) <sup>1</sup>	Typical (V)	Maximum (V)	
±10	±10.37	±10.5	±10.63	±12 V of ground
±5	±5.18	± 5.25	±5.32	±10 V of ground
±2	±2.07	±2.1	±2.13	±8.5 V of ground
±1	±1.03	±1.05	±1.06	±8 V of ground

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

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 = 10,000
- CoverageFactor = 3  $\sigma$

**Table 2.** AI Absolute Accuracy (Calibrated)

Specifications	Range			
	±10 V	±5 V	±2 V	±1 V
Residual Gain Error (ppm of Reading)	104.4	105.9	110.6	118.4
Gain Tempco (ppm/°C)	20	20	20	20
Reference Tempco (ppm/°C)	4	4	4	4
Residual Offset Error (ppm of Range)	16.4	16.4	16.4	16.4

<sup>1</sup> The minimum measurement voltage range is the largest voltage the NI PCIe-7846 is guaranteed to accurately measure.

**Table 2. AI Absolute Accuracy (Calibrated) (Continued)**

Specifications	Range			
	±10 V	±5 V	±2 V	±1 V
Offset Tempco (ppm of Range/°C)	4.18	4.17	4.41	4.63
INL Error (ppm of range)	42.52	46.52	46.52	50.52
Random Noise, $\sigma$ ( $\mu\text{V}_{\text{rms}}$ )	263	156	90	74
Absolute Accuracy at Full Scale ( $\mu\text{V}$ )	2,283	1,170	479	252

**Table 3. AI Absolute Accuracy (Uncalibrated)**

Specifications	Range			
	±10 V	±5 V	±2 V	±1 V
Residual Gain Error (ppm of Reading)	2,921	3,021	3,021	3,021
Gain Tempco (ppm/°C)	20	20	20	20
Reference Tempco (ppm/°C)	4	4	4	4
Residual Offset Error (ppm of Range)	661	671	700	631
Offset Tempco (ppm of Range/°C)	4.18	4.17	4.41	4.63
INL Error (ppm of range)	42.52	46.52	46.52	50.52
Random Noise, $\sigma$ ( $\mu\text{V}_{\text{rms}}$ )	263	156	90	74
Absolute Accuracy at Full Scale ( $\mu\text{V}$ )	36,895	19,018	7,667	3,769

## Calculating Absolute Accuracy

$$\text{AbsoluteAccuracy} = \text{Reading} \times (\text{GainError}) + \text{Range} \times (\text{OffsetError}) + \text{NoiseUncertainty}$$

$$\text{GainError} = \text{ResidualGainError} + \text{GainTempco} \times (\text{TempChangeFromLastInternalCal}) + \text{ReferenceTempco} \times (\text{TempChangeFromLastExternalCal})$$

$$\text{OffsetError} = \text{ResidualOffsetError} + \text{OffsetTempco} \times (\text{TempChangeFromLastInternalCal}) + \text{INL\_Error}$$

$$\text{NoiseUncertainty} = \frac{\text{RandomNoise} \times \text{CoverageFactor}}{\sqrt{\text{number\_of\_readings}}}$$

Refer to the following equation for an example of calculating absolute accuracy for a 10 V reading.

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 = 10,000
- CoverageFactor = 3  $\sigma$

$$\text{GainError} = 104.4 \text{ ppm} + 20 \text{ ppm} \times 1 + 4 \text{ ppm} \times 10$$

$$\text{GainError} = 164.4 \text{ ppm}$$

$$\text{OffsetError} = 16.4 \text{ ppm} + 4.18 \text{ ppm} \times 1 + 42.52 \text{ ppm}$$

$$\text{OffsetError} = 63.1 \text{ ppm}$$

$$\text{NoiseUncertainty} = \frac{263 \mu\text{V} \times 3}{\sqrt{10,000}}$$

$$\text{NoiseUncertainty} = 7.89 \mu\text{V}$$

$$\text{AbsoluteAccuracy} = 10 \text{ V} \times (\text{GainError}) + 10 \text{ V} \times (\text{OffsetError}) + \text{NoiseUncertainty}$$

$$\text{AbsoluteAccuracy} = 2,283 \mu\text{V}$$

## DC Transfer Characteristics

INL	Refer to the AI Accuracy Table
DNL	$\pm 0.4$ LSB typical, $\pm 0.9$ LSB maximum
No missing codes	16 bits guaranteed
CMRR, DC to 60 Hz	-100 dB

# Dynamic Characteristics

## Bandwidth

Small signal	1 MHz
Large signal	500 kHz

**Table 4. Settling Time**

Range (V)	Step Size (V)	Accuracy		
		±16 LSB	±4 LSB	±2 LSB
±10	±20.0	1.50 μs	4.00 μs	7.00 μs
	±2.0	0.50 μs	0.50 μs	1.00 μs
	±0.2	0.50 μs	0.50 μs	0.50 μs
±5	±10	1.50 μs	3.50 μs	7.50 μs
	±1	0.50 μs	0.50 μs	1.00 μs
	±0.1	0.50 μs	0.50 μs	0.50 μs
±2	±4	1.00 μs	3.50 μs	8.00 μs
	±0.4	0.50 μs	0.50 μs	1.00 μs
	±0.04	0.50 μs	0.50 μs	0.50 μs
±1	±2	1.00 μs	3.50 μs	12.00 μs
	±0.2	0.50 μs	0.50 μs	2.00 μs
	±0.02	0.50 μs	0.50 μs	0.50 μs

Crosstalk -80 dB, DC to 100 kHz, at 50 Ω

## Analog Output

Output type	Single-ended, voltage output
Number of channels	8
Resolution	16 bits
Update time	1 μs
Maximum update rate	1 MS/s
Type of DAC	Enhanced R-2R

Range	±10 V
Output coupling	DC
Output impedance	0.5 Ω
Current drive	±2.5 mA
Protection	Short circuit to ground
Overvoltage protection	
Powered on	±15 V maximum
Powered off	±10 V maximum
Power-on state	User-configurable
Power-on glitch	-1 V for 2 μs
Power-down glitch	-500 mV for 100 μs

**Table 5.** AO Operating Voltage Ranges for Over Temperature

Range (V)	Measurement Voltage, AO+ to AO GND		
	Minimum (V) <sup>2</sup>	Typical (V)	Maximum (V)
±10	±10.1	±10.16	±10.22

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

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

- TempChangeFromLastExternalCal = 10 °C
- TempChangeFromLastInternalCal = 1 °C

**Table 6.** AO Absolute Accuracy (Calibrated)

Specifications	±10 V Range
Residual Gain Error (ppm of Reading)	87.3
Gain Tempco (ppm/°C)	12.6
Reference Tempco (ppm/°C)	4

<sup>2</sup> The minimum measurement voltage range is the largest voltage the NI PCIe-7846 is guaranteed to accurately measure.

**Table 6. AO Absolute Accuracy (Calibrated) (Continued)**

Specifications	±10 V Range
Residual Offset Error (ppm of Range)	41.1
Offset Tempco (ppm of Range/°C)	7.8
INL Error (ppm of range)	61
Absolute Accuracy at Full Scale (μV)	2,498

**Table 7. AO Absolute Accuracy (Uncalibrated)**

Specifications	±10 V Range
Residual Gain Error (ppm of Reading)	2,968.6
Gain Tempco (ppm/°C)	12.6
Reference Tempco (ppm/°C)	4
Residual Offset Error (ppm of Range)	1,004.1
Offset Tempco (ppm of Range/°C)	7.8
INL Error (ppm of range)	61
Absolute Accuracy at Full Scale (μV)	40,941

## Calculating Absolute Accuracy

$$\text{AbsoluteAccuracy} = \text{OutputValue} \times (\text{GainError}) + \text{Range} \times (\text{OffsetError})$$

$$\text{GainError} = \text{ResidualGainError} + \text{GainTempco} \times (\text{TempChangeFromLastInternalCal}) + \text{ReferenceTempco} \times (\text{TempChangeFromLastExternalCal})$$

$$\text{OffsetError} = \text{ResidualGainError} + \text{AOffsetTempco} \times (\text{TempChangeFromLastInternalCal}) + \text{INL\_Error}$$

Refer to the following equation for an example of calculating absolute accuracy for a 10 V reading.

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

- TempChangeFromLastExternalCal = 10 °C
- TempChangeFromLastInternalCal = 1 °C

$$\text{GainError} = 87.3 \text{ ppm} + 12.6 \text{ ppm} \times 1 + 4 \text{ ppm} \times 10$$

$$\text{GainError} = 139.9 \text{ ppm}$$

$$\text{OffsetError} = 41.1 \text{ ppm} + 7.8 \text{ ppm} \times 1 + 61 \text{ ppm}$$

$$\text{OffsetError} = 109.9 \text{ ppm}$$

$$\text{AbsoluteAccuracy} = 10 \text{ V} \times (\text{GainError}) + 10 \text{ V} \times (\text{OffsetError})$$

$$\text{AbsoluteAccuracy} = 2,498 \text{ } \mu\text{V}$$

## DC Transfer Characteristics

INL	Refer to the AO Accuracy Table
DNL	$\pm 0.5$ LSB typical, $\pm 1$ LSB maximum
Monotonicity	16 bits, guaranteed

## Dynamic Characteristics

**Table 8.** Settling Time

Step Size (V)	Accuracy		
	$\pm 16$ LSB	$\pm 4$ LSB	$\pm 2$ LSB
$\pm 20.0$	5.3 $\mu\text{s}$	6.5 $\mu\text{s}$	7.8 $\mu\text{s}$
$\pm 2.0$	3.2 $\mu\text{s}$	3.9 $\mu\text{s}$	4.4 $\mu\text{s}$
$\pm 0.2$	1.8 $\mu\text{s}$	2.8 $\mu\text{s}$	3.8 $\mu\text{s}$

Slew rate	10 V/ $\mu\text{s}$
Noise	250 $\mu\text{V}$ RMS, DC to 1 MHz
Glitch energy at midscale transition	$\pm 10$ mV for 3 $\mu\text{s}$

## 5V Output

Output voltage	4.75 V to 5.1 V
Output current	0.5 A maximum



Overvoltage protection	$\pm 30$ V
Overcurrent protection	650 mA

## Digital I/O

**Table 9.** Channel Frequency

Connector	Number of Channels	Maximum Frequency
Connector 0	16	10 MHz
Connector 1	32	80 MHz

Compatibility	LVTTL, LVCMOS
Logic family	Software-selectable
Default software setting	3.3 V

**Table 10.** Digital Input Logic Levels

Logic Family	Input Low Voltage ( $V_{IL}$ )		Input High Voltage ( $V_{IH}$ )	
	Minimum	Maximum	Minimum	Maximum
1.2 V	-0.3 V	0.40 V	0.84 V	1.5 V
1.5 V	-0.3 V	0.50 V	1.05 V	1.8 V
1.8 V	-0.3 V	0.60 V	1.25 V	2.1 V
2.5 V	-0.3 V	0.70 V	1.70 V	2.8 V
3.3 V	-0.3 V	0.80 V	2.00 V	3.6 V

Input leakage current	$\pm 15$ $\mu$ A maximum
Input impedance	50 k $\Omega$ typical, pull-down

**Table 11.** Digital Output Logic Levels

Logic Family	Current	Output Low Voltage ( $V_{OL}$ ) Maximum	Output High Voltage ( $V_{OH}$ ) Minimum
1.2 V	100 $\mu$ A	0.20 V	1.00 V
1.5 V	100 $\mu$ A	0.20 V	1.25 V
1.8 V	100 $\mu$ A	0.20 V	1.54 V

**Table 11.** Digital Output Logic Levels (Continued)

Logic Family	Current	Output Low Voltage (V <sub>OL</sub> ) Maximum	Output High Voltage (V <sub>OH</sub> ) Minimum
2.5 V	100 $\mu$ A	0.20 V	2.22 V
3.3 V	100 $\mu$ A	0.20 V	3.00 V
	4 mA	0.40 V	2.40 V

Maximum DC output current per channel

Source	4.0 mA
Sink	4.0 mA
Output impedance	50 $\Omega$
Power-on state	Programmable, by line
Protection	$\pm$ 20 V, single line <sup>3</sup>
Digital I/O voltage selection	Programmable, per connector, and defined at compilation (not run-time configurable)
Direction control of digital I/O channels	Per channel
Minimum I/O pulse width	6.25 ns
Minimum sampling period	5 ns

## External Clock

Direction	Input into device
Maximum input leakage	$\pm$ 15 $\mu$ A
Characteristic impedance	50 $\Omega$
Power-on state	Tristated
Minimum input	Inherited from programmed digital voltage selection per connector
Maximum input	Inherited from programmed digital voltage selection per connector

<sup>3</sup> NI recommends minimizing long-term over/under-voltage exposure to the Digital I/O. Prolonged DC voltage stresses that violate the maximum and minimum digital input voltage ratings may reduce device longevity. Over/under-voltage stresses are considered prolonged if the cumulative time in the abnormal condition exceeds 1 year.

Logic level	Inherited from programmed digital voltage selection per connector
Maximum input frequency	80 MHz

## Reconfigurable FPGA

FPGA type	Kintex-7 160T
Number of flip-flops	202,800
Number of LUTs	101,400
Embedded Block RAM	11,700 kbits
Number of DSP48 slices	600
Timebase	40 MHz, 80 MHz, 120 MHz, 160 MHz, or 200 MHz
Default timebase	40 MHz
Timebase accuracy	±100 ppm, 250 ps peak-to-peak jitter
Data transfers	DMA, interrupts, programmed I/O

## Synchronization Resources

Input/output source	RTSI<0..7>
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## Bus Interface

Form factor	x4 PCI Express, specification v1.0 compliant
Slot compatibility	x4, x8, and x16 PCI Express slots
Data transfers	DMA, interrupts, programmed I/O
Number of DMA channels	16

## Power Requirements

Power requirements are dependent on the digital output loads and configuration of the LabVIEW FPGA VI used in your application.

+3.3 V	3 A
+12 V	2 A

# Physical Characteristics

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Weight	141.4 g (4.99 oz)
Printed circuit board dimensions	16.8 cm × 11.1 cm (6.60 in. × 4.38 in.)
Form factor	standard height, half length, single slot
I/O connectors	2 × 68-pin VHDCI

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## Safety Voltages

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Connect only voltages that are below these limits.

Channel-to-earth	±12 V, Measurement Category I
Channel-to-channel	±24 V, Measurement Category I

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**Caution** Do not connect the NI PCIe-7846 to signals or use for measurements within Measurement Categories II, III, or IV.



**Attention** Ne connectez pas le NI PCIe-7846 à des signaux et ne l'utilisez pas pour effectuer des mesures dans les catégories de mesure II, III ou IV.

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.



**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.

## Safety Compliance Standards

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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 UL and other safety certifications, refer to the product label or the [Product Certifications and Declarations](#) section.

# Electromagnetic Compatibility Standards

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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
- 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.

## CE Compliance

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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

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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/certification](https://ni.com/certification), search by model number or product line, and click the appropriate link in the Certification column.

## Environmental Guidelines

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**Notice** This model is intended for use in indoor applications only.

## Operating Environment

Operating temperature, local <sup>4</sup>	0 °C to 55 °C (IEC 60068-2-1 and IEC 60068-2-2)
Operating humidity	10% RH to 90% RH, noncondensing (IEC 60068-2-78)

## Storage Environment

Temperature	
Operating <sup>5</sup>	0 °C to 55 °C
Storage	-20 °C to 70 °C
Humidity	
Operating	10% RH to 90% RH, noncondensing
Storage	5% RH to 95% RH, noncondensing
Pollution Degree	2
Maximum altitude	2,000 m (at 25 °C ambient temperature)

## Maximum Altitude and Pollution Degree

Refer to the manual for the chassis you are using for more information about meeting these specifications.

Maximum altitude	2,000 m (at 25 °C ambient temperature)
Pollution degree	2

## 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.

<sup>4</sup> For PCI Express adapter cards without integrated air movers, NI defines the local operational ambient environment to be 25 mm (1 in.) upstream of the leading edge of the card with system airflow of at least 0.4 m/s (80 LFM) for half length cards and 0.6 m/s (120 LFM) for three-quarter length cards. For more information about the local operational ambient environment definition for PCI Express adapter cards, visit [ni.com/info](http://ni.com/info) and enter the Info Code `pcielocalambient`.

<sup>5</sup> For PCI Express adapter cards without integrated air movers, NI defines the local operational ambient environment to be 25 mm (1 in.) upstream of the leading edge of the card with system airflow of at least 0.4 m/s (80 LFM) for half length cards and 0.6 m/s (120 LFM) for three-quarter length cards. For more information about the local operational ambient environment definition for PCI Express adapter cards, visit [ni.com/info](http://ni.com/info) and enter the Info Code `pcielocalambient`.

For additional environmental information, refer to the *Minimize Our Environmental Impact* web page at [ni.com/environment](https://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 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](https://ni.com/environment/weee).

## 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](https://ni.com/environment/rohs_china)。(For information about China RoHS compliance, go to [ni.com/environment/rohs\\_china](https://ni.com/environment/rohs_china).)

## Calibration

Recommended warm-up time	15 minutes
Calibration interval	1 year
Onboard calibration reference	
DC level <sup>6</sup>	5.000 V (±2 mV)
Temperature coefficient	±4 ppm/°C maximum
Long-term stability	±25 ppm/1,000 h



**Note** Refer to Calibration Certifications at [ni.com/calibration](https://ni.com/calibration) to generate a calibration certificate for the NI PCIe-7846

## Worldwide Support and Services

The NI website is your complete resource for technical support. At [ni.com/support](https://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.

Visit [ni.com/services](https://ni.com/services) for information about the services NI offers.

Visit [ni.com/register](https://ni.com/register) to register your NI product. Product registration facilitates technical support and ensures that you receive important information updates from NI.

<sup>6</sup> Actual value stored in Flash memory

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