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SPECIFICATIONS

R Series for USB Multifunction RIO with Kintex-7 160T FPGA

This document contains the specifications for the NI USB-7856R. Specifications are typical at 25 $^{\circ}\text{C}$ unless otherwise noted.



Caution Using the NI USB-7856R in a manner not described in this document may impair the protection the NI USB-7856R provides.

Analog Input

Number of channels	8
Input modes	DIFF, NRSE, RSE (software-selectable; selection applies to all channels)
Type of ADC	Successive approximation register (SAR)
Resolution	16 bits
Conversion time	1 μs
Maximum sampling rate	1 MS/s (per channel)
Input impedance	
Powered on	1.25 GΩ 2 pF
Powered off/overload	4.0 kΩ minimum
Input signal range	± 1 V, ± 2 V, ± 5 V, ± 10 V (software-selectable)
Input bias current	±5 nA
Input offset current	±5 nA
Input coupling	DC
Overvoltage protection	
Powered on	±42 V maximum
Powered off	±35 V maximum



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

Table 1. Al Operating Voltage Ranges Over Temperature

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 = 3σ

	Range			
Specifications	±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
Residual Offset Error (ppm of Range)	16.4	16.4	16.4	16.4
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

Table 2. Al Absolute Accu	racy (Calibrated)
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¹ The minimum measurement voltage range is the largest voltage the NI USB-7856R is guaranteed to accurately measure.

	Range			
Specifications	±10 V	±5 V	±2 V	±1 V
Random Noise, σ (μVrms)	263	156	90	74
Absolute Accuracy at Full Scale (µV)	2,283	1,170	479	252

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

	Range			
Specifications	±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, σ (µVrms)	263	156	90	74
Absolute Accuracy at Full Scale (µV)	36,895	19,018	7,667	3,769

Table 3. AI Absolute Accuracy (Uncalibrated)

Calculating Absolute Accuracy

$$\label{eq:absoluteAccuracy} \begin{split} AbsoluteAccuracy &= Reading \times (GainError) + Range \times (OffsetError) \\ + NoiseUncertainty \end{split}$$

GainError = ResidualGainError + GainTempco × (TempChangeFromLastInternalCal) + ReferenceTempco × (TempChangeFromLastExternalCal)

OffsetError = ResidualOffsetError + OffsetTempco × (TempChangeFromLastInternalCal) + INL_Error

 $NoiseUncertainty = \frac{RandomNoise \times CoverageFactor}{\sqrt{number_of_readings}}$

Refer to the following equation for an example of calculating absolute accuracy.

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 = 3σ

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

GainError = 164.4 ppm

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

OffsetError = 63.1 ppm

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

NoiseUncertainty = $7.89 \mu V$

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

AbsoluteAccuracy = 2,283 μV

DC Transfer Characteristics

INL	Refer to the AI Accuracy Table	
DNL	±0.4 LSB typical, ±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

		Accuracy		
Range (V)	Step Size (V)	±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

Analog Output

Output type	Single-ended, voltage output
Number of channels	8
Resolution	16 bits
Update time	1.0 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 1 μs

Table 5. AO Operating Voltage Ranges for Over Temperature

	Measurement Voltage, AO+ to AO GND			
Range	Minimum (V) ²	Typical (V)	Maximum (V)	
±10 V	±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)
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Specifications	±10 V Range
Residual Gain Error (ppm of Reading)	87.3
Gain Tempco (ppm/°C)	12.6
Reference Tempco (ppm/°C)	4
Residual Offset Error (ppm of Range)	41.1

² The minimum measurement voltage range is the largest voltage the NI USB-7856R is guaranteed to accurately measure.

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

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

Table 7. AO Absolute Accuracy (Uncalibrated)

Calculating Absolute Accuracy

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

GainError = ResidualGainError + GainTempco × (TempChangeFromLastInternalCal) + ReferenceTempco × (TempChangeFromLastExternalCal)

OffsetError = ResidualOffsetError + AOOffsetTempco × (TempChangeFromLastInternalCal) + INL_Error

Refer to the following equation for an example of calculating absolute accuracy.

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

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

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

GainError = 139.9 ppm

 $OffsetError = 41.1 \ ppm + 7.8 \ ppm \times 1 + 61 \ ppm$

OffsetError = 109.9 *ppm*

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

AbsoluteAccuracy = 2,498 μV

DC Transfer Characteristics

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

Dynamic Characteristics

	Accuracy		
Step Size	±16 LSB	±4 LSB	±2 LSB
±20.0 V	5.3 μs	6.5 μs	7.8 μs
±2.0	3.2 µs	3.9 µs	4.4 μs
±0.2	1.8 μs	2.8 µs	3.8 µs
Slew rate	10	V/µs	
loise 250		μVrms, DC to 1 MH	Z
Glitch energy at midscale	the transition $\pm 10 \text{ mV}$ for 3 µs		
5V Output			
Output voltage	4.7	5 V to 5.1 V	

0.5 A maximum

Table 8. Settling Time

Output current

Overvoltage protection	±30 V
Overcurrent protection	650 mA

Digital I/O

Table 9. Channel Frequency			
Connector	Number of Channels	Maximum Frequency	
Connector 0	32	80 MHz	
Connector 1	16	10 MHz	
Compatibility	LVTTL, LVCMOS		
Logic family	User-selectable		
Default software setting	g 3.3 V		

Table 10. Digital Input Logic Levels

	Input Low Voltage	Input High Voltage
Logic Family	V _{IL} (Maximum)	V _{IH} (Minimum)
1.2 V	0.42 V	0.84 V
1.5 V	0.51 V	1.01 V
1.8 V	0.61 V	1.21 V
2.5 V	0.70 V	1.60 V
3.3 V	0.80 V	2.00 V

Maximum input

3.6 V

Table 11. Digital Output Logic Levels

		Output Low Voltage	Output High Voltage
Logic Family	Current	V _{OL} (Maximum)	V _{OH} (Minimum)
1.2 V	100 µA	0.20 V	1.00 V
1.5 V	100 µA	0.20 V	1.25 V
1.8 V	100 µA	0.20 V	1.54 V
2.5 V	100 µA	0.20 V	2.22 V

		Output Low Voltage	Output High Voltage
Logic Family	Current	V _{OL} (Maximum)	V _{OH} (Minimum)
3.3 V	100 µA,	0.20 V,	3.00 V,
	4 mA	0.40 V	2.40 V

Table 11. Digital Output Logic Levels (Continued)

Output current

4.0 mA
4.0 mA
±15 μA maximum
50 k Ω typical, pull-down
50 Ω
Programmable, by line
±20 V, single line
2 ms maximum



Note Refer to *NI RIO Software Help* for more information about switching times.

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
Timebase accuracy, onboard clock	±100 ppm

Bus Interface

USB compatibility	USB 2.0 Hi-Speed or Full-Speed ³
Data transfers	DMA, interrupts, programmed I/O
Number of DMA channels	3

Power Requirement

Input voltage	9 V to 30 V
Maximum power	20 W
Overvoltage protection	40 V



Caution You must use either the power supply provided in the shipping kit, or another UL Listed ITE power supply marked LPS with the NI USB-7856R.

Physical Characteristics

Note If you need to clean the device, wipe it with a dry, clean towel.

Dimensions	18.5 cm × 17.3 cm × 3.6 cm (7.3 in. × 6.8 in. × 1.4 in.)
Weight	1,000 g (35.27 oz)
I/O connectors	2×68 -pin VHDCI

Maximum Working Voltage

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

Channel-to-earth	±12 V, Measurement Category I
Channel-to-channel	±24 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 lowvoltage sources, and electronics.

³ Operating on a full-speed bus will result in lower performance and you might not be able to achieve maximum sampling/update rates.



Caution Do not use the NI USB-7856R for connection to signals in Measurement 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.

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
- 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 $C \in$

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

- 2006/95/EC; Low-Voltage Directive (safety)
- 2004/108/EC; Electromagnetic Compatibility Directive (EMC)

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

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 °C to 70 °C
Storage temperature (IEC 60068-2-1, IEC 60068-2-2)	-40 °C to 85 °C
Operating humidity (IEC 60068-2-56)	10% RH to 90% RH, noncondensing
Storage humidity (IEC 60068-2-56)	5% RH to 95% RH, noncondensing
Pollution Degree	2
Maximum altitude	2,000 m

Indoor use only.

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.

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*.

电子信息产品污染控制管理办法(中国 RoHS)

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Calibration

15 minutes
1 year
5.000 V (±2 mV)
±4 ppm/°C maximum
±25 ppm/1,000 h



Note Refer to Calibration Certifications at *ni.com/calibration* to generate a calibration certificate for the NI USB-7856R

Worldwide Support and Services

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⁴ Actual value stored in Flash memory

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