## COMPREHENSIVE SERVICES

We offer competitive repair and calibration services, as well as easily accessible documentation and free downloadable resources.

## SELL YOUR SURPLUS

We buy new, used, decommissioned, and surplus parts from every NI series. We work out the best solution to suit your individual needs.

Sell For Cash  Get Credit  Receive a Trade-In Deal

## OBSOLETE NI HARDWARE IN STOCK & READY TO SHIP

We stock **New, New Surplus, Refurbished,** and **Reconditioned** NI Hardware.

APEX WAVES

***Bridging the gap*** *between the manufacturer and your legacy test system.*


1-800-915-6216

www.apexwaves.com

sales@apexwaves.com




## *Request a Quote* CLICK HERE *USB-7856*

SPECIFICATIONS

# NI USB-7856R OEM

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

This document contains the specifications for the NI USB-7856R OEM device. Specifications are typical at 25 °C unless otherwise noted.

**Caution** Using the NI USB-7856R OEM device in a manner not described in this document may impair the protection the NI USB-7856R OEM device 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 |

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

| Range | Measurement Voltage, AI+ to AI- | | | Maximum Working Voltage (Signal + Common Mode) |
|---|---|---|---|---|
| | Minimum (V)[1] | Typical (V) | Maximum (V) | |
| ±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 |

# 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 σ

**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 |
| 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 |

[1] The minimum measurement voltage range is the largest voltage the NI USB-7856R OEM device is guaranteed to accurately measure.

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

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

## Calculating Absolute Accuracy

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

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

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

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

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 = 3 σ

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

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

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

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

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

$$NoiseUncertainty = 7.89\ \mu V$$

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

$$AbsoluteAccuracy = 2,283\ \ \mu V$$

# 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

| Range (V) | Step Size (V) | Accuracy | | |
|---|---|---|---|---|
| | | ±16 LSB | ±4 LSB | ±2 LSB |
| ±10 | ±20.0 | 1.50 µs | 3.50 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 | 1.00 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

| Range | Measurement Voltage, AO+ to AO GND | | |
|---|---|---|---|
| | 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)

| 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 OEM device is guaranteed to accurately measure.

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

| 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 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

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

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

$$OffsetError = ResidualOffsetError + AOOffsetTempco \times (TempChangeFromLastInternalCal) + INL\_Error$$

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

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

$$GainError = 139.9\ ppm$$

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

$$OffsetError = 109.9\,ppm$$

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

$$AbsoluteAccuracy = 2,498\ \mu V$$

# DC Transfer Characteristics

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

# Dynamic Characteristics

**Table 8.** Settling Time

| Step Size | Accuracy | | |
|---|---|---|---|
| | ±16 LSB | ±4 LSB | ±2 LSB |
| ±20.0 V | 5.1 µs | 5.8 µs | 7.5 µs |
| ±2.0 | 3.0 µs | 3.7 µs | 4.3 µs |
| ±0.2 | 1.7 µs | 2.9 µs | 3.4 µs |

| | |
|---|---|
| Slew rate | 10 V/µs |
| Noise | 250 µVrms, DC to 1 MHz |
| Glitch energy at midscale transition | ±10 mV for 3 µs |

# 5V Output

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

| | |
|---|---|
| Overvoltage protection | ±30 V |
| Overcurrent protection | 650 mA |

# Digital I/O

**Table 9.** Channel Frequency

| Connector | Number of Channels | Maximum Frequency |
|---|---|---|
| Connector 1 | 16 | 10 MHz |
| Connector 2 | 16 | 10 MHz |
| Connector 3 | 16 | 10 MHz |

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

**Table 10.** Digital Input Logic Levels

| Logic Family | Input Low Voltage, $V_{IL}$ (Maximum) | Input High Voltage, $V_{IH}$ (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

| Logic Family | Current | Output Low Voltage, $V_{OL}$ (Maximum) | Output High Voltage, $V_{OH}$ (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 |

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

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

| | |
|---|---|
| Output current | |
| Source | 4.0 mA |
| Sink | 4.0 mA |
| Input leakage current | ±15 µA maximum |
| Input impedance | 50 kΩ typical, pull-down |
| Output impedance | 50 Ω |
| Power-on state | Programmable, by line |
| Protection | ±20 V, single line |
| Digital I/O voltage switching time | 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 OEM device.

# Physical Characteristics

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

| | |
|---|---|
| Dimensions | 17.5 cm × 16.3 cm (6.9 in. × 6.4 in.) |
| Weight | 183 g (6.45 oz) |
| I/O connectors | Analog: 1 × 50 pin box header,<br>Digital: 3 × 34 pin box header |

# 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,

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

special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.

**Caution** Do not use the NI USB-7856R OEM device 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.

# 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）

**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。(For information about China RoHS compliance, go to ni.com/environment/rohs_china.)

# Calibration

| | |
|---|---|
| Recommended warm-up time | 15 minutes |
| Calibration interval | 1 year |
| Onboard calibration reference | |
| DC level[4] | 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* to generate a calibration certificate for the NI USB-7856R OEM device

# Worldwide Support and Services

The NI website is your complete resource for technical support. At *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* for NI Factory Installation Services, repairs, extended warranty, and other services.

Visit *ni.com/register* to register your NI product. Product registration facilitates technical support and ensures that you receive important information updates from NI.

NI corporate headquarters is located at 11500 North Mopac Expressway, Austin, Texas, 78759-3504. NI also has offices located around the world. For telephone support in the United States, create your service request at *ni.com/support* or dial 1 866 ASK MYNI (275 6964). For

[4] Actual value stored in Flash memory

telephone support outside the United States, visit the *Worldwide Offices* section of *ni.com/niglobal* to access the branch office websites, which provide up-to-date contact information, support phone numbers, email addresses, and current events.



374242B-01 Aug16