

USB-2404 Series Datasheet

24-Bit Devices for Voltage, Temperature, or Bridge-Based Sensors



The USB-2404-UI provides four 24-bit simultaneous analog inputs with support for voltage, current, thermocouples, RTDs, resistance, and bridge-based sensors.



The USB-2404-10 provides four 24-bit simultaneous sampling analog inputs supporting a ± 10 V voltage range.

Highlighted Features

- Four analog input channels
- 24-bit resolution
- Simultaneous sampling
- Voltage measurements from ± 125 mV to ± 60 V
- USB-2404-UI measures current, thermocouples, RTDs, resistance, and bridge-based sensors
- Cold junction compensation (CJC)
- Anti-alias filter (USB-2404-10)
- Channel-channel and channel-ground continuous functional isolation
- Detachable screw terminals
- No external power required
- Supported OS: Windows 11/10 (32 & 64-bit)

Overview

The USB-2404-10 is designed for both high-speed and accuracy. Its resolution, sample rate, and input range make it an ideal general-purpose analog input device. The USB-2404-UI is designed for multipurpose testing, and can measure several signals from different sensors such as RTDs, thermocouples, load cells, and other powered sensors.

All USB-2404 Series devices include channel-to-channel functional isolation to eliminate measurement errors caused by ground loops.

USB-2404 Series Selection Chart						
Model	Analog Inputs	Sample Rate Per Channel	Measurement Types	Voltage Ranges	Isolation	Anti-Alias Filter
USB-2404-10	4	Up to 50 kS/s	Voltage	±10 V	✓	✓
USB-2404-UI	4	Up to 100 S/s	Voltage, Current, Thermocouples, RTDs, Resistance, and Bridge-Based Sensors	±60 V, ±15 V, ±4 V, ±1 V, ±125 mV	✓	–

1 Features

1.1 Analog Input

Each USB-2404 Series device provides simultaneous sampling of four analog inputs, and channel-to-channel and channel-to-ground continuous functional isolation.

All devices can connect to either ground-referenced or floating signal sources

1.2 USB-2404-UI

The USB-2404-UI provides four individually configurable channels of 24-bit universal analog input with integrated signal conditioning. All channels are measured simultaneously at up to 100 S/s per channel.

The USB-2404-UI can perform the following measurements:

- Voltage
- Current
- Thermocouple
- RTD (4-wire and 3-wire)
- Resistance (4-wire and 2-wire)
- Bridge-based sensors (quarter-, half-, and full-bridge)

Measurement ranges vary for each type of measurement.

The USB-2404-UI features built-in current and voltage excitation. The excitation circuit is protected from overcurrent and overvoltage fault conditions. The USB-2404-UI supports class II TEDS smart sensors, and includes a built-in thermistor for cold-junction compensation (CJC).

An analog pre-filter removes noise that may be present in the signals prior to conversion.

1.2.1 Timing Options

The following timing options are supported. Each option is optimized for different types of applications by using different ADC conversion times.

- **High Speed** – Optimized for high-speed applications at the expense of noise rejection.
- **Best 60 Hz Rejection** – Optimized for rejection of 60 Hz noise.
- **Best 50 Hz Rejection** – Optimized for rejection of 50 Hz noise.
- **High Resolution** – Optimized for maximum overall noise rejection, and provides a good rejection of both 50 Hz and 60 Hz noise.

Refer to the analog input specifications for the conversion time and rejection ratio of each option.

1.2.2 Terminal Connectors

Each channel has a 6-position detachable spring connector for field wiring connections. Four additional six-position connectors are available with the optional NI 9973 connector kit.

1.3 USB-2404-10

The USB-2404-10 has four channels of 24-bit simultaneous analog inputs and a sampling rate of 50 kS/s per channel, maximum. A master timebase frequency controls the sample rate. The input voltage range is ± 10 V for the USB-2404-10.

Anti-Alias Filtering

The anti-alias filter removes noise that may be present in the signals prior to conversion. These devices combine analog and digital filtering to accurately represent in-band signals while rejecting out-of-band signals. The filters discriminate between signals based on the frequency range, or bandwidth, of the signal.

The passband, stopband, and alias-free bandwidths are important. These devices represent signals within the passband frequency, as quantified primarily by passband ripple and phase nonlinearity.

All signals within the alias-free bandwidth are either unaliased signals or signals that have been filtered by at least the amount of the stopband rejection.

- **Passband bandwidth:** The signals within the passband bandwidth have frequency-dependent gain or attenuation. The small amount of variation in gain with respect to frequency is the passband flatness. The device's digital filters adjust the frequency range of the passband to match the data rate, so, the amount of gain or attenuation at a given frequency depends on the sample rate.
- **Stopband bandwidth:** The filter significantly attenuates all signals above the stopband frequency ($0.547 \cdot f_s$, where f_s is the sample rate). The filter is used primarily to prevent aliasing, so the stopband frequency scales precisely with the sample rate.
The stopband rejection (100 dB) is the minimum amount of attenuation applied by the filter to all signals with frequencies within the stopband bandwidth.
- **Alias-Free bandwidth:** Signals that appear in the alias-free bandwidth these devices are not aliased artifacts of signals at a higher frequency. The alias-free bandwidth ($0.453 \cdot f_s$) is defined by the ability of the filter to reject frequencies above the stopband frequency. The alias-free bandwidth equals the sample rate minus the stopband frequency.

Terminal Connectors

Each channel has a 2-position detachable screw terminal for field wiring connections. Ten additional two-position connectors are available with the optional NI 9976 connector kit.

1.4 Voltage Applications

For voltage applications with the USB-2404-10, consider using the NI 9971 backshell to ensure that the terminals are not accessible. The backshell also provides strain relief to protect the USB-2404-10 screw terminals.

For voltage applications with the USB-2404-UI, consider using the NI 9972 backshell to ensure that the terminals are not accessible.

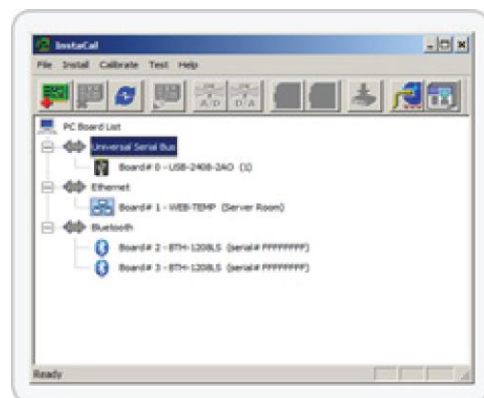
2 Software

The USB-2404 Series is supported by a wide variety of software.

2.1 InstaCal™

An interactive installation, configuration, and test utility for MCC hardware for Windows.

InstaCal is included with the free MCC DAQ Software bundle.



2.2 TracerDAQ™ and TracerDAQ Pro

Virtual strip chart, oscilloscope, function generator, and rate generator applications used to generate, acquire, analyze, display, and export data. Supported features may vary by hardware. The Pro version provides enhanced features. Available on Windows.

TracerDAQ is included with the free MCC DAQ Software bundle. TracerDAQ Pro is available as a purchased software download.

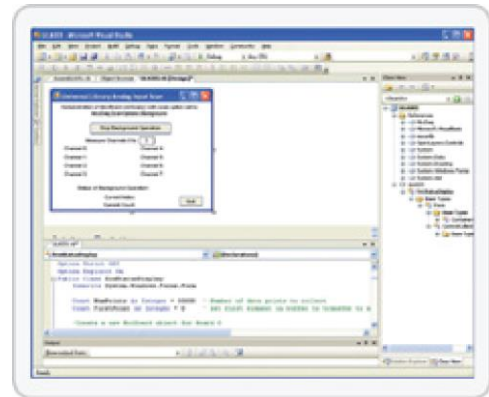


2.3 Universal Library™ for Windows

Library for developing applications in C, C++, VB, C# .Net, VB .Net, and Python on Windows.

The UL for Windows is included with the free MCC DAQ Software bundle.

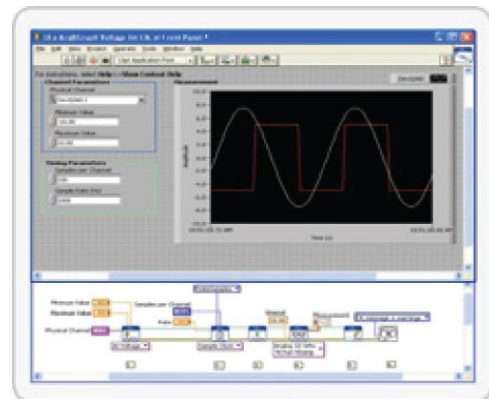
The UL Python API for Windows is available on GitHub (github.com/mccdaq/mcculw).



2.4 ULx for NI LabVIEW™

A comprehensive library of VIs and example programs for NI LabVIEW that is used to develop custom applications that interact with most MCC devices, available for Windows.

ULx for NI LabVIEW is included with the free MCC DAQ Software bundle.



2.5 DASyLab™

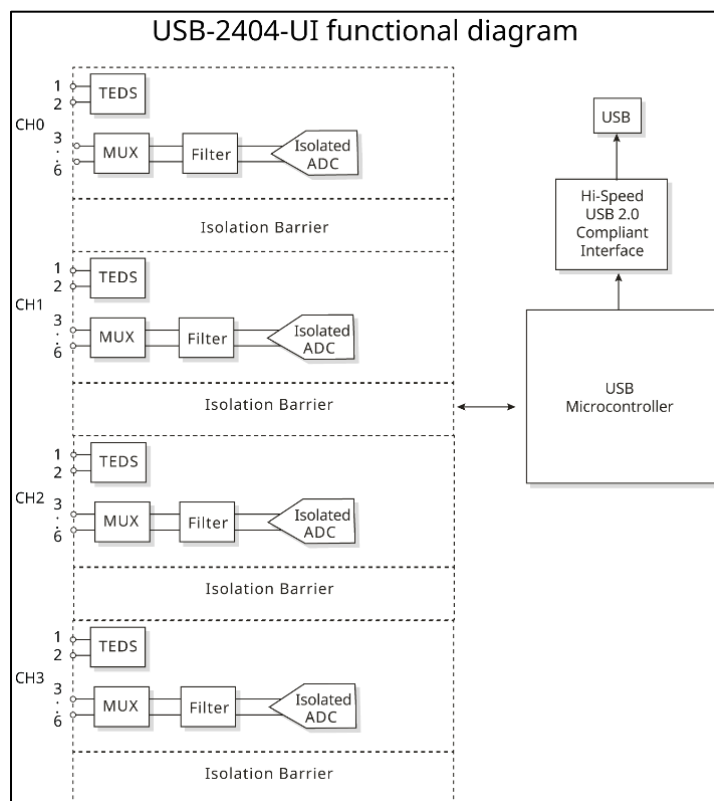
Icon-based data acquisition, graphics, control, and analysis software that allows users to create complex applications in minimal time without text-based programming, available for Windows.

DASyLab is available as a purchased software download. An evaluation version is available for 28 days.

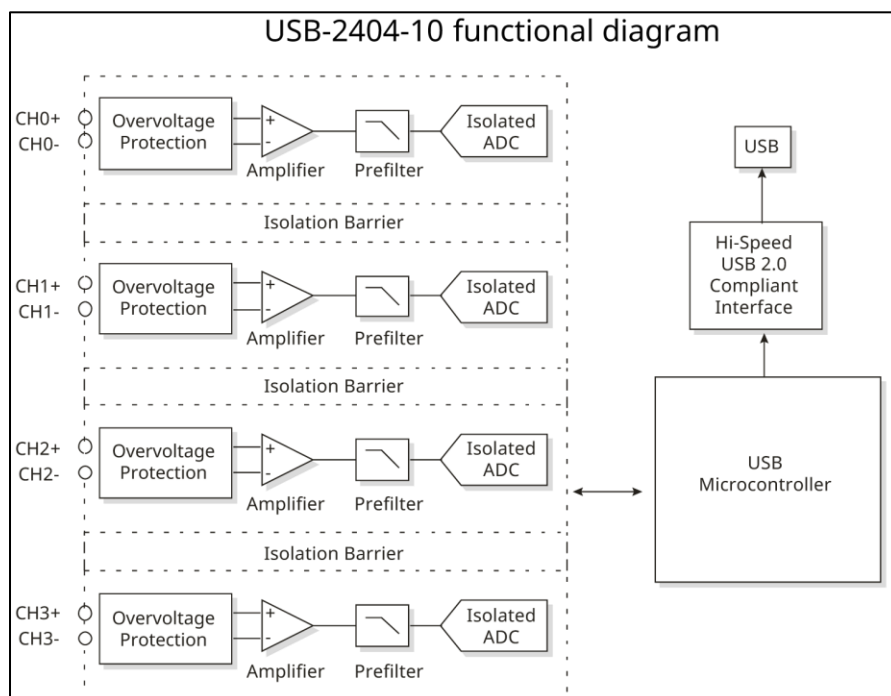


3 Functional Diagrams

USB-2404-UI



USB-2404-10



4 USB-2404 Series Specifications

All specifications are subject to change without notice.

Typical for the range 0 °C to 60 °C unless otherwise noted.

All voltages are relative to the CH– signal on each channel unless otherwise noted.

4.1 USB-2404-UI

Analog Input

Number Of Channels	4	
A/D Converter Resolution	24-bit	
A/D Converter Type	Delta-Sigma with analog pre-filtering	
Sampling Mode	Simultaneous	
TEDS Sensor Type Supported	IEEE 1451.4 TEDS Class II (interface)	
Input Modes	Voltage, current, resistance (4-wire and 2-wire), RTD (3-wire and 4-wire), thermocouple, quarter-bridge, half-bridge, full-bridge	
Conversion Time (No Channels in TC Mode)	High Speed:	10 ms for all channels
	Best 60 Hz Rejection:	110 ms for all channels
	Best 50 Hz Rejection:	130 ms for all channels
	High Resolution:	500 ms for all channels
Conversion Time (One or More Channels in TC Mode)	High Speed:	20 ms for all channels
	Best 60 Hz Rejection:	120 ms for all channels
	Best 50 Hz Rejection:	140 ms for all channels
	High Resolution:	510 ms for all channels
Overvoltage Protection	Terminals 1 and 2:	±30 V
	Terminals 3 Through 6, Across Any Combination:	±60 V
Input Impedance	Voltage Mode (±60 V, ±15 V, ±4 V):	1 MΩ
	Current Mode:	<40 Ω
	All Other Modes:	>1 GΩ
Input Bias Current	<1 nA	
Integral Non-Linearity (INL)	±15 ppm	
Common Mode Rejection Ratio (f_{in}= 60 Hz)	>100 dB	
Rejection	90 dB at 60 Hz	
Best 50 Hz Rejection	80 dB at 50 Hz	
High Resolution	65 dB at 50 Hz and 60 Hz	

Input Mode Ranges

Input Mode	Nominal Ranges	Actual Ranges
Voltage	$\pm 60\text{ V}$, $\pm 15\text{ V}$, $\pm 4\text{ V}$, $\pm 1\text{ V}$, $\pm 125\text{ mV}$	$\pm 60\text{ V}$, $\pm 15\text{ V}$, $\pm 4\text{ V}$, $\pm 1\text{ V}$, $\pm 125\text{ mV}$
Current	$\pm 25\text{ mA}$	$\pm 25\text{ mA}$
4- and 2-Wire Resistance	10 k Ω , 1 k Ω	10.5 k Ω , 1.05 k Ω
Thermocouple	$\pm 125\text{ mV}$	$\pm 125\text{ mV}$
4- and 3-Wire RTD	Pt 1000, Pt 100	5.05 k Ω , 505 Ω
Quarter-Bridge	350 Ω , 120 Ω	390 Ω , 150 Ω
Half-Bridge	$\pm 500\text{ mV/V}$	$\pm 500\text{ mV/V}$
Full-Bridge	$\pm 62.5\text{ mV/V}$, $\pm 7.8\text{ mV/V}$	$\pm 62.5\text{ mV/V}$, $\pm 7.8125\text{ mV/V}$

Accuracy

The Gain Error and Offset error are for a temperature of 25 °C, $\pm 5\text{ }^{\circ}\text{C}$ Typical and $-40\text{ }^{\circ}\text{C}$ to 70 °C Maximum.

Mode, Range	Gain Error (% of Reading)	Offset Error (PPM of Range)
Voltage, $\pm 60\text{ V}$	± 0.3 , ± 0.4	± 20 , ± 50
Voltage, $\pm 15\text{ V}$	± 0.3 , ± 0.4	± 60 , ± 180
Voltage, $\pm 4\text{ V}$	± 0.3 , ± 0.4	± 240 , ± 720
Voltage, $\pm 1\text{ V}$	± 0.1 , ± 0.18	± 15 , ± 45
Voltage/Thermocouple, $\pm 125\text{ mV}$	± 0.1 , ± 0.18	± 120 , ± 360
Current, $\pm 25\text{ mA}$	± 0.1 , ± 0.6	± 30 , ± 100
4- and 2-Wire* Resistance, 10 k Ω	± 0.1 , ± 0.5	± 120 , ± 320
4- and 2-Wire* Resistance, 1 k Ω	± 0.1 , ± 0.5	± 1200 , ± 3200
4- and 3-Wire RTD, Pt 1000	± 0.1 , ± 0.5	± 240 , ± 640
4- and 3-Wire RTD, Pt 100	± 0.1 , ± 0.5	± 2400 , ± 6400
Quarter-Bridge, 350 Ω	± 0.1 , ± 0.5	± 2400 , ± 6400
Quarter-Bridge, 120 Ω	$\Omega \pm 0.1$, ± 0.5	± 2400 , ± 6400
Half-Bridge, $\pm 500\text{ mV/V}$	± 0.03 , ± 0.07	± 300 , ± 450
Full-Bridge, $\pm 62.5\text{ mV/V}$	± 0.03 , ± 0.08	± 300 , ± 1000
Full-Bridge, $\pm 7.8\text{ mV/V}$	± 0.03 , ± 0.08	± 2200 , ± 8000
CJC Sensor Accuracy	N/A	$\pm 1\text{ }^{\circ}\text{C}$, typical

Note*: 2-Wire resistance mode accuracy depends on the lead wire resistance. This table assumes 0 Ω of lead wire resistance.

Stability

Measurement Conditions	Gain Drift (PPM of Reading/ °C)	Offset Drift (PPM of Range/°C)
Voltage, ± 60 V	± 20	± 0.2
Voltage, ± 15 V	± 20	± 0.8
Voltage, ± 4 V	± 20	± 3.2
Voltage, ± 1 V	± 10	± 0.2
Voltage/Thermocouple, ± 125 mV	± 10	± 1.6
Current, ± 25 mA	± 15	± 0.4
4- and 2-Wire Resistance, 10 k Ω	± 15	± 3
4- and 2-Wire Resistance, 1 k Ω	± 15	± 30
4- and 3-Wire RTD, Pt 1000	± 15	± 6
4- and 3-Wire RTD, Pt 100	± 15	± 60
Quarter-Bridge, 350 Ω	± 15	± 120
Quarter-Bridge, 120 Ω	± 15	± 240
Half-Bridge, ± 500 mV/V	± 3	± 20
Full-Bridge, ± 62.5 mV/V	± 3	± 20
Full-Bridge, ± 7.8 mV/V	± 3	± 20

Half-Bridge and Full-Bridge Mode Excitation Level

Measurement Conditions	Load Resistance (Ω)	Excitation (V)
Half-Bridge	700	2.5
Half-Bridge	240	2.0
Full-Bridge	350	2.7
Full-Bridge	120	2.2

Resistance, RTD, and Quarter-Bridge Mode Excitation Level

Load Resistance (Ω)	Excitation (mV)
120	50
350	150
1,000	430
10,000	2,200

Input Noise

Mode, Range	Conversion Time			
	High Speed	Best of 60 Hz Rejection	Best of 50 Hz Rejection	High Resolution
Voltage, ± 60 V	7.6	1.3	1.3	0.5
Voltage, ± 15 V	10.8	1.9	1.9	0.7
Voltage, ± 4 V	10.8	2.7	2.7	1.3
Voltage, ± 1 V	7.6	1.3	1.3	0.5
Voltage/Thermocouple, ± 125 mV	10.8	1.9	1.9	1.0
Current, ± 25 mA	10.8	1.9	1.9	1.0
4- and 2-Wire resistance, 10 k Ω	4.1	1.3	0.8	0.3
4- and 2-Wire resistance, 1 k Ω	7.1	1.8	1.2	0.7
4- and 3-Wire RTD, Pt 1000	7.6	1.7	1.1	0.4
4- and 2-Wire resistance, 10 k Ω	10.8	1.9	1.9	0.9
Quarter-Bridge, 350 Ω	5.4	1.0	1.0	0.7
Quarter-Bridge, 120 Ω	5.4	1.0	1.0	0.7
Half-Bridge, ± 500 mV/V	3.8	0.5	0.5	0.2
Full-Bridge, ± 62.5 mV/V	5.4	1.0	1.0	0.8
Full-Bridge, ± 7.8 mV/V	30	4.7	4.7	2.3

Power

Current Consumption from USB	500 mA, max
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Bus Interface

USB Specification	USB 2.0 Hi-Speed
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Environmental

The USB-2404-UI is intended for indoor use only, but may be used outdoors if installed in a suitable enclosure.

Operating Temperature Range	0 °C to 60 °C
Storage Temperature Range	–40 to 85 °C
Operating Humidity	10% to 90% RH, non-condensing
Storage Humidity	5% to 95% RH, non-condensing
Maximum Altitude	2000 meter (6562 feet)

Mechanical

Dimensions (L × W × H)	134 × 143 × 39 mm (5.27 × 5.64 × 1.54 in.)
Weight	1.25 lbs (567 grams)

Isolation Voltages

Channel-To-Earth Ground Isolation	Functional isolation
Channel-To-Channel Isolation	Functional isolation

Spring Terminal Connectors

Connector Type	Four 6-position detachable spring terminal connectors
Spring Terminal Wiring	18 AWG to 28 AWG copper conductor wire with 7 mm (0.28 in.) of insulation stripped from the end

4.2 USB-2404-10

Analog Input

Number Of Channels	4
A/D Converter Resolution	24-bit
A/D Converter Type	Delta-Sigma with analog pre-filtering
Sampling Mode	Simultaneous
Sample Rate	1.613 kS/s to 50 kS/s ¹
Sample Rates (f_s)	$(f_M \div 256)/n$, $n = 1, 2, \dots 31$
Internal Master Timebase	Frequency: 12.8 MHz
Accuracy	± 100 ppm maximum
Input Voltage Ranges (CH+ to CH–)	± 10 V nominal ± 10.52 V typ ± 10.3 min
Overvoltage Protection	± 100 V
Input Coupling	DC
Input Impedance (CH+ to CH–)	1 M Ω
Input Noise	70 μ V rms
Gain Drift	± 5 ppm/ $^{\circ}$ C
Offset Drift	± 24 μ V/ $^{\circ}$ C
Post Calibration Gain Match (Channel-to- Channel, 20 kHz)	0.22 dB max
Crosstalk (1 kHz)	–130 dB
Phase Mismatch (Channel-to-Channel)	0.075 $^{\circ}$ /kHz max
Phase Nonlinearity ($f_s = 50$ kS/s)	0.11 $^{\circ}$ max
Input Delay	38.4 +3 μ s
Passband Frequency	0.453
Passband Flatness ($f_s = 50$ kS/s)	± 100 mdB max
Stopband Frequency	0.547 $\cdot f_s$
Stopband Rejection	100 dB
Alias-Free Bandwidth	0.453 $\cdot f_s$
Common Mode Rejection Ratio ($f_{in} = 60$ Hz)	126 dB
Spurious Free Dynamic Range	–128 dBFS

(1 kHz, –60 dBFS)	
Total Harmonic Distortion	
1 kHz, –1 dBFS:	–99 dB
1 kHz, –20 dBFS:	–105 dB

Note 1: Full performance requires connections to a USB 2.0 Hi-Speed host controller and USB 2.0 high-speed hubs.) The maximum sample rate may be lower on USB 1.1 ports.

Accuracy

Measurement Conditions	Percent of Reading (Gain Error)	Percent of Range* (Offset Error)	
Calibrated Maximum (–0 °C To 60 °C)		±0.13%	±0.05%
Calibrated Typical (25 °C, ±5 °C)		±0.03%	±0.008%
Uncalibrated Maximum (–0 °C To 60 °C)		USB-2404-10: ±1.4%	USB-2404-10: ±0.67%
Uncalibrated Typical (25 °C, ±5 °C)		±0.3%	±0.11%

*The USB-2404-10 range equals 10.52 V.

Power

Current Consumption from USB	500 mA, max
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Bus Interface

USB Specification	USB 2.0 Hi-Speed mode (480 Mbps) is recommended. Otherwise, USB 1.1 Full Speed mode (12 Mbps)
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Environmental

Operating Temperature Range	0 °C to 60 °C
Storage Temperature Range	–40 °C to 85 °C
Operating Humidity	10% to 90% relative humidity, non-condensing
Storage Humidity	5% to 95% relative humidity, non-condensing
Maximum Altitude	2000 m (6562 feet)
Pollution Degree (IEC60664)	2

Mechanical

Dimensions (L × W × H)	114.30 × 139.7 × 38.1 mm (4.5 × 5.5 × 1.5 in)
Weight	1.2 lbs. (544 grams)

Isolation Voltages

Channel-To-Earth Ground Isolation	Functional isolation
Channel-To-Channel Isolation	Functional isolation

Certifications and Statements

- Certifications: <https://ni.com/certification>
- RoHS-Compliant Product Listing: <https://files.digilent.com/manuals/ROHS-hw.pdf>

Ordering Information and Purchasing Options



Digilent Part Numbers:

- 6069-410-182 – USB-2404-10
- 6069-410-035 – USB-2404-UI

NI Part Numbers (www.ni.com):

- 785993-01 – NI 9973, 6-position spring terminal connector kit for the USB-2404-UI (Qty 4)
- 786162-01 – NI 9972, Backshell Strain Relief for 6-position connector block, for the USB-2404-UI (Qty 4)
- 196739-01 – NI 9976, 2-position spring terminal connector kit for the USB-2404-10 (Qty 10)
- 196375-01 – NI 9971, Backshell Strain Relief for 2-position connector block, for the USB-2404-10 (Qty 4)

Additional Resources

Reference materials are available on Digilent's Reference site (<https://digilent.com/reference>).

About Digilent

Digilent, part of the NI Product Family, has been at the forefront of innovation since 2000, crafting hardware and software solutions that empower engineers, researchers, educators, and scientists to design and test with unparalleled flexibility. Our customizable solutions cater to both seasoned professionals and emerging engineers, accelerating development while maintaining a low barrier to entry.

We're committed to making engineering accessible, offering competitive pricing, portable products, and comprehensive documentation. With a global presence spanning three continents, Digilent ensures speedy and cost-effective access to our products through an extensive distribution network. Specializing in USB-based test and measurement devices, flexible and intuitive software, low-cost data acquisition and data logging tools, and AMD-based FPGA development boards, our products' design philosophy champions your creativity. By providing world class documentation and support and keeping our hardware and software flexible and practical, we are continuing to provide the building blocks while you bring the brilliance.