

USB-2404 Series

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



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



The USB-2404-10 and USB-2404-60 (above) provide four isolated, 24-bit simultaneous sampling analog inputs supporting ± 10 V or ± 60 V voltage ranges

Features

- Four analog inputs
- 24-bit resolution
- simultaneous sampling
- Voltage measurements from ± 125 mV to ± 60 V
- USB-2404-UI also measures current, thermocouples, RTDs, resistance, and bridge-based sensors
- Cold junction compensation (CJC)
- 250 Vrms ch-ch and ch-gnd isolation
- Anti-alias filter (USB-2404-10 and USB-2404-60)
- Detachable screw terminals
- No external power required

Supported Operating Systems

- Windows 10/8/7/Vista® 32/64-bit

Overview

The USB-2404-10 and USB-2404-60 are designed for both high-speed and accuracy. Their resolution, sample rate, and input range make them ideal general-purpose analog input devices. 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 isolation to protect the entire system from harmful voltage spikes and to eliminate measurement errors caused by ground loops.

Analog Input

Each USB-2404 Series device provides simultaneous sampling of four analog inputs, and 250 Vrms channel-to-channel and channel-to-ground isolation.

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

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.

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-2404-60	4	Up to 50 kS/s	Voltage	± 60 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	✓	–

* 250 Vrms channel-to-channel and channel-to-ground

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.

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 ACC-164 connector kit.

USB-2404-10 and USB-2404-60

The USB-2404-10 and the USB-2404-60 each provide 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, and ± 60 V, for the USB-2404-60.

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 ACC-102 connector kit.

High-Voltage Applications

For high-voltage applications with the USB-2404-10 or the USB-2404-60, MCC recommends using the ACC-160 backshell to ensure that the terminals are not accessible. The backshell also provides strain relief to protect the USB-2404-10/2404-60 screw terminals

For high-voltage applications with the USB-2404-UI, MCC recommends using the ACC-176 backshell to ensure that the terminals are not accessible.

USB-2404 Series

Software

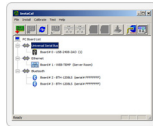


Software Support

The USB-2404 Series is supported by the software in the table below.

Ready-to-Run Applications

[InstaCal™](#)



An interactive installation, configuration, and test utility for MCC hardware. Windows OS
InstaCal is included with the free MCC DAQ Software bundle.

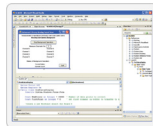
[TracerDAQ™](#) and
[TracerDAQ Pro](#)



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

General-Purpose Programming Support

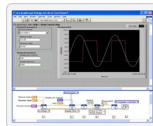
[Universal Library™
\(UL\) for Windows](#)



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).

Application-Specific Programming Support

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

[DASYLab®](#)

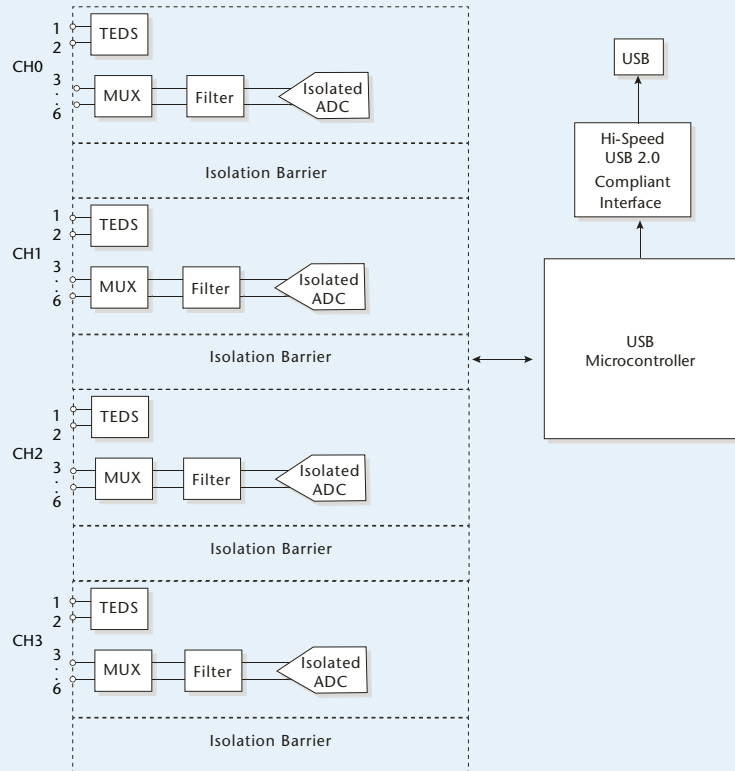


Icon-based data acquisition, graphics, control, and analysis software that allows users to create complex applications in minimal time without text-based programming. Windows OS
DASYLab is available as a purchased software download. An evaluation version is available for 28 days.

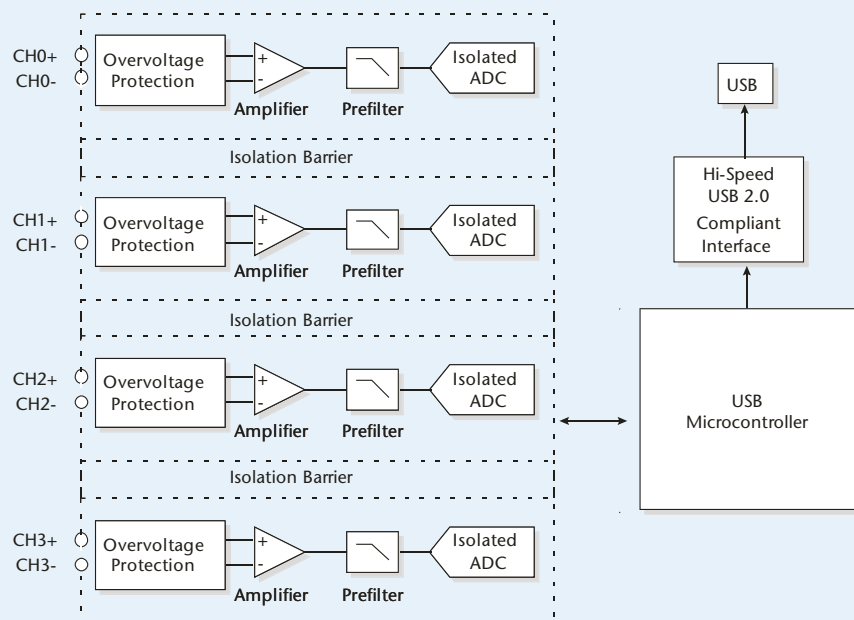
USB-2404 Series

Functional Diagrams

USB-2404-UI functional diagram



USB-2404-10/2404-60 functional diagram



USB-2404 Series

Specifications (USB-2404-UI)



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.

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 M Ω
 Current Mode: < 40 Ω
 All Other Modes: > 1 G Ω
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	± 60 V, ± 15 V, ± 4 V, ± 1 V, ± 125 mV	± 60 V, ± 15 V, ± 4 V, ± 1 V, ± 125 mV
Current	± 25 mA	± 25 mA
4- and 2-Wire Resistance	10 k Ω , 1 k Ω	10.5 k Ω , 1.05 k Ω
Thermocouple	± 125 mV	± 125 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	± 500 mV/V	± 500 mV/V
Full-Bridge	± 62.5 mV/V, ± 7.8 mV/V	± 62.5 mV/V, ± 7.8125 mV/V

Accuracy		
Mode, Range	Gain Error (% of Reading)	Offset Error (PPM of Range)
	25 °C, ± 5 °C Typical, -40 °C to 70 °C Maximum	
Voltage, ± 60 V	$\pm 0.3, \pm 0.4$	$\pm 20, \pm 50$
Voltage, ± 15 V	$\pm 0.3, \pm 0.4$	$\pm 60, \pm 180$
Voltage, ± 4 V	$\pm 0.3, \pm 0.4$	$\pm 240, \pm 720$
Voltage, ± 1 V	$\pm 0.1, \pm 0.18$	$\pm 15, \pm 45$
Voltage/Thermocouple, ± 125 mV	$\pm 0.1, \pm 0.18$	$\pm 120, \pm 360$
Current, ± 25 mA	$\pm 0.1, \pm 0.6$	$\pm 30, \pm 100$
4- and 2-Wire* Resistance, 10 k Ω	$\pm 0.1, \pm 0.5$	$\pm 120, \pm 320$
4- and 2-Wire* Resistance, 1 k Ω	$\pm 0.1, \pm 0.5$	$\pm 1200, \pm 3200$
4- and 3-Wire RTD, Pt 1000	$\pm 0.1, \pm 0.5$	$\pm 240, \pm 640$
4- and 3-Wire RTD, Pt 100	$\pm 0.1, \pm 0.5$	$\pm 2400, \pm 6400$
Quarter-Bridge, 350 Ω	$\pm 0.1, \pm 0.5$	$\pm 2400, \pm 6400$
Quarter-Bridge, 120 Ω	$\pm 0.1, \pm 0.5$	$\pm 2400, \pm 6400$
Half-Bridge, ± 500 mV/V	$\pm 0.03, \pm 0.07$	$\pm 300, \pm 450$
Full-Bridge, ± 62.5 mV/V	$\pm 0.03, \pm 0.08$	$\pm 300, \pm 1000$
Full-Bridge, ± 7.8 mV/V	$\pm 0.03, \pm 0.08$	$\pm 2200, \pm 8000$
CJC Sensor Accuracy	N/A	± 1 °C, typical

* 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

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Specifications (USB-2404-UI)



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 3-Wire RTD, Pt 100	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

Bus interface

USB Specification: USB 2.0 Hi-Speed

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 x W x H): 134 x 143 x 39 mm (5.27 x 5.64 x 1.54 in.)

Weight: 1.25 lbs (567 grams)

Safety Voltages

Connect only voltages that are within the limits specified below.

Channel-To-Earth Ground Isolation

Continuous: 250 VAC, Measurement Category II

Withstand: 2300 VAC, verified by a 5 second dielectric withstand test

Channel-To-Channel Isolation

Continuous: 250 VAC, Measurement Category II

Withstand: 1390 VAC, verified by a 5 second dielectric withstand test

Measurement Category II is for measurements performed on circuits directly connected to the electrical distribution system. This category refers to local-level electrical distribution, such as that provided by a standard wall outlet, for example 115 V for US or 230 V for Europe.

Do *not* connect the device to signals or use for measurements within Measurement Categories III or IV.

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.

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Specifications (USB-2404-10/USB-2404-60)



USB-2404-10 and USB-2404-60

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/s¹

Sample Rates (f_s): $\frac{(f_m \div 256)}{n}$, $n = 1, 2, \dots, 31$.

Internal Master Timebase: Frequency: 12.8 MHz

Accuracy: ± 100 ppm maximum

Input Voltage Ranges (CH+ to CH-)

USB-2404-10

± 10 V nominal

± 10.52 V typ

± 10.3 min

USB-2404-60

± 60 V nominal

± 62.64 V typ

± 61.5 V min

Overvoltage Protection: ± 100 V

Input Coupling: DC

Input Impedance (CH+ to CH-): $1 \text{ M}\Omega$

Input Noise

USB-2404-10: $70 \mu\text{V rms}$

USB-2404-60: $320 \mu\text{V rms}$

Gain Drift: $\pm 5 \text{ ppm}/^\circ\text{C}$

Offset Drift

USB-2404-10: $\pm 24 \mu\text{V}/^\circ\text{C}$

USB-2404-60: $\pm 150 \mu\text{V}/^\circ\text{C}$

Post Calibration Gain Match (Channel-to-Channel, 20 kHz): 0.22 dB max

Crosstalk (1 kHz): -130 dB

Phase Mismatch (Channel-to-Channel)

USB-2404-10: $0.075^\circ/\text{kHz max}$

USB-2404-60: $0.045^\circ/\text{kHz max}$

Phase Nonlinearity ($f_s = 50 \text{ kS/s}$): 0.11° max

Input Delay

USB-2404-10: $38.4 + 3 \mu\text{s}$

USB-2404-60: $38.4 + 2.6 \mu\text{s}$

Passband Frequency: 0.453

Passband Flatness ($f_s = 50 \text{ kS/s}$): $\pm 100 \text{ dB max}$

Stopband Frequency: $0.547 \cdot f_s$

Stopband Rejection: 100 dB

Alias-Free Bandwidth: $0.453 \cdot f_s$

$-3 \text{ dB Pre-Filter Bandwidth}$ ($f_s = 50 \text{ kS/s}$): 24.56 kHz

Common Mode Rejection Ratio ($f_m = 60 \text{ Hz}$):

USB-2404-10: 126 dB

USB-2404-60: 116 dB

Spurious Free Dynamic Range (1 kHz, -60 dBFS): -128 dBFS

Total Harmonic Distortion

1 kHz, -1 dBFS : -99 dB

1 kHz, -20 dBFS : -105 dB

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)	$\pm 0.13\%$	$\pm 0.05\%$
Calibrated Typical (25°C , $\pm 5^\circ\text{C}$)	$\pm 0.03\%$	$\pm 0.008\%$
Uncalibrated Maximum (-0°C To 60°C)	USB-2404-10: $\pm 1.4\%$ USB-2404-60: $\pm 1.2\%$	USB-2404-10: $\pm 0.67\%$ USB-2404-60: $\pm 0.55\%$
Uncalibrated Typical (25°C , $\pm 5^\circ\text{C}$)	$\pm 0.3\%$	$\pm 0.11\%$

* The USB-2404-10 range equals 10.52 V.
The USB-2404-60 range equals 62.64 V.

Power

Current Consumption from USB: 500 mA, max

Bus Interface

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

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 x W x H): 114.30 x 139.7 x 38.1 mm (4.5 x 5.5 x 1.5 in)

Weight: 1.2 lbs. (544 grams)

Safety Voltages

Connect only voltages that are within the limits specified in this table.

Channel-to-Earth Ground Isolation

Continuous: 250 Vrms, Measurement Category II

Measurement Category II is for measurements performed on circuits directly connected to the electrical distribution system. This category refers to local-level electrical distribution, such as that provided by a standard wall outlet, for example 115 V for US or 230 V for Europe. Do not connect the device to signals or use for measurements within Measurement Categories III or IV.

Withstand: 2,300 Vrms, verified by a 5 sec dielectric withstand test

Channel-to-Channel Isolation

Continuous: 250 Vrms, Measurement Category II (Note 4)

Withstand: 1390 Vrms, verified by a 5 sec dielectric withstand test

USB-2404 Series

Ordering



Order Information

Hardware

Part No.	Description
USB-2404-UI	24-bit, 100 S/s, simultaneous-sampling DAQ device with 4 simultaneous analog inputs for voltage, temperature, and bridge-based sensors; includes USB cable and MCC DAQ software
USB-2404-10	24-bit, 50 kS/s DAQ device with 4 simultaneous analog inputs ± 10 V; includes USB cable and MCC DAQ software
USB-2404-60	24-bit, 50 kS/s DAQ device with 4 simultaneous analog inputs ± 60 V; includes USB cable and MCC DAQ software

Accessories and Cables

Part No.	Description
ACC-102	2-position screw terminal connector kit for the USB-2404-10 and USB-2404-60 (quantity of 10)
ACC-160	Backshell kit for the USB-2404-10 and USB-2404-60 (quantity of 4)
ACC-164	6-position spring terminal connector kit for the USB-2404-UI (quantity of 4)
ACC-176	Backshell kit for the USB-2404-UI (quantity of 4)

Software also Available from MCC

Part No.	Description
TracerDAQ Pro	Out-of-the-box virtual instrument suite with strip chart, oscilloscope, function generator, and rate generator – professional version
DASYLab	Icon-based data acquisition, graphics, control, and analysis software