

# USB-2408 Series

## 24-Bit Multifunction Temperature & Voltage Devices



### Features

- Measure thermocouples (TCs) or voltage
- Up to 16 analog inputs
- 24-bit resolution
- Up to 1 kS/s sampling
- 8 digital I/O
- Two counters
- Up to 2 analog outputs
- 500 VDC isolation between field wiring and the USB interface

### Supported Operating Systems

- Windows® 10/8/7/Vista®XP, 32/64-bit
- Linux®

USB-2408 Series devices offer high-resolution voltage or thermocouple measurements along with digital I/O and counter inputs. The USB-2408-2AO (shown here) includes analog output functionality.

### Overview

The USB-2408 Series are multifunction DAQ devices designed for highly-accurate voltage or temperature measurements. Each device features provides up to 16 single-ended (SE)/8 differential (DIFF) analog inputs, 8 digital I/O, and two counter inputs. The USB-2408-2AO also features two analog outputs.

Each device in the series offers 24-bit resolution for ultra-accurate voltage or thermocouple measurements.

### Analog Input

Each device includes 16 SE/8 DIFF analog inputs which you can configure for voltage or TC input on a per-channel basis. Eight software-selectable voltage input ranges are provided. You can configure these ranges on a per-channel basis from  $\pm 10$  V to  $\pm 0.078$  V.

When measuring TCs, configure analog inputs in DIFF mode. All devices also include open TC detection to identify improperly working thermocouples.

### Sample Rate

USB-2408 Series devices can sample analog input channels at up to a 1 kS/s. Refer to the hardware user's guide for information about how noise filtering affects the throughput rate for analog inputs.

### Analog Output (USB-2408-2AO only)

The USB-2408-2AO includes two 16-bit analog outputs. Each output has a  $\pm 10$  V range. Both outputs can be updated at a rate of up to 500 S/s per channel; one output can be updated at a rate of 1 kS/s.

### Digital I/O

Eight digital I/O channels are included with each USB-2408 Series device, and you can read from or write to each individual bit.

### Counter Input

Two 32-bit event counters are provided to count TTL pulses at read/write rates of up to 500 Hz. The counters accept inputs of up to 1 MHz.

### Calibration

The USB-2408 Series is factory-calibrated using a NIST-traceable calibration process. Specifications are guaranteed for one year.

The USB-2408 Series also supports field calibration for users to calibrate the device locally with the InstaCal utility.

USB-2408 Series Selection Chart					
Model	Analog Inputs	Throughput Rate	Analog Outputs	Digital I/O	Counters
USB-2408	16 SE/8 DIFF	Up to 1 kS/s	—	8	2
USB-2408-2AO	16 SE/8 DIFF	Up to 1 kS/s	2	8	2






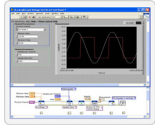

# USB-2408 Series

## Software

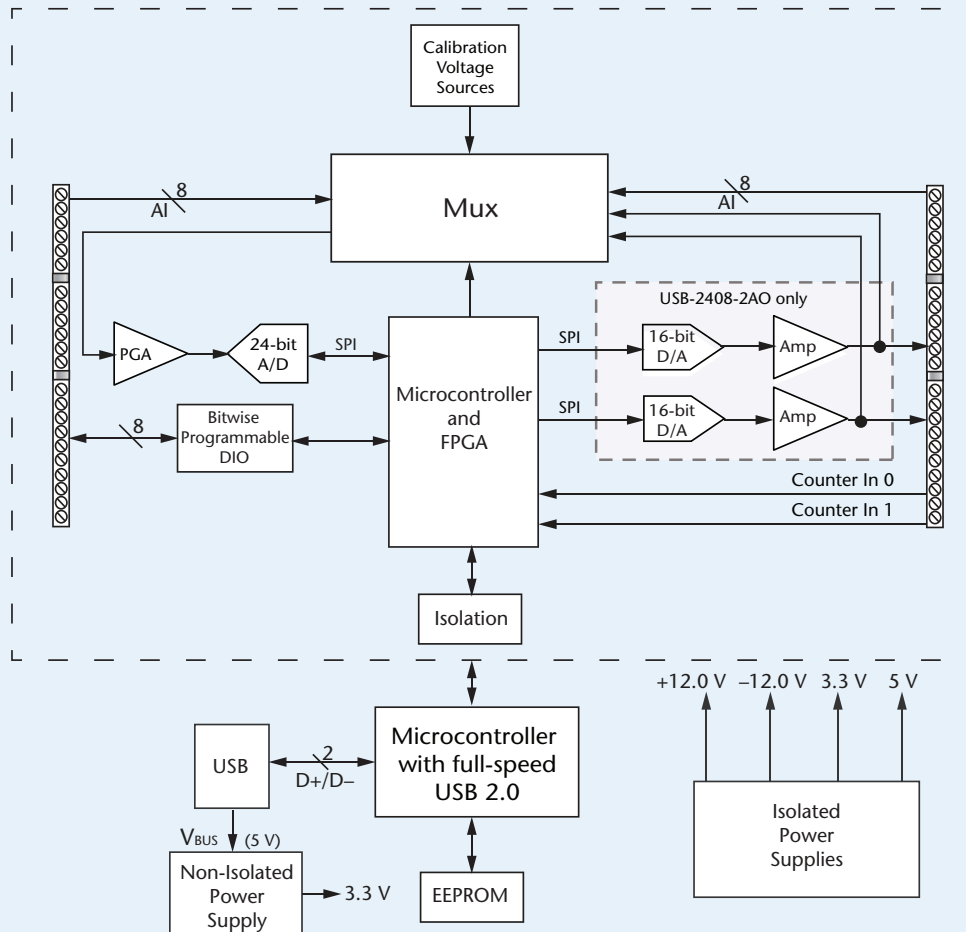


### Software Support

USB-2408 Series devices are supported by the software in the table below.

Ready-to-Run Applications	
<a href="#">DAQami™</a>	 <p>Data acquisition companion software with drag-and-drop interface that is used to acquire, view, and log data, and generate signals. DAQami can be configured to log analog, digital, and counter channels, and to view that data in real-time or post-acquisition on user-configurable displays. Logged data can be exported for use in Excel® or MATLAB®. Windows OS</p> <p>DAQami is included with the free MCC DAQ Software bundle. Install DAQami and try the fully-functional software for 30 days. After 30 days, all features except for data logging and data export will continue to be available – data logging and data export features can be unlocked by purchasing the software.</p>
<a href="#">InstaCal™</a>	 <p>An interactive installation, configuration, and test utility for MCC hardware. Windows OS</p> <p>InstaCal is included with the free MCC DAQ Software bundle.</p>
<a href="#">TracerDAQ™ and TracerDAQ Pro</a>	 <p>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</p> <p>TracerDAQ is included with the free MCC DAQ Software bundle.</p> <p>TracerDAQ Pro is available as a purchased software download.</p>
General-Purpose Programming Support	
<a href="#">Universal Library™ (UL) for Windows</a>	 <p>Library for developing applications in C, C++, VB, C# .Net, VB .Net, and Python on Windows.</p> <p>The UL for Windows is included with the free MCC DAQ Software bundle.</p> <p>The UL Python API for Windows is available on GitHub (<a href="https://github.com/mccdaq/mcculw">https://github.com/mccdaq/mcculw</a>).</p>
<a href="#">UL for Linux®</a>	 <p>Library for developing applications in C, C++, and Python on Linux.</p> <p>UL for Linux is available on GitHub (<a href="https://github.com/mccdaq/uldaq">https://github.com/mccdaq/uldaq</a>).</p> <p>Open-source, third-party Linux drivers are also available for supported MCC devices.</p>
Application-Specific Programming Support	
<a href="#">ULx for NI LabVIEW™</a>	 <p>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</p> <p>ULx for NI LabVIEW is included with the free MCC DAQ Software bundle.</p>
<a href="#">DASYLab®</a>	 <p>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</p> <p>DASYLab is available as a purchased software download. An evaluation version is available for 28 days.</p>

### USB-2408 Series Block Diagram



## Specifications

All specifications are subject to change without notice.  
 Typical for 25 °C unless otherwise specified.  
 All specifications apply to all temperature and voltage input channels unless otherwise specified.

### Analog Input

A/D converter type: ADS1256, 24-bit Sigma Delta  
 A/D data rates (S/s): 3750, 2000, 1000, 500, 100, 60, 50, 25, 10, 5, 2.5  
 A/D resolution: 24 bits

### Throughput

Single channel: 2.5 S/s to 1102.94 S/s  
 Multiple channels: 0.16 Hz to 1102.94 Hz  
 Number of channels: Up to 16 channels individually software-selectable SE/ DIFF  
 Input isolation: 500 VDC min between field wiring and USB interface  
 Channel configurations: Temperature sensor input, voltage input  
 Input voltage range

Thermocouple mode (V):  $\pm 0.078125$   
 Voltage mode (V):  $\pm 10, \pm 5, \pm 2.5, \pm 1.25, \pm 0.625, \pm 0.3125, \pm 0.15625, \pm 0.078125$   
 Absolute maximum input voltage  
 CxH-CxL relative to GND:  $\pm 22$  V max (power on),  $\pm 10$  V max (power off)  
 Input impedance: 10 M $\Omega$  (power on), 390  $\Omega$  (power off)  
 Input leakage current:  $\pm 20$  nA; voltage  $> \pm 22$  V (power on/off):  $\pm 1$   $\mu$ A max  
 Input capacitance: 590 pF  
 Working voltage (signal + common mode): Voltage mode  $\pm 10.25$  V max

### Common mode rejection ratio

Thermocouple mode ( $f_{IN} = 60$  Hz): 110 dB  
 Voltage mode ( $f_{IN} = 60$  Hz, all input ranges): 90 dB

Crosstalk: adjacent channels, 100 dB

Input coupling: DC

Channel gain queue: Up to 64 elements, software-selectable channel and range

Warm-up time: 45 minutes min

Open thermocouple detect: Software-selectable for each channel

CJC sensor accuracy  
 15 °C to 35 °C:  $\pm 0.5$  °C typ  
 0 °C to 55 °C:  $\pm 1.0$  °C max

## Channel Configurations

CxH/CxL

Thermocouple: 8 DIFF channels

Voltage: 16 SE or 8 DIFF; individually configurable

## Compatible Sensors (Thermocouple)

J: -210 °C to 1200 °C  
 K: -270 °C to 1372 °C  
 R: -50 °C to 1768 °C  
 S: -50 °C to 1768 °C  
 T: -270 °C to 400 °C  
 N: -270 °C to 1300 °C  
 E: -270 °C to 1000 °C  
 B: 0 °C to 1820 °C

# USB-2408 Series

## Specifications



Analog Input DC Voltage Measurement Accuracy						
Range	Gain Error (% of Reading)	Offset Error	INL Error (% of Range)	Absolute Accuracy	Gain Temperature Coefficient (% Reading/°C)	Offset Temperature Coefficient (μV/°C)
±10 V	±0.0037	50 μV	±0.0008	500 μV	±0.0006	3
±5 V	±0.0047	25 μV	±0.0008	300 μV	±0.0006	2
±2.5 V	±0.0059	20 μV	±0.0008	200 μV	±0.0006	1
±1.25 V	±0.0056	20 μV	±0.0008	100 μV	±0.0006	1
±0.625 V	±0.0068	15 μV	±0.0005	60 μV	±0.0006	1
±0.3125 V	±0.0104	15 μV	±0.0006	50 μV	±0.0006	1
±0.15625 V	±0.0184	10 μV	±0.0005	40 μV	±0.0006	1
±0.078125 V	±0.0384	10 μV	±0.0009	40 μV	±0.0006	1

Thermocouple Measurement Accuracy				
TC Type	Temp. Range	Accuracy Error, max	Accuracy Error, typ	Tempco (°C/°C)
J	-210 °C	±2.572 °C	±1.416 °C	±0.022
	0 °C	±0.935 °C	±0.469 °C	
	1200 °C	±1.869 °C	±1.456 °C	
K	-210 °C	±2.917 °C	±1.699 °C	±0.029
	0 °C	±1.017 °C	±0.526 °C	
	1372 °C	±2.478 °C	±2.022 °C	
N	-200 °C	±3.480 °C	±2.030 °C	±0.029
	0 °C	±1.201 °C	±0.659 °C	
	1300 °C	±1.991 °C	±1.600 °C	
R	-50 °C	±4.826 °C	±3.133 °C	±0.082
	250 °C	±2.117 °C	±1.424 °C	
	1768 °C	±2.842 °C	±2.347 °C	
S	-50 °C	±4.510 °C	±2.930 °C	±0.089
	250 °C	±2.165 °C	±1.468 °C	
	1768 °C	±3.187 °C	±2.597 °C	
B	250 °C	±5.489 °C	±3.956 °C	±0.14
	700 °C	±2.283 °C	±1.743 °C	
	1820 °C	±2.202 °C	±1.842 °C	
E	-200 °C	±2.413 °C	±1.352 °C	±0.017
	0 °C	±1.069 °C	±0.551 °C	
	1000 °C	±1.575 °C	±1.211 °C	
T	-200 °C	±2.821 °C	±1.676 °C	±0.027
	0 °C	±1.050 °C	±0.558 °C	
	400 °C	±0.957 °C	±0.595 °C	

Includes CJC measurement error and polynomial linearization error; valid for one year or 3000 operating hours. Each terminal block has a CJC sensor. The accuracy listed above assumes the screw terminals are at the same temperature as the CJC sensor. Connect thermocouples so that they float with respect to AGND.

Input Bandwidth	
A/D Data Rate (S/s)	-3 db Bandwidth (Hz)
3750	1615
2000	878
1000	441
500	221
100	44.2
60	26.5
50	22.1
25	11.1
10	4.42
5	2.21
2.5	1.1

Refer to the [USB-2408](#) or [USB-2408-2AO](#) user's guide for the following specifications:  
 - Noise performance  
 - Channel switching error

**Throughput rate:** The maximum throughput is 1.1 kS/s aggregate. The USB-2408 can set conversion rates on a per-channel basis. Refer to the hardware user's guide for tables and formulas for single- and multichannel throughputs.

### Analog Voltage Output (USB-2408-2AO only)

Leave unused AOUTx output channels disconnected. The USB-2408-2AO output voltage level defaults to 0 V whenever the host PC is reset, shut down or suspended, or if a reset command is issued to the device.

The duration of the output transient depends on the enumeration process of the host computer. The output of the USB-2408-2AO is typically stable after two seconds.

**Digital to analog converter:** DAC8552

**Number of channels:** 2

**Resolution:** 16 bits

**Output ranges**

Calibrated: ±10 V

Uncalibrated: ±10.05 V, software-selectable

**Output transient**

Host computer is reset, powered on, suspended or reset command issued

Duration: 2 s

Amplitude: 2 V p-p

**Initial power on**

Duration: 50 ms

Amplitude: 5 V peak

**Differential nonlinearity:** ±0.25 LSB typ, ±1 LSB max

**Output current:** AOUTx pins, ±5.0 mA max

**Output short-circuit protection (AOUTx connected to AGND):** Unlimited duration

**Output coupling:** DC

# USB-2408 Series

## Specifications



**Power on and reset state:** DACs cleared to zero-scale, 0 V,  $\pm 50$  mV

**Output noise:** 60  $\mu$ Vrms (BW=1.5 KHz)

**Settling time:** To rated accuracy, 10 V step, 75  $\mu$ s

**Slew rate:** 1.0 V/ $\mu$ s

### Throughput

**Single-channel:** 1000 S/s max, system-dependent

**Multi-channel:** 1000 S/s /#ch max, system-dependent

### Calibrated absolute accuracy

**Range:**  $\pm 10$  V

**Accuracy ( $\pm$ LSB):** 16.0

### Calibrated absolute accuracy components

**Range:**  $\pm 10$  V

**% of Reading:**  $\pm 0.0183$

**Offset:**  $\pm 1.831$  mV

**Temp drift (%/°C):** 0.00055

**Absolute accuracy at FS:**  $\pm 3.661$  mV

### Relative accuracy

**Range:**  $\pm 10$  V

**Relative accuracy:**  $\pm 4.0$  LSB typ

## Analog Input/Output Calibration

**Warm-up time:** 45 minutes min

**Calibration:** Firmware calibration

**Calibration interval:** 1 year

**AI calibration reference:** 10.000 V,  $\pm 5$  mV max; measured values stored in EEPROM

**Tempco:** 5 ppm/°C max

**Long-term stability:** 30 ppm/1000 hours

**AO calibration procedure (USB-2408-2AO only):** The analog output pin is internally routed to the analog input pin.

**AOUTx readback (USB-2408-2AO only, software-selectable):** Each AOUTx output can be independently measured by the onboard A/D converter

## Digital Input/Output

### Digital Input

**Number of I/O:** 8 channels

**Configuration:** Each DIO bit can be independently read from (DIN) or written to (DOUT). DIN bits can be read at any time whether the DOUT is active or tri-stated.

**Input voltage range:** 0 to 15 V

**Input type:** CMOS (Schmitt trigger)

**Input characteristics:** 47 k $\Omega$  pull-up/pull-down resistor, 28 k $\Omega$  series resistor

**Maximum input voltage range:** 0 V to 20 V max (power on/off, relative to DGND)

**Pull-up/down configuration:** All pins pulled up to 5 V through individual 47 k $\Omega$  resistors. Configure for pull-down with J6 shorting block across pins 2 and 3

**Transfer rate (software paced):** 500 port reads or single bit reads per second typ

**Input high voltage:** 1.3 V to 2.2 V

**Input low voltage:** 1.5 V to 0.6 V

**Schmitt trigger hysteresis:** 0.4 V to 1.2

### Digital Output

**Number of I/O:** 8 channels

**Configuration:** Each DIO bit can be independently read from (DIN) or written to (DOUT). DIN bits can be read at any time whether the DOUT is active or tri-stated.

**Output characteristics:** 47 k $\Omega$  pull-up, open drain (DMOS transistor)  
Each DMOS transistor source pin is internally connected to DGND

**Pull-up configuration:** All pins pulled up to 5 V through individual 47 k $\Omega$  resistors (the J6 shorting block default position is pins 1 and 2).

**Transfer rate (software paced)**

**Digital output:** 500 port writes or single bit writes per second typ

**Output voltage range:** 0 V to 5 V (no external pull up resistor, internal 47 k $\Omega$  pull-up resistors connected to 5 V by default); 0 V to 15 V max

**Drain to source breakdown voltage:** 50 V min

**Off state leakage current:** 1.0  $\mu$ A

**Sink current capability:** 150 mA max (continuous) per output pin

150 mA max (continuous) for all eight channels

**DMOS transistor on-resistance (drain to source):** 4  $\Omega$

## Counter

**Pin names:** CTR0, CTR1

**Number of channels:** 2

**Resolution:** 32-bits

**Counter type:** Event counter

**Input type:** Schmitt trigger, rising edge triggered

**Input source:** CTR0 (pin 44), CTR1 (pin 42)

**Counter read/writes rates (software paced)**

**Counter read:** System-dependent, 500 reads per second.

**Counter write:** System-dependent, 500 writes per second.

**Input characteristics:** Each CTRx input pin has 562 k $\Omega$  resistor pulled up to 5 V and a 10 k $\Omega$  series resistor

**Input voltage range:**  $\pm 15$  V max

**Maximum input voltage range:** CTR0,CTR1 relative to GND and DGND,  $\pm 20$  V max (power on/off)

**Input high voltage:** 1.3 V to 2.2 V

**Input low voltage:** 1.5 V to 0.6 V

**Schmitt trigger hysteresis:** 0.4 V to 1.2

**Input bandwidth (-3 dB):** 1 MHz

**Input capacitance:** 25 pF

**Input leakage current:**  $\pm 120$  nA @5 V,  $\pm 1.6$  mA @ $\pm 15$  V

**Input frequency:** 1 MHz, max

**High pulse width:** 500 ns, min

**Low pulse width:** 500 ns, min

## Memory

**EEPROM:** 4096 bytes isolated micro reserved for sensor configuration, 256 bytes USB micro for external application use

## Microcontroller

**Type:** One high-performance 8-bit RISC microcontroller with USB interface (non-isolated)

One high-performance 16-bit RISC microcontroller for measurements (isolated)

## Power

**Supply current:** Quiescent current, 275 mA

This is the total quiescent current requirement for the USB-2408 Series which includes up to 10 mA for the status LED. This does not include any potential loading of the digital I/O bits, +5 V user terminal or the AOUTx outputs.

**Voltage supervisor limits:** 4.5 V > V<sub>ext</sub> or V<sub>ext</sub> > 5.5 V, PWR LED = Off, (power fault)  
4.5 V < V<sub>ext</sub> < 5.5 V, PWR LED = On

**5 V user output voltage range:** Available at terminal block pin 40, 4.75 V to 5.25 V

**+5 V user output current:** Available at terminal block pin 40, 10 mA max

**Isolation:** Measurement system to computer, 500 VDC min

## USB Specifications

**USB device type:** USB 2.0 (full-speed)

**Device compatibility:** USB 1.1, USB 2.0

**USB cable type:** A-B cable, UL type AWM 2527 or equivalent (min 24 AWG VBUS/GND, min 28 AWG D+/D-)

**USB cable length:** 3 m (9.84 ft) max

## Environmental

**Operating temperature range:** 0 °C to 50 °C

**Storage temperature range:** -40 °C to 85 °C

**Humidity:** 0% to 90% non-condensing

## Mechanical

**Dimensions (L  $\times$  W  $\times$  H):** 127  $\times$  89.9  $\times$  35.6 mm (5.00  $\times$  3.53  $\times$  1.40 in.)

**User connection length:** 3 m (9.84 ft) max

## Screw Terminal Connector

**Connector type:** Fixed screw terminal

**Wire gauge range:** 16 AWG to 30 AWG

# USB-2408 Series

## Ordering



### Order Information

#### Hardware

Part No.	Description
USB-2408	USB-based 24-bit, isolated, 16 SE/8 DIFF temperature and voltage measurement device with 8 digital I/O, and 2 counter inputs
USB-2408-2AO	USB-based 24-bit, isolated, 16 SE/8 DIFF temperature and voltage measurement device with 8 digital I/O, 2 counter inputs, and 2 analog outputs

#### Accessories

Part No.	Description
745690-E001	E-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 1 m
745690-E002	E-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 2 m
745690-J001	J-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 1 m
745690-J002	J-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 2 m
745690-K001	K-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 1 m
745690-K002	K-type thermocouples wire, fiberglass (0 °C to 482 °C, 32 °F to 900 °F), 2 m
745690-T001	T-type thermocouples wire, fiberglass (0 °C to 260 °C, 32 °F to 500 °F), 1 m
745690-T002	T-type thermocouples wire, fiberglass (0 °C to 260 °C, 32 °F to 500 °F), 2 m

### Software also Available from MCC

Part No.	Description
DAQami	Data acquisition companion software for acquiring data and generating signals
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