USB-2408

24-Bit Multifunction Temperature and Voltage Device

User's Guide

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Table of Contents

About this User's Guide

What you will learn from this user's guide

This user's guide describes the Measurement Computing USB-2408 data acquisition device and lists device specifications.

Conventions in this user's guide

For more information
Text presented in a box signifies additional information and helpful hints related to the subject matter you are reading.

Caution! Shaded caution statements present information to help you avoid injuring yourself and others, damaging your hardware, or losing your data.

bold text — **Bold** text is used for the names of objects on a screen, such as buttons, text boxes, and check boxes.

italic text — *Italic* text is used for the names of manuals and help topic titles, and to emphasize a word or phrase.

Where to find more information

Additional information about USB-2408 hardware is available on our website at www.mccdaq.com. You can also contact Measurement Computing Corporation by phone, fax, or email with specific questions.

- Knowledgebase: kb.mccdaq.com
- Tech support form: www.mccdaq.com/support/support_form.aspx
- Email: techsupport@mccdaq.com
- Phone: 508-946-5100 and follow the instructions for reaching Tech Support

For international customers, contact your local distributor. Refer to the International Distributors section on our website at www.mccdaq.com/International.

Introducing the USB-2408

The USB-2408 is a USB 2.0 high-speed device that provides the following features:

- 16 single-ended (SE) or eight differential (DIFF) analog input channels
  - Up to eight analog inputs can be configured for thermocouples measurements
- Eight digital I/O channels
- Two counter channels (32-bit) that count TTL pulses
- 500 VDC input isolation between field wiring and the USB interface.
- Screw terminals for field wiring connections

The USB-2408 is powered by the +5 volt USB supply from your computer; no external power is required. A USB cable is shipped with the device.

Functional block diagram

USB-2408 functions are illustrated in the block diagram shown here.

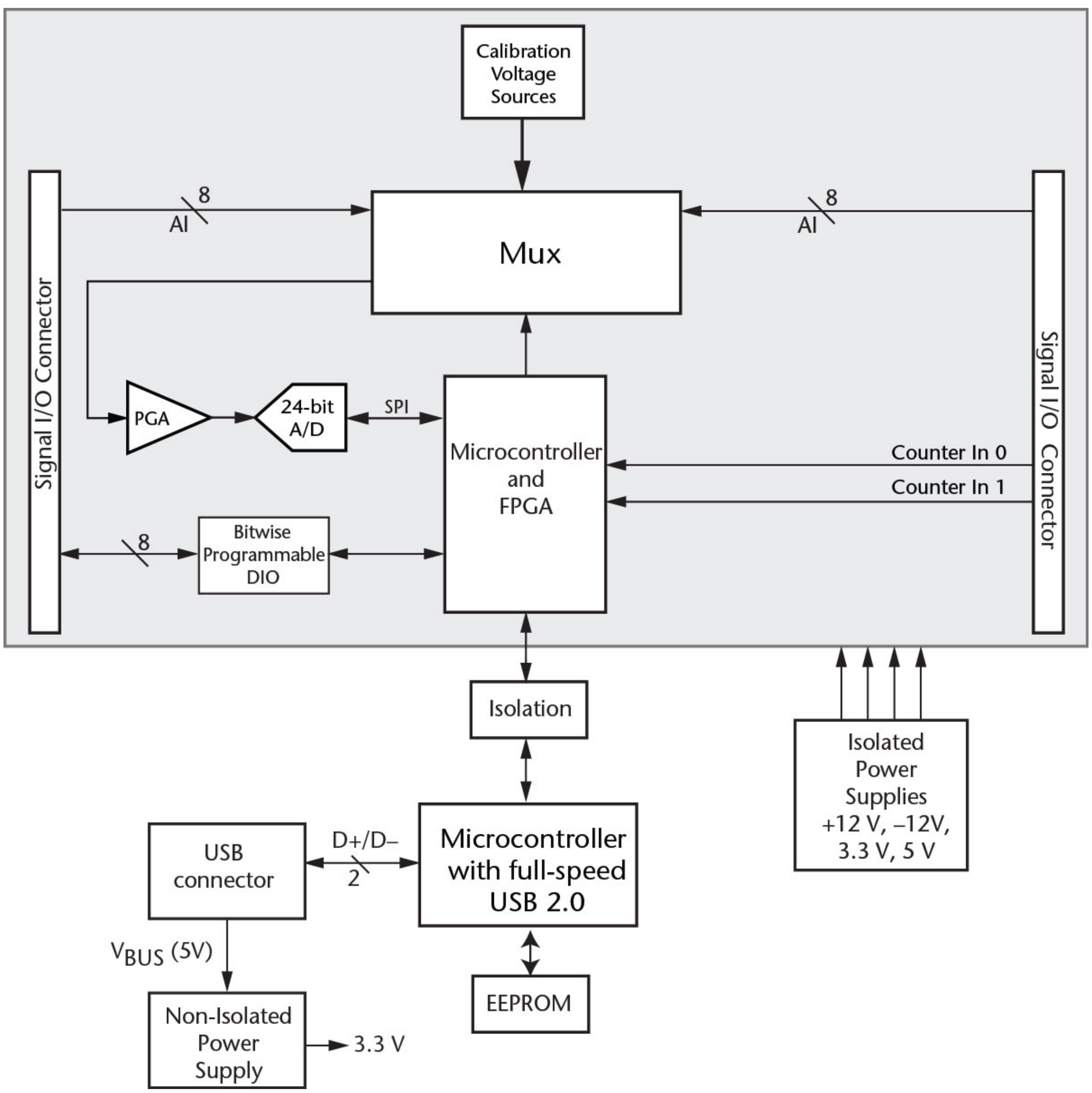


Figure 1. Functional block diagram

Installing the USB-2408

Unpacking

As with any electronic device, you should take care while handling to avoid damage from static electricity. Before removing the device from its packaging, ground yourself using a wrist strap or by simply touching the computer chassis or other grounded object to eliminate any stored static charge.

Contact us immediately if any components are missing or damaged.

Installing the software

Refer to the MCC DAQ Quick Start and the USB-2408 product page on our website for information about the software supported by the USB-2408.

Install the software before the hardware

The driver needed to run the USB-2408 is installed with the software. Therefore, you need to install the software package you plan to use before you install the hardware.

Installing the hardware

To connect a USB-2408 to your system, turn on your computer and connect the USB cable to an available USB port on the computer or to an external USB hub connected to the computer. Connect the other end of the USB cable to the USB connector on the device. No external power is required.

When you connect the device for the first time, a **Found New Hardware** dialog opens when the operating system detects the device. The dialog closes after the device is installed.

A green **Status** LED indicates the device status. When the LED is on, the device is powered and ready for operation. If the LED is not on, the device is not powered or did not initialize.

Figure 2 on page 8 shows the location of the **STATUS** LED.

Caution! Do not disconnect any device from the USB bus while the computer is communicating with the device, or you may lose data and/or your ability to communicate with the device.

If the Status LED turns off

If the **Status** LED turns on but then turns off, the computer has lost communication with the USB-2408. To restore communication, disconnect the USB cable from the computer and then reconnect it. This should restore communication, and the **Status** LED should turn on.

Calibrating

Factory calibration

The Measurement Computing Manufacturing Test department performs the initial factory calibration. Contact Measurement Computing for details about how to return your device and have it calibrated to the factory specifications.

Field calibration

The USB-2408 supports field calibration. You should calibrate the device with InstaCal whenever the ambient temperature changes by more than ±10 °C from the last calibration.

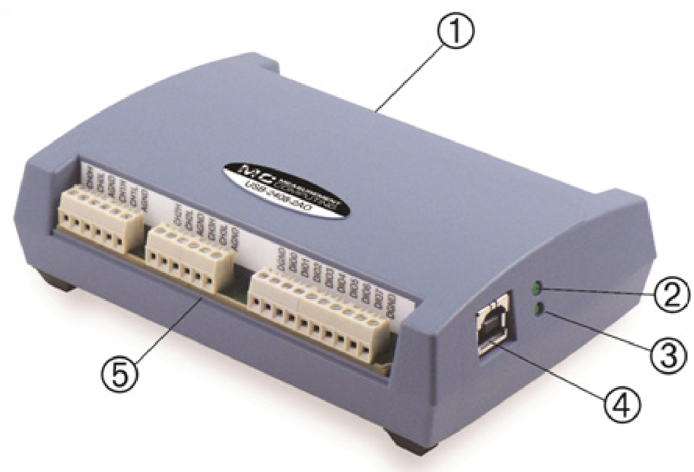
Functional Details

External components

The USB-2408 has the following external components:

- USB connector
- LEDs
- Screw terminals

Figure 2 shows the location of each component.



1	Screw terminal pins 23 to 44	4	USB Connector
2	Status LED	5	Screw terminal pins 1 to 22
3	Activity LED		

Figure 2. USB-2408 external components

USB connector

The USB connector provides 5 V power and communication. No external power supply is required.

LEDs

The USB-2408 has two LEDs – **STATUS** and **ACTIVITY**.

- The **Status** LED is lit when the device is detected and installed on the computer.
- The **Activity** LED indicates the communication status of a device. This LED blinks when data is transferred and is off when the device is not communicating.

Screw terminals

The USB-2408 has two banks of screw terminals that provide the following connections:

- 16 SE (**CH0** to **CH15**) or eight DIFF (**CH0H/CH0L** to **CH7H/CH7L**) analog inputs
- Eight DIO bits (**DI00** to **DI07**)
- Two counter inputs (**CTR0**, **CTR1**)
- One power output (**+5V**)
- Analog ground (**AGND**), digital ground (D**GND**), and chassis ground (**CHAS**)

The single-ended mode pinout is shown in Figure 3, and the differential mode pinout is shown in Figure 4.

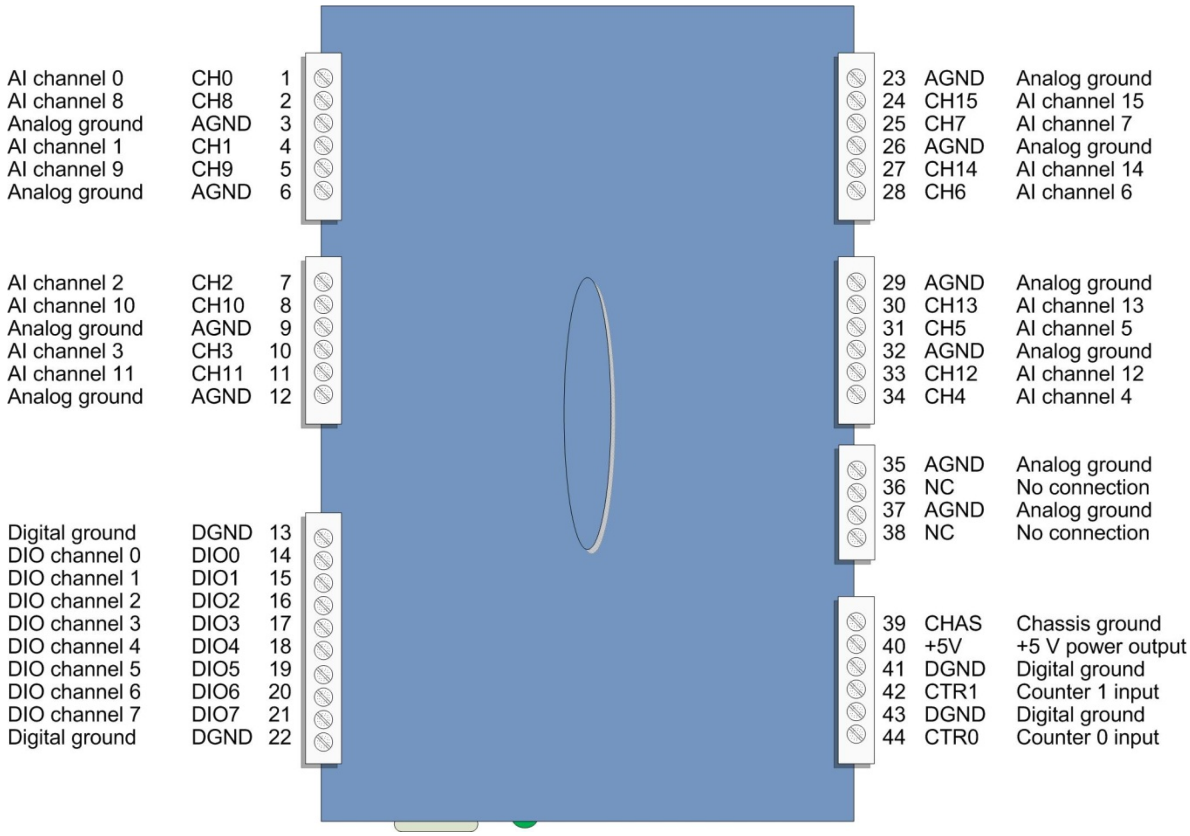


Figure 3. SE mode pinout

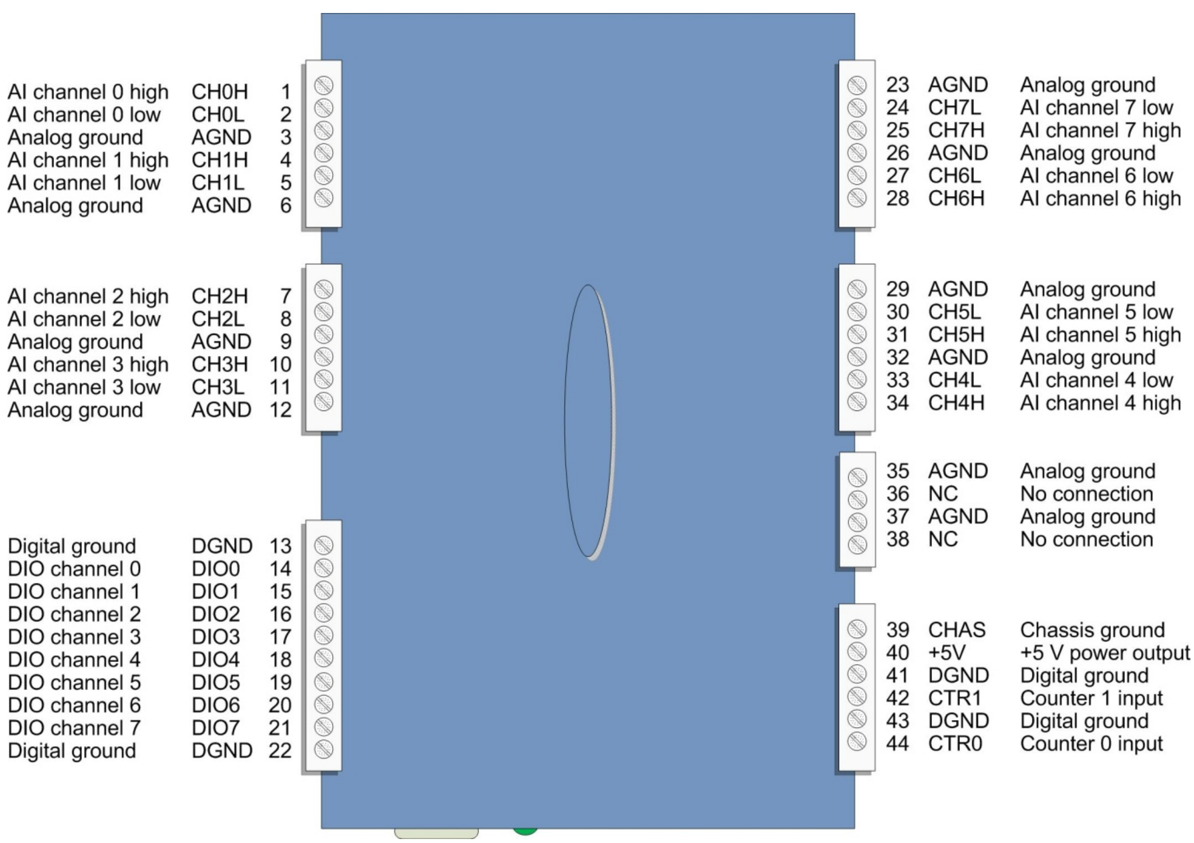


Figure 4. DIFF mode pinout

Input isolation

The USB-2408 is an isolated data acquisition device in which the analog I/O, digital I/O, counters, and all the digital control/timing are referenced to an isolated ground; refer to Figure 5. This ground is physically and electrically separate from the ground used by the circuit connected to the system bus interface.

Isolation provides a barrier between the host computer and potentially hazardous voltages by physically and electrically separating two parts of the measurement device.

- The *non-isolated* ground is common to the chassis ground of the computer, while the *isolated* ground is not.
- All analog measurements are made relative to the isolated ground.

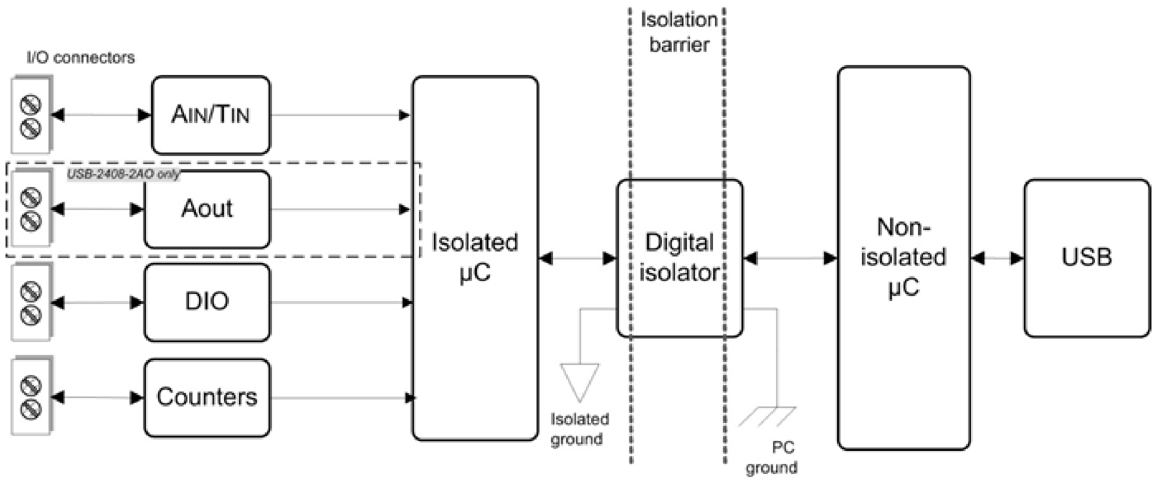


Figure 5. Input isolation diagram

When making measurements in industrial environments, DAQ devices can encounter hazardous voltages, transients, large common mode voltages and fluctuating ground potentials. Any one of these issues can seriously degrade the measurement accuracy of the device and possibly damage the measurement instrument. To overcome these issues, some DAQ devices provide physical and electrical isolation. Some of the benefits of isolation include:

- Safety: A DAQ device employing physical and electrical isolation helps to keep high voltages and transients from damaging the system-side host computer.
- Ground loops: Improper grounding of the signal source that the DAQ device is measuring is one of the most common sources of noise and measurement inaccuracies. Isolation improves the measurement accuracy by physically preventing ground loops. Ground loops – a common source of noise and error – are the results of a measurement system having multiple grounds at different potentials.
- Common mode rejection: With isolation, a DAQ device can measure small signals in the presence of large common mode voltages. Isolation increases the ability of the measurement system to reject common mode voltages. The common mode voltage is the signal that is common to both the positive and negative inputs of the measurement device but is not part of the signal to measure.

Signal connections

Analog/TC input

Each analog input channel has the following measurement parameters:

- Voltage input range
- TC type J, K, T, E, R, S, B, or N

You can select a unique input range or signal type for each channel. For example, one channel could be used for volts and another for temperature.

Analog input mode

You can configure the analog inputs for SE or DIFF mode. The input voltage range is software selectable for ±10 V, ±5 V, ±2.5 V, ±1.25 V, ±0.625 V, ±0.312 V, ±0.156 V, or ±0.078 V.

With SE mode, connect up to 16 inputs to screw terminals **CH0** to **CH15**. SE mode requires two wires:

- Connect one wire to the signal you want to measure (**CHx**).
- Connect one wire to the analog ground reference (**AGND**).

Refer to Figure 3 on page 9 for the location of the SE inputs.

With DIFF mode, connect up to eight differential inputs to screw terminals **CH0H/CH0L** to **CH7H/CH7L**. DIFF mode requires two wires plus a ground reference:

- Connect one wire to the high/positive signal (**CHxH**).
- Connect one wire to the low/negative signal (**CHxL**).
- Connect one wire to the analog ground reference (**AGND**).

Refer to Figure 4 on page 9 for the location of the DIFF inputs.

When connecting DIFF voltage inputs to a "floating" voltage source, make sure there is a DC return path from each voltage input to ground. You make this path by connecting a resistor from each low channel input to an AGND pin. A value of approximately 100 kΩ can be used for most applications. This does not apply to channels configured for TC input, as they have their own internal reference.

Leave unused input channels either floating or tied to an AGND terminal. Source impedances should be kept as small as possible to avoid settling time and accuracy errors.

Figure 6 shows a DIFF voltage connection using a ground path resistor.

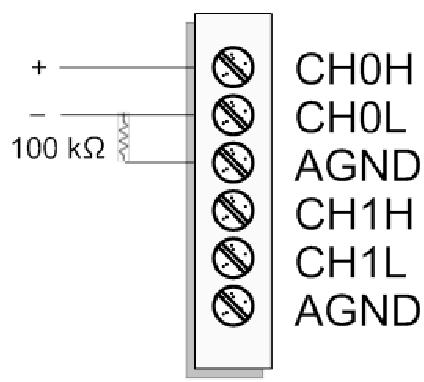


Figure 6. DIFF voltage connection with ground path resistor

Channel-gain queue

The USB-2408 channel-gain queue feature allows you to configure a list of channels, modes, and gains for each scan. The settings are stored in a channel-gain queue list that is written to local memory on the device.

The channel-gain queue list contains one or more channel numbers and range settings. You can configure up to 64 elements. The channels can be listed in any order and can include duplicate channels for sampling at different ranges.

An example of a 12-element list is shown in the table below.

Sample channel-gain queue list

Element	Channel	Range
0	CH0	BIP10V
1	CH1	BIP5V
2	CH0	BIP2Pt5VOLTS
3	CH4	BIP2Pt5VOLTS
4	CH8	BIP2Pt5VOLTS
5	CH0	BIP5V
6	CH1	BIP1Pt25VOLTS
7	CH7	BIP5V
8	CH0	BIP1Pt25VOLTS
9	CH15	BIP10V
10	CH9	BIP1Pt25VOLTS
11	CH10	BIP2Pt5VOLTS

Carefully match the gain to the expected voltage range on the associated channel or an over range condition may occur. Although this condition does not damage the device, it does produce a useless full-scale reading, and can introduce a long recovery time due to saturation of the input channel.

For more information about analog signal connections

For more information about analog input connections, refer to the *Guide to DAQ Signal Connections* on our website at www.mccdaq.com/support/DAQ-Signal-Connections.aspx.

TC input mode

You can make up to eight high-resolution differential thermocouple measurements. Built-in cold-junction compensation (CJC) sensors are provided for each of the screw-terminal blocks, and any supported TC type can be attached to any of the 8 TC channels.

Thermocouple measurements require a differential mode configuration

Do not connect thermocouples as single-ended, as doing so may result in false readings.

You do not need to use ground-referencing resistors for TC inputs because the analog front-end circuit level-shifts the TC output into the common-mode input range of the A/D.

An open thermocouple detection feature can be enabled with software to detect whether an open-circuit condition exists at a TC sensor.

Electrostatic discharge (ESD) protection is provided for each TC input. Follow standard ESD practices and discharge any accumulated ESD charge before handling TC sensors.

Warm up

After connecting a thermocouple sensor and selecting configuration options, allow the USB-2408 to warm up for 45 minutes before taking measurements. This warm up time minimizes thermal drift and achieves the specified rated accuracy of measurements.

Built-in cold junction compensation (CJC) automatically compensates for the additional thermal EMFs generated by connecting the TC leads to the device terminal blocks. CJC is performed using a high-resolution temperature sensor connected close to the device terminal blocks. The device includes two separate CJC sensors – one on each side of the PCB. Software corrects for the additional TCs created at the terminals.

Once A/D and CJC data is collected, application software uses this data to linearize to an accurate temperature reading. The TC linearization uses the latest NIST linearization coefficients for each supported TC type.

When configuring TC sensors, keep any stray capacitance as small as possible relative to AGND; this helps to avoid settling time and accuracy errors. TC channels do not provide a return path to ground as this is done internally.

Figure 7 shows a typical TC connection.

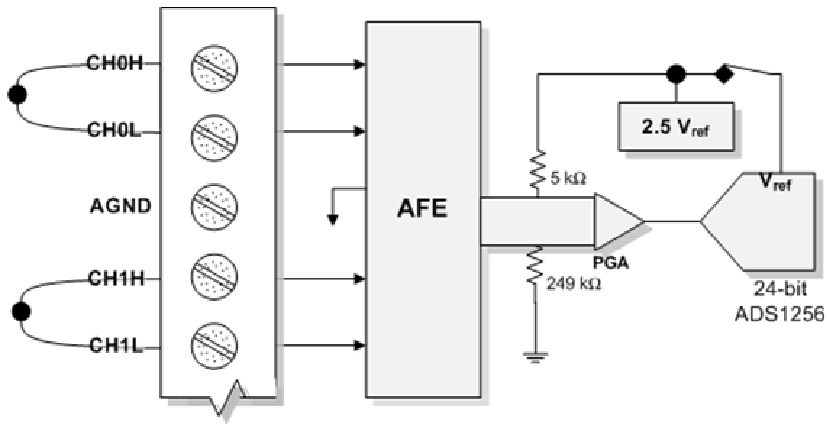


Figure 7. DIFF TC connection example

Noise filtering, data rate and throughput rate

Although the USB-2408 A/D converter has a maximum data rate of 3,750 samples per second, the actual throughput rate you observe for voltage and temperature data is determined by these formulas:

- Maximum single-channel throughput:

$$\frac{1}{\frac{1}{data\ rate} + 640\mu s}$$

- Maximum multiple-channel throughput:

$$\frac{1}{\sum_{n}\left(\frac{1}{data\ rate} + 640\mu s\right)}$$

  where n is the number of channels

Refer to the "Throughput rate" section in the *Specifications* chapter for details.

This drop-off in throughput rate is due to the noise filtering feature in the device. You can control the amount of the noise filtering by adjusting the data rate setting. By reducing the data rate, the averaging of samples increases, and noise drops correspondingly.

Figure 8 illustrates this inverse relationship. This graph applies to the A/D converter only – do not expect this level of performance from the USB-2408.

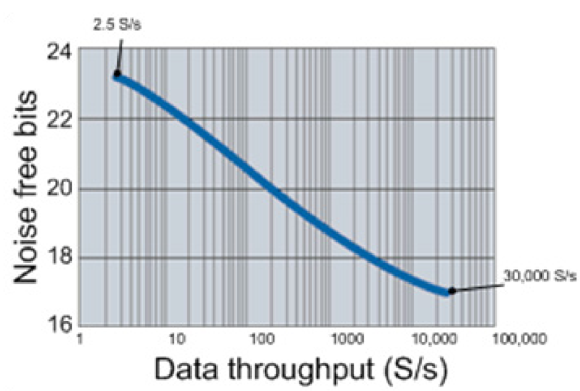


Figure 8.A/D converter data rate vs. noise graph

If low noise is a concern, you can operate the USB-2408 at very low data rates, starting from 2.5 (S/s). At low rates, much of the noise is averaged out of the data, and issues such as reference noise become less important.

At higher data rates, higher-frequency noise sources are not averaged out and begin to be troublesome. These noise sources include the noise inherent in the A/D converter itself, which is not reducible.

Since TCs can pick up noise in your environment, select a data rate based on the primary noise frequency. For example, to reduce the effect of 60 Hz noise, select a data rate of 60 (or a supported submultiple of 60, such as 10 or 5).

Multiple-channel throughput rates

When sampling multiple channels at different sample rates, note that the channels are sampled within the same sample window based on the channel with the lowest sample rate.

For example, if you set a 10 Hz data rate for channel 0, and a 50 Hz data rate for channel 1, basically, both channels pass the same number of samples per second to the host computer. However, more averaging is performed on channel 0 samples; therefore, channel 0 is sampled at a higher resolution.

The USB-2408 A/D converter performs averaging, and the number of averages equals *30,000/data rate.*

Figure 9 shows an example of the relationship between data rate and resolution. In this example, channel 0 is sampled 3,000 times over 100 ms, and all samples are averaged into one sample. Then channel 1 is sampled 600 times over 20 ms, and the samples are averaged into one sample. The final samples are available at a maximum rate of approximately 8 Hz (8.245 Hz).

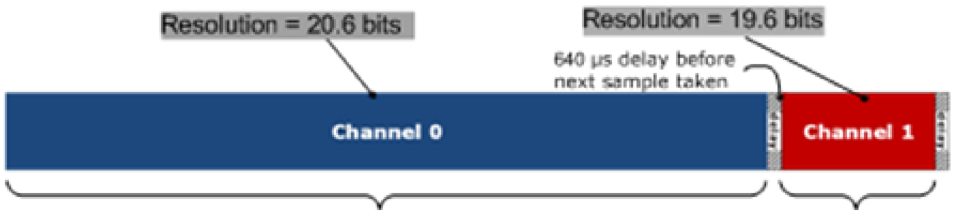


Figure 9. Data rate vs. resolution example

Digital I/O

You can connect up to eight digital I/O lines to **DIO0** through **DIO7**. The digital I/O terminals can detect the state of any TTL-level input.

Digital input voltage ranges of up to 0 to +15 V are permitted, with thresholds of 0.6 V (low) and 2.2 V (high). Each DIO channel is an *open-drain*, which, when used as an output, is capable of sinking up to 150 mA for direct drive applications.

Figure 10 shows a typical DIO connection.

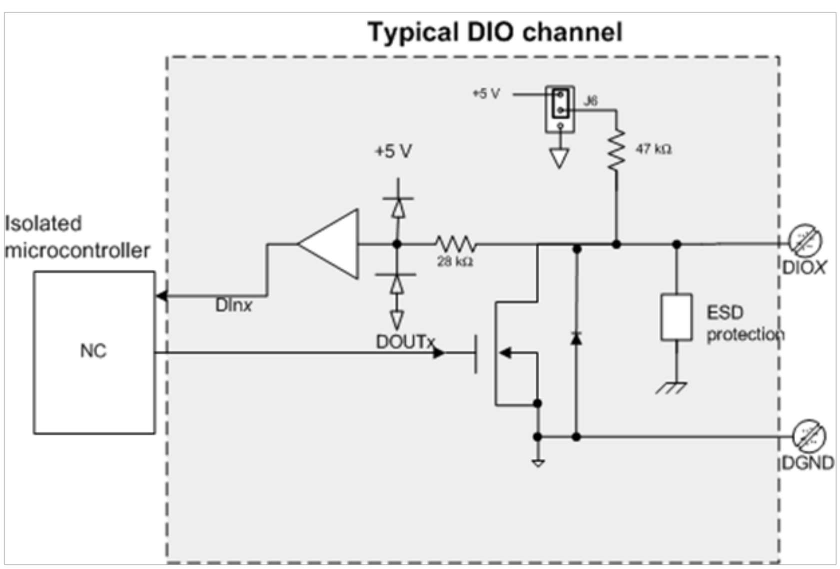


Figure 10. Digital output connection example

The maximum sink current is 150 mA per 8-channel bank, or if all eight channels are used, 18 mA (maximum) per channel.

Internal pull-up/pull-down capability

Unconnected inputs are pulled high by default to 5 V using 47 kΩ resistors through jumper **J6** on the circuit board. The pull-up/pull-down voltage is common to all 47 kΩ resistors. Complete the following steps to configure these inputs.

Caution! The discharge of static electricity can damage some electronic components. Before removing the USB-2408 from its housing, ground yourself using a wrist strap or touch the computer chassis or other grounded object to eliminate any stored static charge.

To open the case and set the J6 jumper, do the following.

1. Turn the device over and rest the top of the housing on a flat, stable surface.
2. Peel off the four rubber feet on the bottom of the device to access the screws.
3. Remove the four screws from the bottom of the device.
4. Hold both the top and bottom sections together, turn the device over and rest it on the surface, then carefully remove the top section of the case to expose the circuit board.
5. Configure jumper **J6** for either pull-up (pins 1-2) or pull-down (pins 2-3). The jumper is configured by default for pull-up. Figure 11 shows the location of the jumper on the board.

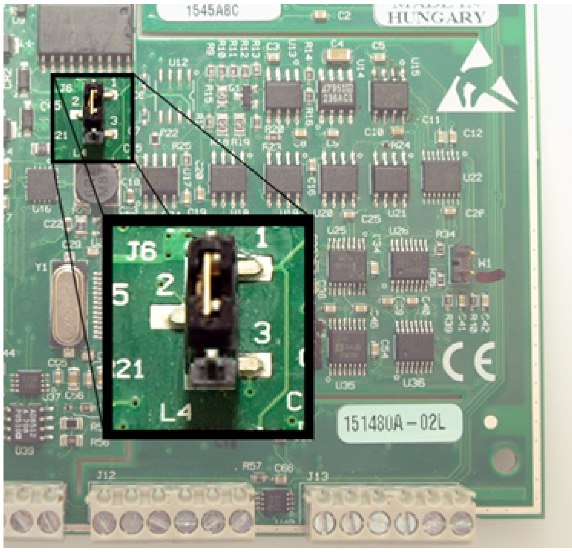


Figure 11. J6 jumper location

Figure 12 shows the jumper configured for pull-up and pull-down.

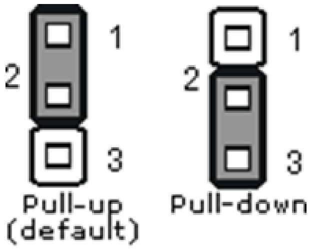


Figure 12. J6 jumper configurations

6. Replace the top section of the case and fasten it to the bottom section with the four screws. Replace the rubber feet.

For more information about digital signal connections

For general information about digital signal connections and digital I/O techniques, refer to the *Guide to DAQ Signal Connections* on our website at www.mccdaq.com/support/DAQ-Signal-Connections.aspx.

The pull-up/pull-down voltage is common to all of the internal 47 kΩ resistors.

External pull-up/pull-down capability

You can place an external pull-up resistor on any of the DIO bits and pull the DIO bit up to a voltage that exceeds the internal +5 V pull-up voltage. A diagram of this scenario is shown in Figure 13.

When using external pull-up resistors, be aware of the following:

- You should either remove the J6 jumper or store it by attaching it to one of the three pins.
- The internal resistors cause a slight voltage impedance shift to digital lines in the "on" state as various lines change between the on/off states.

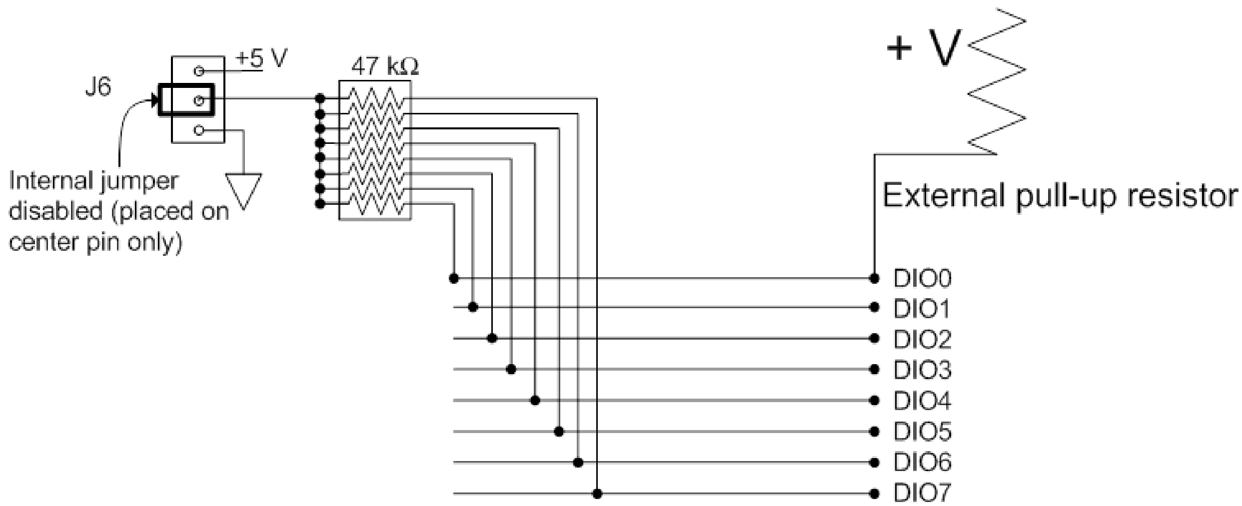


Figure 13. Digital I/O external resistor configuration

Counter input

The **CTR0** and **CTR1** terminals are 32-bit event counters that can accept frequency inputs up to 1 MHz. The internal counter increments when the TTL levels transition from low to high.

Ground

The analog ground (**AGND**) terminals provide a common ground for all analog channels.

The digital ground (**GND**) terminals provide a common ground for the digital and counter channels and the power terminal.

Mechanical drawings

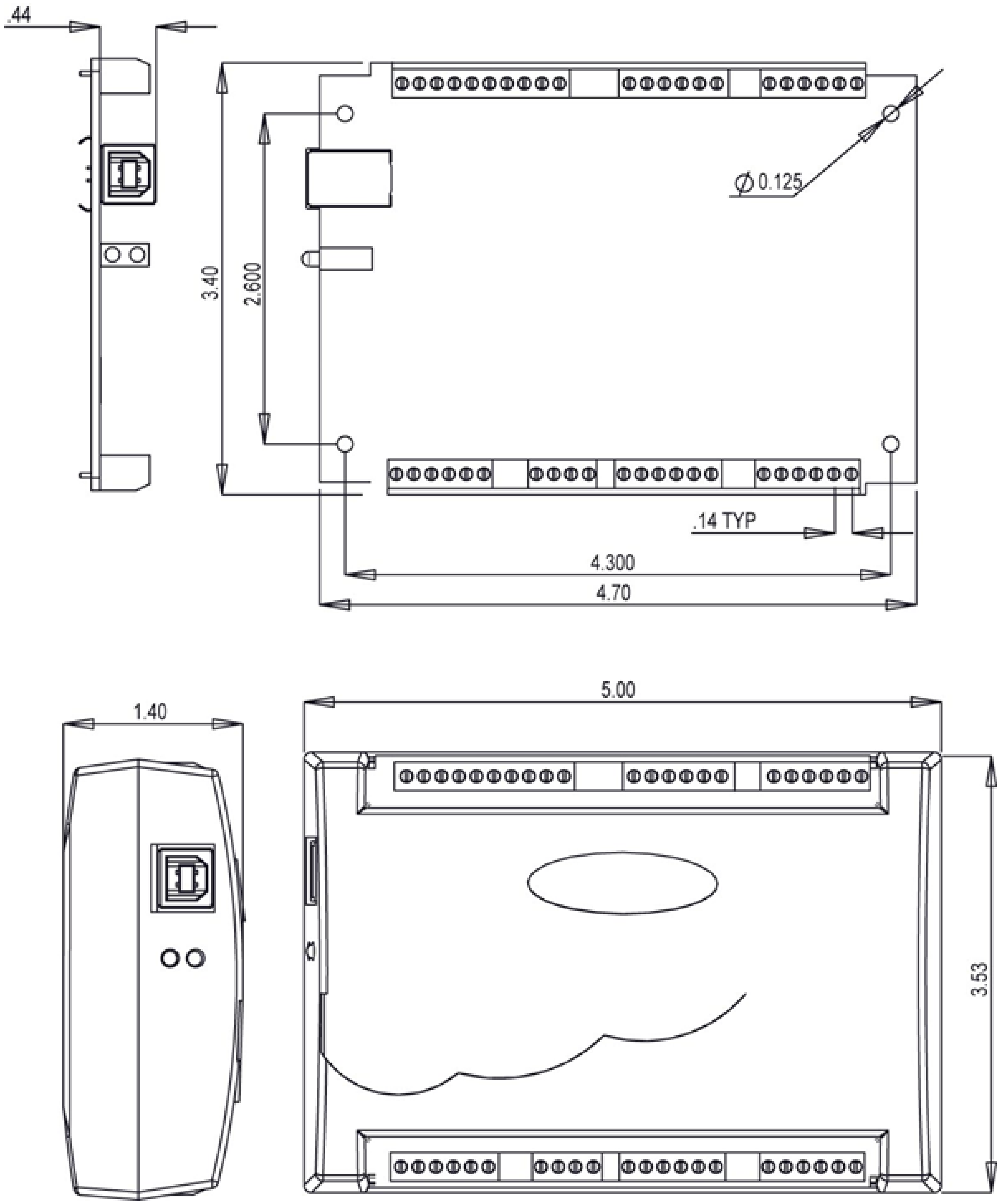


Figure 14. USB-2408 circuit board (top) and enclosure dimensions

Specifications

All specifications are subject to change without notice.
Typical for 25 °C unless otherwise specified.
Specifications apply to all temperature and voltage input channels unless otherwise specified.
Specifications in *italic* text are guaranteed by design.

Analog input

Table 1. General analog input specifications

Parameter	Conditions	Specification
A/D converter type		ADS1256, 24-bit Sigma Delta
A/D data rates		3750 S/s, 2000 S/s, 1000 S/s, 500 S/s, 100 S/s, 60 S/s, 50 S/s, 25 S/s, 10 S/s, 5 S/s, 2.5 S/s
Throughput		■ Single channel: 2.5 S/s to 1102.94 S/s (software-selectable) ■ Multiple channels: 0.16 S/s to 551.47 S/s (software-selectable) See Table 11 and Table 12 for details.
Number of channels		16 single-ended or 8 differential (software-selectable). Thermocouples require differential mode. For each channel configured as differential, you essentially lose two single-ended channels.
Input isolation		*500 VDC min between field wiring and USB interface*
Channel configurations		Temperature sensor input, software-selectable to match sensor type
		Voltage input
Input voltage range	Thermocouple mode	±0.078125 V
	Voltage mode (Note 1)	±10 V, ±5 V, ±2.5 V, ±1.25 V, ±0.625 V, ±0.3125 V, ±0.15625 V, ±0.078125 V (software-selectable)
Absolute maximum input voltage	*CxH-CxL relative to GND*	■ *±22 V max (power on)* ■ *±10 V max (power off)*
Input impedance		■ *10 MΩ (power on)* ■ *390 Ω (power off)*
Input leakage current		*±20 nA*
	Input voltage >±30 V (power on/off)	*±1 µA max*
Input capacitance		590 pf
Maximum working voltage (signal + common mode)	Voltage mode	±10.25 V max
Common mode rejection ratio (Note 1)	*Thermocouple mode, (f_{IN} = 60 Hz)*	*110 dB*
	Voltage mode, (f_{IN} = 60 Hz, all input ranges)	*90 dB*
ADC resolution		24 bits
Crosstalk	Adj chan, DIFF mode	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*	*±0.5 °C typ*

Parameter	Conditions	Specification
	0 °C to 55 °C	*±1.0 °C max*

Note 1: Placing a notch of the A/D digital filter at 60 Hz (setting A/D data rate = 60 S/s, 10 S/s, 5 S/s or 2.5 S/s) further improves the common mode rejection of this frequency.

Channel configurations

When any item is changed, the firmware stores channel configurations in the EEPROM of the isolated microcontroller. An external application issues commands over the USB to make changes, and the configuration is made non-volatile through the use of the EEPROM.

When connecting differential voltage inputs to a floating voltage source, provide a DC return path from each voltage input to ground. To do this, connect a resistor from each input to an AGND pin. A value of approximately 100 kΩ can be used for most applications. Leave unused input channels either floating or tied to AGND. For each voltage/thermocouple channel configured as differential, you essentially lose one single-ended channel.

Keep source impedances as small as possible to avoid settling time and accuracy errors.

Table 2. Channel configurations

Channel	Category	Specification
CxH/CxL	Thermocouple	8 differential channels
CxH/CxL	Voltage	16 individually-configurable channels that can be configured as either single-ended or 8 differential.
CxH/CxL	Voltage	

Thermocouple sensors

Table 3. Compatible thermocouple sensor specifications

Parameter	Specification
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

Accuracy

Thermocouple measurement accuracy

Thermocouple measurement accuracy specifications include polynomial linearization error, cold-junction compensation measurement error, and are for sample rates up to 60S/s. These specs are for one year, or 3000 operating hours, whichever comes first.

There is a CJC sensor for each terminal block of the module. The accuracy listed below assumes the screw terminals are at the same temperature as the CJC sensor.

The accuracy errors shown do not include the inherent accuracy error of the thermocouple sensor itself. Contact your thermocouple supplier for details on the actual thermocouple sensor accuracy limitations.

Connect thermocouples to the USB-2408 such that they are floating with respect to AGND. To avoid settling time and accuracy errors, keep any stray capacitance relative to AGND as small as possible.

The AGND and DGND pins are isolated from earth ground. You can connect thermocouple sensors to voltages referenced to earth ground as long as isolation between the AGND/DGND pins and earth ground is maintained.

Table 4. Thermocouple accuracy specifications, including CJC measurement error. All specifications are (±).

Thermocouple	Sensor temperature range	Accuracy error, maximum	Accuracy error, typical	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 °Co	.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	

To achieve the thermocouple accuracies listed above, warm up the device for 45 minutes after the initial power on. The accuracies listed above are only guaranteed if the device is housed in the plastic enclosure.

Analog input DC voltage measurement accuracy

Table 5. DC accuracy components and specifications. All values are (±)

Range	Gain error (% of reading)	Offset error (µV)	INL error (% of range)	Absolute accuracy (µV)	Gain temperature coefficient (% reading/°C)	Offset temperature coefficient (µV/°C)
±10 V	0.0037	50	0.0008	500	0.0006	3
±5 V	0.0047	25	0.0008	300	0.0006	2
±2.5 V	0.0059	20	0.0008	200	0.0006	1
±1.25 V	0.0056	20	0.0008	100	0.0006	1
±0.625 V	0.0068	15	0.0005	60	0.0006	1
±0.3125 V	0.0104	15	0.0006	50	0.0006	1
±0.15625 V	0.0184	10	0.0005	40	0.0006	1
±0.078125 V	0.0384	10	0.0009	40	0.0006	1

Input bandwidth

Table 6. Input bandwidth specifications

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

Noise performance

For the peak-to-peak noise distribution test, a differential input channel is connected to AGND at the input terminal block, and 50,000 samples are acquired at the maximum rate available at each setting.

Table 7. Peak-to-peak noise performance specifications (µV)

	A/D data rate (S/s)										
Range (V)	3750	2000	1000	500	100	60	50	25	10	5	2.5
±10	126.84	100.14	71.76	45.06	30.52	30.52	26.70	19.07	11.92	9.54	9.54
±5	56.74	47.56	34.21	25.87	16.21	14.31	14.31	14.30	5.96	4.77	4.77
±2.5	32.96	28.79	17.94	14.19	7.51	7.09	7.09	5.72	3.81	4.00	4.00
±1.25	18.57	17.52	13.83	9.30	5.48	5.48	5.01	3.81	3.34	3.34	2.86
±0.625	18.88	16.58	8.45	7.41	5.32	4.80	4.38	3.86	2.50	2.61	1.98
±0.3125	15.33	14.76	8.19	6.94	4.75	4.69	4.49	3.70	3.34	2.56	2.45
±0.15625	13.28	16.84	7.47	6.61	5.70	4.48	4.48	4.24	2.66	3.07	2.29
±0.078125	13.47	15.02	9.17	6.88	4.28	4.16	4.00	3.57	2.28	2.13	2.40

Table 8. RMS noise performance specifications (µVRMS)

	A/D data rate (S/s)										
Range (V)	3750	2000	1000	500	100	60	50	25	10	5	2.5
±10	19.22	15.17	10.87	6.83	4.62	4.62	4.05	2.89	1.81	1.44	1.44
±5	8.60	7.21	5.18	3.92	2.46	2.17	2.17	2.16	0.90	0.72	0.72
±2.5	4.99	4.36	2.72	2.15	1.14	1.07	1.07	0.87	0.58	0.60	0.60
±1.25	2.81	2.66	2.10	1.41	0.83	0.83	0.76	0.58	0.51	0.51	0.43
±0.625	2.86	2.51	1.28	1.12	0.81	0.73	0.66	0.58	0.38	0.40	0.30
±0.3125	2.32	2.24	1.24	1.05	0.72	0.71	0.68	0.56	0.51	0.39	0.37
±0.15625	2.01	2.55	1.13	1.00	0.86	0.68	0.68	0.64	0.40	0.47	0.35
±0.078125	2.04	2.28	1.39	1.04	0.65	0.63	0.60	0.54	0.35	0.32	0.36

Table 9. Noise-free resolution specifications (bits)

	A/D data rate (S/s)										
Range (V)	**3750**	**2000**	**1000**	**500**	**100**	**60**	**50**	**25**	**10**	**5**	**2.5**
±10	17.2	17.6	18.1	18.7	19.3	19.3	19.5	20.0	20.6	21.0	21.0
±5	17.4	17.6	18.1	18.5	19.2	19.4	19.4	19.4	20.6	21.0	21.0
±2.5	17.2	17.4	18.1	18.4	19.3	19.4	19.4	19.7	20.3	20.7	21.0
±1.25	17.0	17.1	17.4	18.0	18.8	18.8	18.9	19.3	19.5	19.5	19.7
±0.625	16.0	16.2	17.1	17.3	17.8	18.0	18.1	18.3	18.9	18.8	19.2
±0.3125	15.3	15.3	16.2	16.4	17.0	17.0	17.0	17.3	17.5	17.9	17.9
±0.15625	14.5	14.1	15.3	15.5	15.7	16.1	16.1	16.1	16.8	16.9	17.1
±0.078125	14.5	14.3	15.0	15.4	16.1	16.2	16.2	16.4	17.0	17.1	16.9

Channel switching error

Table 10. Step response accuracy specifications

	Accuracy										
Range (V)	**3750 S/s**	**2000 S/s**	**1000 S/s**	**500 S/s**	**100 S/s**	**60 S/s**	**50 S/s**	**25 S/s**	**10 S/s**	**5 S/s**	**2.5 S/s**
±10	0.0010%	0.0008%	0.0005%	0.0004%	0.0002%	0.0002%	0.0003%	0.0002%	0.0001%	0.0001%	0.0001%
±5	0.0009%	0.0008%	0.0004%	0.0004%	0.0003%	0.0002%	0.0002%	0.0002%	0.0001%	0.0001%	0.0001%
±2.5	0.0010%	0.0007%	0.0008%	0.0004%	0.0003%	0.0002%	0.0002%	0.0002%	0.0002%	0.0001%	0.0001%
±1.25	0.0013%	0.0009%	0.0008%	0.0007%	0.0004%	0.0004%	0.0003%	0.0003%	0.0003%	0.0003%	0.0003%
±0.625	0.0022%	0.0016%	0.0011%	0.0011%	0.0007%	0.0007%	0.0005%	0.0005%	0.0004%	0.0005%	0.0003%
±0.3125	0.0031%	0.0031%	0.0020%	0.0017%	0.0015%	0.0012%	0.0010%	0.0010%	0.0012%	0.0009%	0.0009%
±0.15625	0.0056%	0.0062%	0.0048%	0.0037%	0.0032%	0.0025%	0.0024%	0.0021%	0.0019%	0.0022%	0.0016%
±0.078125	0.0114%	0.0123%	0.0076%	0.0070%	0.0041%	0.0051%	0.0046%	0.0036%	0.0032%	0.0030%	0.0034%

Channel switching error is defined as the accuracy that can be expected after one conversion when switching from a channel with a DC input at one extreme of full scale to another channel with a DC input at the other extreme of full scale, expressed in terms of percentage of full scale value.

Throughput rate

The single channel throughput rate is calculated using this formula:

$$Maximum\ throughput = \frac{1}{\frac{1}{data\ rate} + 640\mu s}$$

Table 11. Single channel throughput rate specifications

A/D data rate (S/s)	Maximum throughput (Hz)
3750	1102.94
2000	877.19
1000	609.76
500	378.79
100	93.98
60	57.78
50	48.45
25	24.61
10	9.94
5	4.98
2.5	2.50

The multiple-channel throughput rate is calculated using this formula:

$$\textit{Maximum throughput} = \frac{1}{\sum_n \left(\frac{1}{data\ rate} + 640\mu s\right)}$$, where n is the number of channels

Table 12. Multiple-channel throughput rate specifications (Hz)

Number of input channels	3750 S/s	2000 S/s	1000 S/s	500 S/s	100 S/s	60 S/s	50 S/s	25 S/s	10 S/s	5 S/s	2.5 S/s
1	1102.94	877.19	609.76	378.79	93.98	57.78	48.45	24.61	9.94	4.98	2.50
2	551.47	438.60	304.88	189.39	46.99	28.89	24.22	12.30	4.97	2.49	1.25
3	367.65	292.40	203.25	126.26	31.33	19.26	16.15	8.20	3.31	1.66	0.83
4	275.74	219.30	152.44	94.70	23.50	14.45	12.11	6.15	2.48	1.25	0.62
5	220.59	175.44	121.95	75.76	18.80	11.56	9.69	4.92	1.99	1.00	0.50
6	183.82	146.20	101.63	63.13	15.66	9.63	8.07	4.10	1.66	0.83	0.42
7	157.56	125.31	87.11	54.11	13.43	8.25	6.92	3.52	1.42	0.71	0.36
8	137.87	109.65	76.22	47.35	11.75	7.22	6.06	3.08	1.24	0.62	0.31
9	122.55	97.47	67.75	42.09	10.44	6.42	5.38	2.73	1.10	0.55	0.28
10	110.29	87.72	60.98	37.88	9.40	5.78	4.84	2.46	0.99	0.50	0.25
11	100.27	79.74	55.43	34.44	8.54	5.25	4.40	2.24	0.90	0.45	0.23
12	91.91	73.10	50.81	31.57	7.83	4.82	4.04	2.05	0.83	0.42	0.21
13	84.84	67.48	46.90	29.14	7.23	4.44	3.73	1.89	0.76	0.38	0.19
14	78.78	62.66	43.55	27.06	6.71	4.13	3.46	1.76	0.71	0.36	0.18
15	73.53	58.48	40.65	25.25	6.27	3.85	3.23	1.64	0.66	0.33	0.17
16	68.93	54.82	38.11	23.67	5.87	3.61	3.03	1.54	0.62	0.31	0.16

Analog input calibration

Table 13. Analog input/output calibration specifications

Parameter	Specifications
Recommended warm-up time	45 minutes min
Calibration	Firmware calibration
Calibration interval	1 year
AI calibration reference	+10.000 V, ±5 mV max. Actual measured values stored in EEPROM
	Tempco: 5 ppm/°C max
	Long term stability: 30 ppm/1000 hours

Digital input/output

Table 14. Digital I/O specifications

Parameter	Specifications
Number of I/O	8 channels
Configuration	Each DIO bit can be independently read from (DIN) or written to (DOUT). The 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 kΩ pull-up/pull-down resistor, 28 kΩ series resistor
Maximum input voltage range	*0 V to +20 V max (power on/off, relative to DGND)* (Note 2)
Pull-up/pull-down configuration	All pins pulled up to +5 V via individual 47 kΩ resistors (the J6 shorting block default position is pins 1 and 2). Pull down capability is available by placing the 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 min, 2.2 V max
Input low voltage	1.5 V max, 0.6 V min
Schmitt trigger hysteresis	0.4 V min, 1.2 V max

Note 2: DGND pins are recommended for use with digital input and digital output pins. The DGND and AGND pins are common and are isolated from earth ground.

Table 15. Digital output specifications

Parameter	Specifications
Number of I/O	8 channels
Configuration (Note3)	Each DIO bit can be independently read from (DIN) or written to (DOUT). The DIN bits may be read at any time whether the DOUT is active or tri-stated
Output characteristics (Note 4)	47 kΩ pull-up, open drain (DMOS transistor)
Pull-up configuration	All pins pulled up to +5 V via individual 47 kΩ 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 kΩ pull-up resistors connected to +5 V by default) 0 V to +15 V max (Note 5)
Drain to source breakdown voltage	+50 V min
Off state leakage current (Note 6)	1.0 µA
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 Ω

Note 3: DGND pins are recommended for use with digital input and digital output pins. The DGND and AGND pins are common and are isolated from earth ground.

Note 4: Each DMOS transistor source pin is internally connected to DGND.

Note 5: The external pull-up is connected to the digital output bit through an external pull-up resistor. Adding an external pull-up resistor connects it in parallel with the internal 47 kΩ pull-up resistor of that particular digital input/output bit. Careful consideration should be made when considering the external pull-up resistor value and the resultant pull-up voltage produced at the load.

Note 6: Does not include the additional leakage current contribution that may occur when using an external pull-up resistor.

Counter

Table 16. Counter specifications

Parameter	Conditions	Specification
Pin name		CTR0, CTR1
Number of channels		2 channels
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	562 kΩ pull-up resistor to +5 V, 10 kΩ series resistor
Input voltage range		±15 V max
Max input voltage range	*CTR0,CTR1 relative to AGND and DGND (Note 7)*	*±20 V max (power on/off)*
Input high voltage		1.3 V min, 2.2 V max
Input low voltage		1.5 V max, 0.6 V min
Schmitt trigger hysteresis		0.4 V min, 1.2 V max
Input bandwidth (–3 dB)		1 MHz
Input capacitance		*25 pf*
Input leakage current		*±120 nA@5 V, ±1.6 mA@±15 V*
Input frequency		1 MHz, max
High pulse width		*500 ns, min*
Low pulse width		*500 ns, min*

Note 7: DGND pins are recommended for use with counter input pins. The DGND and AGND are common and are isolated from earth ground.

Memory

Table 17. Memory specifications

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

Microcontroller

Table 18. Microcontroller specifications

Type	One high-performance 8-bit RISC microcontroller with USB interface (non-isolated) One high-performance 16-bit RISC microcontroller for measurements (isolated)

Power

Table 19. Power specifications

Parameter	**Conditions**	**Specification**
Supply current (Note 8)	Quiescent current	275 mA
Voltage supervisor limits	4.5 V > V_{ext} or V_{ext} > 5.5 V	PWR LED = Off; (power fault)
	4.5 V < V_{ext} < 5.5 V	PWR LED = On
+5 V user output voltage range	Available at terminal block pin 40	4.75 V min to 5.25 V max
+5 V user output current	Available at terminal block pin 40	10 mA max
Isolation	Measurement system to PC	500 VDC min

Note 8: This is the total quiescent current requirement for the USB-2408 which includes up to 10 mA for the status LED. This does not include any potential loading of the digital I/O bits or the +5V terminal.

USB specifications

Table 20. USB specifications

Parameter	**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 2725 or equivalent. (Min 24 AWG VBUS/GND, min 28 AWG D+/D–)*
USB cable length	3 meters (9.8 ft) max

Environmental

Table 21. Environmental specifications

Parameter	**Specifications**
Operating temperature range	0 °C to 50 °C max
Storage temperature range	–40 °C to 85 °C max
Humidity	0 to 90% non-condensing max

Mechanical

Table 22. Mechanical specifications

Parameter	**Specifications**
Dimensions (L x W x H)	127 □ 89.9 □ 35.6 mm (5.00 x 3.53 x 1.40 in.)

Screw terminal connector

Table 23. Screw terminal connector specifications

Connector type	Fixed screw terminal
Wire gauge range	16 AWG to 30 AWG

Differential mode pinout

Table 24. 8-channel differential mode pinout

Pin	Signal name	Pin description	Pin	Signal name	Pin description
1	CH0H	AI channel 0 HI	23	AGND	Analog ground
2	CH0L	AI channel 0 LO	24	CH7L	AI channel 7 LO
3	AGND	Analog ground	25	CH7H	AI channel 7 HI
4	CH1H	AI channel 1 HI	26	AGND	Analog ground
5	CH1L	AI channel 1 LO	27	CH6L	AI channel 6 LO
6	AGND	Analog ground	28	CH6H	AI channel 6 HI
7	CH2H	AI channel 2 HI	29	AGND	Analog ground
8	CH2L	AI channel 2 LO	30	CH5L	AI channel 5 LO
9	AGND	Analog ground	31	CH5H	AI channel 5 HI
10	CH3H	AI channel 3 HI	32	AGND	Analog ground
11	CH3L	AI channel 3 LO	33	CH4L	AI channel 4 LO
12	AGND	Analog ground	34	CH4H	AI channel 4 HI
13	DGND	Digital ground	35	AGND	Analog ground
14	DIO0	DIO channel 0	36	NC	No connection
15	DIO1	DIO channel 1	37	AGND	Analog ground
16	DIO2	DIO channel 2	38	NC	No connection
17	DIO3	DIO channel 3	39	CHAS	Chassis ground
18	DIO4	DIO channel 4	40	+5V	+5 V power output
19	DIO5	DIO channel 5	41	DGND	Digital ground
20	DIO6	DIO channel 6	42	CTR1	Counter 1 input
21	DIO7	DIO channel 7	43	DGND	Digital ground
22	DGND	Digital ground	44	CTR0	Counter 0 input

Single-ended mode pinout

Table 25. 16-channel single-ended mode pinout

Pin	Signal name	Pin description	Pin	Signal name	Pin description
1	CH0	AI channel 0	23	AGND	Analog ground
2	CH8	AI channel 8	24	CH15	AI channel 15
3	AGND	Analog ground	25	CH7	AI channel 7
4	CH1	AI channel 1	26	AGND	Analog ground
5	CH9	AI channel 9	27	CH14	AI channel 14
6	AGND	Analog ground	28	CH6	AI channel 6
7	CH2	AI channel 2	29	AGND	Analog ground
8	CH10	AI channel 10	30	CH13	AI channel 13
9	AGND	Analog ground	31	CH5	AI channel 5
10	CH3	AI channel 3	32	AGND	Analog ground
11	CH11	AI channel 11	33	CH12	AI channel 12
12	AGND	Analog ground	34	CH4	AI channel 4
13	DGND	Digital ground	35	AGND	Analog ground
14	DIO0	DIO channel 0	36	NC	No connection
15	DIO1	DIO channel 1	37	AGND	Analog ground
16	DIO2	DIO channel 2	38	NC	No connection
17	DIO3	DIO channel 3	39	CHAS	Chassis ground
18	DIO4	DIO channel 4	40	+5V	+5 V power output
19	DIO5	DIO channel 5	41	DGND	Digital ground
20	DIO6	DIO channel 6	42	CTR1	Counter 1 input
21	DIO7	DIO channel 7	43	DGND	Digital ground
22	DGND	Digital ground	44	CTR0	Counter 0 input

CE EU Declaration of Conformity

According to ISO/IEC 17050-1:2010

Manufacturer:	Measurement Computing Corporation
Address:	10 Commerce Way
	Norton, MA 02766
	USA
Product Category:	Electrical equipment for measurement, control and laboratory use.
Date and Place of Issue:	July 21, 2016, Norton, Massachusetts USA
Test Report Number:	EMI5775.10

Measurement Computing Corporation declares under sole responsibility that the product

USB-2408

is in conformity with the relevant Union Harmonization Legislation and complies with the essential requirements of the following applicable European Directives:

Electromagnetic Compatibility (EMC) Directive 2014/30/EU

Low Voltage Directive 2014/35/EU

RoHS Directive 2011/65/EU

Conformity is assessed in accordance to the following standards:

EMC:

Emissions:

- EN 61326-1:2013 (IEC 61326-1:2012), Class A
- EN 55011: 2009 + A1:2010 (IEC CISPR 11:2009 + A1:2010), Group 1, Class A

Immunity:

- EN 61326-1:2013 (IEC 61326-1:2012), Controlled EM Environments
- EN 61000-4-2:2008 (IEC 61000-4-2:2008)
- EN 61000-4-3 :2010 (IEC61000-4-3:2010)

Safety:

- EN 61010-1:2010 (IEC 61010-1:2010)

Environmental Affairs:

Articles manufactured on or after the Date of Issue of this Declaration of Conformity do not contain any of the restricted substances in concentrations/applications not permitted by the RoHS Directive.

Carl Haapaoja, Director of Quality Assurance

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