USB-5201

Thermocouple Measurement and Data Logger

User's Guide

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MEASUREMENT COMPUTING™

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About this Manual

This document describes the Measurement Computing USB-5201 data acquisition device and lists device specifications.

Conventions

For more information
Text presented in a box signifies additional information related to the subject matter.

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-5201 hardware is available on our website at www.mccdaq.com. You can also contact Measurement Computing Corporation 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
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For international customers, contact your local distributor. Refer to the International Distributors section on our website at www.mccdaq.com/International.

Introducing the USB-5201

The USB-5201 provides eight differential thermocouple input channels and two integrated cold junction compensation (CJC) sensors. You can take measurements from type J, K, R, S, T, N, E, and B thermocouples. An open thermocouple detection feature lets you detect a broken thermocouple. An on-board microprocessor automatically linearizes the measurement data.

Eight independent, TTL-compatible digital I/O channels are provided to monitor TTL-level inputs, communicate with external devices, and to generate alarms. The digital I/O channels are software programmable for input or output.

The USB-5201 features eight independent temperature alarms. Each alarm controls an associated digital I/O channel as an alarm output. The input to each alarm is one of the temperature input channels. The output of each alarm is software configurable as active high or low. You set up the temperature threshold conditions to activate each alarm. When an alarm is activated, the associated DIO channel is driven to the output state.

You can log your measurements to a CompactFlash® memory card. CompactFlash is a removable non-volatile storage device. A 512 MB CompactFlash memory card is shipped with the device to store your data. For more information, refer to the section *Logging data with the USB-5201* below.

The USB-5201 device is compatible with both USB 1.1 and USB 2.0 ports. The speed of the device may be limited when using a USB 1.1 port due to the difference in transfer rates on the USB 1.1 versions of the protocol (low-speed and full-speed).

External power is required for data logging operations

Due to processing limitations, you cannot log data to the memory card when the USB-5201 is connected to your computer's active USB bus. When operating as a data logger, disconnect the USB cable from the computer, and connect the external power supply shipped with the device.

The USB-5201 is a standalone plug-and-play device. External power is required for data logging mode only. All configurable options are software-programmable. The USB-5201 is fully software-calibrated.

Logging data with the USB-5201

The USB-5201 has many software-selectable options for setting up data logging.

You can record:

- temperature (° C) or raw data from selected input channels
- timestamp data
- CJC sensor readings

You can specify the number of seconds between samples. You can begin logging data at power up, when you press the data logging button, or at a specific date and time.

Data is stored on the memory card in binary files. After logging measurements, you can transfer the files to your computer. You can use InstaCal to convert the files to .csv format for use in Microsoft Excel files, or to .txt format for use in other applications.

Functional block diagram

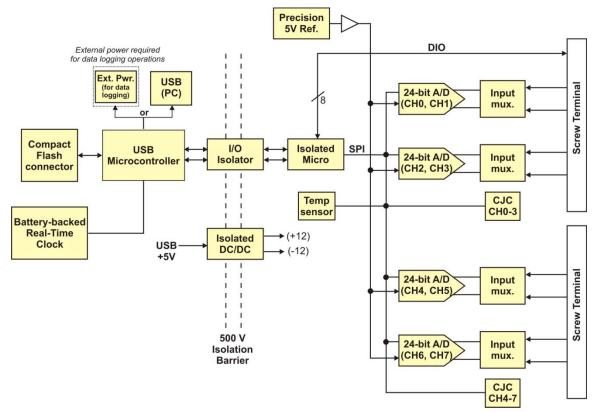USB-5201 functions are illustrated in the block diagram shown here.

Figure 1. Functional block diagram

Installing the USB-5201

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 for instructions on installing the software on the MCC DAQ CD. Refer to the device product page on the Measurement Computing website for information about the included and optional software supported by the USB-5201.

> **Install the software before you install your device**
> The driver needed to run the USB-5201 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 the USB-5201 to your system, turn your computer on, and connect the USB cable to a USB port on your computer or to an external USB hub that is connected to your computer. The USB cable provides power and communication to the USB-5201.

If you are connecting the USB-5201 to an external self-powered hub, connect the USB hub to the computer *before* you connect the device to the hub. This ensures that the device detects the hub as an active USB port.

Firmware revision 2.12 and earlier

When you connect the USB-5201 for the first time, a **Found New Hardware** dialog opens when the operating system detects the device. When this balloon or dialog closes, the installation is complete. The device LED should blink and then remain on; this indicates that communication is established between the device and the computer.

Firmware revision 3.0 and later

The USB-5201 installs as a composite device with separate devices attached. When you connect the device for the first time, a **Found New Hardware** dialog opens as each device interface is detected. This is normal. For additional information, refer to the "Notes on installing and using the USB-5201 and 18200-80 data logging devices" that shipped with the USB-5201.

After the device is installed its LED will blink and then remain on. This indicates that communication is established between the device and the computer.

Configuring the hardware

All hardware configuration options on the USB-5201 are software-selectable. Settings are stored on an isolated microcontroller in EEPROM – which is non-volatile memory on the USB-5201 – and are loaded on power-up. The factory default configuration is *Type J* thermocouple.

Allow the USB-5201 to warm up for 30 minutes before taking measurements. This warm up time minimizes thermal drift and achieves the specified rated accuracy of measurements.

Configuring data logging options

The following data logging options are programmable with software.

- select the input channels to log
- set the data format
- set the start mode
- set up alarm conditions
- copy and convert saved binary files
- delete data files

All data logging options are stored on the USB-5201 in non-volatile memory in EEPROM, and are loaded on power up.

Calibrating the hardware

Factory calibration

The Measurement Computing Manufacturing Test department performs the initial factory calibration. Return the device to Measurement Computing Corporation when calibration is required. The recommended calibration interval is one year.

Field-calibration

The USB-5201 supports field-calibration with InstaCal. Calibrate the device whenever the ambient temperature changes by more than ±10 °C from the last self-calibration.

Allow the USB-5201 to operate for at least 30 minutes before calibrating.

Sensor Connections

The USB-5201 supports type types J, K, R, S, T, N, E, and B thermocouples.

Thermocouple selection

The thermocouple type you select depends on your application needs. Review the temperature ranges and accuracies of each type to determine which is best suited for your application.

Screw terminal pinout

The USB-5201 has four rows of screw terminals – two rows on the top edge of the housing, and two rows on the bottom edge. Each row has 26 connections. Between each bank of screw terminals are two integrated CJC sensors used for thermocouple measurements. Signals are identified in Figure 2.

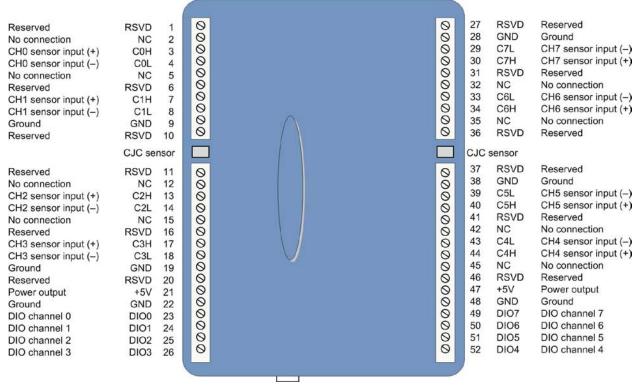| Description	Label	Pin		Pin	Label	Description
Reserved	RSVD	1		27	RSVD	Reserved
No connection	NC	2		28	GND	Ground
CH0 sensor input (+)	C0H	3		29	C7L	CH7 sensor input (−)
CH0 sensor input (−)	C0L	4		30	C7H	CH7 sensor input (+)
No connection	NC	5		31	RSVD	Reserved
Reserved	RSVD	6		32	NC	No connection
CH1 sensor input (+)	C1H	7		33	C6L	CH6 sensor input (−)
CH1 sensor input (−)	C1L	8		34	C6H	CH6 sensor input (+)
Ground	GND	9		35	NC	No connection
Reserved	RSVD	10		36	RSVD	Reserved
	CJC sensor				CJC sensor	
Reserved	RSVD	11		37	RSVD	Reserved
No connection	NC	12		38	GND	Ground
CH2 sensor input (+)	C2H	13		39	C5L	CH5 sensor input (−)
CH2 sensor input (−)	C2L	14		40	C5H	CH5 sensor input (+)
No connection	NC	15		41	RSVD	Reserved
Reserved	RSVD	16		42	NC	No connection
CH3 sensor input (+)	C3H	17		43	C4L	CH4 sensor input (−)
CH3 sensor input (−)	C3L	18		44	C4H	CH4 sensor input (+)
Ground	GND	19		45	NC	No connection
Reserved	RSVD	20		46	RSVD	Reserved
Power output	+5V	21		47	+5V	Power output
Ground	GND	22		48	GND	Ground
DIO channel 0	DIO0	23		49	DIO7	DIO channel 7
DIO channel 1	DIO1	24		50	DIO6	DIO channel 6
DIO channel 2	DIO2	25		51	DIO5	DIO channel 5
DIO channel 3	DIO3	26		52	DIO4	DIO channel 4

Figure 2. USB-5201 screw terminal pin numbers

Use 16 AWG to 30 AWG wire for your signal connections. Do not connect anything to the pins labeled RSVD.

Tighten screw terminal connections

When making connections to the screw terminals, fully tighten the screw. Simply touching the top of the screw terminal is not sufficient to make a proper connection.

Thermocouple inputs

You can connect up to eight thermocouples to the differential sensor inputs (**C0H**/**C0L** to **C7H**/**C7L**). Thermocouple types J, K, R, S, T, N, E, and B are supported.

CJC sensors

The USB-5201 has two built in high-resolution temperature sensors. One sensor is located on the right side of the package, and one sensor is located on the left side.

Digital I/O

You can connect up to eight digital I/O lines to the screw terminals labeled **DIO0** to **DIO7**. Each terminal is software-configurable for input or output. If a digital bit is set up as an alarm, the bit is configured for output on power-up, and assumes the state defined by the alarm configuration.

Power outputs

The two **+5V** output terminals are isolated (500 VDC) from the USB +5V.

Caution!   Each +5V terminal is an output. Do not connect to an external power supply to these terminals or you may damage the USB-5201 and possibly the computer.

Ground terminals

The six analog ground terminals (**GND**) provide a common ground for the input channels and DIO bits and are isolated (500 VDC) from the USB GND.

Thermocouple connections

A thermocouple consists of two dissimilar metals that are joined together at one end. When the junction of the metals is heated or cooled, a voltage is produced that correlates to temperature.

The USB-5201 makes fully-differential thermocouple measurements without the need of ground-referencing resistors. A 32-bit floating point value in either a voltage or temperature format is returned by software. An open thermocouple detection feature is available for each analog input which automatically detects an open or broken thermocouple.

Use InstaCal to select the thermocouple type (J, K, R, S, T, N, E, and B) and one or more sensor input channels to connect the thermocouple.

Wiring configuration

Connect the thermocouple to the USB-5201 using a differential configuration, as shown in Figure 3.
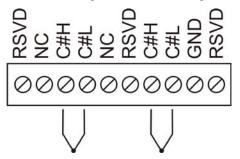

Figure 3. Typical thermocouple connection

Connect thermocouples to the USB-5201 such that they are floating with respect to GND. The ground pins are isolated from earth ground, so you can connect thermocouple sensors to voltages referenced to earth ground as long as the isolation between the GND pins and earth ground is maintained.

When thermocouples are attached to conductive surfaces, the voltage differential between multiple thermocouples must remain within ±1.4 V. For best results, you should use insulated or ungrounded thermocouples when possible.

Maximum input voltage between analog input and ground

The absolute maximum input voltage between an analog input and the isolated GND pins is ±25 VDC when the device is powered on, and ±40 VDC when the device is powered off.

If you need to increase the length of your thermocouple, use the same type of thermocouple wires to minimize the error introduced by thermal EMFs.

Digital I/O connections

You can connect up to eight digital I/O lines to the screw terminals labeled **DIO0** to **DIO7**. You can configure each digital bit for either input or output. All digital I/O lines are pulled up to +5 V with a 47 kΩ resistor (default). You can request the factory to configure the resistor for pull-down to ground, if desired.

Caution!   If a digital bit is set up as an alarm, the bit will be configured for output on power-up, and assume the state defined by the alarm configuration.

When you configure the digital bits for input, you can use the USB-5201 digital I/O terminals to detect the state of any TTL-level input. Refer to the schematic shown in Figure 4. If you set the switch to the +5 V input, DIO0 reads *TRUE* (1). If you move the switch to GND, DIO0 reads *FALSE* (0).
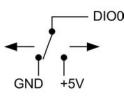

Figure 4. Schematic showing switch detection by digital channel DIO0

Caution!   All ground pins are common and are isolated from earth ground. If a connection is made to earth ground when using digital I/O and conductive thermocouples, the thermocouples are no longer isolated. In this case, thermocouples must not be connected to any conductive surfaces that may be referenced to earth ground

For general information regarding digital signal connections and digital I/O techniques, refer to the *Guide to Signal Connections* (available on our web site at www.mccdaq.com/signals/signals.pdf).

Configuring the DIO channels to generate alarms

The USB-5201 features eight independent temperature alarms. All alarm options are software configurable.

When a digital bit is configured as an alarm, that bit is configured as an output on the next power cycle and assumes the state defined by the alarm configuration.

Each alarm controls an associated digital I/O channel as an alarm output. The input to each alarm is one of the temperature input channels. You set up the temperature conditions to activate an alarm, and the output state of the channel (active high or low) when activated. When an alarm is activated, its associated DIO channel is driven to the output state specified.

The alarm configurations are stored in non-volatile memory and are loaded on power up. The temperature alarms function both in data logging mode and while attached to the USB port on a computer.

Functional Details

Thermocouple measurements

A thermocouple consists of two dissimilar metals that are joined together at one end. When the junction of the metals is heated or cooled, a voltage is produced that correlates to temperature.

The USB-5201 hardware level-shifts the thermocouple's output voltage into the A/D's common mode input range by applying +2.5 V to the thermocouple's low side at the C#L input. Always connect thermocouple sensors to the USB-5201 in a floating fashion. Do not attempt to connect the thermocouple low side C#L to GND or to a ground referencing resistor.

Cold junction compensation (CJC)

When you connect the thermocouple sensor leads to the sensor input channel, the dissimilar metals at the USB-5201 terminal blocks produce an additional thermocouple junction. This junction creates a small voltage error term which must be removed from the overall sensor measurement using a cold junction compensation technique. The measured voltage includes both the thermocouple voltage and the cold junction voltage. To compensate for the additional cold junction voltage, the USB-5201 subtracts the *cold junction* voltage from the thermocouple voltage.

The USB-5201 has two high-resolution temperature sensors that are integrated into the design of the USB-5201. One sensor is located on the right side of the package, and one sensor is located at the left side. The CJC sensors measure the average temperature at the terminal blocks so that the cold junction voltage can be calculated. A software algorithm automatically corrects for the additional thermocouples created at the terminal blocks by subtracting the calculated cold junction voltage from the analog input's thermocouple voltage measurement.

Increasing the thermocouple length

If you need to increase the length of your thermocouple, use the same type of thermocouple wires to minimize the error introduced by thermal EMFs.

Data linearization

After the CJC correction is performed on the measurement data, an on-board microcontroller automatically linearizes the thermocouple measurement data using National Institute of Standards and Technology (NIST) linearization coefficients for the selected thermocouple type.

The measurement data is then output as a 32-bit floating point value in the configured format (voltage or temperature).

Open-thermocouple detection (OTD)

The USB-5201 is equipped with an open-thermocouple detection for each analog input channel. With OTD, any open-circuit or short-circuit condition at the thermocouple sensor is detected by the software. An open channel is detected by driving the input voltage to a negative value outside the range of any thermocouple output. The software recognizes this as an invalid reading and flags the appropriate channel. The software continues to sample all channels when OTD is detected.

Input leakage current

With open-thermocouple detection enabled, 105 nA (max.) of input leakage current is injected into the thermocouple. This current can cause an error voltage to develop across the lead resistance of the thermocouple that is indistinguishable from the thermocouple voltage you are measuring. You can estimate this error voltage with the following formula:
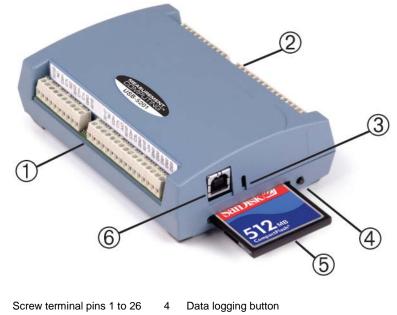
$$\text{error voltage} = \text{resistance of the thermocouple} \times 105 \text{ nA}$$

To reduce the error, reduce the length of the thermocouple to lower its resistance, or lower the AWG of the wire by using a wire with a larger diameter. With open-thermocouple detection disabled, 30 nA (max.) of input leakage current is injected into the thermocouple.

External components

The USB-5201 has the following external components, as shown in Figure 5.

- Screw terminals
- USB connector
- LED
- CompactFlash slot with memory card

1	Screw terminal pins 1 to 26	4	Data logging button
2	Screw terminal pins 27 to 52	5	CompactFlash memory card slot (with card)
3	LED	6	USB connector

Figure 5. External component locations

Screw terminals

The device's four banks of screw terminals are for connecting temperature sensors and digital I/O lines. These terminals also provide ground and power output connections. Refer to the Sensor Connections chapter for screw terminal descriptions.

USB connector

When not logging data, connect the USB cable to a USB port on your computer or to an external USB hub that is connected to your computer. When connected to an active USB bus, the device's USB connector provides +5 V power and communication. The voltage supplied through the USB connector is system-dependent, and may be less than 5 V. No external power supply is required.

Due to processing limitations, you cannot log data when the device is attached to an active USB bus. For data logging operations, connect the device's USB connector to the external power supply.

LED

The LED uses up to 5 mA of current. The function of the LED varies according to whether the USB-5201 is connected to an active USB port, or when the device is logging data and connected to the external power supply.

Refer to the following table for the function of the LED when the device is connected to an active USB port and not logging data.

LED function when the USB-5201 is connected to an active USB port

LED Illumination	Indication
Steady green	The USB-5201 is connected to a computer or external USB hub.
Blinks continuously	Data is being transferred. Upon connection, the LED should flash a few times and then remain lit (indicates a successful installation).
Blinks three times	Initial communication is established between the USB-5201 and the computer.
Off	The USB-5201 is not connected to an active USB port.

Refer to the following table for the function of the USB-5201 LED when the device is connected to the external supply and is logging data. The function of the LED varies according to the selected logging mode.

LED function when the USB-5201 is logging data

Logging mode	LED Illumination	Indication
Logging off	The LED is off.	The USB-5201 is not logging data, and/or the device is not powered
Start Logging on Power Up	The LED turns on when external power is connected, then blinks each time data is captured.	Blinks when logging data.
Start Logging on Button	The LED stays off until the data logging button is pressed and held for approximately 1 second. At that time, the LED turns on and blinks each time data is captured.	Blinks when logging data.
Start Logging at Specified Time	The LED is off – blinks on once per second until the specified date/time to start logging is reached. At that time, the LED turns on – blinks off each time data is captured.	Blinks on once per second until specified data/time to log data occurs. Then it turns on and blinks each time data is captured.
Any logging mode	Blinks rapidly (250 ms period) and continuously.	▪ The memory card is full. ▪ The memory card was removed during logging. Insert the memory card again to stop the device blinking.

CompactFlash memory card slot

The CompactFlash slot accepts standard memory cards. A 512 MB memory card is shipped with the device. For extensive data logging, you can insert a higher capacity card of up to 2 GB. You must format the memory card before logging data for the first time.

Calculating the logging time for a memory card

Use the following formula to calculate the approximate amount of logging time in seconds that one of the supported memory card allows. The USB-5201 supports 512 MB , 1 GB, and 2 GB CompactFlash memory cards.

$$\text{time} = R \times \frac{N_{Disk}}{N_{TS} + N_{DIO} + \left(N_{Temp} \times n_{Channels}\right) + N_{CJC}}$$

where

- time = total disk time in seconds
- N_{Disk} = size of memory card in bytes
- N_{DIO} = 1 byte for digital I/O
- $n_{Channels}$ = number of channels logged

- R = logging rate in seconds
- N_{TS} = 6 bytes for timestamp, if enabled
- N_{Temp} = 4 bytes for a temperature reading
- N_{CJC} = 8 bytes if CJC sensor readings are enabled

The following table provides examples of logging one channel and eight channels of temperature readings at the max logging rate of 1 S/s to a 512 MB memory card with DIO, timestamp, and CJC sensor logging enabled:

Memory card (bytes)	DIO enabled	Number of channels	Logging rate (S/s)	Timestamp enabled	Temperature reading	CJC enabled
512,000,000	1	1	1	6	4	8
$$\text{time} = 1 \times \frac{512{,}000{,}000}{6 + 1 + (4 \times 1) + 8} = 26947368 \text{ seconds} = 311.9 \text{ days}$$						
512,000,000	1	8	1	6	4	8
$$\text{time} = 1 \times \frac{512{,}000{,}000}{6 + 1 + (4 \times 8) + 8} = 10893617 \text{ seconds} = 126 \text{ days}$$						

Data logging button

The data logging button is used to end a data logging session. The data logging button is also used to start recording data when the logging mode is set in InstaCal to *Start Logging on Button*.

▪ *To begin recording data*, press and hold the button until the LED begins to blink. The first sample is taken one second after the LED illuminates.

When you first power on the USB-5201, wait at least five seconds before pressing the data logging button. To achieve rated accuracy, allow the USB-5201 to warm up for 30 minutes before logging data.

▪ *To stop recording data*, press and hold the button again until the LED is off.

Caution! To prevent loss of data, always use the button to stop logging. Make sure the data is written to the memory card before you disconnect the device from the power source.

The device caches log data in volatile memory prior to writing to the memory card.

Pressing the data logging button has no effect when the USB-5201 is connected to an active USB port and not logging data.

External power required for data logging
Due to processing limitations, data logging is not allowed when the USB-5201 is attached to an active USB bus. The USB-5201 must be connected to the standalone power supply to perform data logging.

External power supply

The external power supply is a 2.5 W USB power adapter used to power the USB-5201 during data logging operations.

Disconnecting the USB-5201 from the computer

You don't need to shut down your computer to disconnect the USB-5201. For devices installed with firmware revision 3 or later and you are running Windows XP, use the **Unplug** or **Eject** icon on the computer taskbar to safely stop the device before you unplug it. To do this, right-click on the icon, select the USB-5201 and click **Stop**. Windows will notify you when it is safe to disconnect the device from your computer.

Transferring binary data after a logging session

Data is stored on the memory card in binary files. After logging measurements, you can transfer the files to your computer by reconnecting the USB-5201 to a USB port on your computer or by removing the CompactFlash card from the USB-5201 and using a card reader connected to your computer.

Note that when installed with firmware version 3 and later the USB-5201 appears as a Mass Storage Device when connected to a USB port on your computer, so you can copy files using Windows Explorer.

Converting binary data after a logging session

If your USB-5201 is connected to a USB port on your computer, you can use InstaCal or TracerDAQ to convert the files on the CompactFlash card to .CSV format for use in Microsoft Excel files, or to .TXT format for use in other applications.

If you transferred binary files to your computer hard drive or removed the CompactFlash card from the device and are using a card reader connected to a computer, use TracerDAQ to import the files and save them as .CSV or.TXT format. InstaCal can only convert files when the CompactFlash card is in a device connected to a computer.

Specifications

All specifications are subject to change without notice.
Typical for 25 °C unless otherwise specified.
Specifications in *italic* text are guaranteed by design.

Analog input

Table 1. Generic analog input specifications

Parameter	Conditions	Specification
A/D converters		Four dual 24-bit, Sigma-Delta type
Number of channels		8 differential
Input isolation		*500 VDC minimum between field wiring and USB interface*
Channel configuration		Thermocouple sensor type
Differential input voltage range	Thermocouple	±0.080 V
Absolute maximum input voltage	*±C0x through ±C7x relative to GND*	±25 V power on, ±40 V power off.
Input impedance		5 GΩ, min
Input leakage current	Open thermocouple detect enabled	105 nA max
Normal mode rejection ratio	$f_{IN} = 60\ Hz$	*90 dB min*
Common mode rejection ratio	$f_{IN} = 50\ Hz/60\ Hz$	*100 dB min*
Resolution		24 bits
No missing codes		*24 bits*
Input coupling		DC
Warm-up time		30 minutes min
Open thermocouple detect		Automatically enabled when the channel pair is configured for thermocouple sensors. The maximum open detection time is 3 seconds.
CJC sensor accuracy	*15 °C to 35 °C*	*±0.25 °C typ, ±0.5 °C max*
	0 °C to 70 °C	*−1.0 to +0.5 °C max*

Channel configuration

Channel configuration information is stored in the EEPROM of the isolated microcontroller by the firmware whenever any item is modified. Modification is performed by commands issued over USB from an external application, and the configuration is made non-volatile through the use of the EEPROM.

Table 2. Channel configuration specifications

Sensor Category	Conditions	Specification
Thermocouple	J, K, S, R, B, E, T, or N (Note 1)	8 differential channels

Note 1: The factory default configuration is *Type J*.

Accuracy

Thermocouple specifications include linearization, cold-junction compensation and system noise. These specs are for one year, or 3000 operating hours, whichever comes first and for operation of the device between 15 °C and 35 °C. For measurements outside this range, add ±0.5 °C to the maximum error shown.

There are CJC sensors on each side of the device. The accuracy listed in Table 3 assumes the screw terminals are at the same temperature as the CJC sensor. Errors shown do not include inherent thermocouple error. Contact your thermocouple supplier for details on the actual thermocouple error.

Thermocouples must be connected to the device such that they are floating with respect to GND (pins 9, 19, 28, 38). The device GND pins are isolated from earth ground, so connecting thermocouple sensors to voltages referenced to earth ground is permissible as long as the isolation between the GND pins and earth ground is maintained.

When thermocouples are attached to conductive surfaces, the voltage differential between multiple thermocouples must remain within ±1.4 V. For best results, MCC recommends using ungrounded or insulated thermocouples when possible.

Thermocouple measurement accuracy

Table 3. Thermocouple accuracy specifications, including CJC measurement error

Sensor type	Maximum error (°C)	Typical error (°C)	Temperature range (°C)
J	±1.499	±0.507	–210 to 0
	±0.643	±0.312	0 to 1200
K	±1.761	±0.538	–210 to 0
	±0.691	±0.345	0 to 1372
S	±2.491	±0.648	–50 to 250
	±1.841	±0.399	250 to 1768.1
R	±2.653	±0.650	–50 to 250
	±1.070	±0.358	250 to 1768.1
B	±1.779	±0.581	250 to 700
	±0.912	±0.369	700 to 1820
E	±1.471	±0.462	–200 to 0
	±0.639	±0.245	0 to 1000
T	±1.717	±0.514	–200 to 0
	±0.713	±0.256	0 to 600
N	±1.969	±0.502	–200 to 0
	±0.769	±0.272	0 to 1300

Throughput rate to PC

The analog inputs are configured to run continuously. Each channel is sampled twice per second. The maximum latency between when a sample is acquired and the temperature data is provided by the USB unit is approximately 0.5 seconds.

Maximum throughput to a CompactFlash® memory card is 1 S/s per channel.

Table 4. Throughput rate to PC specifications

Number of input channels	Maximum throughput
1	2 S/s
2	2 S/s on each channel, 4 S/s total
3	2 S/s on each channel, 6 S/s total
4	2 S/s on each channel, 8 S/s total
5	2 S/s on each channel, 10 S/s total
6	2 S/s on each channel, 12 S/s total
7	2 S/s on each channel, 14 S/s total
8	2 S/s on each channel, 16 S/s total

Digital I/O

All ground pins on the device (pins 9, 19, 28, 38) are isolated from earth ground. If a connection is made to earth ground when using digital I/O and conductive thermocouples, the thermocouples are no longer isolated. In this case, do not connect thermocouples to any conductive surfaces that may be referenced to earth ground.

Table 5. Digital input/output specifications

Parameter	Specification
Digital type	CMOS
Number of I/O	8 (DIO0 through DIO7)
Configuration	Independently configured for input or output. Power on reset is input mode unless bit is configured for alarm.
Pull up/pull-down configuration	All pins pulled up to +5 V through 47 kΩ resistors (default). Pull-down to ground also available.
Digital I/O transfer rate (software paced)	■ Digital input: 50 port reads or single bit reads per second typ ■ Digital output: 100 port writes or single bit writes per second typ
Input high voltage	2.0 V min, 5.5 V absolute max
Input low voltage	0.8 V max, –0.5 V absolute min
Output low voltage (IOL = 2.5 mA)	0.7 V max
Output high voltage (IOH = –2.5 mA)	3.8 V min

Temperature alarms

Table 6. Temperature alarm specifications

Parameter	Specification
Number of alarms	8 (one per digital I/O line)
Alarm functionality	Each alarm controls its associated digital I/O line as an alarm output. The input to each alarm may be any of the analog temperature input channels. When an alarm is enabled, its associated I/O line is set to output (after the device is reset) and driven to the appropriate state determined by the alarm options and input temperature. The alarm configurations are stored in non-volatile memory and are loaded at power on. Alarms function both in data logging mode and while attached to USB.
Alarm input modes	■ Alarm when input temperature $> T1$ ■ Alarm when input temperature $> T1$, reset alarm when input temperature goes below T2 ■ Alarm when input temperature $< T1$ ■ Alarm when input temperature $< T1$, reset alarm when input temperature goes above T2 ■ Alarm when input temperature is $< T1$ or $> T2$ T1 and T2 may be independently set for each alarm.
Alarm output modes	■ Disabled, digital I/O line may be used for normal operation ■ Enabled, active high output (digital I/O line goes high when alarm conditions met) ■ Enabled, active low output (digital I/O line goes low when alarm conditions met)
Alarm update rate	1 second

Memory

Table 7. Memory specifications

Parameter	Specification
EEPROM	1,024 bytes isolated micro reserved for sensor configuration 256 bytes USB micro for external application use 256 bytes USB micro reserved for data logging configuration

Microcontroller

Table 8. Microcontroller specifications

Parameter	Specification
Type	Two high performance 8-bit RISC microcontrollers

Data logging

Table 9. Data logging specifications

Parameter	Specification
Standalone power supply	USB power adapter 2.5 watt USB adapter with interchangeable plugs (includes plug for USA)
Memory card type	CompactFlash
Supplied memory card	512 MB CompactFlash card
Memory card host access	USB Mass Storage Device (MSD)
File systems supported	FAT16, FAT32 The device only creates 8.3 file names in the root subdirectory.
Log file format	binary
Logging rate	Min 1 second between entries, max 2^{32} seconds, 1 second granularity
Data items logged	Timestamp, temperature, or raw reading from selected channels, state of DIO lines, CJC sensor readings
Throughput to memory card	1 S/s per channel
Logging start methods	Configurable: ■ **Start Logging on Power Up** – Logging begins 5 seconds after power on to allow hardware to settle. ■ **Start Logging on Button** – Device is idle on power on. Press and hold the button until the LED turns on to begin logging. The first sample is acquired 1 second after the LED turns on unless less than 5 seconds have elapsed since power on. ■ **Start Logging at Specified Time** – Device is idle until the real-time clock indicates the time is equal to or greater than the specified time, at which time the LED turns on. The first sample is acquired 1 second after the LED turns on unless less than 5 seconds have elapsed since power on.
Logging stop methods	Stop on button press – To stop logging, press and hold the button until the LED turns off. The device caches logged data in volatile memory prior to writing to memory card. When logging, always use the button to stop logging and ensure data is written to memory card prior to removing power.
Logging status indication	The LED operations when connected to the AC adapter power supply are different than when connected to USB: Logging modes: ■ **Logging Off** mode: the LED is off (disabled). ■ **Start Logging on Power Up** mode: the LED turns on, but blinks off momentarily every time data is captured. ■ **Start Logging on Button** mode: the LED is initially off. When the button is pressed and held for approximately 1 second, the LED turns on and act the same as Start Logging on Power Up mode. ■ **Start Logging at Specified Time** mode: the LED turns off, with a momentary on flash every second until the specified date/time is reached. At that time, the LED turns on and acts the same as Start Logging on Power Up mode. Other indication: ■ To stop logging and store the remaining data to memory card, press and hold the button until the LED turns off. It is then safe to remove the memory card. ■ If the memory card becomes full, the LED blinks rapidly (250 ms period). ■ If the memory card is removed while logging is in progress, the LED blinks rapidly (250 ms period). Inserting a memory card stops the LED from blinking.

Real-time clock

Table 10. Real-time clock specifications

Parameter	Specification
Battery backup	CR-2032 lithium coin cell, replaceable
Accuracy	±1 minute per month

USB +5V voltage

Table 11. USB +5 V voltage specifications

Parameter	Conditions	Specification
USB +5 V (VBUS) input voltage range		4.75 V min to 5.25 V max

Power

Table 12. Power specifications

Parameter	Conditions	Specification
Connected to USB		
Supply current	USB enumeration	<100 mA
Supply current (Note 2)	Continuous mode	500 mA max
User +5 V output voltage range (pins 21 and 47)	Connected to a self-powered hub. (Note 3)	4.75 V min to 5.25 V max
User +5 V output current (pins 21 and 47)	Connected to a self-powered hub. (Note 3)	10 mA max
Isolation	Measurement system to PC	500 VDC min
AC Adapter Power Supply (used for data logging operation)		
Output voltage		5 V ±5%
Output wattage		2.5 W
Input voltage		100 – 240 VAC 50 – 60 Hz
Input current		0.2 A

Note 2: This is the total current requirement for the device which includes up to 10 mA for the status LED.

Note 3: Self-powered hub refers to a USB hub with an external power supply. Self-powered hubs allow a connected USB device to draw up to 500 mA. This device may not be used with bus-powered hubs due to the power supply requirements.

Root port hubs reside in the PC USB host controller. The USB port(s) on your PC are root port hubs. All externally powered root port hubs (desktop PCs) provide up to 500 mA of current for a USB device. Battery-powered root port hubs provide 100 mA or 500 mA, depending upon the manufacturer. A laptop PC that is not connected to an external power adapter is an example of a battery-powered root port hub.

USB specifications

Table 13. USB specifications

Parameter	Specification
USB device type	USB 2.0 (full-speed)
Device compatibility	USB 1.1, USB 2.0
	Self-powered, 500 mA consumption max
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 (9.84 ft) max

Environmental

Table 14. Environmental specifications

Parameter	Specification
Operating temperature range	0 °C to 70 °C
Storage temperature range	–40 °C to 85 °C
Humidity	0% to 90% non-condensing

Mechanical

Table 15. Mechanical specifications

Parameter	Specification
Dimensions (L × W × H)	128.52 x 88.39 × 35.56 mm (5.06 × 3.48 × 1.43 ft)
User connection length	3 m (9.84 ft) max

Screw terminal connector

Table 16. Screw terminal connector specifications

Parameter	Specification
Connector type	Screw terminal
Wire gauge range	16 AWG to 30 AWG

Table 17. Screw terminal pinout

Pin	Signal Name	Pin Description	Pin	Signal Name	Pin Description
1	RSVD	Reserved, do not use	27	RSVD	Reserved, do not use
2	NC	No connection	28	GND	Ground
3	C0H	CH0 sensor input (+)	29	C7L	CH7 sensor input (–)
4	C0L	CH0 sensor input (–)	30	C7H	CH7 sensor input (+)
5	NC	No connection	31	RSVD	Reserved, do not use
6	RSVD	Reserved, do not use	32	NC	No connection
7	C1H	CH1 sensor input (+)	33	C6L	CH6 sensor input (–)
8	C1L	CH1 sensor input (–)	34	C6H	CH6 sensor input (+)
9	GND	Ground	35	NC	No connection
10	RSVD	Reserved, do not use	36	RSVD	Reserved, do not use
	CJC sensor			CJC sensor	
11	RSVD	Reserved, do not use	37	RSVD	Reserved, do not use
12	NC	No connection	38	GND	Ground
13	C2H	CH2 sensor input (+)	39	C5L	CH5 sensor input (–)
14	C2L	CH2 sensor input (–)	40	C5H	CH5 sensor input (+)
15	NC	No connection	41	RSVD	Reserved, do not use
16	RSVD	Reserved, do not use	42	NC	No connection
17	C3H	CH3 sensor input (+)	43	C4L	CH4 sensor input (–)
18	C3L	CH3 sensor input (–)	44	C4H	CH4 sensor input (+)
19	GND	Ground	45	NC	No connection
20	RSVD	Reserved, do not use	46	RSVD	Reserved, do not use
21	+5V	+5V output	47	+5V	+5V output
22	GND	Ground	48	GND	Ground
23	DIO0	DIO channel 0	49	DIO7	DIO channel 7
24	DIO1	DIO channel 1	50	DIO6	DIO channel 6
25	DIO2	DIO channel 2	51	DIO5	DIO channel 5
26	DIO3	DIO channel 0	52	DIO4	DIO channel 4

$C\epsilon$ Declaration of Conformity

Manufacturer: Measurement Computing Corporation
Address: 10 Commerce Way
     Suite 1008
     Norton, MA 02766
     USA
Category: Electrical equipment for measurement, control and laboratory use.

Measurement Computing Corporation declares under sole responsibility that the product

USB-5201

to which this declaration relates is in conformity with the relevant provisions of the following standards or other documents:

EC EMC Directive 2004/108/EC: Electromagnetic Compatibility, EN 61326-1:2006, (IEC 61326-1:2005)

Emissions:

- EN 55011 (1990)/CISPR 11 Radiated emissions: Group 1, Class A
- EN 55011 (1990)/CISPR 11 Conducted emissions: Group 1, Class A

Immunity: EN61326-1:2006, (IEC 61326-1:2005) Table 3 Immunity requirements for equipment used in controlled EM environments.

- IEC 61000-4-2 (2001): Electrostatic Discharge immunity.
- IEC 61000-4-3 (2002): Radiated Electromagnetic Field immunity.

To maintain the safety, emission, and immunity standards of this declaration, the following conditions must be met.

- The host computer, peripheral equipment, power sources, and expansion hardware must be CE compliant.
- Equipment must be operated in a controlled electromagnetic environment as defined by Standards EN 61326-1:2006, or IEC 61326-1:2005.
- Shielded wires must be used for all I/Os and must be less than 3 meters (9.75 feet) in length.
- The host computer must be properly grounded.
- The host computer must be USB 2.0 compliant.
- A protective ESD wrist strap should be used when connecting or disconnecting leads from screw terminal blocks.

Note: Data acquisition equipment may exhibit noise or increased offsets when exposed to high RF fields (>1V/m) or transients.

Declaration of Conformity based on tests conducted by Chomerics Test Services, Woburn, MA 01801, USA in February, 2006. Test records are outlined in Chomerics Test Report #EMI4445.06. Further testing was conducted by Chomerics Test Services, Woburn, MA. 01801, USA in November, 2008. Test records are outlined in Chomerics Test report #EMI5193.08.

We hereby declare that the equipment specified conforms to the above Directives and Standards.

Carl Haapaoja

Carl Haapaoja, Director of Quality Assurance