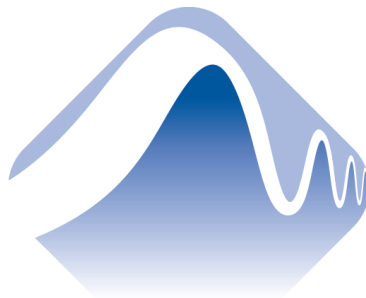




# USB-5201

## USB-based 8-Channel Thermocouple Input Device and Data Logger

### User's Guide



**MEASUREMENT  
COMPUTING™**

Document Revision 7, June, 2008

© Copyright 2008, Measurement Computing Corporation

Your new Measurement Computing product comes with a fantastic extra —

## Management committed to your satisfaction!

Refer to [www.mccdaq.com/execteam.html](http://www.mccdaq.com/execteam.html) for the names, titles, and contact information of each key executive at Measurement Computing.

Thank you for choosing a Measurement Computing product—and congratulations! You own the finest, and you can now enjoy the protection of the most comprehensive warranties and unmatched phone tech support. It's the embodiment of our mission:

- To provide PC-based data acquisition hardware and software that will save time and save money.

Simple installations minimize the time between setting up your system and actually making measurements. We offer quick and simple access to outstanding live FREE technical support to help integrate MCC products into a DAQ system.

**Limited Lifetime Warranty:** Most MCC products are covered by a limited lifetime warranty against defects in materials or workmanship for the life of the product, to the original purchaser, unless otherwise noted. Any products found to be defective in material or workmanship will be repaired, replaced with same or similar device, or refunded at MCC's discretion. For specific information, please refer to the terms and conditions of sale.

**Harsh Environment Warranty® Program:** Any Measurement Computing product that is damaged due to misuse, or any reason, may be eligible for replacement with the same or similar device for 50% of the current list price. I/O boards face some harsh environments, some harsher than the boards are designed to withstand. Contact MCC to determine your product's eligibility for this program

**30 Day Money-Back Guarantee:** Any Measurement Computing Corporation product may be returned within 30 days of purchase for a full refund of the price paid for the product being returned. If you are not satisfied, or chose the wrong product by mistake, you do not have to keep it.

*These warranties are in lieu of all other warranties, expressed or implied, including any implied warranty of merchantability or fitness for a particular application. The remedies provided herein are the buyer's sole and exclusive remedies. Neither Measurement Computing Corporation, nor its employees shall be liable for any direct or indirect, special, incidental or consequential damage arising from the use of its products, even if Measurement Computing Corporation has been notified in advance of the possibility of such damages.*

### **Trademark and Copyright Information**

TracerDAQ, Universal Library, Harsh Environment Warranty, Measurement Computing Corporation, and the Measurement Computing logo are either trademarks or registered trademarks of Measurement Computing Corporation.

Windows, Microsoft, and Visual Studio are either trademarks or registered trademarks of Microsoft Corporation

LabVIEW is a trademark of National Instruments.

CompactFlash is a registered trademark of SanDisk Corporation.

XBee and XBee-PRO are trademarks of MaxStream, Inc.

All other trademarks are the property of their respective owners.

Information furnished by Measurement Computing Corporation is believed to be accurate and reliable. However, no responsibility is assumed by Measurement Computing Corporation neither for its use; nor for any infringements of patents or other rights of third parties, which may result from its use. No license is granted by implication or otherwise under any patent or copyrights of Measurement Computing Corporation.

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form by any means, electronic, mechanical, by photocopying, recording, or otherwise without the prior written permission of Measurement Computing Corporation.

#### **Notice**

Measurement Computing Corporation does not authorize any Measurement Computing Corporation product for use in life support systems and/or devices without prior written consent from Measurement Computing Corporation. Life support devices/systems are devices or systems which, a) are intended for surgical implantation into the body, or b) support or sustain life and whose failure to perform can be reasonably expected to result in injury. Measurement Computing Corporation products are not designed with the components required, and are not subject to the testing required to ensure a level of reliability suitable for the treatment and diagnosis of people.

---

# Table of Contents

## Preface

<b>About this User's Guide .....</b>	<b>7</b>
What you will learn from this user's guide.....	7
Conventions in this user's guide.....	7
Where to find more information .....	7

## Chapter 1

<b>Introducing the USB-5201 .....</b>	<b>8</b>
Overview: USB-5201 features.....	8
Logging data with the USB-5201 .....	8
USB-5201 block diagram .....	9
Software features .....	9
Connecting a USB-5201 to your computer is easy .....	10

## Chapter 2

<b>Installing the USB-5201 .....</b>	<b>11</b>
What comes with your USB-5201 shipment?.....	11
Hardware .....	11
Additional documentation.....	12
Unpacking the USB-5201.....	12
Installing the software .....	12
Installing the hardware .....	12
Firmware revision 2.12 and earlier .....	12
Firmware revision 3.0 and later .....	12
Configuring the USB-5201.....	13
Configuring data logging options.....	13
Calibrating the USB-5201 .....	13

## Chapter 3

<b>Sensor Connections .....</b>	<b>14</b>
Screw terminal pin out.....	14
Thermocouple input terminals (C0H/C0L to C7H/C7L) .....	15
Ground terminals (GND) .....	15
Power terminals (+5V).....	15
Digital terminals (DIO0 to DIO7).....	15
CJC sensors.....	16
Thermocouple connections.....	16
Wiring configuration.....	16
Digital I/O connections.....	17
Configuring the DIO channels to generate alarms .....	17

## Chapter 4

<b>Functional Details .....</b>	<b>18</b>
Thermocouple measurements .....	18
Cold junction compensation (CJC) .....	18
Data linearization.....	18
Open-thermocouple detection (OTD) .....	18
External components .....	19
Screw terminals.....	19
USB connector.....	19
LED .....	19
CompactFlash® memory card slot.....	20
Data logging button .....	20
External power supply .....	21

Disconnecting the USB-5201 from the computer.....	21
Transferring binary data after a logging session.....	21
Converting binary data after a logging session.....	21
<b>Chapter 5</b>	
<b>Specifications .....</b>	<b>22</b>
Analog input section.....	22
Channel configurations.....	22
Accuracy.....	23
Thermocouple measurement accuracy.....	23
Throughput rate to PC.....	23
Digital input/output.....	24
Temperature alarms.....	24
Memory.....	24
Microcontroller.....	25
Data Logging.....	25
Real time clock.....	26
USB +5V voltage.....	26
Power.....	26
USB specifications.....	27
Environmental.....	27
Mechanical.....	27
Screw terminal connector type and pin out.....	27
Screw terminal pin out.....	28
<b>Declaration of Conformity.....</b>	<b>29</b>

---

## About this User's Guide

### What you will learn from this user's guide

This user's guide explains how to install, configure, and use the USB-5201 so that you get the most out of its USB-based temperature measurement features.

This user's guide also refers you to related documents available on our web site, and to technical support resources that can also help you get the most out of these boards.

### Conventions in this user's guide

#### For more information on ...

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.

<#:#> Angle brackets that enclose numbers separated by a colon signify a range of numbers, such as those assigned to registers, bit settings, etc.

**bold text** **Bold** text is used for the names of objects on the screen, such as buttons, text boxes, and check boxes. For example:  
1. Insert the disk or CD and click the **OK** button.

*italic text* *Italic* text is used for the names of manuals and help topic titles, and to emphasize a word or phrase. For example:  
The *InstaCal* installation procedure is explained in the *Quick Start Guide*.  
*Never* touch the exposed pins or circuit connections on the board.

### Where to find more information

- MCC's *Specifications: USB-5201* (the PDF version of the *Specifications* chapter in this guide) is available on our web site at [www.mccdaq.com/pdfs/USB-5201.pdf](http://www.mccdaq.com/pdfs/USB-5201.pdf).
- MCC's *Quick Start Guide* is available on our web site at [www.mccdaq.com/PDFmanuals/DAQ-Software-Quick-Start.pdf](http://www.mccdaq.com/PDFmanuals/DAQ-Software-Quick-Start.pdf).
- MCC's *Guide to Signal Connections* is available on our web site at [www.mccdaq.com/signals/signals.pdf](http://www.mccdaq.com/signals/signals.pdf).
- MCC's *Universal Library User's Guide* is available on our web site at [www.mccdaq.com/PDFmanuals/sm-ul-user-guide.pdf](http://www.mccdaq.com/PDFmanuals/sm-ul-user-guide.pdf).
- MCC's *Universal Library Function Reference* is available on our web site at [www.mccdaq.com/PDFmanuals/sm-ul-functions.pdf](http://www.mccdaq.com/PDFmanuals/sm-ul-functions.pdf).
- MCC's *Universal Library for LabVIEW™ User's Guide* is available on our web site at [www.mccdaq.com/PDFmanuals/SM-UL-LabVIEW.pdf](http://www.mccdaq.com/PDFmanuals/SM-UL-LabVIEW.pdf).

*USB-5201 User's Guide* (this document) is also available on our web site at [www.mccdaq.com/PDFmanuals/USB-5201.pdf](http://www.mccdaq.com/PDFmanuals/USB-5201.pdf).

---

# Introducing the USB-5201

## Overview: USB-5201 features

This user's guide contains all of the information you need to connect the USB-5201 to your computer and to the signals you want to measure.

The USB-5201 is a USB 2.0 full-speed, thermocouple input device that is supported under popular Microsoft® Windows® operating systems. The USB-5201 is fully compatible with both USB 1.1 and USB 2.0 ports.

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 256 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.

### **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-configurable options for setting up data logging.

You can record:

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

You 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.



## USB-5201 block diagram

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

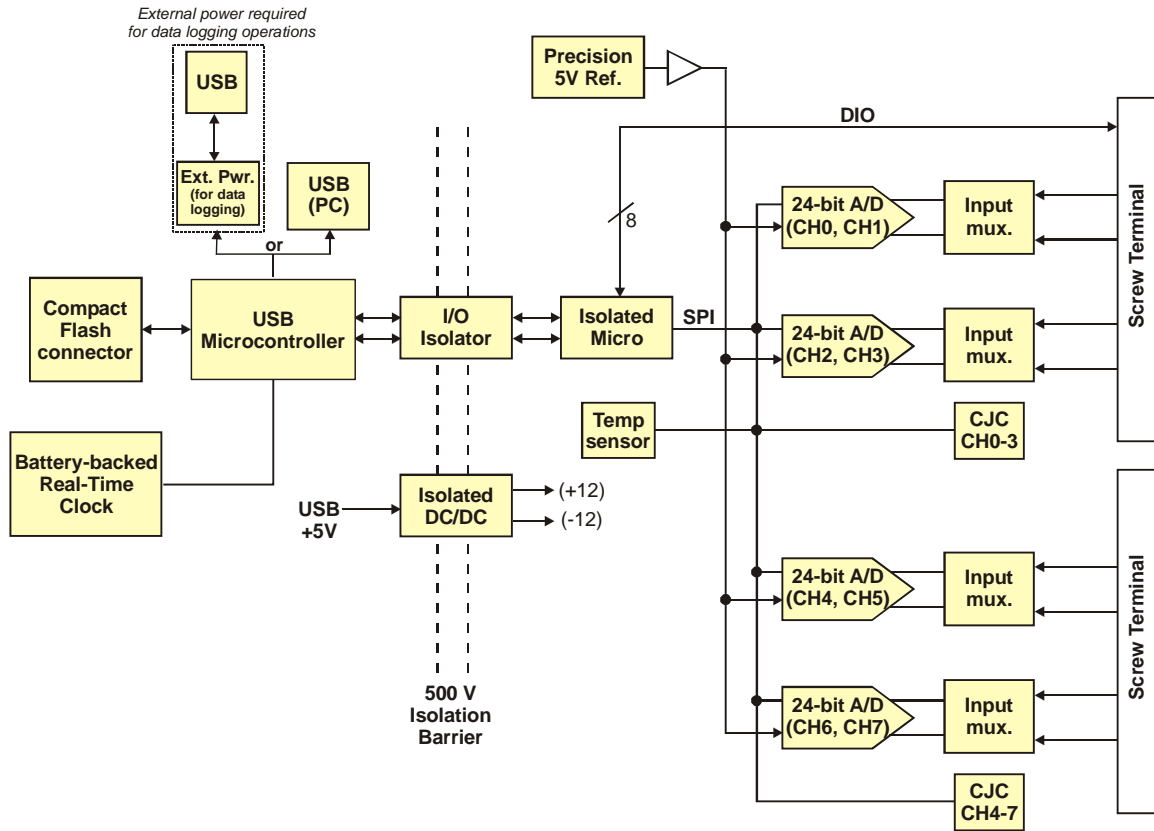


Figure 1. USB-5201 functional block diagram

## Software features

For information on the features of *InstaCal* and the other software included with your USB-5201, refer to the *Quick Start Guide* that shipped with your device. The *Quick Start Guide* is also available in PDF at [www.mccdaq.com/PDFmanuals/DAQ-Software-Quick-Start.pdf](http://www.mccdaq.com/PDFmanuals/DAQ-Software-Quick-Start.pdf).

Check [www.mccdaq.com/download.htm](http://www.mccdaq.com/download.htm) for the latest software version.

## Connecting a USB-5201 to your computer is easy

Installing a data acquisition device has never been easier.

- The USB-5201 relies upon the Microsoft Human Interface Device (HID) class drivers. The HID class drivers ship with every copy of Windows that is designed to work with USB ports. We use the Microsoft HID because it is a standard, and its performance delivers full control and maximizes data transfer rates for your USB-5201. No third-party device driver is required.
- In addition to utilizing the HID class drivers, the USB-5201 also utilizes the Mass Storage Device interface to allow the CompactFlash Card adapter to appear as a storage device. This feature allows direct access to data files stored on the USB-5201.
- The USB-5201 is plug-and-play. There are no jumpers to position, DIP switches to set, or interrupts to configure.
- You can connect the USB-5201 before or after you install the software, and without powering down your computer first. When you connect an HID to your system, your computer automatically detects it and configures the necessary software. You can connect and power multiple HID peripherals to your system using a USB hub.
- You can connect your system to various devices using a standard four-wire cable. The USB connector replaces the serial and parallel port connectors with one standardized plug and port combination.
- You do not need a separate power supply device. The USB automatically delivers the electrical power required by each peripheral connected to your system. *However, for data logging operations, an external power supply is required.*
- Data can flow two ways between a computer and peripheral over USB connections.

---

## Installing the USB-5201

### What comes with your USB-5201 shipment?

The following items are shipped with the USB-5201.

#### Hardware

The following items should be included with your shipment.

- USB-5201 with memory card



- USB cable (2 meter length)



- External power supply – 2.5 watt USB adapter for data logging operations. MCC part number *USB Power Adapter*.



## Additional documentation

In addition to this hardware user's guide, you should also receive the *Quick Start Guide* (available in PDF at [www.mccdaq.com/PDFmanuals/DAQ-Software-Quick-Start.pdf](http://www.mccdaq.com/PDFmanuals/DAQ-Software-Quick-Start.pdf)). This booklet supplies a brief description of the software you received with your USB-5201 and information regarding installation of that software. Please read this booklet completely before installing any software or hardware.

## Unpacking the USB-5201

As with any electronic device, you should take care while handling to avoid damage from static electricity. Before removing the USB-5201 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.

If your USB-5201 is damaged, notify Measurement Computing Corporation immediately by phone, fax, or e-mail. For international customers, contact your local distributor where you purchased the USB-5201.

- Phone: 508-946-5100 and follow the instructions for reaching Tech Support.
- Fax: 508-946-9500 to the attention of Tech Support
- Email: [techsupport@mccdaq.com](mailto:techsupport@mccdaq.com)

## Installing the software

Refer to the *Quick Start Guide* for instructions on installing the software on the *Measurement Computing Data Acquisition Software CD*. This booklet is available in PDF at [www.mccdaq.com/PDFmanuals/DAQ-Software-Quick-Start.pdf](http://www.mccdaq.com/PDFmanuals/DAQ-Software-Quick-Start.pdf).

## 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.

**Caution!** 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** popup balloon (Windows XP) or dialog (other Windows versions) opens as the USB-5201 is detected.

When this balloon or dialog closes, the installation is complete. The **LED** on the side of the device should flash and then remain lit. This indicates that communication is established between the USB-5201 and your computer.

### Firmware revision 3.0 and later

The USB-5201 installs as a composite device with separate devices attached. When you connect the USB-5201 for the first time, **Found New Hardware** popup balloons (Windows XP) or dialogs (other Windows version) open as each USB-5201 interface is detected.

It is normal for multiple dialogs to open when you connect the USB-5201 for the first time. For additional information, refer to the "Notes on installing and using the USB-5201 and USB-5203 data logging devices" that was shipped with the USB-5201.

When the last balloon or dialog closes, the installation is complete. The LED on the USB-5201 should flash and then remain lit. This indicates that communication is established between the USB-5201 and your computer.

**Caution!** Do not disconnect any device from the USB bus while the computer is communicating with the USB-5201, or you may lose data and/or your ability to communicate with the USB-5201.

**If the LED turns off**

If the LED is lit but then turns off, the computer has lost communication with the USB-5201. To restore communication, disconnect the USB cable from the computer, and then reconnect it. This should restore communication, and the LED should turn back on.

## Configuring the USB-5201

All hardware configuration options on the USB-5201 are programmable with software. Use *InstaCal* to set the thermocouple type for each channel. Configuration options are stored on the USB-5201's isolated microcontroller in EEPROM, which is non-volatile memory on the USB-5201. Configuration options are loaded on power up. The factory default configuration is *Type J* thermocouple.

**Warm up**

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 configuration options are programmable with *InstaCal*.

- 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 USB-5201

The USB-5201 is fully calibrated with *InstaCal*. Calibration coefficients are stored in EEPROM. 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 pin out

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.

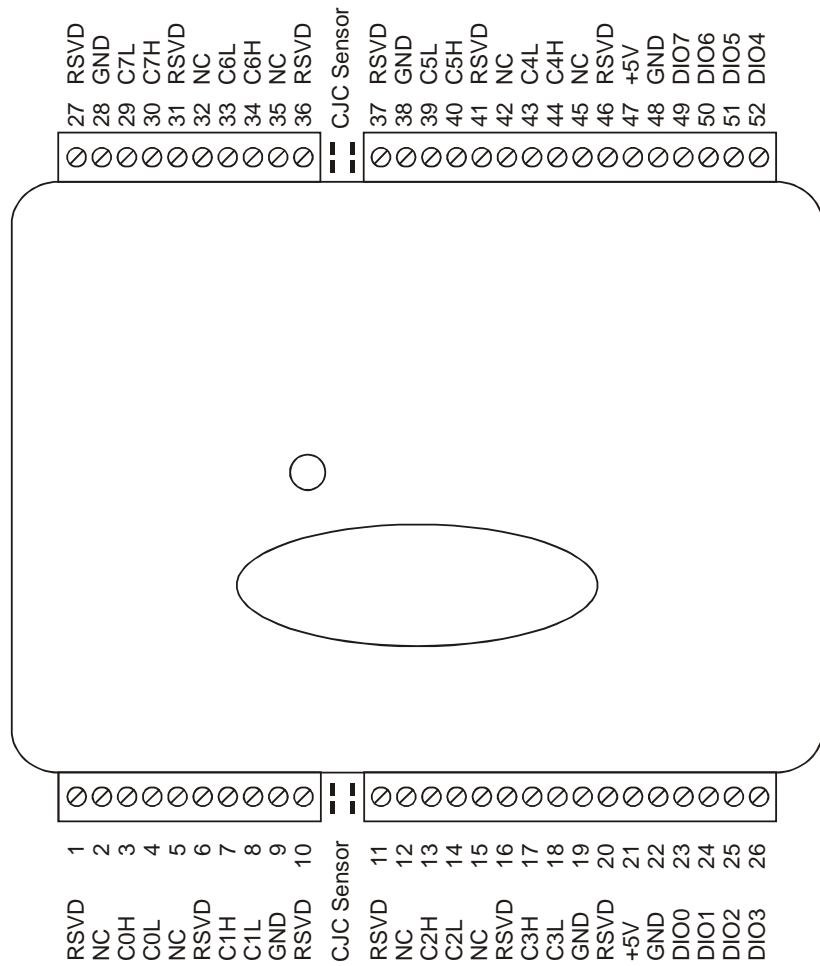


Figure 2. USB-5201 screw terminal pin numbers

USB-5201 screw terminal descriptions

Pin	Signal Name	Pin Description	Pin	Signal Name	Pin Description
1	RSVD	Reserved, Do Not Use	27	RSVD	Reserved, Do Not Use
2	NC	Not connected	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	Not connected	31	RSVD	Reserved, Do Not Use
6	RSVD	Reserved, Do Not Use	32	NC	Not connected
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	Not connected
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	Not connected	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	Not connected	41	RSVD	Reserved, Do Not Use
16	RSVD	Reserved, Do Not Use	42	NC	Not connected
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	Not connected
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	Digital Input/output	49	DIO7	Digital Input/output
24	DIO1	Digital Input/output	50	DIO6	Digital Input/output
25	DIO2	Digital Input/output	51	DIO5	Digital Input/output
26	DIO3	Digital Input/output	52	DIO4	Digital Input/output

Use 16 AWG to 30 AWG wire for your signal connections.

#### 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 input terminals (C0H/C0L to C7H/C7L)

You can connect up to eight thermocouples to the differential sensor inputs (C0H/C0L to C7H/C7L). The USB-5201 supports type types J, K, R, S, T, N, E, and B thermocouples.

### Ground terminals (GND)

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.

### Power terminals (+5V)

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.

### Digital terminals (DIO0 to DIO7)

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.

## 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.

## 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, 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.

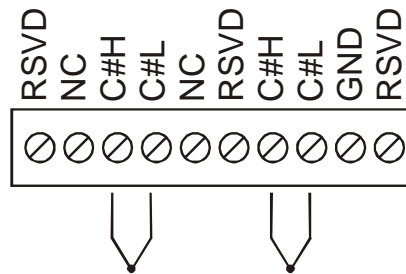


Figure 3. Typical thermocouple connection

Connect thermocouples to the USB-5201 such that they are floating with respect to GND (pins 9, 19, 28, 38). The USB-5201 **GND** 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 (9, 19, 28, 38) and earth ground is maintained.

When thermocouples are attached to conductive surfaces, the voltage differential between multiple thermocouples must remain within  $\pm 1.4$  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  $\pm 25$  VDC when the USB-5201 is powered on, and  $\pm 40$  VDC when the USB-5201 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 k $\Omega$  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).

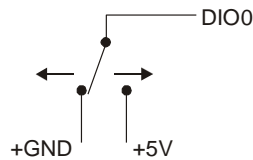


Figure 4. Schematic showing switch detection by digital channel DIO0

**Caution!** All ground pins on the USB-5201 (pins 9, 19, 28, 38) 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](http://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

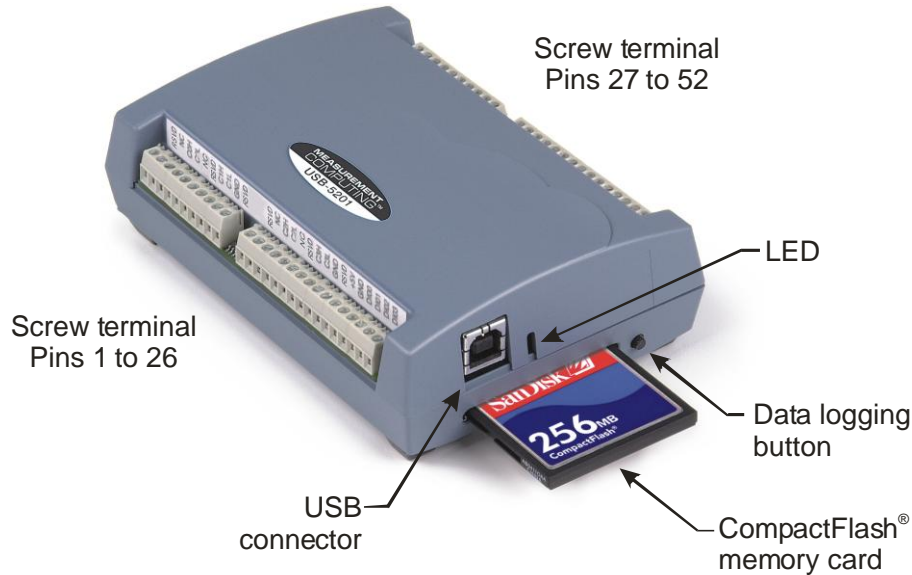


Figure 5. USB-5201 component locations

### 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.

The following table lists the function of the USB-5201 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 table below 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
<i>Logging off</i>	The LED is off.	The USB-5201 is not logging data, and/or the device is not powered
<i>Start Logging on Power Up</i>	The LED turns on when external power is connected, then blinks each time data is captured.	Blinks when logging data.
<i>Start Logging on Button</i>	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.
<i>Start Logging at Specified Time</i>	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.	<ul style="list-style-type: none"> <li>▪ The memory card is full.</li> <li>▪ The memory card was removed during logging. Insert the memory card again to stop the device blinking.</li> </ul>

## CompactFlash<sup>®</sup> memory card slot

The CompactFlash slot accepts standard memory cards. A 256 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.

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

## Disconnecting the USB-5201 from the computer

You don't need to shut down your computer to disconnect the USB-5201. Refer to the instructions below when disconnecting the USB-5201 from your computer's USB port.

When the USB-5201 is installed with firmware revision 3 or later and you are running Windows XP, use the Unplug or Eject icon on the computer's taskbar to safely stop the USB-5201 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.

When running Windows 2000, the Unplug or Eject icon does not appear in the taskbar when the USB-5201 is connected to the USB port. Do not disconnect the USB-5201 from the computer when the device's LED is flashing (transferring data), or data may be lost. When you disconnect the device, an Unsafe Removal of Device warning may appear. However, no data is lost on the device when you remove the USB-5201 when the LED is steady green. This information applies to all USB-5201 devices, regardless of the firmware version installed.

## 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 your USB-5201 and are using a card reader connected to your 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 USB-5201 connected to your computer.

## Specifications

Typical for 25 °C unless otherwise specified.  
Specifications in *italic text* are guaranteed by design.

### Analog input section

Table 1. Generic analog input specifications

Parameter	Conditions	Specification
A/D converters		Four dual 24-bit, Sigma-Delta type
Number of channels		8 differential
<i>Input isolation</i>		<i>500 VDC minimum between field wiring and USB interface</i>
Channel configuration		Thermocouple sensor type
Differential input voltage range	Thermocouple	±0.080 V
<i>Absolute maximum input voltage</i>	<i>±C0x through ±C7x relative to GND (pins 9, 19, 28, 38)</i>	±25 V power on, ±40 V power off.
Input impedance		5 Gigohm, min.
Input leakage current	Open thermocouple detect enabled	105 nA max.
<i>Normal mode rejection ratio</i>	<i>f<sub>IN</sub> = 60 Hz</i>	<i>90 dB min.</i>
<i>Common mode rejection ratio</i>	<i>f<sub>IN</sub> = 50 Hz/60 Hz</i>	<i>100 dB min.</i>
Resolution		24 bits
<i>No missing codes</i>		<i>24 bits</i>
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.
<i>CJC sensor accuracy</i>	<i>15 °C to 35 °C</i>	<i>±0.25 °C typ., ±0.5 °C max.</i>
	<i>0 °C to 70 °C</i>	<i>-1.0 to +0.5 °C max</i>

### Channel configurations

Table 2. Channel configuration specifications

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

**Note 1:** 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.

**Note 2:** The factory default configuration is *Type J*.

## Accuracy

### Thermocouple measurement accuracy

Table 3. Thermocouple accuracy specifications, including CJC measurement error

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

**Note 3:** 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 degree to the maximum error shown. There are CJC sensors on each side of the module. The accuracy listed above assumes the screw terminals are at the same temperature as the CJC sensor. Errors shown do not include inherent thermocouple error. Please contact your thermocouple supplier for details on the actual thermocouple error.

**Note 4:** 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.

**Note 5:** When thermocouples are attached to conductive surfaces, the voltage differential between multiple thermocouples must remain within ±1.4 V. For best results we recommend the use of ungrounded or insulated thermocouples when possible.

## Throughput rate to PC

Table 4. Throughput rate specifications

Number of input channels	Maximum throughput
1	2 Samples/second
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

**Note 6:** 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. Throughput to CompactFlash memory card is limited to 1 S/s per channel.

## Digital input/output

Table 5. Digital input/output specifications

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 via 47 K resistors (default). Pull down to ground (GND) also available.
Digital I/O transfer rate (software paced)	<ul style="list-style-type: none"> <li>▪ Digital input – 50 port reads or single bit reads per second typ.</li> <li>▪ Digital output – 100 port writes or single bit writes per second typ.</li> </ul>
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.

**Note 7:** 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, thermocouples must not be connected to any conductive surfaces that may be referenced to earth ground.

## Temperature alarms

Table 6. Temperature alarm specifications

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 will function both in data logging mode and while attached to USB.
Alarm input modes	<ul style="list-style-type: none"> <li>▪ Alarm when input temperature &gt; T1</li> <li>▪ Alarm when input temperature &gt; T1, reset alarm when input temperature goes below T2</li> <li>▪ Alarm when input temperature &lt; T1</li> <li>▪ Alarm when input temperature &lt; T1, reset alarm when input temperature goes above T2</li> <li>▪ Alarm when input temperature is &lt; T1 or &gt; T2</li> </ul> <p><b>Note:</b> T1 and T2 may be independently set for each alarm.</p>
Alarm output modes	<ul style="list-style-type: none"> <li>▪ Disabled, digital I/O line may be used for normal operation</li> <li>▪ Enabled, active high output (digital I/O line goes high when alarm conditions met)</li> <li>▪ Enabled, active low output (digital I/O line goes low when alarm conditions met)</li> </ul>
Alarm update rate	1 second

## Memory

Table 7. Memory specifications

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

Type	Two high performance 8-bit RISC microcontrollers
------	--

## Data Logging

Table 9. Data logging specifications

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	256 MB CFCARD 256 MB Compact Flash Card for MCC Dataloggers
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
Logging start methods	Configurable: <ul style="list-style-type: none"> <li>▪ Start Logging on Power Up – Logging begins 5 seconds after power on to allow hardware to settle.</li> <li>▪ Start Logging on Button – Device is idle on power on. Press and hold button until LED comes on to begin logging. The first sample will be taken 1 second after LED comes on unless less than 5 seconds have elapsed since power on.</li> <li>▪ 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 will come on. The first sample will be taken 1 second after LED comes on unless less than 5 seconds have elapsed since power on.</li> </ul> <p><b>Note:</b> Data logging is not allowed when the device is attached to an active USB bus due to processing limitations. The device must be connected to the standalone power supply to perform data logging.</p>
Logging stop methods	Stop on button press – To stop logging, press and hold button until LED turns off. <b>Note:</b> The device caches log 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: <ul style="list-style-type: none"> <li>▪ Logging Off mode: the LED is off (disabled).</li> <li>▪ Start Logging on Power Up mode: the LED is on, with a momentary off flash every time data is captured.</li> <li>▪ Start Logging on Button mode: the LED is initially off. When the button is pressed and held for approximately 1 second the LED will turn on and act the same as Start Logging on Power Up mode.</li> <li>▪ Start Logging at Specified Time mode: the LED is off, with a momentary on flash every second until the specified date/time is reached. At that time, the LED will turn on and act the same as Start Logging on Power Up mode.</li> </ul> Other indication: <ul style="list-style-type: none"> <li>▪ 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.</li> <li>▪ If the memory card becomes full the LED will blink rapidly (250 ms period).</li> <li>▪ If the memory card is removed while logging is in progress the LED will blink rapidly (250 ms period). Inserting a memory card will stop the blinking.</li> </ul>

## Real time clock

Table 10. Real time clock specifications

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

## USB +5V voltage

Table 11. USB +5V voltage specifications

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

## Power

Table 12. Power specifications

Parameter	Conditions	Specification
<b>Connected to USB</b>		
Supply current	USB enumeration	<100 mA
Supply current (Note 8)	Continuous mode	500 mA max.
User +5V output voltage range (terminal block pin 21 and 47)	Connected to a self-powered hub. (Note 9)	4.75 V min. to 5.25 V max.
User +5V output current (terminal block pin 21 and pin 47)	Connected to a self-powered hub. (Note 9)	10 mA max.
Isolation	Measurement system to PC	500 VDC min.
<b>AC Adapter Power Supply (used for data logging operation)</b>		
Output voltage		5V ±5%
Output wattage		2.5 W
Input voltage		100 – 240 VAC 50 – 60 Hz
Input current		0.2 A

**Note 8:** This is the total current requirement for the device which includes up to 10 mA for the status LED.

**Note 9:** 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's USB Host Controller. The USB port(s) on your PC are root port hubs. All externally powered root port hubs (desktop PC's) 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

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 2527 or equivalent. (min 24 AWG VBUS/GND, min 28 AWG D+/D-)
USB cable length	3 meters max.

## Environmental

Table 14. Environmental specifications

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

## Mechanical

Table 15. Mechanical specifications

Dimensions	127 mm (L) x 88.9 mm (W) x 35.56 (H)
User connection length	3 meters max.

## Screw terminal connector type and pin out

Table 16. Screw terminal connector specifications

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

## Screw terminal pin out

Table 17. Screw terminal pin out

Pin	Signal Name	Pin Description	Pin	Signal Name	Pin Description
1	RSVD	Reserved, Do Not Use	27	RSVD	Reserved, Do Not Use
2	NC		28	GND	
3	C0H	CH0 sensor input (+)	29	C7L	CH7 sensor input (-)
4	C0L	CH0 sensor input (-)	30	C7H	CH7 sensor input (+)
5	NC		31	RSVD	Reserved, Do Not Use
6	RSVD	Reserved, Do Not Use	32	NC	
7	C1H	CH1 sensor input (+)	33	C6L	CH6 sensor input (-)
8	C1L	CH1 sensor input (-)	34	C6H	CH6 sensor input (+)
9	GND		35	NC	
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		38	GND	
13	C2H	CH2 sensor input (+)	39	C5L	CH5 sensor input (-)
14	C2L	CH2 sensor input (-)	40	C5H	CH5 sensor input (+)
15	NC		41	RSVD	Reserved, Do Not Use
16	RSVD	Reserved, Do Not Use	42	NC	
17	C3H	CH3 sensor input (+)	43	C4L	CH4 sensor input (-)
18	C3L	CH3 sensor input (-)	44	C4H	CH4 sensor input (+)
19	GND		45	NC	
20	RSVD	Reserved, Do Not Use	46	RSVD	Reserved, Do Not Use
21	+5V	+5V output	47	+5V	+5V output
22	GND		48	GND	
23	DIO0	Digital Input/output	49	DIO7	Digital Input/output
24	DIO1	Digital Input/output	50	DIO6	Digital Input/output
25	DIO2	Digital Input/output	51	DIO5	Digital Input/output
26	DIO3	Digital Input/output	52	DIO4	Digital Input/output

# CE 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:

EU EMC Directive 89/336/EEC: Electromagnetic Compatibility, EN 61326 (1997) Amendment 1 (1998)

Emissions: Group 1, Class A

- EN 55011 (1990)/CISPR 11: Radiated and Conducted emissions.

Immunity: EN61326, Annex A

- IEC 61000-4-2 (1995): Electrostatic Discharge immunity, Criteria C.
- IEC 61000-4-3 (1995): Radiated Electromagnetic Field immunity Criteria A.
- IEC 61000-4-8 (1994): Power Frequency Magnetic Field immunity Criteria A.

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.

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



Carl Haapaoja, Director of Quality Assurance

**Measurement Computing Corporation**  
**10 Commerce Way**  
**Suite 1008**  
**Norton, Massachusetts 02766**  
**(508) 946-5100**  
**Fax: (508) 946-9500**  
**E-mail: [info@mccdaq.com](mailto:info@mccdaq.com)**  
**[www.mccdaq.com](http://www.mccdaq.com)**