WLS-TC

Wireless Thermocouple Measurement

User's Guide

Document Revision 4A
April 2014

MEASUREMENT COMPUTING™

Trademark and Copyright Information

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 that, 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

About this User's Guide

What you will learn from this user's guide

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

Conventions in this user's guide

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 WLS-TC hardware is available on our website at www.mccdaq.com. You can also contact Measurement Computing Corporation with specific questions.

- Knowledgebase: kb.mccdaq.com
- 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

Introducing the WLS-TC

Overview: WLS-TC features

The WLS-TC is a wireless-based USB 2.0 full-speed thermocouple input module that is supported under popular Microsoft® Windows® operating systems. The WLS-TC is fully compatible with both USB 1.1 and USB 2.0 ports.

The WLS-TC provides eight differential thermocouple input channels. 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.

With the WLS-TC, you can take measurements from type J, K, R, S, T, N, E, and B thermocouples.

The WLS-TC provides two integrated cold junction compensation (CJC) sensors for thermocouple measurements.

An open thermocouple detection feature lets you detect a broken thermocouple. An onboard microprocessor automatically linearizes the measurement data.

The WLS-TC 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.

All configurable options are software programmable. The WLS-TC is fully software-calibrated.

You can operate the WLS-TC as a standalone plug-and-play device which draws power through the USB cable. You can also operate the WLS-TC as a remote device that communicates with the computer through the WLS-IFC USB-to-wireless interface device. An external power supply is shipped with the device to provide power during remote operations.

Remote wireless operation

When operating as a remote device, the WLS-TC communicates with the computer through the WLS-IFC device connected to the computer's USB port.

Before you can operate the WLS-TC remotely, you must connect it to the computer's USB port and configure the network parameters required to establish a wireless link with the interface device. Only devices with the same parameter settings can communicate with each other. All configurable options are programmable with InstaCal.

LEDs on the WLS-TC indicate the status of communication over the wireless link. An LED bar graph shows the fade margin of signals received by the WLS-TC.

For more information on setting up network parameters, refer to "Network parameters (remote operation)" on page 10.

WLS-TC block diagram

WLS-TC functions are illustrated in the block diagram shown here.

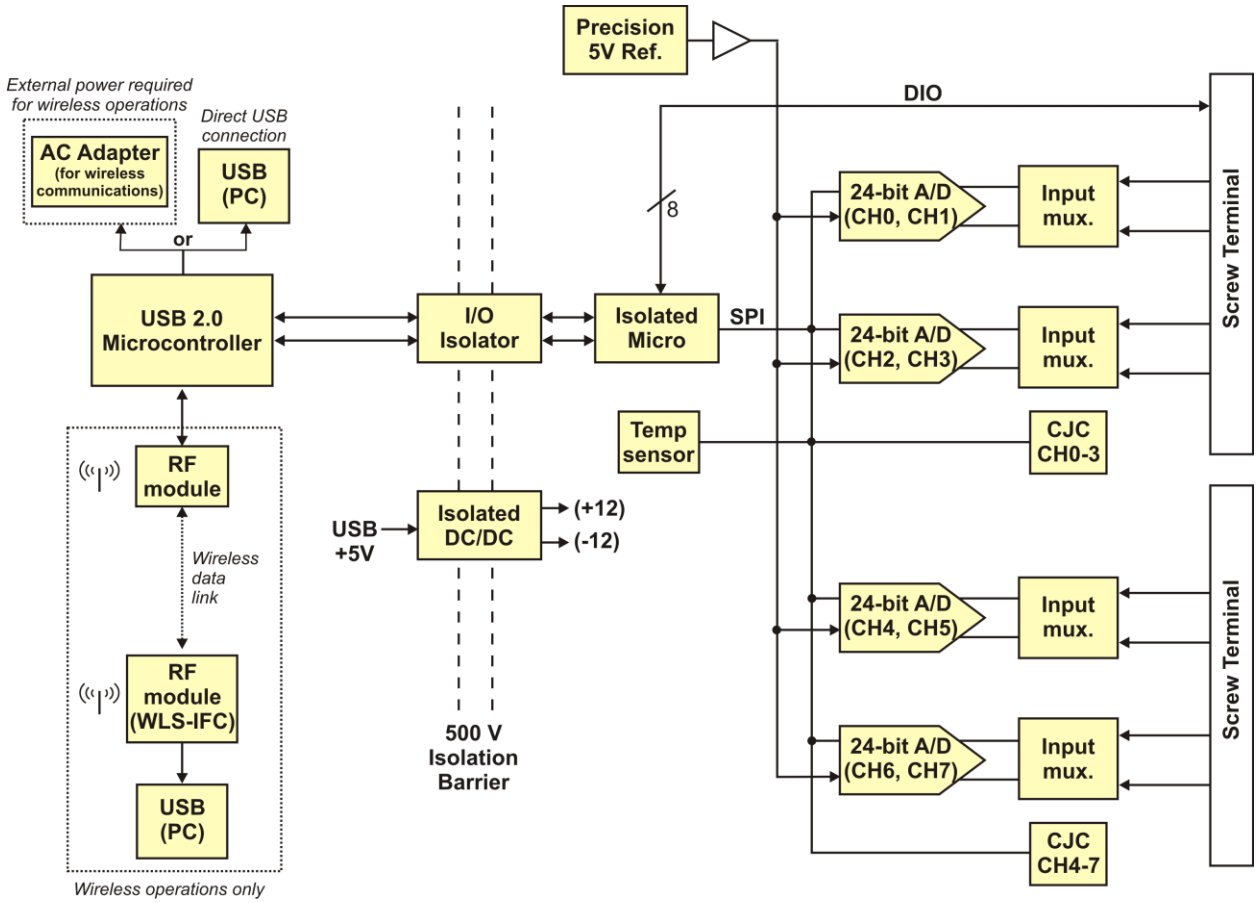


Figure 1. WLS-TC functional block diagram

Installing the WLS-TC

What comes with your WLS-TC shipment?

The following items are shipped with the WLS-TC.

Hardware

- WLS-TC
- USB cable
- USB power adapter (2.5 watt AC-to-USB power adapter for remote wireless operation)

Software

- MCC DAQ Software CD

Documentation

- MCC DAQ Software Quick Start Guide

  This booklet provides an overview of the MCC DAQ software you received with the device, and includes information about installing the software. Please read this booklet completely before installing any software or hardware.
- Setup Options

  An overview of installation options is provided in the *Wireless Setup* document that ships with the device.

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.

If any components are missing or damaged, contact us immediately using one of the following methods:

- Knowledgebase: kb.mccdaq.com
- 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

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

Installing the software

Refer to the *Quick Start Guide* for instructions on installing the software on the MCC DAQ CD. This booklet is available in PDF at www.mccdaq.com/PDFmanuals/DAQ-Software-Quick-Start.pdf.

Installing the hardware

Before you operate the WLS-TC as a local or remote device, first install it onto your system and configure it with InstaCal.

Install the MCC DAQ software before you install the WLS-TC

The driver needed to run your board is installed with the MCC DAQ software. Therefore, you need to install the MCC DAQ software before you install your board. Refer to the *Quick Start Guide* for instructions on installing the software.

Complete the following steps to connect the WLS-TC to your system:

1. 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 WLS-TC.

Always connect an external hub to its power supply

If you are using a hybrid hub (one that can operate in either self-powered or bus-powered mode), always connect it to its external power supply.

If you use a hub of this type without connecting to external power, communication errors may occur that could result in corrupt configuration information on your wireless device. You can restore the factory default configuration settings with InstaCal.

When you connect the WLS-TC for the first time, a notification message opens as the WLS-TC is detected. After your system detects new hardware, the **Found New Hardware Wizard** opens and prompts you to respond to the question "*Can Windows connect to Windows Update to search for software?*"

2. Click on the **No, not this time** option, and then click on the **Next** button.

   The next dialog prompts you for the location of the software required to run the new hardware.

3. Keep the default selection "*Install the software automatically*" and then click on the **Next** button.

   The wizard locates and installs the software on your computer for the WLS-TC. A dialog appears when the wizard completes the installation.

4. Click on the **Finish** button to exit the wizard.

A dialog box opens when the hardware is installed and ready to use. The **Command** LED will blink and then remain on to indicate that communication is established between the WLS-TC and your computer. The **Wireless Power** LED turns on to indicate that the internal RF module is receiving power.

If the Command LED turns off

If the Command LED is on but then turns off, the computer has lost communication with the WLS-TC. If the WLS-TC is connected to the computer USB port, disconnect the USB cable from the computer and then reconnect it. This should restore communication, and the LED should turn back *on*.

If the Command LED turns off when you are operating the WLS-TC remotely through the wireless interface, disconnect the USB cable from the USB power adapter, and then reconnect it. This should restore communication, and the Command LED should turn back *on*.

Configuring the WLS-TC

Before using the WLS-TC, configure the temperature sensors and network parameters for remote wireless communication. All hardware configuration options on the WLS-TC are programmable with InstaCal.

Configuration options are stored on the WLS-TC in non-volatile memory in EEPROM, and are loaded on power up.

Thermocouple type

Use *Insta*Cal to set the thermocouple type for each channel. The factory default thermocouple configuration is *Type J*. You can configure thermocouple settings when the WLS-TC is connected locally to the computer through the USB port, or when the device is operated remotely through the wireless interface.

Network parameters (remote operation)

The following network parameter options are programmable with InstaCal.

- **Identifier**: Text that identifies the device (optional).
- **PAN (hex)**: The personal area network (PAN) ID assigned to the device.

  The PAN value is a number used to identify the interface device with which you want to communicate. The WLS-TC can only communicate with a device whose PAN is set to the same value.

  Most users do not need to change the default value assigned to the device. However, you may want to assign a different PAN ID in the following situations:

  - You have multiple WLS Series devices, and do not want to allow communication between all of them. Set the PAN ID to the same value on each device that you want to communicate.
  - If other WLS Series devices are operating in the vicinity, you can avoid accidental changes to your device settings by changing the default PAN value.
- **CH**: The radio frequency (RF) channel number assigned to the device.

  The channel number is used to transmit and receive data over the wireless link. You may want to change the channel number in InstaCal when another WLS Series device is already transmitting on that channel, or when noise is present on the channel.

  The table below lists each available channel and its corresponding transmission frequency.

RF Channel	Transmission Frequency (GHz)	RF Channel	Transmission Frequency (GHz)
12	2.410	18	2.440
13	2.415	19	2.445
14	2.420	20	2.450
15	2.425	21	2.455
16	2.430	22	2.460
17	2.435	23	2.465

- **AES Key**: Value used to encrypt data (optional).

  AES encryption is disabled by default. Unless you suspect that there are other users of WLS Series devices in the area, there should be no need to enable encryption. However, if you suspect that there are other WLS Series devices in the area, and you need to secure the devices from being accessed by other users, enable AES encryption.

  Enabling encryption does NOT secure the device from access through a local USB connection. A remote device configured for encryption can be connected locally through the USB port to access other remote WLS Series devices with the same settings; you may need to physically secure the remote devices to prevent tampering of the of device's network.

Set the PAN ID, RF channel, and AES key to the same value for each device that you want to communicate

Only devices with matching parameter settings for PAN, CH, and AES Key (if set) can communicate with each other.
For information on setting up the network parameters for your WLS-TC, refer to the "WLS Series" section of the "Temperature Input Boards" chapter in the Universal Library Help.

After configuring the network parameters, disconnect the WLS-TC from the computer, and move the device to its remote location. The WLS-TC can be located up to 150 feet (50 meters) indoors, or up to ½ mile (750 m) outdoors from the interface device.

Restoring factory default settings

You can restore the factory default configuration settings with InstaCal.

Connecting the external power supply for remote operation

Connect the USB cable to the AC-to-USB power adapter when you are operating the WLS-TC remotely through the wireless interface. The **Command** and **Wireless Power** LEDs turn on approximately five seconds after you connect the AC power adapter.

Caution! To satisfy FCC RF exposure requirements for mobile transmitting devices, maintain a separation distance of 20 cm (0.66 feet) or more between the antenna of this device and personnel during device operation. To ensure compliance, operation at closer than this distance is not recommended. The antenna used for this transmitter must not be co-located in conjunction with any other antenna or transmitter.

Calibrating the WLS-TC

You can fully calibrate the WLS-TC using InstaCal. Allow a 30-minute warm up before calibrating. The normal calibration interval is once per year.

You can calibrate the WLS-TC when it is connected locally to the computer through the USB port, or when it is operating remotely through the wireless interface.

Warm up time

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

Sensor Connections

The WLS-TC supports type J, K, R, S, T, N, E, and B thermocouples.

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 WLS-TC has four banks of screw terminals. There are 26 connections on each side. Between each bank of screw terminals are two integrated CJC sensors used for thermocouple measurements. Signals are identified in Figure 2.

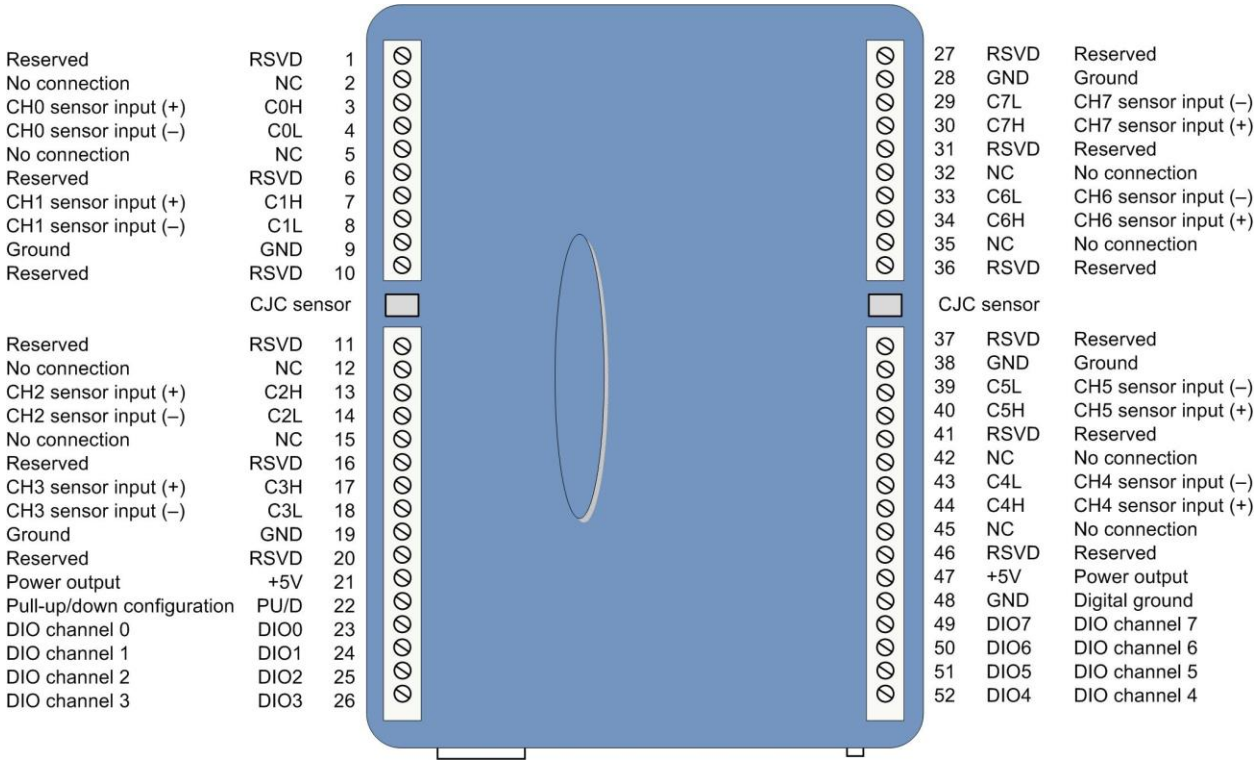


Figure 2. WLS-TC screw terminal pin numbers

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

Tighten screw terminal connections

When making screw terminal connections, be sure to tighten the screw until tight. 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). The WLS-TC supports type J, K, R, S, T, N, E, and B thermocouples.

CJC sensors

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

Power outputs

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

Ground

The six 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 WLS-TC 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 which automatically detects an open or broken thermocouple is available for each analog input.

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 WLS-TC using a differential configuration, as shown in Figure 3.

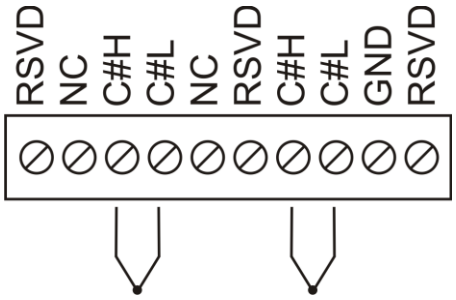


Figure 3. Typical thermocouple connection

Connect thermocouples to the WLS-TC so that they float with respect to GND (pins 9, 19, 28, 38). The WLS-TC **GND** pins are isolated from earth ground, so you can connect thermocouple sensors to voltages referenced to earth ground as long as you maintain the isolation between the GND pins (9, 19, 28, 38) and earth ground.

When you attach thermocouples to conductive surfaces, the voltage differential between multiple thermocouples must remain within ±1.4 V. For best results, 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 WLS-TC is powered on, and ±40 VDC when the WLS-TC 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 +5V with a 47 K ohm resistor (default). You can request the factory to configure the resistor for pull-down to ground if desired.

When you configure the digital bits for input, you can use the WLS-TC 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 +5V input, DIO0 reads *TRUE* (1). If you move the switch to GND, DIO0 reads *FALSE* (0).

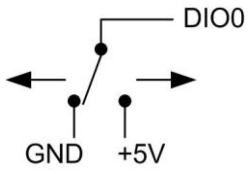


Figure 4. Schematic showing switch detection by digital channel DIO0

Caution! All ground pins on the WLS-TC (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).

Configuring the DIO channels to generate alarms

The WLS-TC features eight independent temperature alarms. All alarm options are software configurable. Remote alarm configuration is supported.

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 also 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 in wireless operations and while attached to the USB port on a computer.

You can configure alarm settings when you connect the WLS-TC locally to the computer through the USB port, or when operating it remotely through the wireless interface.

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 WLS-TC 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 WLS-TC 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 WLS-TC 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 WLS-TC subtracts the *cold junction* voltage from the thermocouple voltage.

The WLS-TC has two high-resolution temperature sensors that are integrated into the design of the WLS-TC. 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 onboard 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 WLS-TC is equipped with open-thermocouple detection for each analog input channel. The maximum open detection time is 3 seconds.

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, a maximum of 105 nA 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:

error voltage = resistance of the thermocouple x 105 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 OTD disabled, a maximum of 30 nA of input leakage current is injected into the thermocouple.

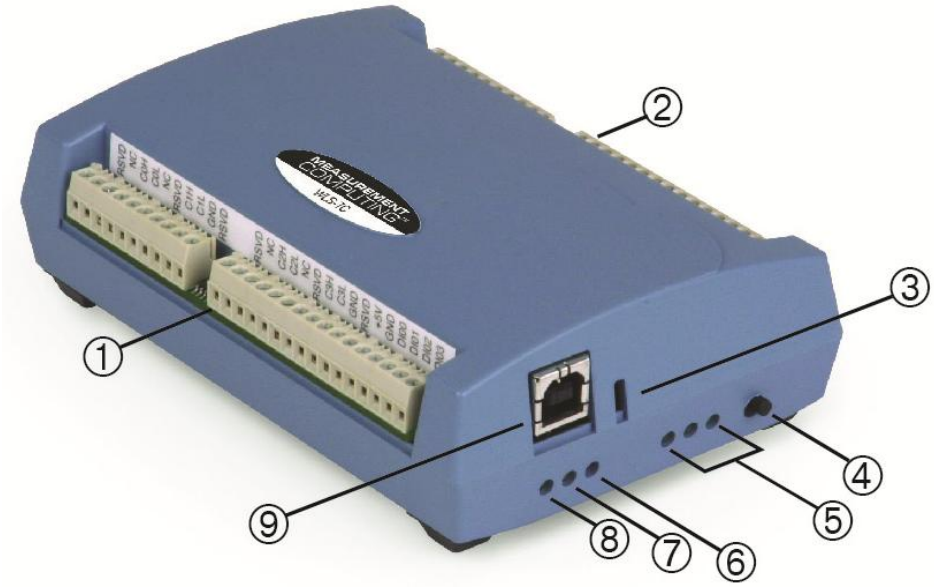
AC power supply

The external power supply is an AC-to-USB 2.5 W supply that is used to power the WLS-TC during remote wireless operations (MCC p/n *USB Power Adapter*.)

External components

The WLS-TC has the following external components, as shown in Figure 5.

- Screw terminals
- USB connector
- Status LEDs (Command, Wireless Power, Transmit, Receive, Received Signal Strength indicators)
- LED Test button



1	Screw terminal pins 1 to 26	6	Receive LED
2	Screw terminal pins 27 to 52	7	Transmit LED
3	Command LED	8	Wireless Power LED
4	LED Test button	9	USB connector
5	Received Signal Strength (RSS) LEDs		

Figure 5. WLS-TC component locations

Screw terminals

The device's four banks of screw terminals are for connecting thermocouples and digital I/O lines. These terminals also provide ground and power output connections. Refer to the "Screw terminal pin out " section on page 12 for screw terminal descriptions.

Caution! The two **+5V** terminals (pin 21 and pin 47) are isolated (500 VDC) from the USB +5V. Each +5V terminal is an output. Do not connect to an external power supply or you may damage the WLS-TC and possibly the computer.

Status LEDs

The LEDs indicate the communication status of USB and wireless operations. In addition, three LEDs indicate the signal strength of data transmitted over the wireless link. Refer to the table below for the function of each LED.

LED functions

LED	Function
Command	Steady green – the WLS-TC is connected to a computer or AC adapter
	Blinking green – the WLS-TC is receiving a command over the USB or wireless link.
Wireless Power (green)	The WLS-TC device's internal RF module is receiving power (USB or AC adapter)
Transmit (yellow)	Data is being transmitted over an active wireless link.
Receive (red)	Data is being received over an active wireless link.
Received Signal Strength (RSS) indicators LEDs	3 green LED bar graph. The LEDs will turn on when receiving a wireless message and stay on for approximately 1 second after the end of the message. They indicate the amount of fade margin present in an active wireless link. Fade margin is defined as the difference between the incoming signal strength and the device's receiver sensitivity. ■ Three LEDs on: Very strong signal (> 30 dB fade margin) ■ Two LEDs on: Strong signal (> 20 dB fade margin) ■ One LED on: Moderate signal (> 10 dB fade margin) ■ No LEDs on: Weak signal (< 10 dB fade margin)

LED Test button

The LED test button tests the functionality of the LEDs. When pressed, each LED lights in sequence (first the Command LED then left to right from the Wireless Power LED to the RSS indicator LEDs).

USB connector

The USB connector provides +5V power and communication. External power is required to operate the WLS-TC remotely through the wireless interface.

For local operation, connect to the USB port or hub on your computer. For remote wireless operation, connect to the AC-to-USB power adapter that shipped with the device.

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	Condition	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 (pins 9, 19, 28, 38)*	±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 configurations

Table 2. Channel configuration specifications

Sensor Category	Condition	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 or wireless 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 (USB or wireless)

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 device is approximately 0.5 seconds.

Digital input/output

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 via 47 K kΩ resistors (default). Pull down to ground (GND) 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

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

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 will function both in wireless 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 **Note**: 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

Microcontroller

Table 8. Microcontroller specifications

Parameter	Specification
Type	Three high performance 8-bit RISC microcontrollers

Wireless communications

Table 9. Wireless communications specifications

Parameter	Specification
Communication standard	*IEEE 802.15.4, ISM 2.4GHz frequency band, non-beacon, point-to-point*
Range	Indoor/urban: Up to 150 ft (50 m) Outdoor RF line-of-sight: Up to ½ mile (750 m)
Transmit power output	10 mW (10 dBm)
Receiver sensitivity	*–100 dBm (1% packet error rate)*
RF channels	*12 direct sequence channels available, channels 12 – 23 (2.410 – 2.465 GHz) (software selectable)*
Addressing	16-bit PAN (personal area network) IDs per channel (software selectable) 64-bit device address
Encryption	*128-bit AES (software selectable)*

Note 8: Contains FCC ID: OUR-XBEEPRO. The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (*i.*) this device may not cause harmful interference and (*ii.*) this device must accept any interference received, including interference that may cause undesired operation.

Note 9: Canada: Contains Model XBee Radio, IC: 4214A-XBEEPRO

Caution! To satisfy FCC RF exposure requirements for mobile transmitting devices, a separation distance of 20 cm or more should be maintained between the antenna of this device and persons during device operation. To ensure compliance, operations at closer than this distance is not recommended. The antenna used for this transmitter must not be co-located in conjunction with any other antenna or transmitter.

USB +5V voltage

Table 10. USB +5V voltage specifications

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

Power

Table 11. Power specifications

Parameter	Condition	Specification
Connected to USB		
Supply current		500 mA max
User +5V output voltage range (terminal block pin 21 and 47)	Connected to a self-powered hub. (Note 10)	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 10)	10 mA max
Isolation	*Measurement system to PC*	*500 VDC min*
Wireless Communications operation		
Supply current		500 mA max
AC Adapter power supply (used for remote wireless communications operation)		
Standalone power supply		USB power adapter 2.5 Watt USB adapter with interchangeable plugs (Includes plug for USA)
Output voltage		5V ±5%
Output wattage		2.5 W
Input voltage		100 – 240 VAC 50 – 60 Hz
Input current		0.2 A

Note 10: 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 12. USB specifications

Parameter	Specification
USB device type	USB 2.0 (full-speed)
Device compatibility	USB 1.1, USB 2.0
	Bus 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 max

Environmental

Table 13. 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

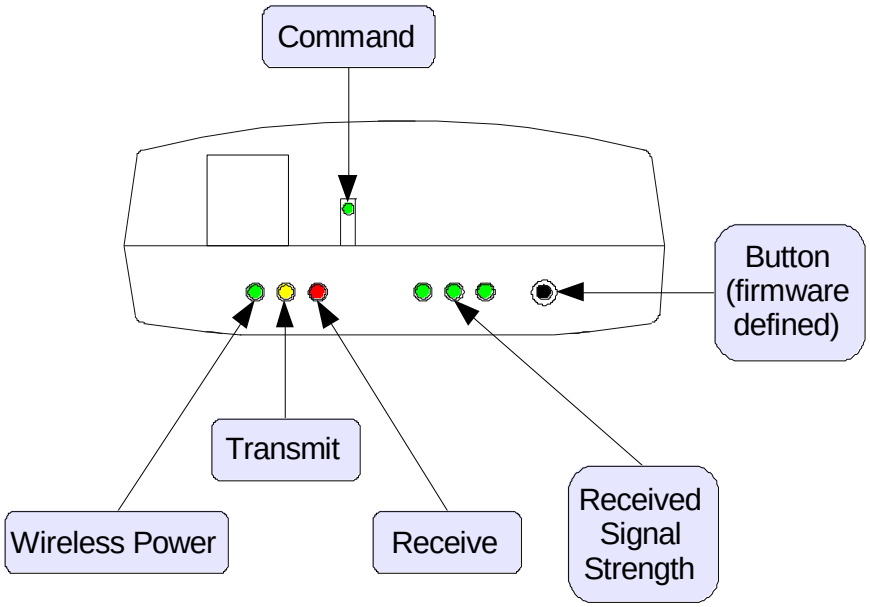
Table 14. Mechanical specifications

Parameter	Specification
Dimensions (L × W × H)	128.52 x 88.39 × 35.56 mm (5.06 × 3.48 × 1.43 in.)
USB cable length	3 m (9.84 ft) max

LED / button configuration

Table 15. LED configuration

Parameter	Specification
Command LED	Green LED – indicates a command was received by the device (either USB or wireless)
Received Signal Strength Indicator (RSSI) LEDs	Three green LED bar graph. The LEDs will turn on when receiving a wireless message, and stay on for approximately 1 second after the end of the message. These LEDs indicate the amount of fade margin present in an active wireless link. Fade margin is defined as the difference between the incoming signal strength and the device's receiver sensitivity. ■ 3 LEDs on: Very strong signal (> 30 dB fade margin) ■ 2 LEDs on: Strong signal (> 20 dB fade margin) ■ 1 LED on: Moderate signal (> 10 dB fade margin) ■ 0 LEDs on: Weak signal (< 10 dB fade margin)
Wireless Power LED	Green LED: the internal RF module is receiving power.
Transmit LED	Yellow LED: data is being transmitted over the wireless link.
Receive LED	Red LED: data is being received over the wireless link.
Button	Firmware defined; this revision executes an LED test.



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	
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	Power output	47	+5V	Power 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 3	52	DIO4	DIO channel 4

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

WLS-TC

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 B

- 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.

ETSI EN301 489-1 (2004)
IEC 61000-3-2 (2001) Harmonic Current Emissions, IEC 61000-3-3 (2003) Voltage Fluctuations and Flicker

Emissions: Group 1, Class B

- CISPR 22 (2004): Radiated and Conducted Electromagnetic Emissions (USB cable with ferrite suppressor assembly required).
- IEC 61000-3-2 (2001): Harmonic Emissions Class A
- IEC 61000-3-3 (2003): Fluctuations and Flicker

Immunity:

- IEC 61000-4-2 (2001): Electrostatic Discharge immunity, Criteria C.
- IEC 61000-4-3 (2002): Radiated Electromagnetic Field immunity Criteria A.
- IEC 61000-4-4 (2004): Electric fast transient burst immunity Criteria B.
- IEC 61000-4-5: Fast surge immunity Criteria B
- IEC 61000-4-6 (2003): Radio Frequency Common Mode immunity Criteria B*.
- IEC 61000-4-11 (2004): Voltage dips and interrupt immunity Criteria B

* There may be a loss of performance in the presence of an RF electromagnetic disturbance on the input/output ports. Performance loss will be limited to measured temperatures outside of specified accuracy. The transmitter / receiver will continue to operate as specified. Stored data and operating state will be maintained during the disturbance. Operation will recover to within specified limits after the disturbance is removed.

Declaration of Conformity based on tests conducted by Chomerics Test Services, Woburn, MA 01801, USA in November, 2006. Test records are outlined in Chomerics Test Report #EMI4660.06.

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
www.mccdaq.com