TC-32

32-Channel Thermocouple Input USB/Ethernet DAQ Device

User's Guide

MEASUREMENT COMPUTING™

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Notice

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 TC-32 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 TC-32 hardware is available on our website at www.mccdaq.com. You can also contact Measurement Computing Corporation with specific questions.

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

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

Introducing the TC-32

The TC-32 is a dual-interface data acquisition device that provides the following features:

- 32 differential thermocouple (TC) inputs, expandable to 64 channels with the TC-32-EXP expansion device [1]
- Two 24-bit ADCs (one ADC per 16 inputs)
- TC channels field-to-host isolation
- 3 S/s per update rate
- Support for type J, K, R, S, T, N, E, and B thermocouples, software-selectable per channel
- One integrated cold junction compensation (CJC) sensor per TC input
- Open thermocouple detection (OTD) to detect faulty TC connections
- 8 digital inputs, isolated from TC and host
- 32 digital outputs/alarms isolated from TC inputs and host
- DIO connections are made to 50-pin header connector
- USB 2.0 or 10/100 Ethernet interface
- Powered by the included +5 V external power adapter (PS-5V2AEPS)

Ethernet interface

The TC-32 has a built-in 10/100 BASE-T auto-negotiation, high-speed communication port.

With the Ethernet interface, you can remotely access and configure your TC-32 from anywhere on the network. Only one computer can control the TC-32 at a time.

A unique *media access control* (MAC) address is assigned to each device at the factory. You configure the Ethernet connection settings through software. The network name uses the format `TC-32-xxxxxx`, where `xxxxxx` are the lower six digits of the factory-assigned MAC address.

USB interface

The TC-32 is a USB 2.0 full-speed device that is compatible with USB 3.0 ports. The device is also compatible with USB 1.1 ports.

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[1] 40-pin ribbon cable for the **EXPANSION** connector is included with the TC-32-EXP.

Functional block diagram

Device functions are illustrated in the block diagram shown here:
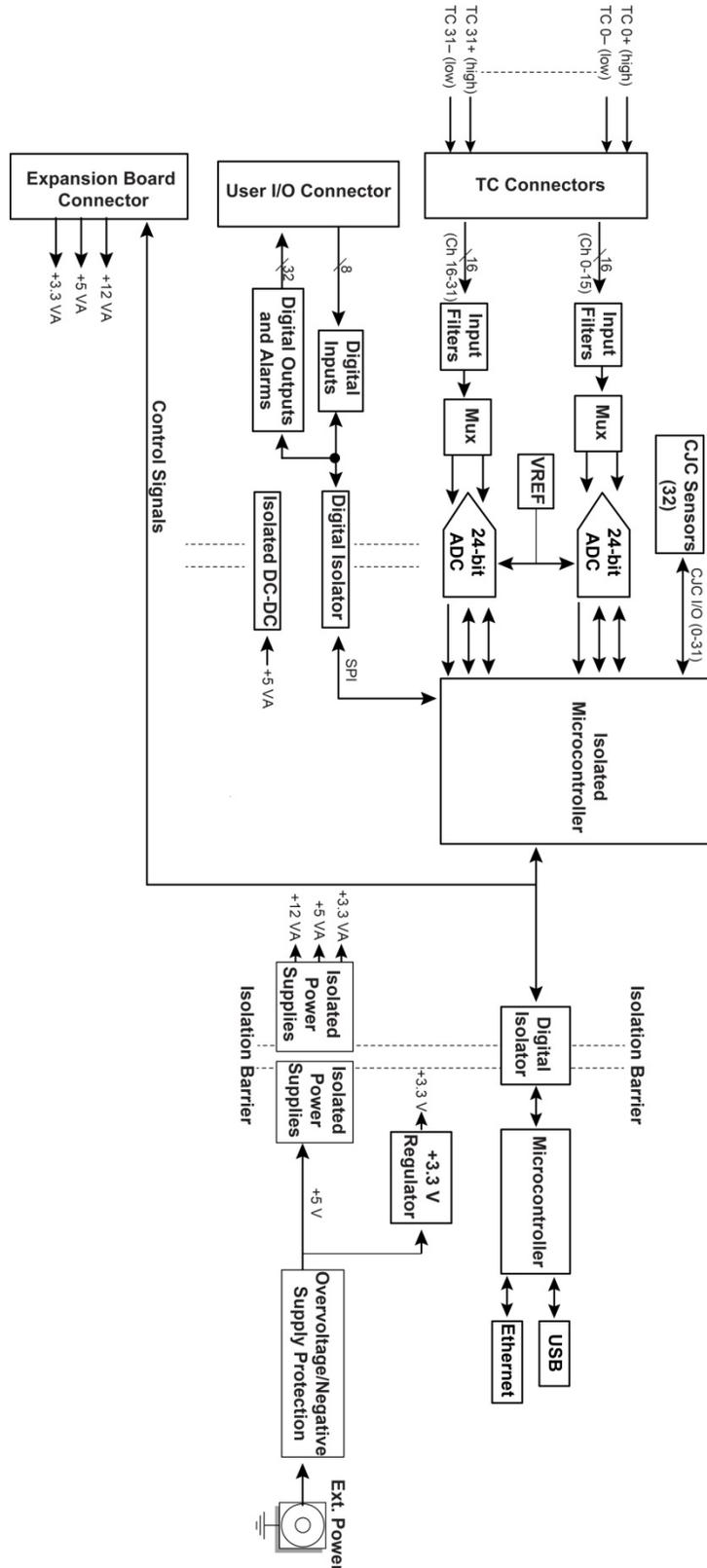
Figure 1. TC-32 functional block diagram

Installing the TC-32

Unpacking

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

Installing the software

Refer to the MCC DAQ Software Quick Start for instructions on installing the software on the MCC DAQ CD. Refer to the device product page on the Measurement Computing website for information about the included and optional software supported by the TC-32.

> **Install the software before you install your device**
>
> The driver needed to run the TC-32 is installed with the software. Therefore, you need to install the software package you plan to use before you install the hardware.

Connecting the external power adapter

Power to the TC-32 is provided with the 5 V external power adapter (PS-5V2AEPS). Connect the adapter cord to the power connector on the TC-32 device, and plug the AC adapter into an electrical outlet.

The **Power** LED turns on when 5 V power is supplied to the TC-32. If the voltage supply is less than 4.0 V or more than 5.75 V, the **POWER** LED does not turn on.

Refer to Figure 2 on page 11 for the location of the **Power** LED.

Installing the hardware

The TC-32 can run on either a USB or Ethernet interface.

Installing on USB

Connect the TC-32 using the cable provided to a to a USB port on a computer running Windows. Windows finds and installs the device driver automatically, and notifies you that the device is ready to use.

Installing on Ethernet

The TC-32 requires a TCP/IP and UDP connection to a network or computer. Use the standard Ethernet cable provided to connect the TC-32 to a 10Base-T or 100Base-TX compatible Ethernet port, hub, or switch.

When connecting the TC-32 for the first time, make sure that you connect to a local network with DHCP enabled.

If you are unsure whether you have access to a local network or that DHCP is enabled on that network, you should use a direct connection to a Windows PC.

It may take a minute or two to detect the device and assign the address. The green **Link/activity** LED on the lower left of the Ethernet connector turns on when there is a valid Ethernet link, and blinks when network activity is detected.

Once the TC-32 is physically connected to the local network or PC, you can run the software (InstaCal for example) to establish a connection. If a connection cannot be established, make sure the device is using the default configuration by following the instructions in the Restoring factory default network settings on page 10.

Once a connection is established and you can communicate to the device, you can change the configuration for other network scenarios.

Configuring network settings

The following TC-32 network settings are software-selectable. Only one user at a time can connect to the TC-32 to configure network options on the device. For typical local networks, the default settings are recommended.

Address mode settings

The address mode setting determines whether the default IP parameters (IPv4 address, subnet mask, and gateway) are assigned to the TC-32 or an auto-addressing method is used to assign these parameters.

DHCP or link-local enabled (default)

If connected to a network with a DHCP server, the service automatically assigns IP addresses to the TC-32.

If the connected network does not have a DHCP server, the address stored in the default IP address is assigned to the TC-32.

If the TC-32 is directly connected to a Windows PC or other host that supports link-local addressing, a link-local address is assigned to the device. A link-local address is valid only for communications between the TC-32 and the device to which it is connected

DHCP Only

Enables configuration by a DHCP server if one is available. The TC-32 is assigned an IP address shortly after it is powered up and attached to the network.

Link Local Only

The TC-32 is assigned a link-local IP address by the Windows PC or other host that supports link-local addressing. A link-local address is valid only for communications between the TC-32 and the device to which it is connected.

Static

The default **IPv4 Address** is manually configured on the TC-32.

IP address settings

The default settings of the following IP address are assigned to the TC-32 when automatic addressing is disabled or not available (DHCP or Link Local for example)

- **IPv4 address** – The IP address that is stored on the device. The default IPv4 address is 192.168.0.101.
- **Subnet mask** – The Subnet mask that is stored on the TC-32 . The subnet mask determines the number of bits of the IP address that is used for the host portion of the address vs. the number of bits used for the network portion. The default subnet mask is 255.255.255.000
- **Gateway** – The gateway IP address that is stored on the TC-32. The gateway address of the device that bridges subnets within a network. The default gateway is 192.168.0.1

Connection code

The connection code is a number between 0 (default) and 999999999. You can change this number from its default of 0 to prevent other users from connecting to and configuring the device. The device remains visible to other users on the network, but connection by another user is not allowed.

Setting up the TC-32 for communication across networks

In order to communicate with the TC-32 from a computer connected to a different network – such as over the Internet – you must change the network configuration of the network router.

In the following procedure, the TC-32 is installed on the *host* LAN, the computer is installed on the *client* LAN, and it is assumed that you have you have successfully connected the device to a local network.

Caution! This procedure should only be performed by a network administrator or computer professional. Incorrect settings can significantly disrupt a network.

1. Determine the IP address of the device. If the address was assigned by DHCP, it is recommended you change it to a static address by setting the default address to the address assigned and setting the device network configuration to static.

2. Configure the firewall/router to forward incoming traffic to the following ports to the IP address assigned to the device:
   o UDP:54211 (discovery)
   o TCP:54211 (commands)

3. On the computer connected to the client LAN, manually enter the WAN address of the host router, and specify the ports that were forwarded to connect to the remote TC-32.

Calibrating the hardware

Factory calibration

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

Field calibration

The TC-32 supports field calibration. Calibrate the device using InstaCal whenever the ambient temperature changes by more than ±10 °C from the last calibration.

The following items are required to perform field calibration on a TC-32:

▪ a precision voltage source
▪ a voltmeter

Each ADC (two ADCs per device) is measured at three points and a linear correction is calculated.

When prompted, enter the voltmeter reading to a precision of three decimal places.

MCC strongly recommends that you warm up the TC-32 for at least 20 minutes prior to performing field calibration.

Updating firmware

Your DAQ device contains firmware that can be updated in the field if required. Firmware is available for download at www.mccdaq.com/firmware.aspx. MCC recommends that you check this page periodically to see if an update to your device firmware is available.

Restoring factory default network settings

To reset the network configuration settings to the factory default values, complete the following steps:

1. Use a ballpoint pen to press and hold in the **Reset** button for at least four seconds until both the **Power** and **Activity** LEDs blink , indicating that the settings have been restored to the factory defaults.

2. Release the button so the device continues startup with the default settings. If the button is released before the two LEDs blink, the settings are not affected and the device starts up normally.

If InstaCal is open when default settings are restored, click the **Refresh Boards** button on the InstaCal toolbar to reflect the changes.

Functional Details

External components

TC-32 front panel components are shown in Figure 2.

1	TC input channels 0 through 31 (32 mini-jack connectors)	4	**ALARM** LED
2	**POWER** LED	5	**OPEN TC** LED
3	**ACTIVITY** LED		
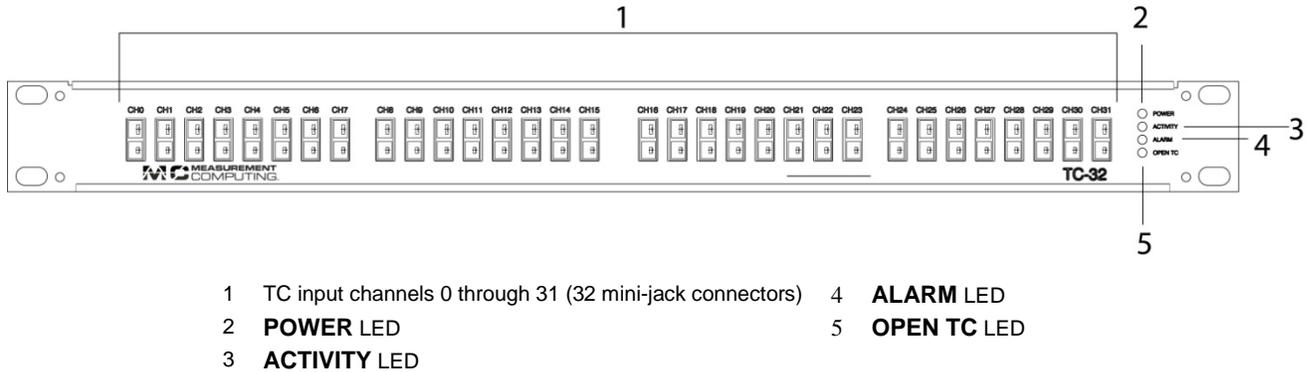
Figure 2. TC-32 front panel components

TC-32 rear panel components are shown in Figure 3.

1	Factory **RESET** button	6	Chassis ground connector
2	**USB** connector	7	40-pin **EXPANSION** connector
3	**ETHERNET** connector	8	Eight digital input (**DIN**) pull-up switches
4	External power (**EXT DC**) connector	9	32 digital output (**DOUT**) pull-up switches
5	Power switch (**PWR**)	10	50-pin **DIGITAL I/O** connector
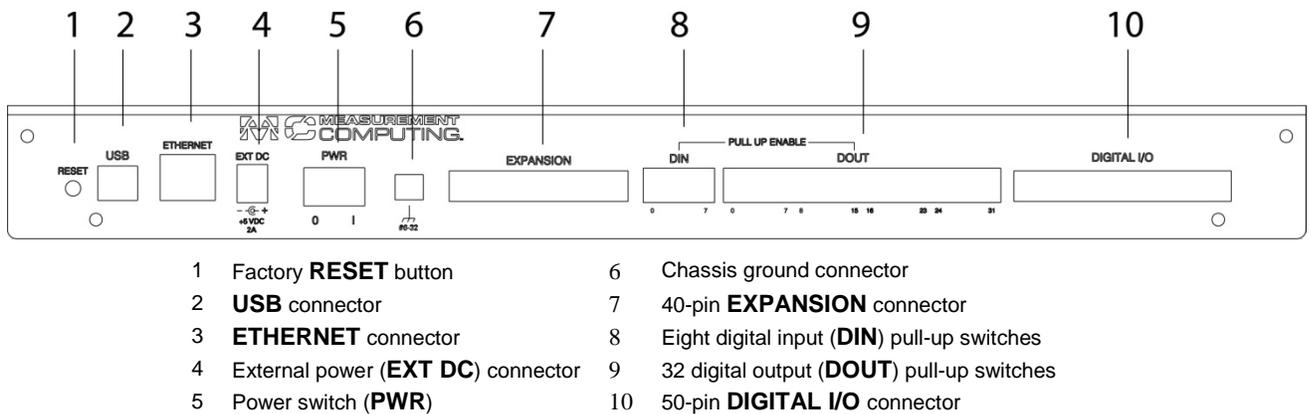
Figure 3. TC-32 rear panel components

USB connector

The USB connector provides USB communication.

Ethernet connector

The TC-32 has one 10/100 BASE-T, auto-negotiation, high-speed communication port. The port connector is an RJ-45, eight-position connector. The Ethernet port accepts CAT-5 shielded or unshielded twisted pair cable. The maximum communication distance without using a repeater is 100 meters.

External power connector

Connect the PS-5V2AEPS power supply to this connector. The power supply provides 5 VDC, 2 A power to the TC-32.

TC input connectors, measurements, and LED

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.

You can add another 32 differential TC input connections to mini-jack connectors labeled CH0 through CH31 (refer to Figure 2).

The device supports type J, K, S, R, B, E, T, N thermocouples.

> **Caution!** MCC strongly recommends that you ground yourself using a wrist strap before handling the thermocouple sensors.

Connecting TCs to common-mode voltage sources

You can connect a thermocouple to a common voltage source (AC or DC) as long as the magnitude of the voltage is within the common mode voltage range specification of 48V (DC) or 3.5V p-p (AC).

Each applied common mode voltage must be less than or equal to the *average* common mode voltage ±1.4 V.

For example, in Figure 4, there are three TCs connected to three different common mode voltage sources and two thermocouples that are not connected to anything (floating).

In this example, the average common mode voltage is calculated as follows: (11.4 V+ 10 V + 8.6 V)/3 = 10 V

- Each TC channel becomes biased to the average common mode voltage of 10 V.
- Each common mode voltage must then be within the 10 V ±1.4 V limits or 8.6 V to 11.4 V.
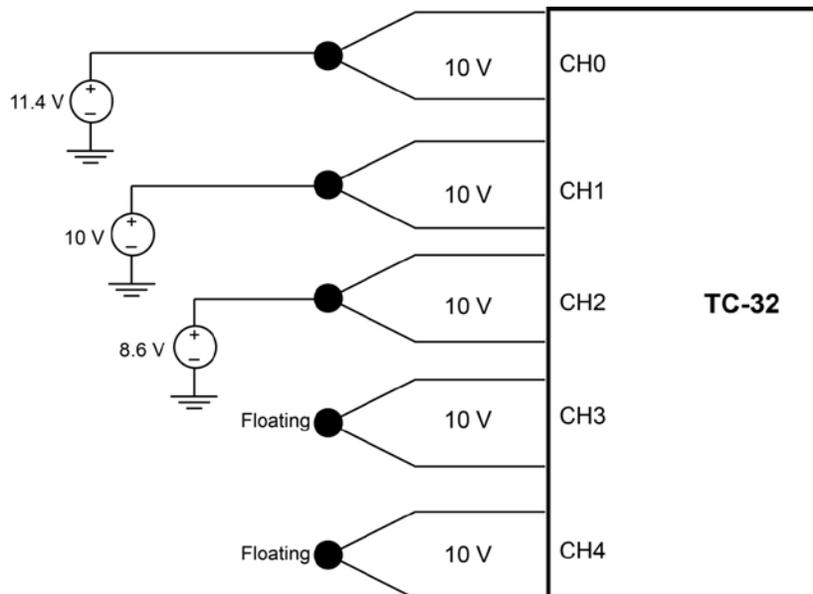
Figure 4. TC-32 common mode voltage connections example

Cold junction compensation (CJC)

Each TC input on the TC-32 has a high-resolution CJC sensor. When you connect the thermocouple sensor leads to the sensor input channel, the dissimilar metals at the TC-32 terminal blocks produce an additional thermocouple junction. This junction creates a small voltage error component which must be removed from the overall sensor measurement using a CJC technique.

The measured voltage includes both the thermocouple voltage and the cold junction voltage. To compensate for the additional cold junction voltage, the TC-32 subtracts the cold junction voltage from the thermocouple voltage.

Increasing the thermocouple length

If you need to increase the length of your thermocouple, use the same type of TC 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)

Open-thermocouple detection on the TC-32 can be enabled or disabled for all analog input channels. With OTD, any open-circuit condition at the TC sensor is detected by the software. An open channel is detected by the use of a pull up and pull down resistors on the thermocouple inputs. An open thermocouple condition forces the input differential voltage outside of the valid thermocouple voltage range. 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 OTD enabled, 75 nA (max) of input leakage current is injected into the TC. This current can cause an error voltage to develop across the lead resistance of the TC 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 × 75 nA

To reduce the error, reduce the length of the TC to lower its resistance, or lower the AWG of the wire by using a wire with a larger diameter. With open-thermocouple detection disabled, 2 nA (max) of input leakage current is injected into the TC.

Digital I/O

The TC-32 provides eight digital inputs and 32 digital outputs that are electrically isolated from the host computer and from the TC-32 analog circuits.

All DIO bits have internal pull-up resistors to 5 V that can be disabled with the rear panel slide switches.

When pull-up is disabled for a digital bit, the bit is left floating.

The recommended maximum length of the 50-pin cable used to connect the **DIGITAL I/O** connector to the digital I/O signal source is 1 foot.

For more information about digital signal connections

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

Digital inputs

The TC-32 provides eight digital inputs with rates of 500 port reads or single bit reads per second.

Digital input voltage ranges of 0 V to 15 V are permitted, with thresholds of 0.6 V (low) and 2.2 V (high).

Each digital input has a 100 kΩ pull-up resistor. Use the eight **PULL-UP ENABLE – DIN** slide switches to enable or disable the 5 V pull-up option.
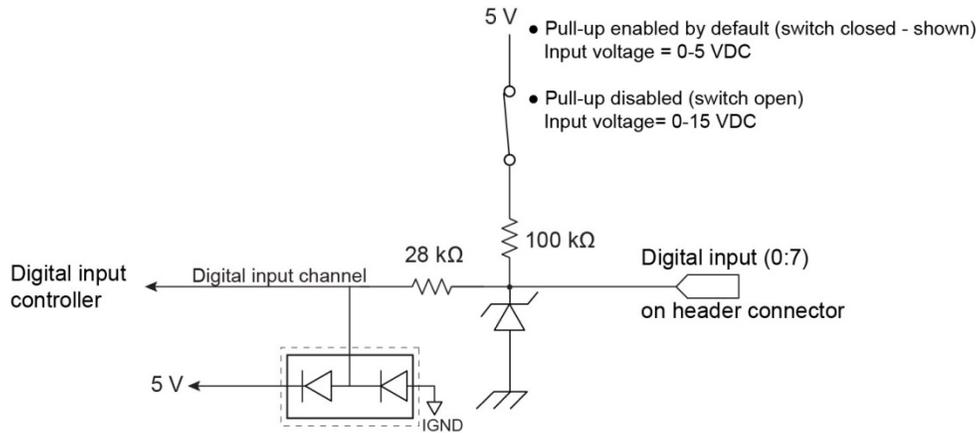
Figure 5. Digital input connection example

Digital outputs/temperature alarms

The TC-32 has 32 digital outputs which are *open-drain*. Each DO bit has a 100 kΩ pull-up resistor and can sink up to 100 mA for direct drive applications. Use the eight **PULL-UP ENABLE – DOUT** slide switches to enable or disable the 5 V pull-up option.
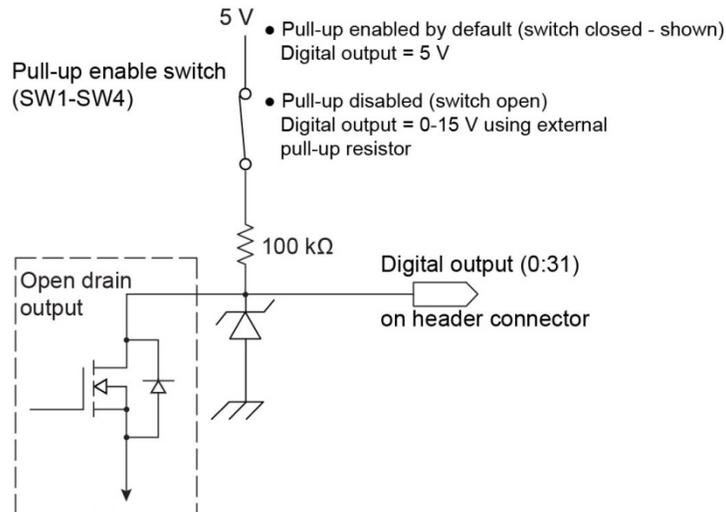
Figure 6. Digital output connection example

Optionally, you can configure each digital output as an alarm for each TC input. When an alarm is enabled, its associated output line is driven to the appropriate state determined by the alarm options and input temperature.

You can also use the alarm outputs to control a device or application that indicates when a temperature threshold has been exceeded.

When its pull-up is disabled, a DO bit can be used to control a device needing up to 15 V (user-provided) @ 100 mA. If the device needs more voltage/current than this, use a TC-32-controlled MOSFET[2] (user-provided) to control higher voltages and currents.

Depending on the MOSFET used, the TC-32 can control up to 50 VDC @ 80 A.

Figure 7 shows a relay requiring 24 VDC @ 100 mA controlled by a TC-32 digital output/alarm. The MOSFET driving the signal to the relay can handle up to 14 amps, 50 volts DC.

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[2] Metal-oxide semiconductor, field-effect transistor that uses an induced electrical field to control current through the device. Either negative or positive gate voltages can be applied to control the current.
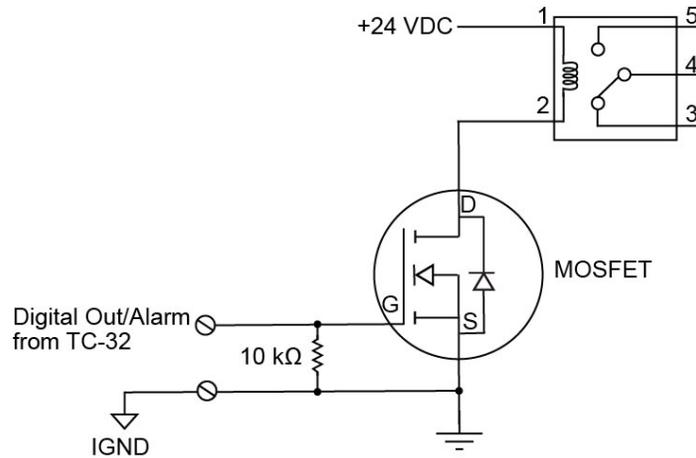
Figure 7. Example of digital output/alarm controlling a relay

The alarm configurations are stored in non-volatile memory and loaded at power up.

Alarm settings are applied when changed and at power on. Temperatures are constantly converted on enabled channels and processed for alarm conditions regardless of the communications connectivity.

Each available alarm mode and setting is explained below.

Alarm input modes Set independent temperature thresholds T1 and T2 for each alarm.	■ Trigger alarm when input temperature $\geq$ T1; reset alarm when input temperature $<$ T2 ■ Trigger alarm when input temperature $\leq$ T1; reset alarm when input temperature $>$ T2 ■ Trigger alarm when input temperature is $<$ T1 or $>$ T2
Alarm error modes	■ Alarm on temperature reading only ■ Alarm on temperature reading, open thermocouple, or common-mode voltage error ■ Alarm on open thermocouple or common-mode voltage out-of-range error only
Alarm output modes	■ Alarm disabled; digital output line can be used for normal operation ■ Alarm enabled; active low output (output line goes low when alarm condition is met) ■ Alarm enabled; active high output (output line goes high when alarm condition is met) ■ Alarm output may be latched and will not clear unless explicitly cleared by the user

The TC-32 provides three alarm indicators – the ALARM LED, the OPEN TC LED on the front panel and, optionally, the user-configurable digital outputs associated with each channel.

Because the digital alarm outputs are user-configurable, they can be used to supply additional information (visually, if the digital outputs are used to drive LEDs), such as the channel associated with the alarm condition or differentiating between threshold and common mode voltage out-of-range alarms.

Pull-up configuration

By default, pull-up is enabled for all eight digital inputs and all 32 digital outputs. Slide switches on the rear of the housing can disable pull-up for each digital input bit and digital output bit.

When pull-up is disabled for a digital bit, the bit is left floating.

LED indicators

The TC-32 has four LEDs that indicate the power, communication, alarm, and open TC status

POWER LED[3]

The **POWER** LED turns on when you plug the power adapter into the TC-32. If a Flash LED command is sent from an application, the **Power** LED blinks five times.

ACTIVITY LED[2]

The **ACTIVITY** LED turns on when there is a valid connection (USB or Ethernet) and blinks when a command is sent to the TC-32.

ALARM LED

The **ALARM** LED turns on when an alarm condition occurs.

OPEN TC LED

The **OPEN TC** LED turns on when there is an open thermocouple condition.

EXPANSION connector

Use the **EXPANSION** connector to connect the TC-32 to a TC-32-EXP expansion device (sold separately) for applications that need additional analog/thermocouple input and digital I/O channels. A 40-pin expansion cable is included with the TC-32-EXP.

Refer to www.mccdaq.com for TC-32-EXP product details.

Chassis ground connector

Provides a connection point (#6-32 threaded screw) for chassis ground. Connect this to an external grounding source.

If the TC-32 is connected by USB or by a shielded Ethernet cable to grounded equipment, connecting to an external grounding source is not needed since the USB/shielded Ethernet connection already grounds the TC-32 and a connected TC-32-EXP.

RESET button

Press and hold this button to restore the TC-32 to its factory default network settings. Refer to Restoring factory default network settings on page 10

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[3] Both the **POWER** and **ACTIVITY** LEDs blink in firmware upgrade mode. Refer to Updating firmware on page 10.

Mechanical drawings
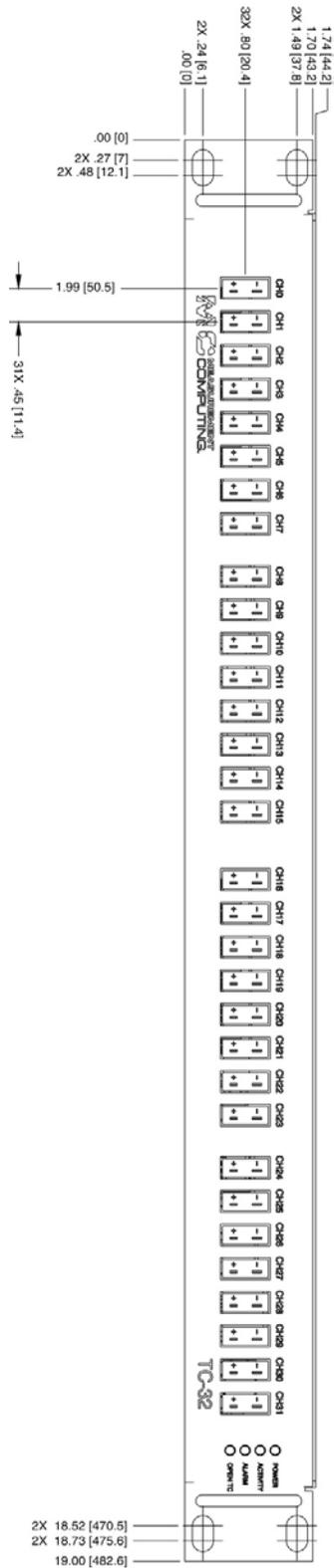
Figure 8. Enclosure dimensions - front
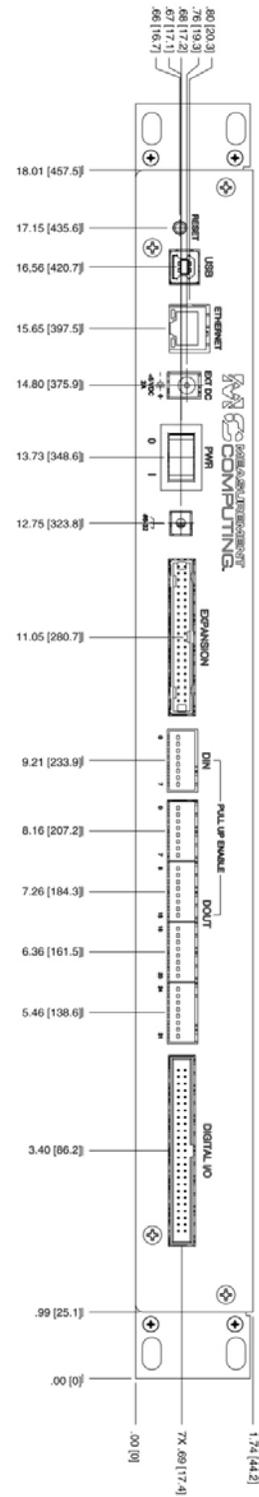
Figure 9. Enclosure dimensions - rear
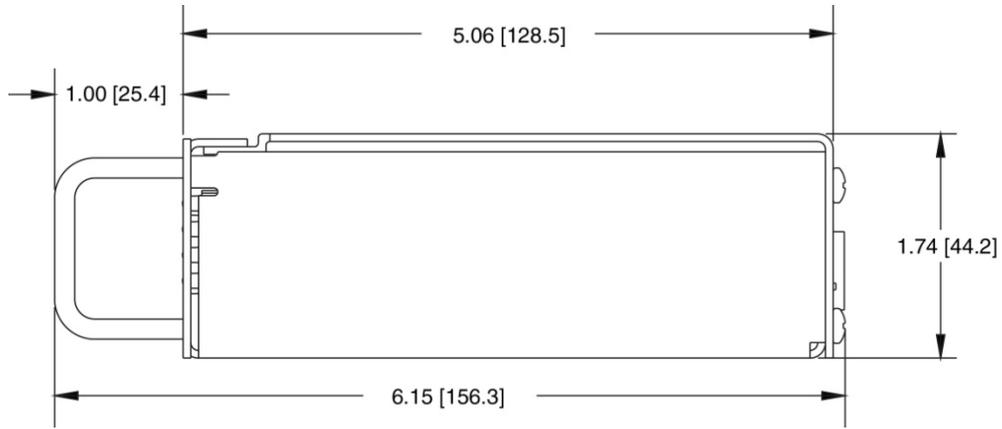
Figure 10. Enclosure dimensions – side
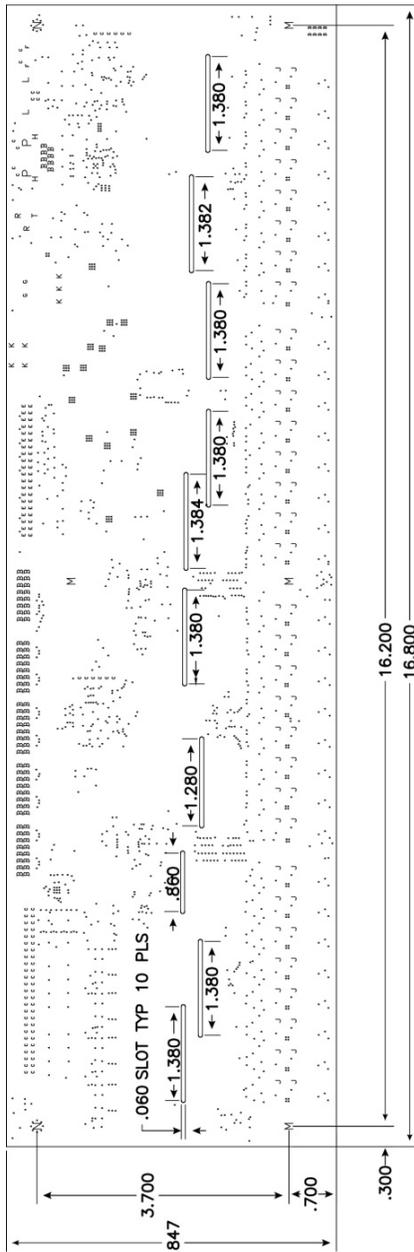
Figure 11. Circuit board dimensions

Specifications

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

Thermocouple input

Table 1. Generic analog input specifications

Parameter	Condition	Specification
A/D converter type		Delta-Sigma
A/D resolution		24-bit
Number of channels		32
Filtering options		*50 Hz or 60 Hz noise filtering, software-selectable*
Isolation	*Between any TCx channel and chassis ground.*	*500 VDC absolute max*
Channel configuration		Software-selectable to match thermocouple sensor type
Differential input voltage range		±78.125 mV
Absolute maximum input voltage	*Between any two TCx inputs*	*±25 V (power on)* *±25 V (power off)*
Differential input impedance	*50 Hz filtering, power on*	*26 MΩ*
	60 Hz filtering, power on	*20 MΩ*
Input current	*Open thermocouple detect disabled*	*2 nA*
	Open thermocouple detect enabled	*75 nA*
Common mode rejection	*50 Hz filtering, at DC and f_{in}=50 Hz*	*110 dB*
	60 Hz filtering at DC and f_{in}=60 Hz	*110 dB*
Noise rejection	*50 Hz filtering at f_{in} =50 Hz*	*80 dB typ.*
	60 Hz filtering at f_{in} =60 Hz	*80 dB typ.*
Input bandwidth	*50 Hz filtering*	22 Hz
	60 Hz filtering	26 Hz
Crosstalk	*Between any two TCx inputs*	-90 dB
Sample rate (Note 1)		3 Hz max (per channel)
Common mode voltage range (Note 2)	TCx channel to TCx channel	±1.40 V
	TCx channel relative to chassis ground, f_{in} = 60 Hz	±3.5 VAC p-p
	TCx channel relative to chassis ground	±48 VDC
Input noise	*50 Hz or 60 Hz filtering*	510 nV rms
Gain error	*50 Hz or 60 Hz filtering*	0.004 %
Offset error	*50 Hz or 60 Hz filtering*	3 µV
Measurement sensitivity (Note 3)	Thermocouple type J,K,T,E,N	0.05 °C
	Thermocouple type R,S	0.10 °C
	Thermocouple type B	0.15 °C
Warm-up time		20 minutes min
Open thermocouple detect response time		1 second
CJC sensor accuracy	*0 °C to 45 °C*	*±0.20 °C typ* *±0.40 °C max*

Calibration method		Factory
Recommended warm-up time		20 minutes min
Calibration interval		1 year (factory calibration)

Note 1: The enabled thermocouple inputs are continuously converted at the maximum A/D converter rate.

Note 2: When thermocouple sensors are connected to different common mode voltages, the channels with floating thermocouples sensors will be biased to approximately the average value of the applied common mode voltages. Each of the applied common mode voltages must then be less than or equal to the average common mode voltage ± 1.40 V or $[CMV_{applied} \leq (CMV_{average} \pm 1.4$ V$)]$.

Note 3: Measurement sensitivity is the smallest change in temperature that can be detected.

Channel configuration

Table 2. Channel configuration specification

Sensor Category	Condition	Specification
Thermocouple	J, K, S, R, B, E, T, N	32 differential channels

Note 4: Channel configuration is stored on EEPROM external to the isolated microcontroller by the firmware whenever any item is modified. Modification is performed by commands issued from an external application, and the configuration is made non-volatile through the use of the EEPROM.

Compatible thermocouple sensors

Table 3. Compatible sensor type specifications

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

Accuracy

Thermocouple measurement accuracy

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

Sensor Type	Sensor Temperature (°C)	Accuracy Error Maximum (°C), 15°C to 35°C	Accuracy Error Typical (°C), 15°C to 35°C	Accuracy Error Maximum (°C), 0°C to 45°C	Accuracy Error Typical (°C), 0°C to 45°C
J	−210	1.965	0.910	2.167	0.989
	0	0.787	0.361	0.816	0.375
	1200	0.752	0.371	1.148	0.508
K	−210	2.295	1.061	2.520	1.152
	0	0.821	0.376	0.852	0.392
	1372	1.029	0.504	1.560	0.688
S	−50	2.467	1.111	2.655	1.223
	250	1.835	0.825	1.961	0.904
	1768	0.893	0.361	1.519	0.590
R	−50	2.609	1.174	2.810	1.293
	250	1.862	0.837	1.992	0.918
	1768	0.754	0.305	1.346	0.520
B	250	2.450	1.090	2.707	1.254
	700	0.937	0.424	1.136	0.520
	1820	0.610	0.300	1.056	0.467
E	−200	1.754	0.811	1.933	0.880
	0	0.775	0.355	0.806	0.369
	1000	0.657	0.323	0.989	0.437
T	−200	2.005	0.923	2.207	1.005
	0	0.836	0.382	0.874	0.400
	400	0.544	0.255	0.659	0.297
N	−200	2.255	1.038	2.481	1.134
	0	0.908	0.415	0.949	0.437
	1300	0.718	0.357	1.157	0.510

Thermocouple measurement accuracy specifications include polynomial linearization, cold-junction compensation, and system noise. The accuracy specifications assume the device is operated within its enclosure and with the enclosure in a horizontal, upright orientation. The board should also be warmed up for the recommended 20 minutes. If the maximum digital output load of 3.2 amps is applied, add an additional 0.30°C to the typical and maximum accuracy specifications listed above. Errors shown do not include inherent thermocouple error. Contact your thermocouple supplier for details on the actual thermocouple accuracy error.

Digital input/output

Table 5. Digital input specifications

Parameter	Specification
Number of inputs	8 channels
Configuration	Fixed input
Input voltage range	0 V to +15 V
Input type	CMOS (Schmitt trigger)
Input characteristics	100 kΩ pull-up resistor, 28.7 kΩ series resistor
Maximum input voltage range	*0 V to +20 V max (power on/off, relative to IGND pins)*
Pull-up configuration	All pins pulled up to +5 V via individual 100 kΩ resistors using slide switch SW5. SW5 default positions are on (pulled up.)
Transfer rate (software paced)	500 port reads per second typ
Input high voltage	1.3 V min, 2.2 V max
Input low voltage	1.5 V max, 0.6 V min
Schmitt trigger hysteresis	0.4 V min, 1.2 V max

Table 6. Digital output specifications

Parameter	Specification
Number of outputs	32 channels, shared with alarms
Configuration	Open drain output
Output characteristics	100 kΩ pull-up, open drain (DMOS transistor)
Pull-up configuration	All pins pulled up to +5 V via individual 100 kΩ resistors using slide switches SW1-SW4. The default positions for SW1-4 are on (pulled up.)
Transfer rate (software-paced)	500 port writes per second typ
Output voltage range	0 V to +5 V (internal 100 kΩ pull-up resistors connected to +5 V by default) 0 V to +15 V max (using external pull up resistor)
Off state leakage current	0.1 µA
Sink current capability	100 mA max (continuous) per output pin
DMOS transistor on-resistance (drain to source)	4 Ω

Note 5: Ground pins labeled IGND are isolated from AGND and chassis ground.

Temperature alarms

Table 7. Temperature alarm specifications

Parameter	Specification
Number of alarms	32, shared with digital output
Alarm functionality	Each alarm controls its associated digital output line as an alarm output. When an alarm is enabled, its associated output line is driven to the appropriate state determined by the alarm options and input temperature. The alarm configurations are stored in non-volatile memory and loaded at power on.
Alarm input modes	■ Alarm when input temperature >= T1, reset alarm when input temperature < T2 ■ Alarm when input temperature <= T1, reset alarm when input temperature > T2 ■ Alarm when input temperature is < T1 or > T2 Note: T1 and T2 may be independently set for each alarm.
Alarm error modes	■ Alarm on temperature reading only ■ Alarm on temperature reading, open thermocouple, or common-mode voltage error ■ Alarm on open thermocouple or common-mode voltage error only
Alarm output modes	■ Disabled, digital output line may be used for normal operation ■ Enabled, active high output (output line goes high when alarm condition is met) ■ Enabled, active low output (output line goes low when alarm condition is met) ■ Alarm output may be latched and will not clear unless explicitly cleared by the user
Alarm latency (Note 6)	1 second, max

Note 6: Alarm settings are applied when changed and at power-on. Temperatures are constantly converted on enabled channels and processed for alarm conditions regardless of the communications connectivity.

Memory

Table 8. Memory specifications

Parameter	Specification
EEPROM	8,192 bytes

Microcontroller

Table 9. Microcontroller specifications

Parameter	Specification
Type	One high-performance 32-bit RISC microcontroller (communications) One high-performance 32-bit RISC microcontroller (measurement)

Power

Table 10. Power specifications

Parameter	Conditions	Specification
Supply current		330 mA typ, 610 mA max 550 mA typ, 1000 mA max (with TC-32-EXP connected)
External power input (Note 7)		+5 VDC ± 5% (+5 VDC power supply provided)
Power switch		Rocker type
External power supply (included)	MCC p/n PS-5V2AEPS	+5 VDC, 10 W, 5% regulation
External power input voltage supervisor limits	4.0 V > V_{ext} > 5.75 V	PWR LED = Off (power fault)
	4.0 V < V_{ext} < 5.75 V	PWR LED = On
Chassis ground connection		6-32 screw on rear of enclosure

Note 7: Voltage specification applies at barrel plug power input. The power supply provided with the device meets this specification at the rated total power supply current. If a different power supply is used, small line resistances could cause significant voltage drop between the power supply and the barrel plug input.

USB

Table 11. USB specifications

Parameter	Specification
Device type	USB 2.0 full speed
Device compatibility	USB 1.1, USB 2.0, USB 3.0
Connector	Standard B
Cable length	5 meters max
Power	Self-powered (no USB current consumed)

Network

Ethernet connection

Table 12. Ethernet connection specifications

Parameter	Specification
Ethernet type	*100 Base-TX* *10 Base-T*
Communication rates	*10/100 Mbps, auto-negotiated*
Connector	*RJ-45, 8 position*
Cable length	*100 meters max*
Additional parameters	*HP Auto-MDIX support*

Network interface

Table 13. Factory default specifications

Parameter	Specification
Protocols used	TCP/IP (IPv4 only), UDP
Network ports used	UDP:54211 (discovery) TCP:54211 (commands)
Network IP configuration	DHCP + link-local, DHCP, static, link-local
Network name	TC-32-xxxxxx, where xxxxxx are the lower 6 digits of the device MAC address
Network name publication	By NBNS (responds to b-node broadcasts, therefore only available on the local subnet)

Network factory default settings

Table 14. Factory default specifications

Parameter	Specification
Factory default IP address	192.168.0.101
Factory default subnet mask	255.255.255.0
Factory default gateway	192.168.0.1
Factory default DHCP setting	DHCP + link-local enabled

Network security

Table 15. Factory default specifications

Parameter	Specification
Security implementation	TCP sockets are not opened unless application sends the correct PIN code (stored in non-volatile memory, may be changed by user, default value 0000)
Number of concurrent sessions	1
Vulnerabilities	TCP Sequence Number Approximation Vulnerability

LED displays and the factory reset button

Table 16. LED and button configurations

Parameter	Specification
POWER LED (top)	Indicates power on. Blinks when blink command is sent. Both the **POWER** and **ACTIVITY** LEDs blink in firmware upgrade mode.
ACTIVITY LED	On when there is a valid connection and blinks when a command is sent to the TC-32. Both the **POWER** and **ACTIVITY** LEDs blink in firmware upgrade mode.
ALARM LED	Indicates that an alarm condition is met.
OPEN TC LED (bottom)	Indicates that there is an open thermocouple condition.
Factory reset button	When held for 3 seconds, the LEDs turn off for a short time, indicating a reset is in process. When the LEDs turn back on, reset is complete and the factory-default network settings are restored.

Environment

Table 17. Environmental specifications

Parameter	Specification
Operating temperature range	0 °C to 45 °C
Storage temperature range	–40 °C to 85 °C
Humidity	0 °C to 90% non-condensing

Mechanical

Table 18. Mechanical specifications

Parameter	Specification
Dimensions (L × W × H)	482.6 × 128.6 × 43.18 mm (19 × 6.15 × 1.74 in.)

Signal I/O connectors

Table 19. Connector specifications

Parameter	Specification
User accessible I/O connectors (excluding USB and Ethernet)	Thermocouple inputs, digital I/O connector, expansion connector, chassis ground
Thermocouple connector type	Thermocouple Mini-Jack (Omega PCC-SMP-V-U-100)
Digital I/O connector type	50-pin IDC header
Compatible cable for the 50-pin DIO connector	C50FF-*x* (where x= length in feet)
Compatible accessory products with the C50FF-*x* cable	■ CIO-MINI50 ■ SCB-50
Expansion connector type	40-pin IDC header
Compatible cables for the 40-pin expansion connector	C40FF-*x* (where x= length in feet)
Chassis ground connector	6-32 threaded screw

Table 20. Thermocouple connector pinout

Pin	Signal Name	Pin Description	Pin	Signal Name	Pin Description
J1	TC0(+)	CH0 sensor input (+)	J17	TC16(+)	CH16 sensor input (+)
	TC0(-)	CH0 sensor input (–)		TC16(-)	CH16 sensor input (–)
J2	TC1(+)	CH1 sensor input (+)	J18	TC17(+)	CH17 sensor input (+)
	TC1(-)	CH1 sensor input (–)		TC17(-)	CH17 sensor input (–)
J3	TC2(+)	CH2 sensor input (+)	J19	TC18(+)	CH18 sensor input (+)
	TC2(-)	CH2 sensor input (–)		TC18(-)	CH18 sensor input (–)
J4	TC3(+)	CH3 sensor input (+)	J20	TC19(+)	CH19 sensor input (+)
	TC3(-)	CH3 sensor input (–)		TC19(-)	CH19 sensor input (–)
J5	TC4(+)	CH4 sensor input (+)	J21	TC20(+)	CH20 sensor input (+)
	TC4(-)	CH4 sensor input (–)		TC20(-)	CH20 sensor input (–)
J6	TC5(+)	CH5 sensor input (+)	J22	TC21(+)	CH21 sensor input (+)
	TC5(-)	CH5 sensor input (–)		TC21(-)	CH21 sensor input (–)
J7	TC6(+)	CH6 sensor input (+)	J23	TC22(+)	CH22 sensor input (+)
	TC6(-)	CH6 sensor input (–)		TC22(-)	CH22 sensor input (–)
J8	TC7(+)	CH7 sensor input (+)	J24	TC23(+)	CH23 sensor input (+)
	TC7(-)	CH7 sensor input (–)		TC23(-)	CH23 sensor input (–)
J9	TC8(+)	CH8 sensor input (+)	J25	TC24(+)	CH24 sensor input (+)
	TC8(-)	CH8 sensor input (–)		TC24(-)	CH24 sensor input (–)
J10	TC9(+)	CH9 sensor input (+)	J26	TC25(+)	CH25 sensor input (+)
	TC9(-)	CH9 sensor input (–)		TC25(-)	CH25 sensor input (–)
J11	TC10(+)	CH10 sensor input (+)	J27	TC26(+)	CH26 sensor input (+)
	TC10(-)	CH10 sensor input (–)		TC26(-)	CH26 sensor input (–)
J12	TC11(+)	CH11 sensor input (+)	J28	TC27(+)	CH27 sensor input (+)
	TC11(-)	CH11 sensor input (–)		TC27(-)	CH27 sensor input (–)
J13	TC12(+)	CH12 sensor input (+)	J29	TC28(+)	CH28 sensor input (+)
	TC12(-)	CH12 sensor input (–)		TC28(-)	CH28 sensor input (–)
J14	TC13(+)	CH13 sensor input (+)	J30	TC29(+)	CH29 sensor input (+)
	TC13(-)	CH13 sensor input (–)		TC29(-)	CH29 sensor input (–)
J15	TC14(+)	CH14 sensor input (+)	J31	TC30(+)	CH30 sensor input (+)
	TC14(-)	CH14 sensor input (–)		TC30(-)	CH30 sensor input (–)
J16	TC15(+)	CH15 sensor input (+)	J32	TC31(+)	CH31 sensor input (+)
	TC15(-)	CH15 sensor input (–)		TC31(-)	CH31 sensor input (–)

Table 21. Digital I/O connector (J33) pinout

Pin	Signal Name	Pin Description	Pin	Signal Name	Pin Description
1	DOUT0	Digital Output 0/ Alarm Output 0	2	DOUT1	Digital Output 1/ Alarm Output 1
3	DOUT2	Digital Output 2/ Alarm Output 2	4	DOUT3	Digital Output 3/ Alarm Output 3
5	DOUT4	Digital Output 4/ Alarm Output 4	6	DOUT5	Digital Output 5/ Alarm Output 5
7	DOUT6	Digital Output 6/ Alarm Output 6	8	DOUT7	Digital Output 7/ Alarm Output 7
9	DOUT8	Digital Output 8/ Alarm Output 8	10	DOUT9	Digital Output 9/ Alarm Output 9
11	DOUT10	Digital Output 10/ Alarm Output 10	12	DOUT11	Digital Output 11/ Alarm Output 11
13	DOUT12	Digital Output 12/ Alarm Output 12	14	DOUT13	Digital Output 13/ Alarm Output 13
15	DOUT14	Digital Output 14/ Alarm Output 14	16	DOUT15	Digital Output 15/ Alarm Output 15
17	IGND	Isolated Digital GND	18	IGND	Isolated Digital GND
19	IGND	Isolated Digital GND	20	IGND	Isolated Digital GND
21	DOUT16	Digital Output 16/ Alarm Output 16	22	DOUT17	Digital Output 17 / Alarm Output 17
23	DOUT18	Digital Output 18/ Alarm Output 18	24	DOUT19	Digital Output 19/ Alarm Output 19
25	DOUT20	Digital Output 20/ Alarm Output 20	26	DOUT21	Digital Output 21/ Alarm Output 21
27	DOUT22	Digital Output 22/ Alarm Output 22	28	DOUT23	Digital Output 23/ Alarm Output 23
29	DOUT24	Digital Output 24/ Alarm Output 24	30	DOUT25	Digital Output 25 / Alarm Output 25
31	DOUT26	Digital Output 26/ Alarm Output 26	32	DOUT27	Digital Output 27/ Alarm Output 27
33	DOUT28	Digital Output 28/ Alarm Output 28	34	DOUT29	Digital Output 29/ Alarm Output 29
35	DOUT30	Digital Output 30/ Alarm Output 30	36	DOUT31	Digital Output 31/ Alarm Output 31
37	IGND	Isolated Digital GND	38	IGND	Isolated Digital GND
39	IGND	Isolated Digital GND	40	IGND	Isolated Digital GND
41	DIN0	Digital Input 0	42	DIN1	Digital Input 1
43	DIN2	Digital Input 2	44	DIN3	Digital Input 3
45	DIN4	Digital Input 4	46	DIN5	Digital Input 5
47	DIN6	Digital Input 6	48	DIN7	Digital Input 7
49	IGND	Isolated Digital GND	50	IGND	Isolated Digital GND

Table 22. Expansion connector (J34) pinout

Pin	Signal Name	Pin Description		Pin	Signal Name	Pin Description
1	+12VA (Note)	+12 VA power output		2	AGND	Isolated Analog GND
3	+12VA	+12 VA power output		4	AGND	Isolated Analog GND
5	+5VA	+5 VA power output		6	AGND	Isolated Analog GND
7	+5VA	+5 VA power output		8	AGND	Isolated Analog GND
9	+5VA	+5 VA power output	Note 8	10	AGND	Isolated Analog GND
11	+5VA	+5 VA power output		12	AGND	Isolated Analog GND
13	+3.3VA	+3.3 VA power output		14	AGND	Isolated Analog GND
15	+3.3VA	+3.3 VA power output		16	AGND	Isolated Analog GND
17	+3.3VA	+3.3 VA power output		18	AGND	Isolated Analog GND
19	+3.3VA	+3.3 VA power output		20	AGND	Isolated Analog GND
21	CS	Chip select		22	AGND	Isolated Analog GND
23	SCK	Serial clock		24	AGND	Isolated Analog GND
25	MOSI	Master output data		26	AGND	Isolated Analog GND
27	MISO	Master input data		28	AGND	Isolated Analog GND
29	IRQ	Interrupt request		30	AGND	Isolated Analog GND
31	RSVD	Reserved		32	AGND	Isolated Analog GND
33	RSVD	Reserved		34	AGND	Isolated Analog GND
35	RSVD	Reserved		36	AGND	Isolated Analog GND
37	RSVD	Reserved		38	AGND	Isolated Analog GND
39	EXP_DETECT	EXP detection		40	AGND	Isolated Analog GND

Note 8: Power supplies (+12 VA, +5 VA, 3.3 VA) located at connector J34 are intended for use with the TC-32-EXP expansion device only.

CE Declaration of Conformity
According to ISO/IEC 17050-1:2010

Manufacturer:	Measurement Computing Corporation
Address:	10 Commerce Way
	Suite 1008
	Norton, MA 02766
	USA
Product Category:	Electrical equipment for measurement, control and laboratory use.
Date and Place of Issue:	October 15, 2015, Norton, Massachusetts USA
Test Report Number:	EMI6774.15

Measurement Computing Corporation declares under sole responsibility that the product(s)

TC-32

Complies with the essential requirements of the following applicable European Directives:

> Electromagnetic Compatibility (EMC) Directive 2004/108/EC
> Low Voltage Directive 2006/95/EC
> RoHS Directive 2011/65/EU

Conformity is assessed in accordance to the following standards:

EMC:

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

Immunity:
- EN 61326-1:2013 (IEC 61326-1:2012), Controlled EM Environments
- EN 61000-4-2:2008 (IEC 61000-4-2:2008)
- EN 61000-4-3 :2010 (IEC61000-4-3:2010)
- EN 61000-4-4 :2012 (IEC61000-4-4:2012)
- EN 61000-4-5 :2005 (IEC61000-4-5:2005)
- EN 61000-4-6 :2013 (IEC61000-4-6:2013)
- EN 61000-4-11:2004 (IEC61000-4-11:2004)

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

Environmental Affairs:

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

Carl Haapaoja, Director of Quality Assurance