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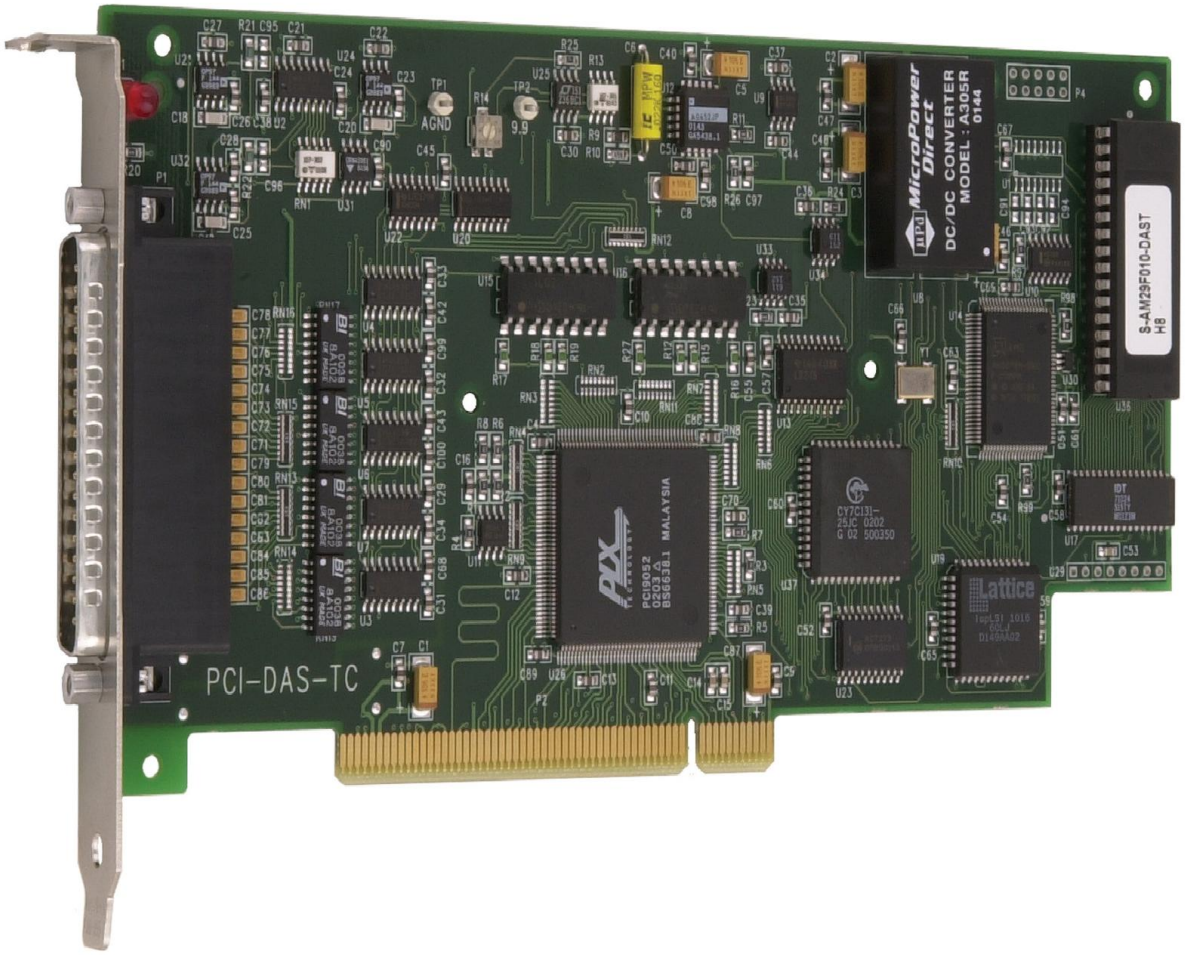
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PCI-DAS-TC

Thermocouple Input Board

User's Guide



MEASUREMENT COMPUTING

PCI-DAS-TC

Thermocouple Input Board

User's Guide



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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 PCI-DAS-TC so that you get the most out of the thermocouple/voltage input features.

This user's guide also refers you to related documents available on our web site, and to technical support resources.

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 *Insta*Cal 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

The following electronic documents provide information relevant to the operation of your PCI-DAS-TC.

- MCC's *Specifications: PCI-DAS-TC* (the PDF version of the *Specifications* chapter in this guide) is available on our web site at www.mccdaq.com/pdfs/Specs/PCI-DAS-TC-spec.pdf.
- MCC's *Quick Start Guide* is available on our web site at 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.
- MCC's *Universal Library User's Guide* is available on our web site at 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.
- MCC's *Universal Library for LabVIEW™ User's Guide* is available on our web site at www.mccdaq.com/PDFmanuals/SM-UL-LabVIEW.pdf.

PCI-DAS-TC User's Guide (this document) is also available on our web site at www.mccdaq.com/PDFmanuals/PCI-DAS-TC.pdf.

Introducing the PCI-DAS-TC

Overview: PCI-DAS-TC features

The PCI-DAS-TC is a 16-channel thermocouple/voltage input board for the PCI bus. The board accepts seven different types of thermocouple input, J, K, E, T, R, S, and B. Its digital output is scaled for temperature in either ºC or ºF. An onboard microprocessor handles all the control and math functions, including: CJC (Cold Junction Compensation), automatic gain and offset calibration, scaling (voltage to temperature translation) and thermocouple linearization. This relieves the computer from performing all these functions. The analog input section is electrically isolated from the computer.

The PCI-DAS-TC is designed for use with the CIO-STA-TC adapter board. The CIO-STA-TC is an external screw terminal board for thermocouple connections. This adapter board provides screw terminals for each thermocouple input channel on the PCI-DAS-TC. A cold junction compensation (CJC) sensor is integrated into an isothermal bar to maintain the screw terminals at a constant temperature. You can configure open thermocouple detection (OTD) for each input channel with on-board switches. The CIO-STA-TC screw terminal board is mounted in an enclosure to minimize errors caused by local currents or air drafts.

The PCI-DAS-TC board is shipped fully-calibrated from the factory, with calibration coefficients stored in nonvolatile RAM. At run-time, these calibration factors are loaded into system memory and automatically retrieved each time a different range is specified.

The PCI-DAS-TC is available by itself (MCC part number PCI-DAS-TC/BRD), or as part of a kit that includes the CIO-STA-TC screw terminal adapter board and a five foot shielded cable. The MCC part number for the kit is PCI-DAS-TC.

Software features

For information on the features of *Insta*Cal and the other software included with your PCI-DAS-TC, 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.

Check www.mccdaq.com/download.htm for the latest software version or versions of the software supported under less commonly used operating systems.

Installing the PCI-DAS-TC

What comes with your PCI-DAS-TC shipment?

The following items are shipped with the PCI-DAS-TC.

Hardware

- PCI-DAS-TC



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). This booklet supplies a brief description of the software you received with your PCI-DAS-TC and information regarding installation of that software. Please read this booklet completely before installing any software or hardware.

Optional components

PCI-DAS-TC is also available as a kit (MCC part number PCI-DAS-TC)

If you ordered this kit, the optional components listed here are included with your shipment (screw terminal board and 5-foot shielded cable).

- CIO-STA-TC screw terminal board with CJC and isothermal block (included with the PCI-DAS-TC kit).



CIO-STA-TC

- C37FFS-x shielded cable (5 foot shielded cable included with the PCI-DAS-TC kit)



C37FFS-x

Unpacking the PCI-DAS-TC

As with any electronic device, you should take care while handling to avoid damage from static electricity. Before removing the PCI-DAS-TC 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, notify Measurement Computing Corporation immediately by phone, fax, or e-mail:

- 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

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.

Installing the PCI-DAS-TC

The PCI-DAS-TC board is completely plug-and-play. There are no switches or jumpers to set on the board. Configuration is controlled by your system's BIOS. To install your board, follow the steps below.

Install the MCC DAQ software before you install your board

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.

1. Turn your computer off, open it up, and insert your board into an available PCI slot.

   If you received the CIO-STA-TC adapter board, connect it now. Plug one cable end into the 37-pin connector on the PCI-DAS-TC, and plug the other cable end into the 37-pin connector on the CIO-STA-TC adapter board.

2. Close your computer and turn it on.

   If you are using an operating system with support for plug-and-play (such as Windows 2000 or Windows XP), a dialog box opens as the system loads, indicating that new hardware has been detected. If the information file for this board is not already loaded onto your PC, you are prompted for the disk containing this file. The *Measurement Computing Data Acquisition Software* CD supplied with your board contains this file. If required, insert the disk or CD and click **OK**

3. To test your installation and configure your board, run the *Insta*Cal utility you installed in the previous section. Refer to the *Quick Start Guide* that came with your board for information on how to initially set up and load *Insta*Cal.

Configuring the PCI-DAS-TC

All hardware configuration options on the PCI-DAS-TC are software controlled. You can select some of the configuration options using *Insta*Cal, such as the thermocouple type, CJC on/off, voltage or thermocouple gain, and temperature units. Once selected, any program that uses the Universal Library will initialize the hardware according to these selections.

Connecting the board for I/O operations

Connectors, cables – main I/O connector

The table below lists the board connector, applicable cable and compatible accessory equipment for the PCI-DAS-TC board.

Board connector, applicable cable, and accessory equipment

Connector type	37-pin D-type
Compatible cable	C37FFS-x (Figure 2)
Compatible accessory product with the C37FFS-x	CIO-STA-TC screw terminal adapter board

Pin out – main I/O connector

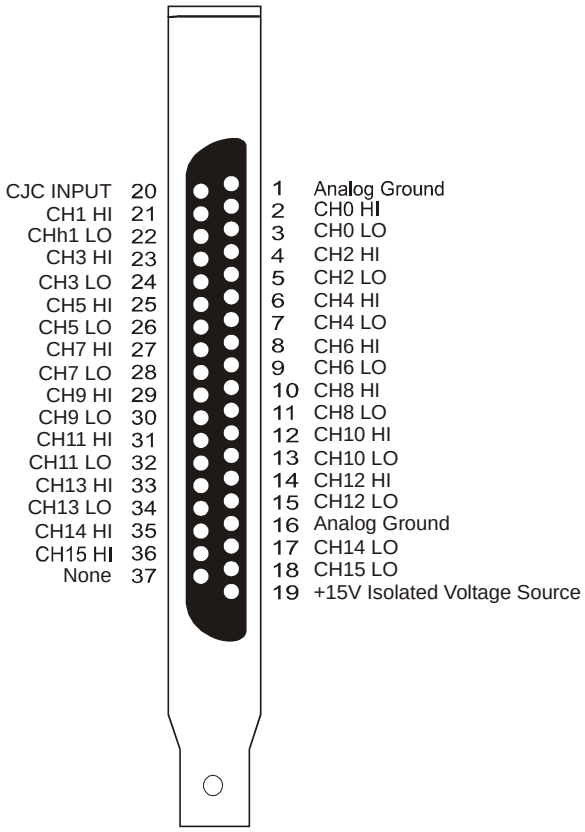


Figure 1. 37-pin board connector

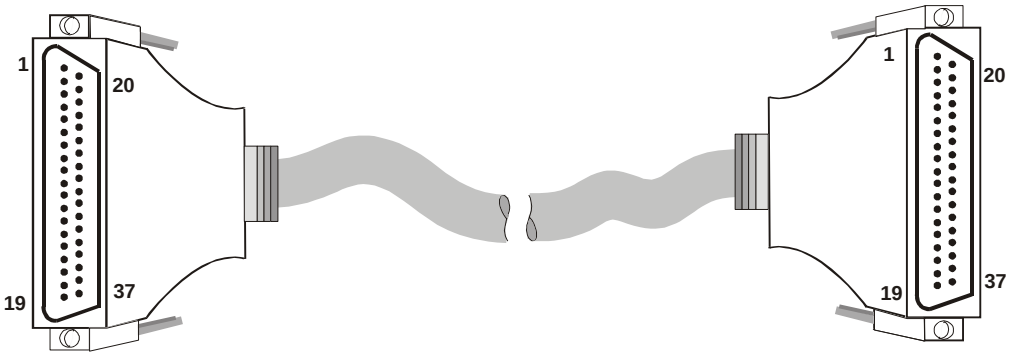


Figure 2. C37FFS-x cable

Field wiring, signal termination and conditioning

You can use the CIO-STA-TC isothermal block with CJC sensor terminal adapter board to terminate field signals and route them into the PCI-DAS-TC using the C37FFS-x cable. Details on this product are available on our web site at www.mccdaq.com.com/products/screw_terminal_bnc.aspx.

Functional Details

PCI-DAS-TC Block diagram

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

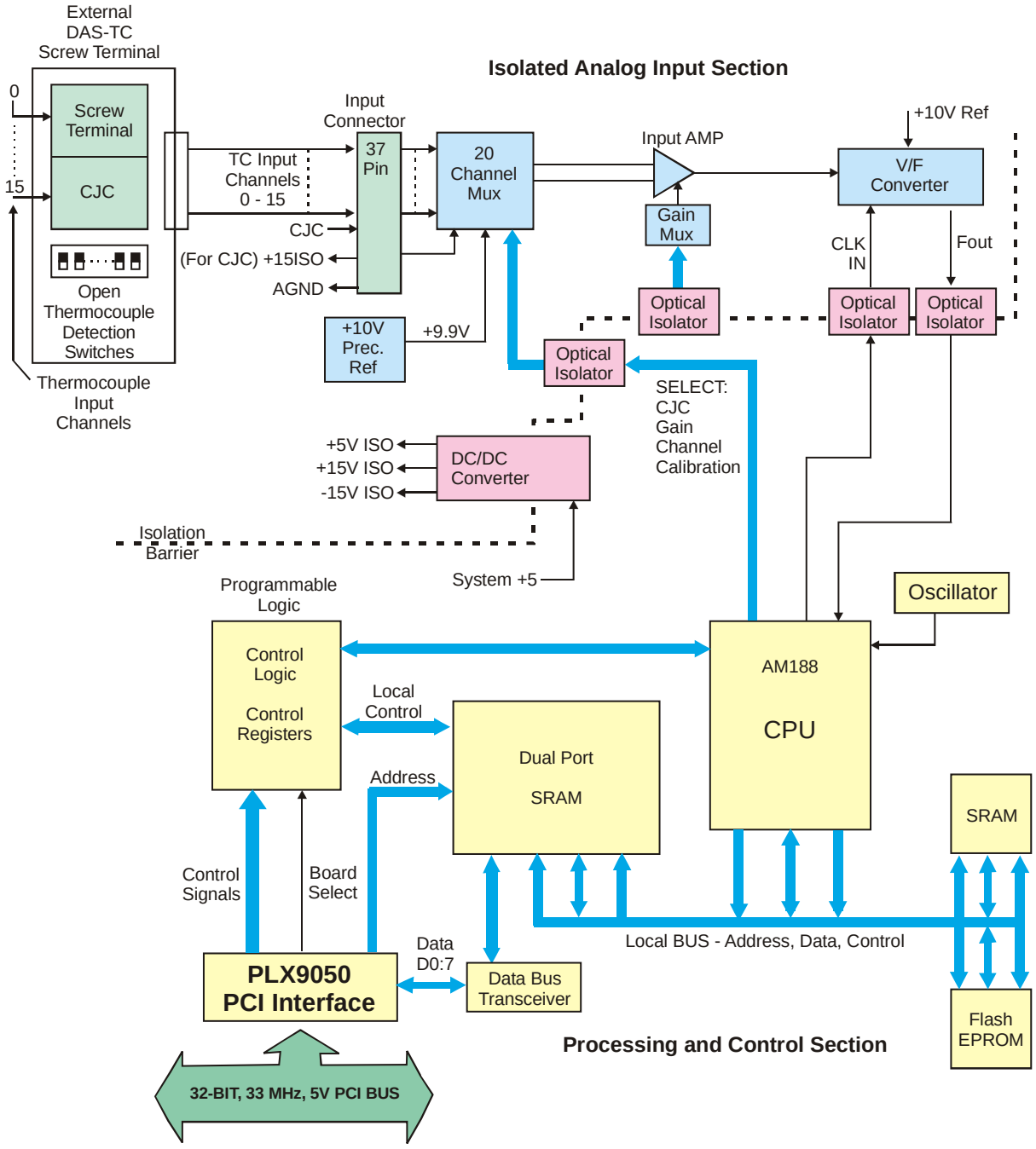


Figure 3. PCI-DAS-TC functional block diagram

CIO-STA-TC screw terminal adapter board

The CIO-STA-TC is a specially configured screw terminal adapter board designed specifically for use with the PCI-DAS-TC. The board has screw terminals for each thermocouple channel, a cold junction sensor integrated into an isothermal bar, and the option of installing an "open thermocouple detection" circuit.

Each thermocouple input is made through two screw terminals — one positive (+) and one negative (-). Connect the thermocouple wires to the appropriate terminals, connect the CIO-STA-TC to the PCI-DAS-TC, and your board is ready for use.

Note the polarity when connecting the thermocouples

Be careful to observe correct polarity when connecting thermocouple wires or extension wires.

The CIO-STA-TC is available by itself (MCC part number CIO-STA-TC), or as part of a kit that includes the PCI-DAS-TC board and five foot shielded cable.

Open thermocouple detection

The only user configurable option in the CIO-STA-TC is the open thermocouple detection resistors. These are a series of 20 MΩ resistors that can be connected between the + terminal of the thermocouple and a known voltage that is larger than any allowable thermocouple output.

The 20 MΩ resistors are large enough so that they do not affect the readings from the thermocouples. If a thermocouple junction should open, a 20 MΩ will drive the input voltage high enough so the software can recognize that it is not a valid thermocouple reading.

Open thermocouple detection circuitry is set via dip switches on the CIO-STA-TC. DIP switches are labeled, and each channel has a switch. To enable open thermocouple detection for a channel, set the switch to ON (up, towards the isothermal block). To disable the function, set the switch to OFF (down, towards the outside of the board).

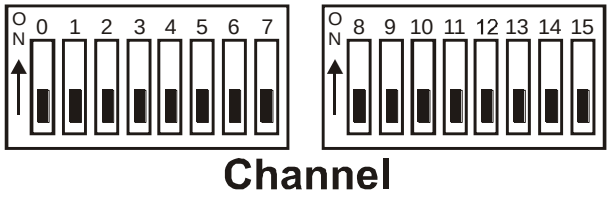


Figure 4. PCI-DAS-TC functional block diagram

The PCI-DAS-TC is shipped with open thermocouple detection disabled.

Theory of operation

Isolated analog inputs

The analog input section of the PCI-DAS-TC consists of the following components:

- CJC (Cold Junction Compensation) sensor input
- 20 (differential) channel multiplexer
- Precision 9.90 V source
- Analog ground source
- Programmable gain amplifier suitable for scaling the seven thermocouple types
- High frequency, synchronous V-F A/D converter.

During normal operation, the V-F converts the CJC input, calibrates the gain at a Gain = 1 using the 9.9 V input, offset using the ground input, and measures the thermocouple or voltage depending on the input type. The CJC and the gain/offset values are stored in an onboard RAM for cold junction scaling and calibration. These parameters are sampled continuously. Refer to the block diagram shown in Figure 3 on page 12.

The V-F converter is an Analog Devices AD652 SVFC (Synchronous V-F Converter) which offers full scale frequency up to 2 MHz and extremely low linearity error. The 4 MHz clock for the V/F converter is supplied by TIMER1 and passes through opto-isolation. The output of the V/F converter, passing back through opto-isolation, is supplied to TIMER0. TIMER0 is gated on by TIMER2 for a period dependent upon the specified conversion frequency of 50Hz, 60Hz or 400Hz. At the end of the sampling period, the count in TIMER0 represents the voltage input. In general, the longer the count time, the higher the resolution and better the noise reduction, unless in the case of periodic noise where the periodic frequency (for example, 50, 60, and 400 Hz) is more effective in reducing the noise.

Processing and control

This section consists of control and decode logic, a microcontroller and local memory to perform channel scanning, CJC measurements, calibration, linearization, averaging, and voltage/temperature translation. The above parameters are set up from a configuration file which is downloaded by the PC to the microcontroller's local memory through the Dual Port RAM. After the microcontroller is given the command to start conversions, these parameters are set on a channel-by-channel basis with data reported to the PC in the format specified by the configuration file. For thermocouple inputs, the microcontroller reads the counter, adjusts the data based on the CJC value and gain/offset calibration, then linearizes and converts the reading to the appropriate temperature units.

To perform linearization, the microcontroller gets the raw frequency count from TIMER0, translates that into bits, factors in the CJC correction and gain/offset calibration, then refers to a previously stored lookup table stored in ROM. There is a separate table for each thermocouple. The lookup tables are a method to optimize the linearization by using more reference points along areas of greatest temperature/voltage change instead of using mathematical translation, which requires lengthy polynomial manipulation. Using lookup tables requires finding two consecutive points, one greater and one less than the measured value, then interpolating the measured temperature value.

Process flow

The PC itself performs very few functions for the PCI-DAS-TC. The driver software (included with the PCI-DAS-TC kit) sets up individual channels, including the thermocouple type, CJC on/off, voltage or thermocouple gain, channel, and temperature units. The sample rate and sample averaging configuration are also set by the driver for all channels. Both during initialization and when the configuration changes, this information is passed to the CPU through the Dual Port RAM and stored for the specified channel. The PC then notifies the CPU to start taking measurements. When the CPU completes a conversion, an interrupt is generated so that the PC reads the data from the Dual Port RAM which the CPU had written to. The 32-bit floating point data is stored in four consecutive locations in the Dual Port RAM. Refer to the "Dual Port RAM Memory Map" section in the *Register Map for the PCI-DAS-TC* for more details on this process. This document is available on our web site at www.mccdaq.com/registermaps/RegMapPCI-DAS-TC.pdf.

The on-board CPU has a much more complicated task. The CPU must set all the parameters for conversion of the selected channel. After conversion, it must get the data, adjust it based on the stored CJC measurement, calibrate against gain/offset error, linearize it based on lookup tables for each associated thermocouple type, and report the data to the PC through the Dual Port RAM. During this process, the CPU goes to the next channel and sets up the parameters for that channel to allow sufficient settling time before the next conversion begins.

Specifications

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

Analog input

Table 1. Analog input specifications

A/D converter type	AD652 V/F converter
Number of channels	16 differential thermocouple inputs, 1 CJC input
Programmable ranges	–2.5 V to +10 V, –20 mV to +80 mV, –15 mV to +60 mV, –6.25 mV to 25 mV
Voltage gains	1, 125, 166.7, 400
Thermocouple types	J, K, E, T, R, S, B
A/D pacing	Continuous conversions. Software-programmable for 50 Hz, 60 Hz, or 400 Hz
A/D trigger sources	Software-triggered
Data transfer	Single I/O register transfer through dual port RAM
Conversion rates (integrating time)	50 Hz, 60 Hz, 400 Hz Software programmable
**Conversion rates (per channel)*	*25.0 msec @ 50 Hz typical, 25.5 msec maximum* *21.6 msec @ 60 Hz typical, 22.1 msec maximum* *7.4 msec @ 400 Hz typical, 7.9 msec maximum* **This is the total time to convert the channel, process the data, and provide a delay to switch the gain and channel.*
Linearity error (A/D specs)	*±0.05% @ 4 MHz clock*
Gain drift (A/D specs)	*±75 ppm/°C max*
Zero drift (A/D specs)	*±50 uV/°C max*
Power supply rejection ratio	*0.01 %/V*
Overvoltage protection	*–40 V to +55 V*
CMRR @ 60 Hz	80 dB minimum
Input leakage current	±80 nA maximum
Input impedance	100 MegOhm minimum
Absolute maximum input voltage	*–40 V to +55 V*
Isolation to PC	*500 V min through DC/DC converter and opto-isolators*

Accuracy and resolution

Table 2. Voltage measurements

Gain	Range	Accuracy (Worst Case)	Resolution		
			@ 50 Hz	@ 60 Hz	@ 400 Hz
1	–2.5 to 10 V	±0.01% of reading ±2.5 mV	312.5 µV	375 µV	2.5 mV
125	–20 to 80 mV	±0.01% of reading ±20 µV	2.5 µV	3.0 µV	20.0 µV
166.7	–15 to 60 mV	±0.01% of reading ±15 µV	1.88 µV	2.25 µV	15.0 µV
400	–6.25 to 25 mV	±0.02% of reading ±6.25 µV	0.781 µV	0.938 µV	6.25 µV

Table 3. Thermocouple measurements (not including CJC errors)

TC Type	Range	Accuracy (Worst Case)	Resolution		
			@ 50 Hz	@ 60 Hz	@ 400 Hz
J	0 to 750 °C	±0.5 °C	0.05 °C	0.05 °C	0.40 °C
K	–200 to 1250 °C	±1.4 °C	0.04 °C	0.05 °C	0.40°C
E	–200 to 900 °C	±1.1 °C	0.03 °C	0.04 °C	0.25 °C
T	–200 to 350 °C	±0.9 °C	0.03 °C	0.04 °C	0.25 °C
R	0 to 1450 °C	±2.3 °C	0.06 °C	0.07 °C	0.44 °C
S	0 to 1450 °C	±2.3 °C	0.06 °C	0.08 °C	0.52 °C
B	0 to 1700 °C	±3.0 °C	0.07 °C	0.08 °C	0.54 °C

Miscellaneous

Table 4. Miscellaneous specifications

Averaging	Moving average, 1 to 16 samples, software-selectable
Calibration	Calibration is performed with each channel scan to remove offset and gain error. CJC channel is also measured with each calibration.
Processor reset	On power-up, watchdog timeout, or software command. Processor boots within one second of reset. Active low.
Watchdog timer	1.6 seconds nominal. Processor generates watchdog disable signal after boot-up.
Temperature units	Programmable for conversion to °C or °F
Interrupts	INTA# mapped to IRQn by PCIBIOS at boot time
Interrupt enable	Programmable
Interrupt sources	Dual port RAM when the processor mailbox has data.

Crystal oscillator

Table 5. Crystal oscillator specifications

Frequency	*32 MHz*
Frequency accuracy	*100 ppm*

CIO-STA-TC adapter

Table 6. CIO-STA-TC adapter specifications

CJC type	AD592CN
Configuration	CJC centered in an isothermal block on which the screw terminals have been mounted.
Channels	16 (plus CJC output)

Calibration error

Table 7. Calibration error specifications

@ 25 °C	0.3 °C typical, 0.5 °C maximum
25 °C to +105 °C	0.5 °C typical, 1.0 °C maximum

Linearity error

Table 8. Linearity error specifications

–25 °C to +105 °C	0.1 °C typical, 0.35 °C maximum
Temperature coefficient	*1 µA/°C typical*
Long term stability	0.1 °C / month
Open thermocouple detect	On/off switch selectable for each channel, full scale reading

Power consumption

Table 9. Power consumption specifications

+5 V operating	887 mA typical, 1441 mA maximum

Environmental

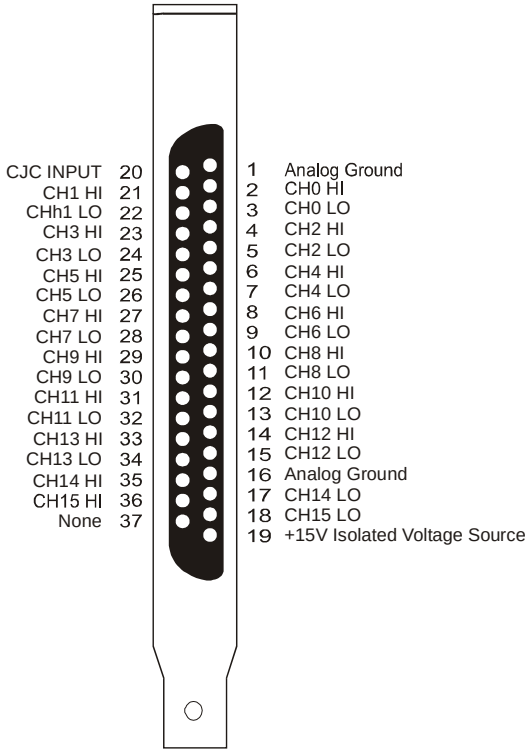
Table 10. Environmental specifications

Operating temperature range	0 to 50 °C
Storage temperature range	–20 to 70 °C
Humidity	0 to 90% non-condensing

Main connector and pin-out

Table 11. Main connector specifications

Connector type	37-pin D-type
Compatible cable	C37FFS-*x*
Compatible accessory product (with C37FFS-x cable)	CIO-STA-TC screw terminal adapter board


CJC INPUT 20
CH1 HI 21
CHh1 LO 22
CH3 HI 23
CH3 LO 24
CH5 HI 25
CH5 LO 26
CH7 HI 27
CH7 LO 28
CH9 HI 29
CH9 LO 30
CH11 HI 31
CH11 LO 32
CH13 HI 33
CH13 LO 34
CH14 HI 35
CH15 HI 36
None 37
1 Analog Ground
2 CH0 HI
3 CH0 LO
4 CH2 HI
5 CH2 LO
6 CH4 HI
7 CH4 LO
8 CH6 HI
9 CH6 LO
10 CH8 HI
11 CH8 LO
12 CH10 HI
13 CH10 LO
14 CH12 HI
15 CH12 LO
16 Analog Ground
17 CH14 LO
18 CH15 LO
19 +15V Isolated Voltage Source

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

PCI-DAS-TC

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

EC EMC Directive 2004/108/EC: General Requirements, EN 61326-1:2006 (IEC 61326-1:2005).

Emissions: IEC 61326-1:2005.

- EN 55011 (2007) / CISPR 11(2003): Radiated emissions: Group 1, Class A
- EN 55011 (2007) / CISPR 11(2003): Conducted emissions: Group 1, Class A

Immunity: EN 61326-1:2006, Table 3.

- IEC 61000-4-2 (2001): Electrostatic Discharge immunity.
- IEC 61000-4-3 (2002): Radiated Electromagnetic Field immunity.
- IEC 61000-4-4 (2004): Electric Fast Transient Burst Immunity.
- IEC 61000-4-5 (2001): Surge Immunity.
- IEC 61000-4-6 (2003): Radio Frequency Common Mode Immunity.
- IEC 61000-4-11 (2004): Voltage Interrupts.

To maintain compliance to the standards of this declaration, the following conditions must be met.

- The host computer, peripheral equipment, power sources, and expansion hardware must be CE compliant.
- All I/O cables must be shielded, with the shields connected to ground.
- I/O cables must be less than 3 meters (9.75 feet) in length.
- The host computer must be properly grounded.
- Equipment must be operated in a controlled electromagnetic environment as defined by Standards EN 61326:2006, or IEC 61326:2005.

Declaration of Conformity based on tests conducted by Chomerics Test Services, Woburn, MA 01801, USA in March, 2009. Test records are outlined in Chomerics Test Report #EMI5299.09.

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



Carl Haapaoja, Director of Quality Assurance

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