

User's Guide

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CIO-DAS-TC
PCI-DAS-TC

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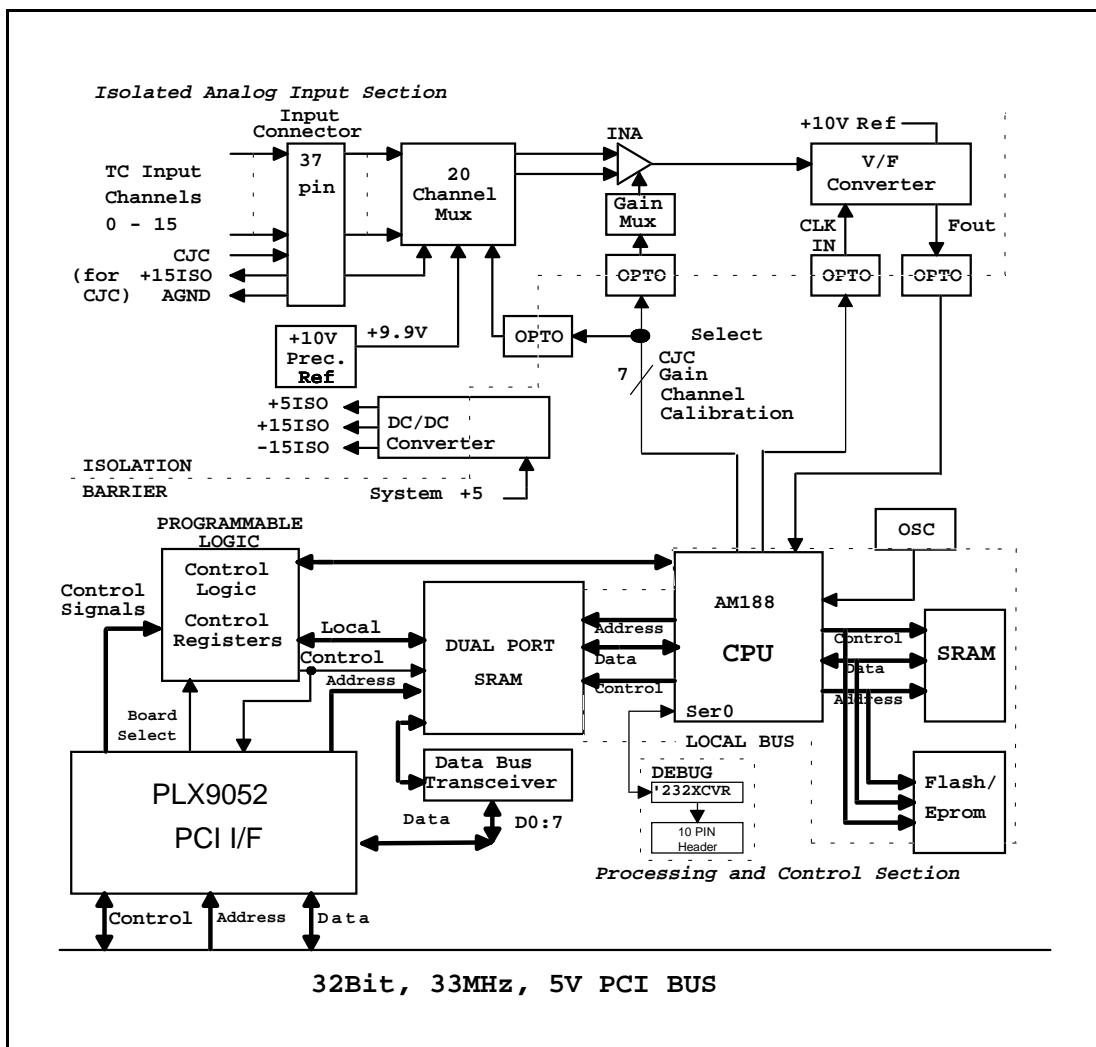
1.0 INTRODUCTION

Thank you for purchasing a CIO-DAS-TC or PCI-DAS-TC. These boards represent the latest technology and are easy to use, powerful and extremely accurate. The DAS-TC includes the CIO-STA-TC, a screw terminal board with an isothermal block and CJC sensor, as well as a C37FFS-5 five-foot shielded cable.

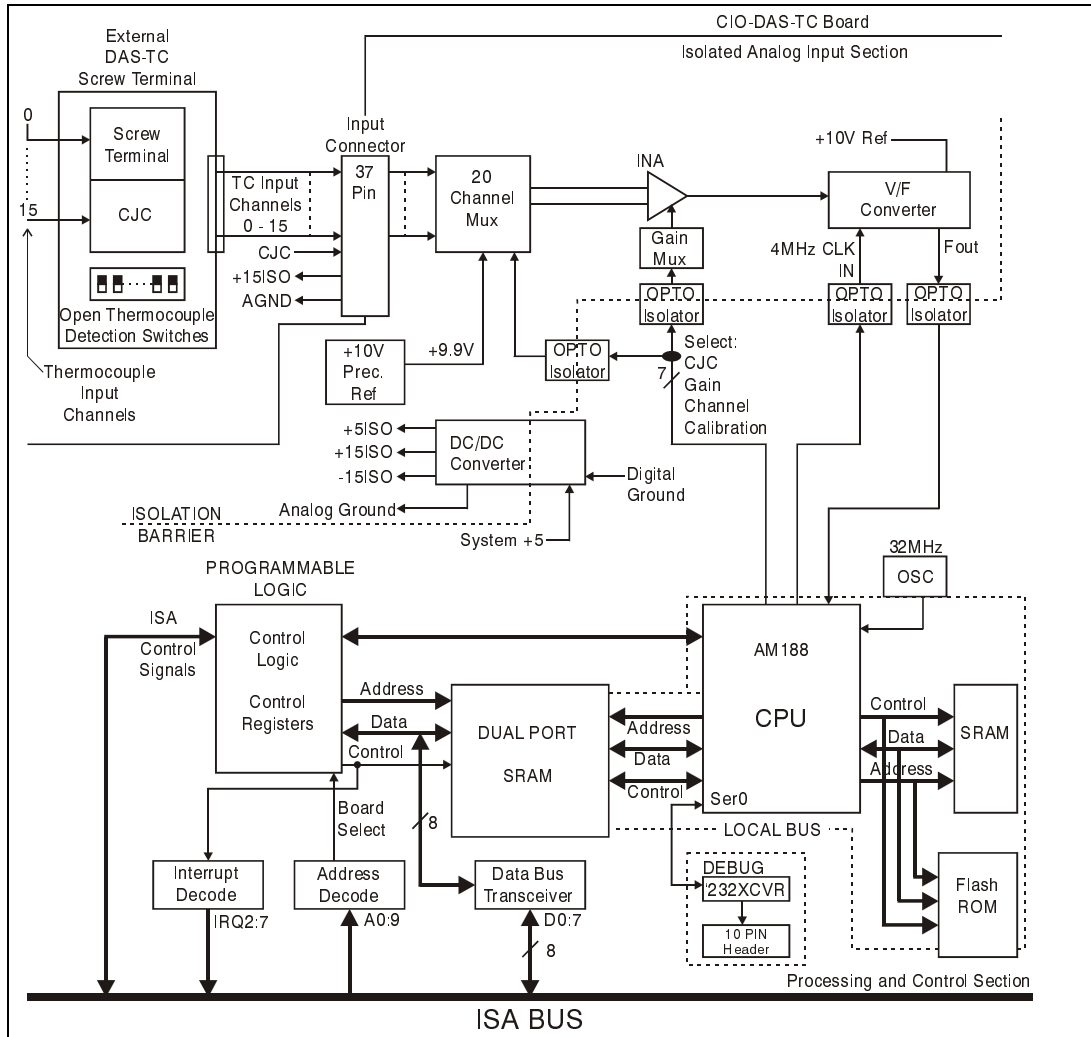
The CIO-DAS-TC and PCI-DAS-TC are 16-channel thermocouple/voltage input boards for the ISA and PCI bus, respectively. The DAS-TC boards accept seven different types of thermocouple input (J, K, E, T, R, S, and B), and provide the user with a temperature in either degrees C or F. An onboard microprocessor handles all the control and math functions including; CJC (Cold Junction Compensation), automatic gain and offset calibration, and thermocouple linearization, thus off-loading the computer CPU from performing these functions. The analog input section is fully isolated from the computer. A block diagram of the DAS-TC is shown on the following page.

The CIO-DAS-TC and PCI-DAS-TC are similar in all respects except two: first, the CIO-DAS-TC is designed to work with the ISA bus and the PCI-DAS-TC with the PCI bus. Second, the CIO-DAS-TC has an onboard dip switch for setting the base address; while the PCI-DAS-TC is completely plug-and-play, with no jumpers or switches to set! For the sake of clarity in this manual, we will refer to both boards collectively as *DAS-TC*, except where these two differences apply.

The DAS-TC is supported by the powerful Universal Library driver package. The boards are also supported by many third-party, high-level data acquisition software.



PCI-DAS-TC Block Diagram



CIO-DAS-TC Block Diagram

2.0 INSTALLATION

The installation routine varies only slightly depending upon whether you are installing the CIO-DAS-TC or the PCI-DAS-TC board. The CIO-DAS-TC requires that you run the included **InstaCal™** program, then verifying and, if necessary, changing the base address using an onboard dip switch before plugging the board in. If you are installing the PCI-DAS-TC, you need only plug it in. The base address is allocated by the PCI plug & play procedure.

2.1 SOFTWARE INSTALLATION

2.1.1 WINDOWS 95, 98, NT AND ABOVE

If you will be using the Universal Library with your board, insert the Universal Library diskette or CD in an appropriate drive run the program SETUP.EXE, and follow the installation instructions provided. This program will install both **InstaCal™** (setup and test utility) and the Universal Library. (If you are using Windows 95 or 98, you will have the option of installing the 16-bit and/or 32-bit library. Unless you have a specific reason to use the 16-bit library (e.g. compatibility with an existing program) install the 32-bit version. Please note that the DAS-TC boards are not currently supported by the 16-bit library and so are not currently compatible with the DOS or Windows 3.x operating systems. Please contact the factory if you require 16-bit library support.

If you are not using the Universal Library, insert the disk or CD labeled **InstaCal™** into an appropriate drive, and run SETUP.EXE. The install wizard will now launch and you will then be prompted for additional information. Follow the instructions and, if possible, accept the defaults, especially if this is your first installation. It will be easier for us to assist you in the unlikely event of trouble during your system setup and operation.

2.1.2 UNIVERSAL LIBRARY INSTALLATION OPTIONS

The Universal Library provides example programs for a wide variety of programming languages. If you are installing the Universal Library, an "Installation Options" dialog box will allow you to select which languages' example programs are loaded onto your computer. Select the desired example programs by checking the appropriate box(s).

2.1.3 FILE DEFAULT LOCATION

InstaCal will place all appropriate files in "C:CB" If you change this default location remember where the installed files are placed as you may need to access them later.

2.1.4 INSTALLATION QUESTIONS

At the end of the installation process the installation wizard will ask a series of questions updating your startup files. Unless you have knowledge to the contrary, simply accept the default (YES) when prompted. You will also be asked if you would like to read an updated README file. If possible, please choose yes and take a look at the information in the file. It will include the latest information regarding the software you are installing.

2.1.5 INSTALLATION COMPLETION

After the installation of **InstaCal** is complete you should restart your computer to take advantage of changes made to the system.

2.1.6 DOS AND WINDOWS 3.x

Most users are now installing PCI Bus boards in systems with 32-bit operating systems (e.g., Windows 95, 98 or NT). The DAS-TC is not currently supported by the 16-bit library required to run under DOS or Windows 3.x.

Please contact us if your application is running under DOS or Windows 3.x.

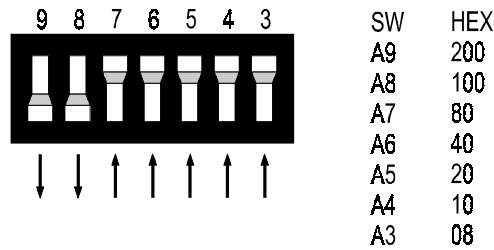
2.2 CIO-DAS-TC HARDWARE INSTALLATION

2.2.1 SETTING THE BASE ADDRESS SWITCH

Prior to installing the CIO-DAS-TC board, you need to set the base address by using the dip switch located on the board. The easiest way to set the base address switch is to let InstaCAL show you the correct settings. This process is described in the section (2.2.2).

However, if are already familiar with setting ISA base addresses, you may use the base address switch description below to guide your base address selection.

Unless there is already another board in your system using address 300 HEX (768 Decimal), you can leave the switches as they are set at the factory. The example shown in the following diagram shows the settings for the factory default base address of 300H.



BASE ADDRESS SWITCH - Address 300H shown here.

A complete address is constructed by calculating the HEX or decimal number which corresponds to all the address bits the CIO-DAS-TC has been instructed to respond to. In the default configuration, shown above, addresses 9 and 8 are DOWN, and all others are UP. Address 9 = 200H (512D) and address 8 = 100H (256D), when added together they equal 300H (768D).

NOTE

DO NOT PAY ATTENTION TO THE NUMBERS PRINTED ON THE SWITCH. PLEASE REFER TO THE NUMBERS PRINTED IN WHITE ON THE PRINTED CIRCUIT BOARD!

The InstaCAL software package will also help you set the base address switch. If you have questions regarding the following diagram, run InstaCAL, and follow the instructions provided.

2.2.2 RUN InstaCAL

To run *InstaCal*[™] from Windows 95, 98 or NT use the familiar START>PROGRAM>ComputerBoards>InstaCAL. Alternatively you may use the START>RUN sequence, type INSCAL32 and hit OK, or find the file named INSCAL32.EXE using your file management system (located in C:\CB\ unless you selected an alternative directory during installation) and double click your mouse on it.

1. Select **Install** (either highlight it and hit enter or double click your mouse on it).
2. Select **Add Board**
3. Select the CIO-DAS-TC
4. Select **Install** again
5. Select **Configure**. The CIO-DAS-TC switch selection options will be displayed.

2.2.3 PLUG IN THE CIO-DAS-TC BOARD

Once you are done selecting and verifying the base address, you may shut the computer off and open the case.

Locate an empty ISA expansion slot in your computer. Push the board firmly down into the expansion bus connector. If it is not seated fully it may fail to work and could short circuit the PC bus power onto a PC bus signal. This could damage the motherboard in your PC as well as the DAS-TC. We also highly recommend that you use the screw provided on your computer's back plate to secure the DAS-TC in its location.

Replace the cover to the computer and turn it on. Plug one end of the cable provided into the DAS-TC board, and the other into the CIO-STA-TC. Your hardware is now installed.

2.2.4 RUN InstaCAL AGAIN

Run the *InstaCal* program in order to test your board and configure it for run-time use. By configuring the board, you add information to the configuration file, *cb.cfg*, that is used by the Universal Library and other third-party data acquisition packages that use the Universal Library to access the board.

Check that the CIO-DAS-TC is still listed as an installed board. Then proceed to the "Calibrate" or "Test" functions of InstaCAL to assure that your board is functioning properly. Once the board has been tested, select **FILE** then **Exit**, and the configuration file will be written to your hard disk.

2.3 PCI-DAS-TC HARDWARE INSTALLATION

2.3.1 PHYSICAL INSTALLATION

The PCI-DAS-TC is completely plug and play. Simply follow the steps shown below to install your PCI hardware.

1. Turn your computer off, unplug it, open it up and insert the PCI board into any available PCI slot.
2. Close your computer up, plug it back in and turn it on. Plug one end of the cable provided into the DAS-TC board, and the other into the CIO-STA-TC. Your hardware is now installed. Run **InstaCal™** again and you may use one of the built-in test functions to assure the board is operating properly
3. Windows will automatically detect the board as it starts up. If the board's configuration file is already on the system, it will load without user interaction. If the configuration file is not detected, you will be prompted to insert the disk containing it. The required file is on the InstaCal or Universal Library disk you received with your board. Simply insert the CD (or Disk 1 if your software is on floppy disk) into an appropriate drive and click on **CONTINUE**. The appropriate file should then be automatically loaded and the PCI board will appear in the Device Manager under DAS Component.

2.3.2 RUN InstaCAL

Run the *InstaCal* program in order to test your board and configure it for run-time use. By configuring the board, you add information to the configuration file, *cb.cfg*, that is used by the Universal Library and other third-party data acquisition packages that use the Universal Library to access the board.

Launch *InstaCal* by going to your Start Menu then to Programs, then to ComputerBoards, and finally choosing *InstaCal*. You may also launch the program by going to START>RUN and typing INSCAL32, or by finding the file named "inscal32.exe" in your installation directory and double clicking it.

InstaCal will display a dialog box indicating the boards that have been detected in the system. If there are no other boards currently installed by *InstaCal*, then the PCI-DAS-TC board will be assigned board number 0. Otherwise it will be assigned the next available board number.

You can now view and change the board configuration by clicking the properties icon or selecting the Install>Configure menu.

In the PCI-DAS-TC installation, InstaCal reads the base address from the PC's BIOS and stores it in the configuration file CB.CFG. This file is accessed by the Universal Library for programmers. Note also that the Universal Library is the I/O board interface for packaged applications such as Labtech Notebook and HP-VEE, therefore the InstaCal settings must be made in order for these and other third-party applications to run.

A word of warning is in order here. We do not advise direct writes to the addresses simply by reference to the base address of the PCI board I/O registers. Since the addresses assigned by the PCI plug & play software are not under your control, there is no way to guarantee that your program will run in any other computer. In addition, when you install new systems or components in your computer, previous base address assignments may be changed, or a particular board may be moved. It is best to use a library such as Universal Library or a program such as HP-VEE to make measurements with your PCI board.

2.3.3 TESTING THE INSTALLATION

With InstaCal running,

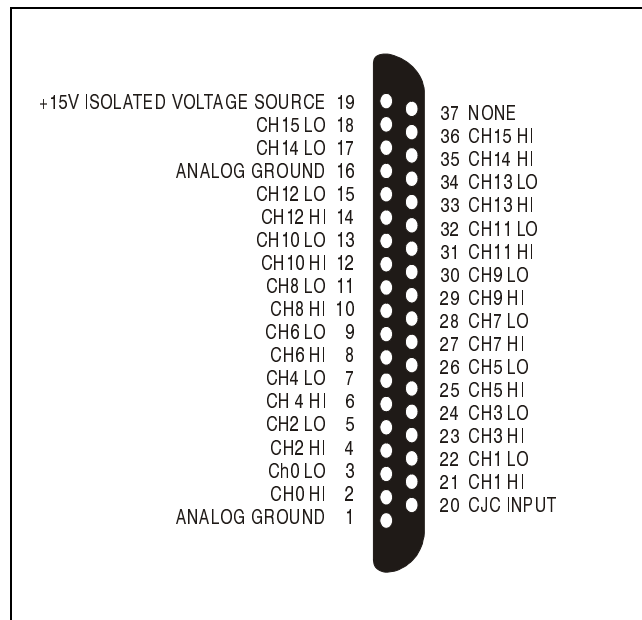
- a. Select the board you just installed
- b. Select the "Test" function
- c. Follow the instructions provided to test for proper board operation.

2.4 EXTERNAL CONNECTIONS & THE CIO-STA-TC

2.4.1 DAS-TC CONNECTOR PINOUT

The DAS-TC uses a single 37-pin connector on the back plate of the board to bring out 16 thermocouple input channels, CJC input, and ground. See the following connector diagram for the correct pinouts on the back plate of the DAS-TC.

Both the CIO-DAS-TC and the PCI-DAS-TC come with the CIO-STA-TC, a screw terminal board that provides an isothermal block and cold-junction sensor, as well as with the C37FFS-5, a 5 foot shielded cable. A description of these items is contained in the following section



2.4.2 THE CIO-STA-TC

The CIO-STA-TC is a specially configured screw terminal adapter board designed specifically for use with the DAS-TC series. The board provides 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 + and one -). Simply connect your thermocouple wires to the appropriate terminals, connect the CIO-STA-TC to the DAS-TC with the shielded cable provided, and your system is ready to go!

2.4.3 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 MegOhm resistors that can be connected between the + terminal of the thermocouple, and a known input voltage that is larger than any allowable thermocouple output.

The 20 MegOhm is large enough so that it does not affect the reading from the thermocouple, but if the thermocouple junction happens to open circuit, the 20 MegOhm will drive the input voltage high enough, so the software can recognize that it is not a valid thermocouple reading.

The open thermocouple detection circuitry is set via dip switch on the CIO-STA-TC. The DIP switches are labeled, and each channel has a unique switch. To enable the open thermocouple detection scheme, set the switch to on (up towards the isothermal block). To disable the circuits, simply set the switch to off (down, towards the outside of the board). The units are shipped with the open thermocouple detection circuitry disabled..

3.0 PROGRAMMING & APPLICATIONS

The DAS-TC is supported by the powerful Universal Library. We strongly recommend that you take advantage of the Universal Library as your software interface. In particular, the complexity of the PCI-BIOS's dynamic allocation of PCI bus addresses and internal resources makes the PCI-DAS-TC series very challenging to program via direct register I/O operations.

3.1 PROGRAMMING LANGUAGES

The Universal Library provides complete access to the DAS-TC functions from a range of Windows programming languages. If you are planning to write programs, or would like to run the example programs for Visual Basic or any other language, please refer to the Universal Library manual. For details regarding programming with Universal Library, please refer to the Universal Library documentation.

The optional VIX Components package may greatly simplify your programming effort. VIX Components is a set of programming tools based on a DLL interface to Windows languages. A set of VBX, OCX, and ActiveX interfaces allows point and click construction of graphical displays, analysis and control structures. Please see a product catalog or contact us for a complete description of VIX Components.

3.2 PACKAGED THIRD-PARTY APPLICATIONS PROGRAMS

In addition to DAS-Wizard, many packaged third-party application programs such as Labtech Notebook and HP-VEE have, or will soon have drivers for the DAS-TC. If the package you own does not appear to have drivers for the DAS-TC, please fax or e-mail the package name and the revision number from the install disks. We will research the package for you and advise how to obtain DAS-TC drivers.

Some application drivers that are included with Universal Library are not included with third-party application packages. If you have purchased an application package directly from the software vendor, you may need to purchase our Universal Library and drivers. Please contact us for more information on this topic.

4.0 THEORY OF OPERATION

4.1 ISOLATED ANALOG INPUT

The analog input section of the DAS-TC consists of a CJC (Cold Junction Compensation) sensor input, a 16 (differential) channel multiplexer, a precision 9.90V source, an analog ground source, a programmable gain amplifier suitable for scaling the seven thermocouple types, and a 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 9.9V input, offset using the ground input, and measures the thermocouple or voltage depending on the setup. The CJC and the gain/offset values are stored in onboard RAM to allow proper cold junction scaling and calibration. These parameters are sampled continuously.

The V-F converter is the 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 (i.e. 50, 60, and 400 Hz) is more effective in reducing the noise.

4.2 PROCESSING AND CONTROL

This section of the DAS-TC consists of ISA or PCI 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. Once 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, with 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. The lookup tables require finding two consecutive points, one greater and the next less than the measured value, then interpolating the measured value to the temperature.

4.3 PROCESS FLOW

The PC itself performs very few functions for the DAS-TC. The driver software included with the DAS-TC board will set 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 software driver, though these settings are for all channels. Both during initialization and when the configuration changes, this information will be passed to the CPU through the Dual Port RAM and stored for the specified channel. The PC will notify 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. See section 7.4 for more details on this process.

The onboard CPU has a much more complicated task. The CPU must set all the parameters for the channel selected to convert. Once converted, it must get the data, adjust based on the CJC measurement stored, calibrate against gain/offset error, linearize 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 must go to the next channel and set up the parameters for that channel to allow proper time for settling before the next conversion begins.

5.0 Self-Calibration

The DAS-TC 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 are automatically retrieved each time a different range is specified. The user has the option to recalibrate with respect to the factory-measured voltage standards at any time by simply selecting the "Calibrate" option in InstaCal. InstaCAL will calibrate all channels at all six ranges. Each channel takes less than a minute to calibrate.

6.0 Register Description

We strongly urge users to take advantage of the Universal Library software package rather than attempt to write register level software for the DAS-TC series. The register level programming information is provided as a matter of completeness only. Register level programming of this or any other PCI board is quite complex and should only be attempted by a highly experienced programmer.

The PCI- and CIO-DAS-TC register maps are virtually identical. The PCI board actually provides two base addresses. The first (BADR1) provides access to the board's PLX 9052 PCI interface chip. This address also provides the interrupt control status and control registers for the board. The second address (BADR2) actually performs the data and address reads and writes.

The CIO-DAS-TC only provides a single base address that is virtually identical to the BADR2 address on the PCI board. The following sections provide a more detailed description of the various addresses and their functions.

6.1 PCI-DAS-TC REGISTER OVERVIEW

REGISTER	READ FUNCTION	WRITE FUNCTION	OPERATIONS
BADR1+4C hex	Interrupt Status	Interrupt Control	32-bitDWORD
BADR2 + 0	N/A	Dual Port RAM Addr (LSBs)	8-bit BYTE
BADR2 + 1	N/A	Dual Port RAM Addr (MSBs)	8-bit BYTE
BADR2 + 2	Dual Port RAM Data Read	Dual Port RAM Data Write	8-bit BYTE
BADR2 + 3	N/A	N/A	8-bit BYTE
BADR2 + 4	Resets DAS-TC microprocessor	Resets DAS-TC microprocessor	8-bit BYTE
BADR2 + 5	N/A	DAS-TC Mode Register	8-bit BYTE

6.1.1 PCI Local Register Map

BADR1 + 4Chex: PLX9052 Interrupt Register: Read/Write

7	6	5	4	3	2	1	0
-	PCI_EN	-	-	-	INT	INTPOL	INTE

This register, as with all the 9052 registers, is 32-bits in length. Since the rest of the register has specific control functions, they would need to be masked off in order to access the interrupt control functions.

INTE is the Local Interrupt Enable: 0 = disabled, 1 = enabled (default).

INTPOL is the Interrupt Polarity: 0 = active low (default), 1 = active high.

INT is the Interrupt Status: 0 = interrupt is not active, 1 = interrupt is active.

PCI_EN is the PCI Interrupt Enable: 0 = disabled (default), 1 = enabled. This control signal allows the interrupt to be passed to the PCI bus.

The PC de-asserts the interrupt by reading the mailbox location 0x3FF¹ in the Dual Port RAM.

6.1.2 Board I/O Register Map

The PCI-DAS-TC and CIO-DAS-TC have virtually identical I/O register maps. These are described in section 6.3, with any differences between the boards noted there.

¹Location 0x3FF is the mailbox for the right side of the DPRAM which is connected to the ISA bus. Please refer to the data sheets for the Cypress CY7C130 and Cypress application note "Understanding Asynchronous Dual-Port RAMs".

6.2 CIO-DAS-TC REGISTER OVERVIEW

REGISTER	READ FUNCTION	WRITE FUNCTION	OPERATIONS
BADR + 0	N/A	Dual Port RAM Addr (LSBs)	8-bit BYTE
BADR + 1	N/A	Dual Port RAM Addr (MSBs)	8-bit BYTE
BADR + 2	Dual Port RAM Data Read	Dual Port RAM Data Write	8-bit BYTE
BADR + 3	Interrupt Status Register	Interrupt Control Register	8-bit BYTE
BADR + 4	Resets DAS-TC microprocessor	Resets DAS-TC microprocessor	8-bit BYTE
BADR + 5	N/A	DAS-TC Mode Register	8-bit BYTE

A detailed description of the registers and their functions is provided in the following section (6.3).

6.3 REGISTER MAP DETAILS

Base + 0: Dual Port RAM Address Byte (LSB): Write Only

7	6	5	4	3	2	1	0
DPRA7	DPRA6	DPRA5	DPRA4	DPRA3	DPRA2	DPRA1	DPRA0

Base + 1: Dual Port RAM Address Byte (MSB): Write Only

7	6	5	4	3	2	1	0
-	-	-	-	-	-	DPRA9	DPRA8

Select the location of the DPRAM to be accessed by writing its address to BASE+0 and BASE+1. The data from this location can be read by reading from BASE+2 or data can be written to this location by writing to BASE+2

Base + 2: Dual Port RAM Data Byte: Read/Write

Data from the DPRAM can be read by reading this register. Conversely, data can be written to DPRAM by writing to this location. The location of the DPRAM is specified in register BASE+0 and BASE+1 respectively.

7	6	5	4	3	2	1	0
DPRD7	DPRD6	DPRD5	DPRD4	DPRD3	DPRD2	DPRD1	DPRD0

Base + 3: PC Interrupt Control Register: Write (*No function on the PCI-DAS-TC*)

Writing to this register selects the interrupt line used to interrupt the PC. The PC can determine the cause of the interrupt and simultaneously de-assert the interrupt by reading mailbox location 0x3FF² in the DPRAM.

7	6	5	4	3	2	1	0
-	-	-	-	-	INT4	INT2	INT1

Interrupt Enable/Select:

INT4	INT2	INT1	Selected IRQ
0	0	0	None
0	1	0	IRQ2
0	1	1	IRQ3
1	0	0	IRQ4
1	0	1	IRQ5
1	1	0	IRQ6
1	1	1	IRQ7

²Location 0x3FF is the mailbox for the right side of the DPRAM which is connected to the ISA bus. Please refer to the data sheets for the Cypress CY7C130 and Cypress application note "Understanding Asynchronous Dual-Port RAMs".

Base + 3: PC Interrupt Status Register: Read (*No function on the PCI-DAS-TC*)

7	6	5	4	3	2	1	0
INTR/	INTL/	-	-	-	INT4	INT2	INT1

INT1-INT4 : Interrupt that is selected by writing to BASE+3.

INTR/³ This bit is 0 when the microcontroller writes to the PC's mailbox location 0x3FF in the DPRAM. The PC can determine the cause of the interrupt and/or status and simultaneously clear the INTR/ bit (i.e. make it 1) by reading mailbox location 0x3FF in the DPRAM.

INTL/⁴ This bit is 0 as soon as the PC writes to the microcontroller's mailbox location 0x3FE in the DPRAM. This bit will be 1 after the microcontroller has read its mailbox. The PC should only write to the microcontroller's mailbox when this bit is 1.

Base + 4: DASTC reset register: Read/Write

Reading or writing to this register will reset the microcontroller on the DAS-TC⁵.

7	6	5	4	3	2	1	0
-	-	-	-	-	-	-	-

Base + 5: Mode select register : Write only

This register is used to select the mode of the DAS-TC on power-up. This register is read by the processor only during power up initialization.

7	6	5	4	3	2	1	0
-	-	-	-	-	-	-	MODE

MODE This bit is 0 for normal operation mode. In normal mode, the board executes the firmware. On power up this bit is cleared.

If this bit is set to 1, the board is forced to download firmware via the dual port RAM and program it into FLASH.

After toggling the MODE bit, the board should be reset, by writing to BASE+4 register, because the processor reads the bit only during initialization.

6.2 DUAL PORT RAM MEMORY MAP

The PC and the AM188 processor in the DAS-TC board communicate and share data through a 1Kx8 dual-port RAM. The PC accesses the DPRAM indirectly via registers at address BASE+0 through BASE+2 as explained in section on page . The AM188 processor, however, accesses the DPRAM directly.

The DPRAM is divided into regions where predefined data is written by one processor and read by the other. The top most two bytes in the DPRAM have special hardware logic associated with them and serve as mailboxes. Byte 0x3ff is the PC's mailbox and byte 0x3fe is the AM188's mailbox. When the PC writes to the AM188's mailbox, it is notified about the arrival of data by the assertion of the INTL/ signal. When the AM188 reads its mailbox this signal is de-asserted. Conversely, when the AM188 writes to the PC's mailbox, the PC is notified either via an interrupt or by the INTR/ bit in register BASE+3. When the PC reads its mailbox, this signal is de-asserted.

³ This bit reflects the status of the INTR/ output of the DPRAM.

⁴ This bit reflects the status of the INTL/ output of the DPRAM.

⁵ Moving the reset control from BASE+3 to a separate register (BASE+4) insures that the DAS-TC is not accidentally reset.

Addr (Hex)	D7	D6	D5	D4	D3	D2	D1	D0	Description of data	Data flow
300	-	-	AVG3	AVG2	AVG1	AVG0	RS1	RS0	Configuration	to 188
310	-	F1	F0	G1	G0	TCT2	TCT1	TCT0	CH0 Configuration	to 188
311	-	F1	F0	G1	G0	TCT2	TCT1	TCT0	CH1 Configuration	to 188
*				*					*	*
*				*					*	*
31F	-	F1	F0	G1	G0	TCT2	TCT1	TCT0	CH15 Configuration	to 188
320	D7	D6	D5	D4	D3	D2	D1	D0	CH0 Float (Byte 0)	to PC
321	D7	D6	D5	D4	D3	D2	D1	D0	CH0 Float (Byte 1)	to PC
322	D7	D6	D5	D4	D3	D2	D1	D0	CH0 Float (Byte 2)	to PC
323	D7	D6	D5	D4	D3	D2	D1	D0	CH0 Float (Byte 3)	to PC
324	D7	D6	D5	D4	D3	D2	D1	D0	CH1 Float (Byte 0)	to PC
325	D7	D6	D5	D4	D3	D2	D1	D0	CH1 Float (Byte 1)	to PC
326	D7	D6	D5	D4	D3	D2	D1	D0	CH1 Float (Byte 2)	to PC
327	D7	D6	D5	D4	D3	D2	D1	D0	CH1 Float (Byte 3)	to PC
*				*					*	*
*				*					*	*
*				*					*	*
35C	D7	D6	D5	D4	D3	D2	D1	D0	CH15 Float (Byte 0)	to PC
35D	D7	D6	D5	D4	D3	D2	D1	D0	CH15 Float (Byte 1)	to PC
35E	D7	D6	D5	D4	D3	D2	D1	D0	CH15 Float (Byte 2)	to PC
35F	D7	D6	D5	D4	D3	D2	D1	D0	CH15 Float (Byte 3)	to PC
360	D7	D6	D5	D4	D3	D2	D1	D0	CJC Float (Byte 0)	to PC
361	D7	D6	D5	D4	D3	D2	D1	D0	CJC Float (Byte 1)	to PC
362	D7	D6	D5	D4	D3	D2	D1	D0	CJC Float (Byte 2)	to PC
363	D7	D6	D5	D4	D3	D2	D1	D0	CJC Float (Byte 3)	to PC
370	D7	D6	D5	D4	D3	D2	D1	D0	CH0 count (Byte 0)	to PC
371	D7	D6	D5	D4	D3	D2	D1	D0	CH0 count (Byte 1)	to PC
372	D7	D6	D5	D4	D3	D2	D1	D0	CH1 count (Byte 0)	to PC
373	D7	D6	D5	D4	D3	D2	D1	D0	CH1 count (Byte 1)	to PC
38E	D7	D6	D5	D4	D3	D2	D1	D0	CH15 count (Byte 0)	to PC
38F	D7	D6	D5	D4	D3	D2	D1	D0	CH15 count (Byte 1)	to PC
390	D7	D6	D5	D4	D3	D2	D1	D0	0V count (Byte 0)	to PC
391	D7	D6	D5	D4	D3	D2	D1	D0	0V count (Byte 1)	to PC
392	D7	D6	D5	D4	D3	D2	D1	D0	9.9V count (Byte 0)	to PC
393	D7	D6	D5	D4	D3	D2	D1	D0	9.9V count (Byte 1)	to PC
394	D7	D6	D5	D4	D3	D2	D1	D0	CJC count (Byte 0)	to PC
395	D7	D6	D5	D4	D3	D2	D1	D0	CJC count (Byte 1)	to PC
3FE	D7	D6	D5	D4	D3	D2	D1	D0	AM188 Mailbox	to 188
3FF	D7	D6	D5	D4	D3	D2	D1	D0	PC Mailbox	to PC

6.3 DUAL PORT RAM BIT DEFINITIONS

6.3.1 Configuration Region (0x300 - 0x31F)

These 32 bytes in the DPRAM are used to set up and configure data acquisition parameters. The configuration region specifies global parameters which affect all channels and parameters for each individual channel. Section on page describes the sequence of operations required to set the configuration.

Sampling Parameters (Address 0x300)

RS1:0	Resolution:		
	<u>RS1</u>	<u>RS0</u>	<u>Resolution (Hz)</u>
	0	X	50
	0	1	60
	1	1	400

AVG3-AVG0 The number of data values used in computing the moving average from each channel. The microcontroller stores the values from each channel in a circular buffer whose size is specified by AVG3-AVG0. When a new sample is acquired, it is added to the buffer overwriting the oldest sample and the moving average is computed. This number must be between 0 and 15; the number of samples used to compute the average is 1 more than this.

Channel Parameters (Address 0x310-0x31f)

This area sets the parameters for each individual channel:

F1:0	Temperature format.		
	<u>F1</u>	<u>F0</u>	
	0	0	Centigrade
	0	1	Fahrenheit
	1	X	Kelvin

G1:0 Voltage gain

TCT2:0	Thermocouple Type			
	TCT2	TCT1	TCT0	Thermocouple Type
	0	0	0	B
	0	0	1	E
	0	1	0	J
	0	1	1	K
	1	0	0	R
	1	0	1	S
	1	1	0	T
	1	1	1	Not connected

6.3.2 Float Region (0x320 - 0x363)

These bytes are used to store either the temperature or voltage from the channels. This region is divided into 4-byte blocks where each block has the data from a channel.

6.3.3 A/D Count Region (0x370 - 0x395)

These bytes are used to store the average A/D count from the thermocouple channels, CJC channel and the ground and 9.9V reference voltage on the board. This region is divided into 2-byte blocks where each block has the 16-bit count from a channel.

6.3.4 AM188 Mailbox (0x3FE)

This byte is used to send commands to the microcontroller in the DAS-TC. Please refer to section for details about the commands. When the PC writes to this location, bit INTL/ in BASE+3 becomes 0. After the microcontroller reads from this location, INTL/ goes high.

6.3.5 PC Mailbox (0x3FF)

This byte is used by the DAS-TC to convey information to the PC. When the microcontroller in the DAS-TC writes to this location, bit INTR/ in BASE+3 (see page) becomes 0 and simultaneously the interrupt selected in BASE+3 is asserted. After the PC reads this location, INTR/ becomes 1 and the interrupt, if any is selected, is de-asserted.

6.4 COMMANDS FROM THE PC TO THE DAS-TC

This section describes the software commands between the PC and the DAS-TC. The commands carry out the following operations.

- Load a new configuration.
- Read a single channel's temperature.
- Read multiple channels' temperature.
- Read the CJC temperature
- Read version number of firmware.

6.4.1 Modify sampling parameters

- a) The PC modifies one or more of the sampling parameters in byte 0x300.
- b) The PC writes the following command to the AM188 mailbox in the DPRAM.

Addr	D7	D6	D5	D4	D3	D2	D1	D0
3FE	1	0	0	0	0	0	0	0

- c) The DAS-TC reads, processes the new configuration and then writes a return code into the PC mailbox in DPRAM. This causes bit INTR/ in BASE+3 to go low and an interrupt (if any is selected) is asserted to the PC. The PC can either poll INTR/ or respond to the interrupt. Note, that it may take some time for the DAS-TC to set the new sampling parameters and start sampling.
- d) When bit INTR/ in BASE+3 is low, the PC reads the following return code from the PC mailbox. Reading the mailbox causes INTR/ to go high and the selected interrupt to be de-asserted.

Addr	D7	D6	D5	D4	D3	D2	D1	D0
3FF	1	0	0	ERR4	ERR3	ERR2	ERR1	ERR0

Please refer to the return codes given in the next section.

6.4.2 Modify one or more channel parameters

- e) The PC modifies one or more of the channel configuration bits in the configuration region of DPRAM (refer to section).
- f) The PC writes the following command to the AM188 mailbox in the DPRAM.

Addr	D7	D6	D5	D4	D3	D2	D1	D0
3FE	1	0	0	0	0	0	0	1

- g) The DAS-TC reads, processes the new configuration and then writes a return code into the PC mailbox in DPRAM. This causes bit INTR/ in BASE+3 to go low and an interrupt (if any is selected) is asserted to the PC. The PC can either poll INTR/ or respond to the interrupt.
- h) When bit INTR/ in BASE+3 is low, the PC reads the following return code from the PC mailbox. Reading the mailbox causes INTR/ to go high and the selected interrupt to be de-asserted.

Addr	D7	D6	D5	D4	D3	D2	D1	D0
3FF	1	0	0	ERR4	ERR3	ERR2	ERR1	ERR0

Please refer to the return codes given in the next section.

6.4.3 Read a single channel's temperature

- i) The PC writes the following command to the AM188 mailbox in the DPRAM specifying the channel to be read

Addr	D7	D6	D5	D4	D3	D2	D1	D0
3FE	1	0	0	1	CHL3	CHL2	CHL1	CHL0

where CHL3-CHL0 specify the channel number.

- b) The DAS-TC writes the temperature into the specified channel's 4-byte block and a return code into the PC mailbox signifying that data is available in DPRAM. This causes bit INTR/ in BASE+3 to go low and an

interrupt (if any is selected) is asserted to the PC. The PC can either poll INTR/ or respond to the interrupt. Note that the CJC channel's temperature in Centigrade is simultaneously updated to bytes 0x360-0x363.

- c) When bit INTR/ in BASE+3 is low, the PC reads the following return code from the PC mailbox. Reading the mailbox causes INTR/ to go high and the selected interrupt to be de-asserted.

Addr	D7	D6	D5	D4	D3	D2	D1	D0
3FF	1	0	0	ERR4	ERR3	ERR2	ERR1	ERR0

Please refer to the return codes given in the next section.

- d) If there are no errors, the PC reads four bytes of data for the selected channel from the float region of the DPRAM. Please refer to section on page for details about data organization in the dual port RAM.

6.4.4 Read multiple channels' temperature

- a) The PC writes the following command to the AM188 mailbox in the DPRAM specifying the low channel number in the block of channels to be read

Addr	D7	D6	D5	D4	D3	D2	D1	D0
3FE	1	0	1	0	CHL3	CHL2	CHL1	CHL0

where CHL3-CHL0 specify the low channel number.

- b) The PC polls bit INTL/ in BASE+3 to go high. This bit will go high as soon as the microcontroller has read its mailbox.
- c) The PC writes the following command to the AM188 mailbox in the DPRAM specifying the high channel number in the block of channels to be read

Addr	D7	D6	D5	D4	D3	D2	D1	D0
3FE	1	0	1	1	CHH3	CHH2	CHH1	CHH0

where CHH3-CHH0 specify the high channel number.

- d) The DAS-TC writes the temperature for the specified channels into the appropriate 4-byte blocks in the float region of the DPRAM. A return code is also written to the PC mailbox signifying that data is available in DPRAM. This causes bit INTR/ in BASE+3 to go low and an interrupt (if any is selected) is asserted to the PC. The PC can either poll INTR/ or respond to the interrupt. Note that the CJC channel's temperature in Centigrade is simultaneously updated to bytes 0x360-0x363.
- e) When bit INTR/ in BASE+3 is low, the PC reads the following return code from the PC mailbox. Reading the mailbox causes INTR/ to go high and the selected interrupt to be de-asserted.

Addr	D7	D6	D5	D4	D3	D2	D1	D0
3FF	1	0	0	ERR4	ERR3	ERR2	ERR1	ERR0

Please refer to the return codes given in the next section.

- f) If there are no errors, the PC reads four bytes of data for each channel from the data region of the DPRAM. Note that the four bytes of data constitute a floating point value. Please refer to section on page for details about data organization in the dual port RAM.

6.4.5 Read A/D counts for all channels

- (a) The PC writes the following command to the AM188 mailbox in the DPRAM

Addr	D7	D6	D5	D4	D3	D2	D1	D0
3FE	1	1	0	0	0	0	1	0

- (b) The DAS-TC writes a return code into the PC mailbox in DPRAM signifying that data is available in DPRAM. This causes bit INTR/ in BASE+3 to go low and an interrupt (if any is selected) is asserted to the PC. The PC can either poll INTR/ or respond to the interrupt.
- (c) When bit INTR/ in BASE+3 is low, the PC reads the following return code from the PC mailbox. Reading the mailbox causes INTR/ to go high and the selected interrupt to be de-asserted.

Addr	D7	D6	D5	D4	D3	D2	D1	D0
3FF	1	0	0	ERR4	ERR3	ERR2	ERR1	ERR0

Please refer to the return codes given in the next section.

- (d) If there are no errors, the PC reads two bytes of A/D count for each channel from the A/D count region of the DPRAM. Please refer to section on page for details about data organization in the dual port RAM.

6.4.6 Read the firmware version number

- a) The PC writes the following command to the AM188 mailbox in the DPRAM .

Addr	D7	D6	D5	D4	D3	D2	D1	D0
3FE	1	1	0	0	0	0	0	0

- b) The DAS-TC writes the firmware version number into the PC mailbox in DPRAM. This causes bit INTR/ in BASE+3 to go low and an interrupt (if any is selected) is asserted to the PC. The PC can either poll INTR/ or respond to the interrupt.
- c) When bit INTR/ in BASE+3 is low, the PC reads the following value from the PC mailbox. Reading the mailbox causes INTR/ to go high and the selected interrupt to be de-asserted.

Addr	D7	D6	D5	D4	D3	D2	D1	D0
3FF	MAJ3	MAJ2	MAJ1	MAJ0	MIN3	MIN2	MIN1	MIN0

where MAJ3:0 is the major version number and MIN3:0 is the minor version number. There is an implied decimal point between the major and minor version number.

6.4.7 Read the voltages from all channels

- a) The PC writes the following command to the AM188 mailbox in the DPRAM

Addr	D7	D6	D5	D4	D3	D2	D1	D0
3FE	1	1	0	0	0	0	1	1

- b) The DAS-TC writes the voltages of all 16 thermocouple channels and the CJC channel into the float region of the DPRAM and a return code into the PC mailbox signifying that data is available. This causes bit INTR/ in BASE+3 to go low and an interrupt (if any is selected) is asserted to the PC. The PC can either poll INTR/ or respond to the interrupt.
- c) When bit INTR/ in BASE+3 is low, the PC reads the following return code from the PC mailbox. Reading the mailbox causes INTR/ to go high and the selected interrupt to be de-asserted.

Addr	D7	D6	D5	D4	D3	D2	D1	D0
3FF	1	0	0	ERR4	ERR3	ERR2	ERR1	ERR0

Please refer to the return codes given in the next section.

- d) If there are no errors, the PC reads four bytes of data for each channel from the float region of the DPRAM. The readings are in volts. Please refer to section on page for details about data organization in the dual port RAM.

6.5 ERROR CODES FROM THE DAS-TC

After the DAS-TC executes a command sent by the PC, it writes back a result code to the PC's mailbox. These are the error codes and their description.

Code in HEX	Description
80	Command executed successfully.
81	Sampling and channel parameters have not been loaded from the PC. This is the error code when the DAS-TC is powered up.
82	Input voltage exceeds the chosen thermocouple's range.
83	Low channel number is more than the high channel number in the command to read a block of channels.
84	Unknown command.
85	Open thermocouple.

Note that the most significant bit of the error code is always '1'

6.6 HOW TO READ FLOATING POINT TEMPERATURE

Each channel's temperature reading is stored as 4-bytes in the DPRAM.. The following function illustrates how the PC can read a given channel's temperature after issuing either the command to read the temperature from a single channel or multiple channels.

```
//Reads the DPRAM and returns the specified channel's temperature.
//The DAS_TC must be sent the command to read one channel or a block of
//channels prior to reading the DPRAM
//Params      nBaseAddr = base address of the board
//      nChan is the channel number to read.
float ReadChanTemp(int nBaseAddr, int nChan)
{
    int nOffset; //offset into dual port RAM for the channels temp.
    float fVal=0.0f; //reading which is in float

    nOffset= 0x320 + nChan*sizeof(float);
    //Read the 4 individual bytes which make up the float, starting from the
    //lowest byte to the highest byte
    BYTE *yTmp= (BYTE *)&fVal;
    for (int nP=nOffset; nP<=nOffset+3; nP++, yTmp++)
        *yTmp= ReadDPRAM(nBaseAddr, nP);
    return fVal;
}

//Reads a byte from the specified offset in the DPRAM
//Params : nBaseAddr=Base address of the board
//      nOffset = byte offset into the DPRAM
//Returns : Byte read
BYTE ReadDPRAM(int nBaseAddr, int nOffset)
{
    //Write the low byte of the offset addr
    _outp(nBaseAddr+REG_ADDR_LO, nOffset);

    //Write the high byte of the offset addr
    _outp(nBaseAddr+REG_ADDR_HI, (nOffset>>8));

    //read the data register and return the byte
    return (_inp(nBaseAddr+REG_DATA));
}
```

7.0 Electrical Specifications

Typical for 25°C unless otherwise specified.

Analog input section

A/D converter type

AD652 V/F Converter

Accuracy & Resolution (voltage measurements):

<u>Gain</u>	<u>Range</u>	<u>Accuracy (Worst Case)</u>	<u>@ 50Hz</u>	<u>Resolution</u>	
				<u>@ 60Hz</u>	<u>@ 400Hz</u>
1	-2.5 to 10V	±.01% of reading ±2.5mV	312.5µV	375µV	2.5mV
125	-20 to 80mV	±.01% of reading ± 20µV	2.5µV	3.0µV	20.0µV
166.7	-15 to 60mV	±.01% of reading ± 15µV	1.88µV	2.25µV	15.0µV
400	-6.25 to 25mV	±.02% of reading ± 6.25µV	0.781µV	.938µV	6.25µV

Accuracy & Resolution (Thermocouple measurements, not including CJC errors):

<u>Type</u>	<u>Range</u>	<u>Accuracy (Worst Case)</u>	<u>@ 50Hz</u>	<u>Resolution</u>	
				<u>@ 60Hz</u>	<u>@ 400Hz</u>
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	-270 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

Number of channels

16 differential Thermocouple inputs, 1 CJC input

Programmable ranges

-2.5V to +10V, -20mV to +80mv, -15mV to +60mV, -6.25mV to 25mV

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)

22.2 msec @ 50 Hz typical, 22.3 msec max

18.8 msec @ 60 Hz typical, 18.9 msec max

4.6 msec @ 400 Hz typical, 4.7 msec max

*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 fclock

Gain drift (A/D specs)

±75ppm/°C max

Zero drift (A/D specs)

±50uV/°C max

Power Supply Rejection Ratio

0.01 %/V

Overvoltage Protection	-40 to +55V
CMRR @ 60Hz	80dB min
Input leakage current	±80 nA max
Input impedance	100Meg Ohms min
Absolute maximum input voltage	-40V to +55V
Isolation to PC	500V min through DC/DC converter and opto-isolators

Miscellaneous	<p>Averaging - Moving average, 1 to 16 samples, software selectable</p> <p>Calibration - Calibration is performed with each channel scan to remove offset and gain error. CJC channel also measured with each calibration.</p> <p>Processor Reset - On power-up, watchdog timeout, or software command. Processor boots within 1 second of reset. Active low.</p> <p>Watchdog timer - 1.6 seconds nominal. Processor generates watchdog disable signal after boot-up.</p> <p>Temperature units - Programmable for conversion to degrees C or degrees F</p>
---------------	--

Interrupts	2, 3, 4, 5, 6 or 7
Interrupt enable	Programmable
Interrupt sources	Dual Port RAM when the Processor Mailbox has data.

Crystal oscillator	
Frequency	32MHz
Frequency accuracy	100ppm

CIO-STA-TC Adapter

CJC Type	AD592CN
Configuration	CJC centered in an iso-thermal block on which the screw terminals have been mounted.

Channels	16 (plus CJC output)
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Calibration error	
@25 °C	0.3°C typ, 0.5°C max
-25°C to +105 °C	0.5°C typ, 1.0°C max

Linearity Error	
-25°C to +105 °C	0.1°C typ, 0.35°C max

Temperature Coefficient	1µA/°C typ
Long Term Stability	0.1 °C / month
Open Thermocouple detect	On/Off switch selectable for each channel, full scale reading

Power consumption

+5V Operating	887mA typical, 1441 mA max
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Environmental

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

EC Declaration of Conformity

CIO-DAS-TC	ISA bus thermocouple input board
PCI-DAS-TC	PCI bus thermocouple input board
Part Numbers	Description

to which this declaration relates, meets the essential requirements, is in conformity with, and CE marking has been applied according to the relevant EC Directives listed below using the relevant section of the following EC standards and other normative documents:

EU EMC Directive 89/336/EEC: Essential requirements relating to electromagnetic compatibility.

EU 55022 Class B: Limits and methods of measurements of radio interference characteristics of information technology equipment.

EN 50082-1: EC generic immunity requirements.

IEC 801-2: Electrostatic discharge requirements for industrial process measurement and control equipment.

IEC 801-3: Radiated electromagnetic field requirements for industrial process measurements and control equipment.

IEC 801-4: Electrically fast transients for industrial process measurement and control equipment.

Carl Haapaoja, Director of Quality Assurance

