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2500 Series TM Compact IO System

2500C-8-AI

8-CHANNEL ANALOG INPUT MODULE

2500 SERIES® COMPACT I/O

INSTALLATION AND OPERATION GUIDE

Version 1.2

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V 1.0	1 Nov 2013	Initial Release
V 1.1	2 Dec 2013	Changed the front Title page format
V 1.2	6 Oct 2014	Added Field Wiring Diagrams

PREFACE

This ***Installation and Operation Guide*** provides reference information for the CTI 2500 2500C-8-8AI 8-Channel Analog Input Model for 2500 Series® Compact I/O. We assume you are familiar with the operation of CTI 2500 Series® programmable controllers. Refer to the appropriate user documentation for specific information on the 2500 Series® programmable controllers and I/O modules.

This Installation and Operation Guide is organized as follows:

Chapter 1 provides a description of the module.
Chapter 2 covers installation, setup, and wiring.
Chapter 3 is a guide to troubleshooting.



USAGE CONVENTIONS

NOTE

Notes alert the user to special features or procedures.

CAUTION

Cautions alert the user to procedures that could damage equipment.

WARNING

Warnings alert the user to procedures that could damage equipment and endanger the user.

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CHAPTER 1 OVERVIEW

1.1 Introduction

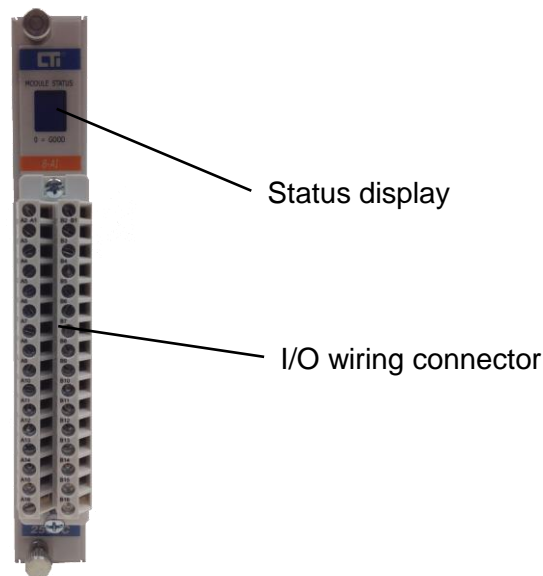
The CTI 2500C-8-AI 8-Channel Analog Input Module is a member of Control Technology's 2500C Compact I/O modules compatible with the 2500 Series® and SIMATIC® 505 programmable controllers. It is designed to translate an analog input signal into an equivalent digital word which is then sent to the programmable controller (PLC).

Features

- 8 analog inputs
- Input ranges 0-5V, 0-10V, 0-20mA, +/-5V, +/-10V, +/-20mA
- 7 Segment Display for Module Status indication
- No user calibration
- Software Configurable Range Selection
- Uses 2500C-32F removable wiring connector
- Module supports hot swapping (see Section 2.4)

1.2 Front Panel Description

The module front panel includes a 7-segment status display for showing module status, and a 32-pin removable I/O wiring connector.



1.2.1 Status Display

The Status Display will be illuminated with a “0” when the module is functioning normally. If the Status Display is not lit, or if it displaying something other than “0”, refer to Chapter 3 for troubleshooting.

1.2.2 I/O Wiring Connector

The 2500C-8-AI module using the standard 2500C-32F Field Wiring Connector. This connector provides 32 connections and accepts 14-22 AWG wires.

1.3 Asynchronous Operation

The module operates asynchronously with respect to the PLC (a scan of the PLC and input sampling of the module do not occur at the same time). Instead, the module will translate all analog inputs in one module update (3.5 milliseconds maximum) and store the translated words in buffer memory. The PLC retrieves the stored words from the module buffer memory at the start of the I/O scan.

1.4 Modes of Operation

The 2500C-8-AI supports two major modes of operation: *Classic* mode and *Classic Plus* mode.

1.4.1 Classic Mode

In *Classic* mode (or Low Density) operation, the 2500-8-AI operates logs in to the PLC as an 8 word input (8WX) module. Analog values for each channel are reported to the PLC in the corresponding input word. In *Classic* mode, the module operates in the 0-5V range (for voltage inputs) or 0-20mA range (for current inputs). To operate the module in other ranges, you must change to *Classic Plus* mode.

1.4.2 Classic Plus Mode

In *Classic Plus* mode (or High Density) operation, the 2500-8-AI operates logs in to the PLC as an 8 word input / 8 word output (8WX/8WY) module. Analog values for each channel are reported to the PLC in the corresponding input word. The WY output words are used to allow the PLC to select the input signal range for the module.

For example, if the module is in *Classic Plus* mode and is logged in at address 1:

WX1 = input channel 1
WX2 = input channel 2
WX3 = input channel 3
WX4 = input channel 4
WX5 = input channel 5
WX6 = input channel 6
WX7 = input channel 7

WX8 = input channel 8
 WY9 = configuration channel 1
 WY10 = configuration channel 2
 WY11 = configuration channel 3
 WY12 = configuration channel 4
 WY13 = configuration channel 5
 WY14 = configuration channel 6
 WY15 = configuration channel 7
 WY16 = configuration channel 8

In *Classic Plus* mode, the PLC can select range operation from any of the following by setting the appropriate bits in the corresponding WY word for each channel. In addition, the PLC can enable or disable digital filtering for each channel.

Voltage Ranges

- 0-5V
- 0-10V
- $\pm 5V$
- $\pm 10V$

Current Ranges

- 0-20mA
- $\pm 20mA$
- 4-20mA

1.5 Measurement Resolution

Basic resolution of the 2500C-8-AI is 16 bits. Since it can be configured for bipolar operation, the resolution reported to the PLC is 15 bits + sign.

The table below shows the resolution of the module for each scale, and the maximum converted value.

Range	Resolution, per step	Maximum Converted Value
0-5V, $\pm 5V$	156uV	5.117V
0-10V, $\pm 10V$	312uV	10.234
0-20mA, $\pm 20mA$	0.625uA	20.468mA

1.6 Accuracy

The module accuracy is 0.25% of full scale (current mode) and 0.15% of full scale (voltage mode)

1.7 Reporting of Analog Values to the PLC

The module reports the converted analog value for each channel into the corresponding WX word. The data is scaled according to the “0-32000” convention usually used in 2500 Series® PLC applications. A “0” indicates 0V or 0mA. A “32000” indicates full scale volts or mA, with the level depending on the range being used.

The data is reported to the PLC in the format shown below:

Sign bit	16,384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1
----------	--------	------	------	------	------	-----	-----	-----	----	----	----	---	---	---	---

In addition to applying a basic scale of 0-32000, the module provides a small overrange capability to convert voltages above the full scale. The maximum valid reading is +32749. Values above +32749 or below -32749 indicate error conditions.

Two error conditions are reported:

Overrange – means the input voltage is higher than the maximum that can be converted (example: 5.117V for the 0-5V range). For this error, a value of “32759” is reported.

Underrange - means the input voltage is lower than the minimum that can be converted (-(- (example: -5.117V for the $\pm 5V$ range). For this error, a value of “32758” is reported.

The table below shows how the module reports for various input signals and range selections.

Range Selection	Input Signal	Value Reported	Comment
0-5V	0V	0	
	2.5V	16000	
	5V	32000	
	5.117V	32749	
	5.2V	32759	overrange
	-0.2V	32758	underrange
0-10V	0V	0	
	5V	16000	
	10V	32000	
	10.234V	32749	
	10.3V	32759	overrange
	-0.2V	32758	underrange
$\pm 5V$	-5.117V	-32749	
	-5V	-32000	

	0V	0	
	+5V	32000	
	+5.117V	32749	
	+5.2V	32759	overrange
	-5.2V	32758	underrange
+10V	-10.234V	-32749	
	-10V	-32000	
	0V	0	
	+10V	32000	
	+10.234V	32749	
	+10.3V	32759	overrange
	-10.3V	32758	underrange
4-20mA	4mA	0	
	12mA	16000	
	20mA	32000	
	20.468mA	32749	
	20.5mA	32759	overrange
0-20mA	0mA	0	
	10mA	16000	
	20mA	32000	
	20.468mA	32749	
	20.5mA	32759	overrange

1.8 Module Setup from the PLC in Classic Plus Mode

When operating in Classic Plus Mode, the module reads setup information that the PLC has stored in the WY word corresponding to each channel.

WYn	Bit 1 (range)	Bit 2 (polarity)	Bit 3 (offset)	Bit 4 (filtering)	Bits 5-16
Function	0 = 5V, 20mA 1 = 10V	0 = unipolar 1 = bipolar	0 = offset disabled 1 = offset enabled	0 = digital filtering disabled 1 = digital filtering enabled	unused

Bit 1 – sets 5V or 10V range

Bit 2 – sets unipolar or bipolar operation

Bit 3 – sets offset (used for operating with 4-20mA) signals. When offset is enabled, a 4mA signal will be reported as “0”. With offset disabled, a 4mA signal will be reported as “6400”.

Bit 3 – sets digital filtering. With digital filtering enabled, the module filters input conversions, which can reduce noise in the values reported to the PLC.

CHAPTER 2 INSTALLATION & SETUP

The installation of the 2500C-8-AI consists of the following steps:

1. Reading this Chapter
2. Installation planning
3. Unpacking the module
4. Configuring the module
5. Physical installation
6. Connecting field wiring
7. Checking operation

2.1 Installation Planning

2.1.1 Safety Considerations

Before installing the module, you must identify the personnel hazards that may be created in the event of a system failure and provide interlocks and safety switches to prevent operation during a system failure. Refer to the NEMA ICS 3-304 Programmable Control Standards.

WARNING

As a system designer, you should be aware that Control devices can fail in an unsafe condition. Unless you incorporate proper safeguards, malfunction of the controller or associated devices, such as operator interface equipment, could cause sudden equipment startup, shutdown, or other unexpected operation. Such startup or shutdown or unexpected operation could result in death or serious injury to personnel, and/or damage to equipment.

If you or your company are using CTI controllers with equipment that requires the presence of a person (such as an operator or attendant), you should be aware of this potential safety hazard and take appropriate precautions.

The precautions below conform to the National Electrical Manufacturers Association guidelines for installation of programmable controllers as recommended in the NEMA ICS 3–304 Programmable Control Standards.

ICS 3-304.81 Safety Recommendations:

Consideration should be given to the use of an emergency stop function which is independent of the programmable controller. Where the operator is exposed to the machinery, such as in loading or unloading a machine tool, or where the machine cycles automatically, consideration should be given to the use of an electromechanical override or other redundant means, independent of the programmable controller, for starting and interrupting the cycle. If provision is required for changing programs while the equipment is in operation, consideration should be given to the use of locks or other means of assuring that such changes can be made only by authorized personnel. These recommendations are intended as safeguards against the failure of critical components and the effects of such

failures or the inadvertent errors that might be introduced if programs are changed while the equipment is in operation.

Operator Safety Switches

Power should be configured so that it can be manually removed from all output devices. You must provide a method that is independent of the control system for disconnecting power from the outputs when a machine is not operating or the operator must reach into the machine. A non-electronic switch or directly wired relay must be used to disconnect the power.

Emergency Stop Switch

You must provide a method for disconnecting power from the outputs if an emergency situation is encountered with the machine operation. Use a non-electronic switch or relay that is wired external to the controller and that is easily accessible.

2.1.2 Electrical Interference

Electrical interference can adversely affect the operation of control equipment. The major sources of electrical interference in an industrial environment are devices that use high voltages and current, such as motors and welders. Electrical interference can be conducted directly through wiring or inducted via electromagnetic coupling.

To ensure a reliable control system, you will need to determine the source of the electrical interference and employ suitable techniques to eliminate it.

2.1.3 Grounding

It is very important that the all equipment is properly grounded. Lack of proper grounding may cause intermittent or erratic operation or may cause the control system to fail. A properly installed grounding system will provide a low-impedance path to earth ground, which will give all PLC internal filtering devices a good ground return for reference. The earth ground of the building site typically provides reliable grounding; however, if excessive ground current is present, a separate grounding electrode should be installed.

A common practice is to provide a central ground bus bar as a single point of reference within each enclosure, connecting all chassis and power supply components to the bus bar. The bus bar is then connected to earth ground. When connecting to the bus bar, use 1 inch copper braid or No. 8 AWG wire. To ensure good connections, scrape paint or other non-conductive coatings away from mounting studs and from enclosure surfaces where mounting bolts and washers make contact.

In addition to connecting the controller rack and power supply to earth ground, you must ensure that the power supply, controller and all modules installed in the base are installed securely and that the thumbscrews are tightened.

2.1.4 Defining Operation Mode and Range Selections

Before you can install the module, you must review your planned input signals by channel and decide on both the operation modes (*Classic* or *Classic Plus*), and the range selections (Voltage or Current) for each input. If your application needs only 0-5V or 0-20mA (and digital filtering enabled) for every channel, then you may use *Classic* mode. All other ranges and options require the selection of *Classic Plus* mode.

2.1.5 Power Requirements

The 2500C-8-AI module consumes 0.75 watts of +5VDC power. To calculate the total power required for the base, you need to add the power requirements for the other modules you will install in the base.

2.2 Unpacking the Module

Open the shipping carton and remove the special anti-static bag that contains the controller. After discharging any static build-up, remove the unit from the static bag. Do not discard the static bag; use it for protection against static damage when the module is not inserted into the I/O base.

CAUTION

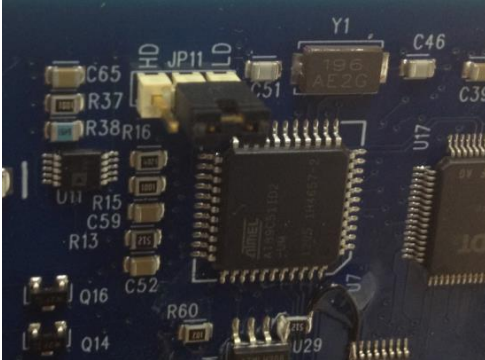
The components on the 2500C-8-AI printed circuit card can be damaged by static electricity discharge. To prevent this damage, the module is shipped in a special anti-static bag. Static control precautions should be followed when removing the module from the bag and when handling the printed circuit card during configuration.

2.3 Configuring the Module

Prior to inserting the module in the base, you must first configure it for operation based on your requirements identified in Section 2.1.4 above. Configuration includes selecting operation mode and selecting voltage or current for each channel. In addition, if you have selected *Classic Plus* mode, you must configure your PLC program to set the necessary bits in the WY word for the module.

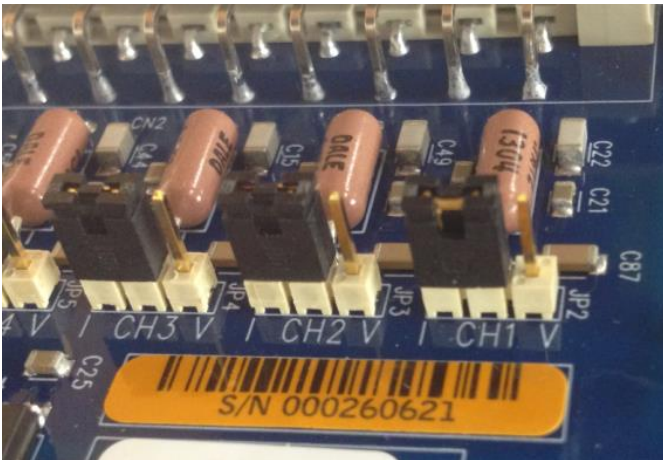
2.3.1 Selecting Operation Mode

The module operational mode is selected using the jumper at JP11. For *Classic* mode, the jumper should be installed at the “LD” position. For *Classic Plus* mode it should be installed at the “HD” position. The module ships from the factory set for *Classic* mode operation.



2.3.2 Selecting Voltage or Current for Each Channel

Voltage or current mode is set for each channel using JP2 – JP9. For voltage mode place the jumper in the “V” position. For current mode, place the jumper in the “I” position. The module ships from the factory with jumpers in the “I” position.



NOTE

Note that in addition to setting the V / I jumper for each channel, you must wire your input to the corresponding V or I terminal on the I/O connector. For more information, see [Section 2.5 Connecting Field Wiring](#).

2.3.3 Factory Default Settings

The 2500C-8-AI ships from the factory configured for *Classic* mode and current operation on each channel. This means each channel is configured for 0-20mA operation.

JP11 = *Classic* or LD position

JP2 – JP9 = “I” position

Note that in *Classic* mode, digital filtering is ON. To disable digital filtering, you must operate in *Classic Plus* mode.

2.4 Physical Installation

Remove AC power from the rack. Align the circuit board with the connector next to the power supply. Slide the controller into the rack until the connector seats. Use the thumbscrews to secure the controller in the rack.



IMPORTANT NOTE:

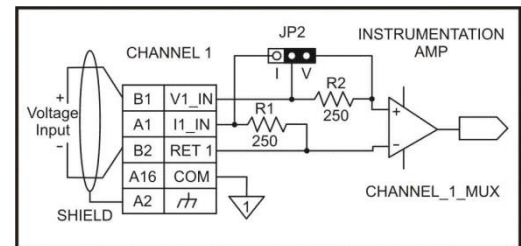
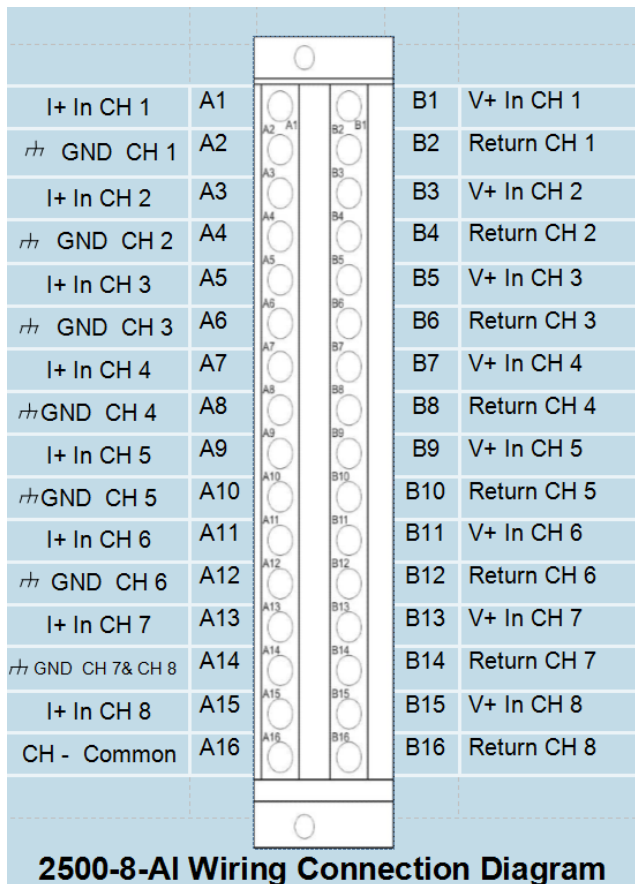
The 2500-8-AI is designed to allow “hot-swapping” the module under power in the event that a replacement is needed. When “hot-swapping” the module, use the following procedure.

1. Make sure all field devices connected to the module are placed into a “safe” state
2. Remove the I/O connector from the front of the module
3. Loosen the module retaining screws and remove it from the base
4. Ensure the jumper configuration of the replacement module matches the one just removed
5. Install the replacement module and tighten the retaining screws. The replacement module must be the same model number as the one removed.

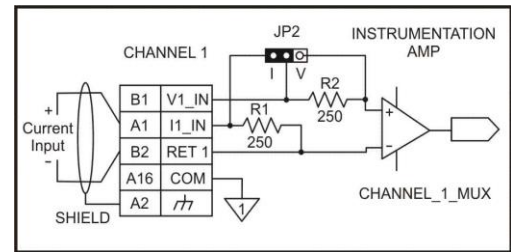
6. Reattach the I/O connector to the module
7. Ensure the replacement module is operating properly
8. Remove the field devices from “safe” state

2.5 Connecting Field Wiring

Field wiring is connected to the 2500C-8-AI as shown in the connector wiring diagram below. NOTE: For current (0-20mA or 4-20mA) inputs you must wire to the “I+” inputs. For voltage, wire to the “V+” input. The “return” or “common” for each channel is wired to the “Return” terminal and the shield (if any) is wired to the GND terminal.



Typical Internal Circuit—Voltage Mode



Typical Internal Circuit—Current Mode

2.6 Checking Operation and Troubleshooting

Apply power to the base power supply. The Power Good LED on the power supply should illuminate, indicating that power is being supplied to the base connectors. The Remote Base Controller will take a few seconds to complete the startup sequence. When this is complete, the status indicator on the 2500-8-AI should display a "0".

Status Indicator	Comments
0	Normal operation
A	Internal RAM failure – contact CTI for assistance
B	Flash memory failure – contact CTI for assistance
C	External RAM failure – contact CTI for assistance
D	Shared RAM failure – contact CTI for assistance

CTI WARRANTY

Warranty. Control Technology Inc. ("CTI") warrants that this CTI Industrial Product (the "Product") shall be free from defects in material and workmanship for a period of one (1) year from the date of purchase from CTI or from an authorized CTI Industrial Distributor, as the case may be. Repaired or replacement CTI products provided under this warranty are similarly warranted for a period of 6 months from the date of shipment to the customer or the remainder of the original warranty term, whichever is longer. This Product and any repaired or replacement products will be manufactured from new and/or serviceable used parts which are equal to new in the Product. This warranty is limited to the initial purchaser of the Product from CTI or from an authorized CTI Industrial Distributor and may not be transferred or assigned.

2. Remedies. Remedies under this warranty shall be limited, at CTI's option, to the replacement or repair of this Product, or the parts thereof, only after shipment by the customer at the customer's expense to a designated CTI service location along with proof of purchase date and an associated serial number. Repair parts and replacement products furnished under this warranty will be on an exchange basis and all exchanged parts or products become the property of CTI. Should any product or part returned to CTI hereunder be found by CTI to be without defect, CTI will return such product or part to the customer. The foregoing will be the exclusive remedies for any breach of warranty or breach of contract arising therefrom.

3. General. This warranty is only available if (a) the customer provides CTI with written notice of a warranty claim within the warranty period set forth above in Section 1 and (b) CTI's examination of the Product or the parts thereof discloses that any alleged defect has not been caused by a failure to provide a suitable environment as specified in the CTI Standard Environmental Specification and applicable Product specifications, or damage caused by accident, disaster, acts of God, neglect, abuse, misuse, transportation, alterations, attachments, accessories, supplies, non-CTI parts, non-CTI repairs or activities, or to any damage whose proximate cause was utilities or utility-like services, or faulty installation or maintenance done by someone other than CTI.

4. Product Improvement. CTI reserves the right to make changes to the Product in order to improve reliability, function or design in the pursuit of providing the best possible products.

5. Exclusive Warranty. THE WARRANTIES SET FORTH HEREIN ARE CUSTOMER'S EXCLUSIVE WARRANTIES. CTI HEREBY DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED. WITHOUT LIMITING THE FOREGOING, CTI SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A

PARTICULAR PURPOSE, NON-INFRINGEMENT, COURSE OF DEALING AND USAGE OF TRADE.

6. Disclaimer and Limitation of Liability. TO THE FULLEST EXTENT PERMITTED BY APPLICABLE LAW, CTI WILL NOT BE LIABLE FOR ANY BUSINESS INTERRUPTION OR LOSS OF PROFIT, REVENUE, MATERIALS, ANTICIPATED SAVINGS, DATA, CONTRACT, GOODWILL OR THE LIKE (WHETHER DIRECT OR INDIRECT IN NATURE) OR FOR ANY OTHER FORM OF INCIDENTAL, INDIRECT OR CONSEQUENTIAL DAMAGES OF ANY KIND. CTI'S MAXIMUM CUMULATIVE LIABILITY RELATIVE TO ALL OTHER CLAIMS AND LIABILITIES, INCLUDING OBLIGATIONS UNDER ANY INDEMNITY, WHETHER OR NOT INSURED, WILL NOT EXCEED THE COST OF THE PRODUCT(S) GIVING RISE TO THE CLAIM OR LIABILITY. CTI DISCLAIMS ALL LIABILITY RELATIVE TO GRATUITOUS INFORMATION OR ASSISTANCE PROVIDED BY, BUT NOT REQUIRED OF CTI HEREUNDER. ANY ACTION AGAINST CTI MUST BE BROUGHT WITHIN EIGHTEEN (18) MONTHS AFTER THE CAUSE OF ACTION ACCRUES. THESE DISCLAIMERS AND LIMITATIONS OF LIABILITY WILL APPLY REGARDLESS OF ANY OTHER CONTRARY PROVISION HEREOF AND REGARDLESS OF THE FORM OF ACTION, WHETHER IN CONTRACT, TORT (INCLUDING NEGLIGENCE AND STRICT LIABILITY) OR OTHERWISE, AND FURTHER WILL EXTEND TO THE BENEFIT OF CTI'S VENDORS, APPOINTED DISTRIBUTORS AND OTHER AUTHORIZED RESELLERS AS THIRD-PARTY BENEFICIARIES. EACH PROVISION HEREOF WHICH PROVIDES FOR A LIMITATION OF LIABILITY, DISCLAIMER OF WARRANTY OR CONDITION OR EXCLUSION OF DAMAGES IS SEVERABLE AND INDEPENDENT OF ANY OTHER PROVISION AND IS TO BE ENFORCED AS SUCH.

7. Adequate Remedy. The customer is limited to the remedies specified herein and shall have no others for a nonconformity in the Product. The customer agrees that these remedies provide the customer with a minimum adequate remedy and are its exclusive remedies, whether based on contract, warranty, tort (including negligence), strict liability, indemnity, or any other legal theory, and whether arising out of warranties, representations, instructions, installations, or non-conformities from any cause. The customer further acknowledges that the purchase price of the Product reflects these warranty terms and remedies.

8. Force Majeure. CTI will not be liable for any loss, damage or delay arising out of its failure (or that of its subcontractors) to perform hereunder due to causes beyond its reasonable control, including without limitation, acts of God, acts or omissions of the customer, acts of civil or military authority, fires, strikes, floods, epidemics, quarantine restrictions, war, riots, acts of terrorism, delays in transportation, or transportation embargoes. In the event of such delay, CTI's performance date(s) will be extended for such length of time as may be reasonably necessary to compensate for the delay.

9. Governing Law. The laws of the State of Tennessee shall govern the validity, interpretation and enforcement of this warranty, without regard to its conflicts of law principles. The application of the United Nations Convention on Contracts for the International Sale of Goods shall be excluded.

REPAIR POLICY

In the event that the Product should fail during or after the warranty period, a Return Material Authorization (RMA) number can be requested orally or in writing from CTI main offices. Whether this equipment is in or out of warranty, a Purchase Order number provided to CTI when requesting the RMA number will aid in expediting the repair process. The RMA number that is issued and your Purchase Order number should be referenced on the returning equipment's shipping documentation. Additionally, if the product is under warranty, proof of purchase date and serial number must accompany the returned equipment. The current repair and/or exchange rates can be obtained by contacting CTI's main office at 1-800-537-8398 or go to www.controltechnology.com/support/repairs/.

When returning any module to CTI, follow proper static control precautions. Keep the module away from polyethylene products, polystyrene products and all other static producing materials. Packing the module in its original conductive bag is the preferred way to control static problems during shipment. Failure to observe static control precautions may void the warranty.

APPENDIX A SPECIFICATIONS

Input Specifications		
Operation Mode Support (See Note 1)	Classic Mode	Classic Plus Mode
8 Analog Input Channels	Yes	Yes
Module Logon	8WX	8WX/8WY
Module Update Time all modes	3.5mS	
Digital Filtering Time Constant	200mS	200mS
Signal Range(Note 2)		
Unipolar	0 to 5VDC, 0 to 20mA	0 to 10VDC, 0 to 5VDC, 0 to 20mA
Bipolar Available in Classic Plus Mode Software configured	NA	+/- 5VDC, +/- 10 VDC +/- 20mA
Input Signal Type	Current	Voltage
DC Input Resistance	250Ω	780Ω
Repeatability	0.0025%	
Accuracy @ 25°C	0.25% of full scale	0.15% of full scale
Resolution (15 bits plus sign)	Unipolar 0 to 32000	Bipolar -32000 to 32000
0 to +5VDC or +/- 5VDC	156μV	
0 to +10 VDC or +/-10VDC	312μV	
0 to +20mA or +/-20mA	.625μA	
Common Mode Rejection Digital Filtering Enabled	>95db @ 100Hz	

Normal Mode Rejection Digital Filtering Enabled	-25db @ 100Hz
Backplane Power (MAX)	.706 watts
Input ESD Protection	IEC 1000-4-2 Level 4
Over-range Protection	± 500V
Isolation	Channel to Channel 200V± Channel to Backplane 1500VDC
Operating Temperature Range	0°C to 60°C (32°F to 140°F)
Agency Approvals Pending	UL, ULC, UL Class 1, Div 2, CE
Shipping Dimensions and Weight	223.84mm x 109.86mm x 34.93mm, 0.234kg
Storage Temperature Range	-40°C to 85°C (-40°F to 185°F)
Relative Humidity	5% to 95% (non-condensing)
Note 1:	Classic or Classic Plus modes are jumper selectable for the module.
Note 2:	In Classic Mode 0 to 5VDC or 0 to 20mA signal range is selected via jumpers for each channel. In Classic Plus Mode additional signal ranges are software configurable.