





Trusted TMR 24 Vdc Analog Input Module 40 Channel

PD-T8431 Issue 19

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Rockwell Automation

Product Description Original Instructions

Important User Information

Read this document and the documents listed in the additional resources section about installation, configuration, and operation of this equipment before you install, configure, operate, or maintain this product. Users are required to familiarize themselves with installation and wiring instructions in addition to requirements of all applicable codes, laws, and standards.

Activities including installation, adjustments, putting into service, use, assembly, disassembly, and maintenance are required to be carried out by suitably trained personnel in accordance with applicable code of practice.

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

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Throughout this manual, when necessary, we use notes to make you aware of safety considerations.



WARNING: Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.



ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you identify a hazard, avoid a hazard, and recognize the consequence.

IMPORTANT Identifies information that is critical for successful application and understanding of the product.

Labels may also be on or inside the equipment to provide specific precautions.



SHOCK HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that dangerous voltage may be present.



BURN HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that surfaces may reach dangerous temperatures.



ARC FLASH HAZARD: Labels may be on or inside the equipment, for example, a motor control center, to alert people to potential Arc Flash. Arc Flash will cause severe injury or death. Wear proper Personal Protective Equipment (PPE). Follow ALL Regulatory requirements for safe work practices and for Personal Protective Equipment (PPE).

This manual includes new and updated information. Use these reference tables to locate changed information.

Grammatical and editorial style changes are not included in this summary.

Global changes

This table identifies changes that apply to all information about a subject in the manual and the reason for the change. For example, the addition of new supported hardware, a software design change, or additional reference material would result in changes to all of the topics that deal with that subject.

Change	Topic
Updated branding.	Throughout

New or enhanced features

This table contains a list of topics changed in this version, the reason for the change, and a link to the topic that contains the changed information.

Topic Name	Reason
About this publication	Updated link for TechConnect℠ Support Contract Access Level and Features. Removed instruction for using By Product when searching Knowledgebase.

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About this publication

This manual specifies the maintenance requirements and describes the procedures to assist troubleshooting and maintenance of a Trusted® system.

Who should use this manual

This manual is for plant maintenance personnel who are experienced in the operation and maintenance of electronic equipment and are trained to work with safety systems.

Disclaimer

It is not intended that the information in this publication covers every possible detail about the construction, operation, or maintenance of a control system installation. You should also refer to your own local (or supplied) system safety manual, installation, and operator/maintenance manuals.

Revision and updating policy

This document is based on information available at the time of its publication. The document contents are subject to change from time to time. The latest versions of the manuals are available at the Rockwell Automation Literature Library: rok.auto/literature.

Latest product information

For the latest information about this product, review the Product Notifications and Technical Notes issued by technical support. Product Notifications and product support are available at the Rockwell Automation Support Center: rok.auto/knowledgebase.

Some of the Answer IDs in the Knowledgebase require a TechConnect℠ Support Contract. For more information about TechConnect Support Contract Access Level and Features, see Knowledgebase Document ID: IP622 - TechConnect Support Contract - Access Level & Features.

Tip: Sign in to your Rockwell Automation account to view Knowledgebase articles.

Download firmware, AOP, EDS, and other files

Download firmware, associated files (such as AOP, EDS, and DTM), and access product release notes from the Product Compatibility and Download Center at rok.auto/pcdc.

Additional resources

These documents contain additional information concerning related Rockwell Automation products.

Resource	Description
Trusted TMR Safety Manual T8094, publication ICSTT-RM459	Provides the requirements that must be met at different stages of a safety-related system to verify that the safety-related objectives of a Trusted® TMR System are achieved.
Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1	Provides general guidelines for installing a Rockwell Automation industrial system.
Product Certifications website, rok.auto/certifications	Provides declarations of conformity, certificates, and other certification details.

You can view or download publications at http://rok.auto/literature.

Product overview

The Trusted® TMR 24 Vdc Analog Input module interfaces to 40 sourcing field input devices, acting as a current sink for all these devices. Comprehensive diagnostic tests are performed on each input channel. Fault tolerance is achieved through a Triple Modular Redundant (TMR) architecture within the Module for each of the 40 input channels.

Using the built-in line-monitoring feature, the Module can detect open and shorted field cables. Line monitoring functions are independently configured for each input channel.

The Module provides onboard Sequence of Events (SOE) reporting with a resolution of 1 ms. A change of state triggers an SOE entry. States are determined by voltage thresholds that can be configured on a per channel basis. When the field voltage and field return are connected to the auxiliary input channels of the Module, thresholds can be specified as a ratio of the field supply voltage.

Features

- 40 Triple Modular Redundant (TMR) input channels per Module.
- Comprehensive, automatic diagnostics and self-test.
- Selectable line monitoring per channel to detect open circuit and short circuit field wiring faults.
- 2500V impulse withstand opto/galvanic isolation barrier.
- Onboard Sequence of Events (SOE) reporting with 1 ms resolution.
- Module can be hot-replaced online using dedicated Companion (adjacent) Slot or SmartSlot (one spare slot for many modules) configurations.
- Front panel input status Light Emitting Diodes (LEDs) for each channel indicate input status and field wiring faults.
- Front panel module status LEDs indicate module health and operational mode (Active, Standby, Educated).
- TÜV Certified IEC 61508 SIL 3.

Description

The Trusted® TMR 24 Vdc Analog Input Module is a member of the Trusted range of Input/Output (I/O) modules. All Trusted I/O Modules share common functionality and form. At the most general level, all I/O Modules interface to the Inter-Module Bus (IMB) which provides power and allows communication with the Trusted TMR Processor. In addition, all Modules have a field interface that is used to connect to module-specific signals in the field. All Modules are Triple Modular Redundant (TMR).

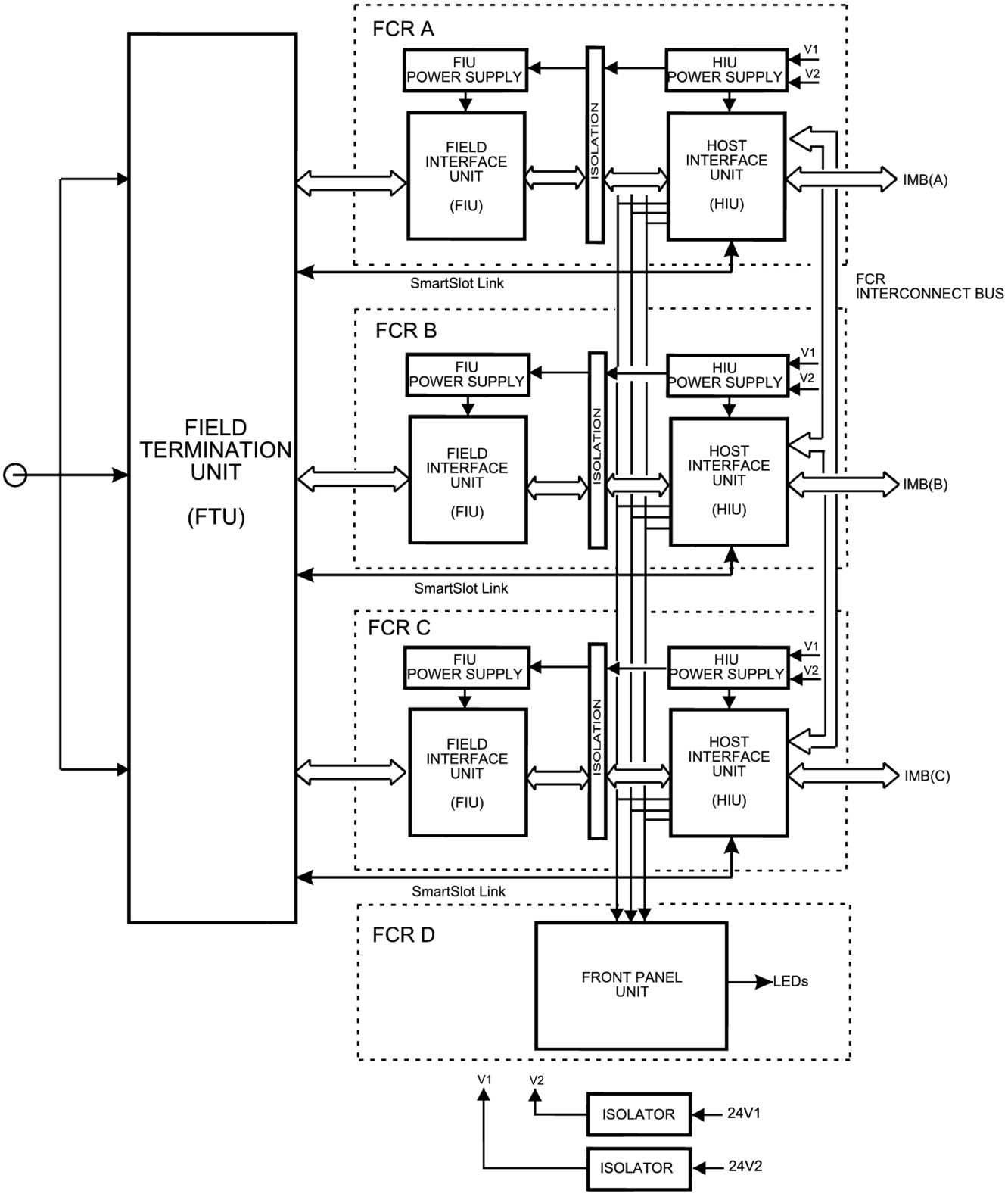


Figure 1: Module Architecture

All High Integrity I/O Modules comprise four sections: Host Interface Unit (HIU), the Field Interface Unit (FIU), the Field Termination Unit (FTU) and the Front Panel Unit (or FPU).

Figure 2 shows a simplified functional block diagram of the Trusted 24 Vdc Analog Input Module.

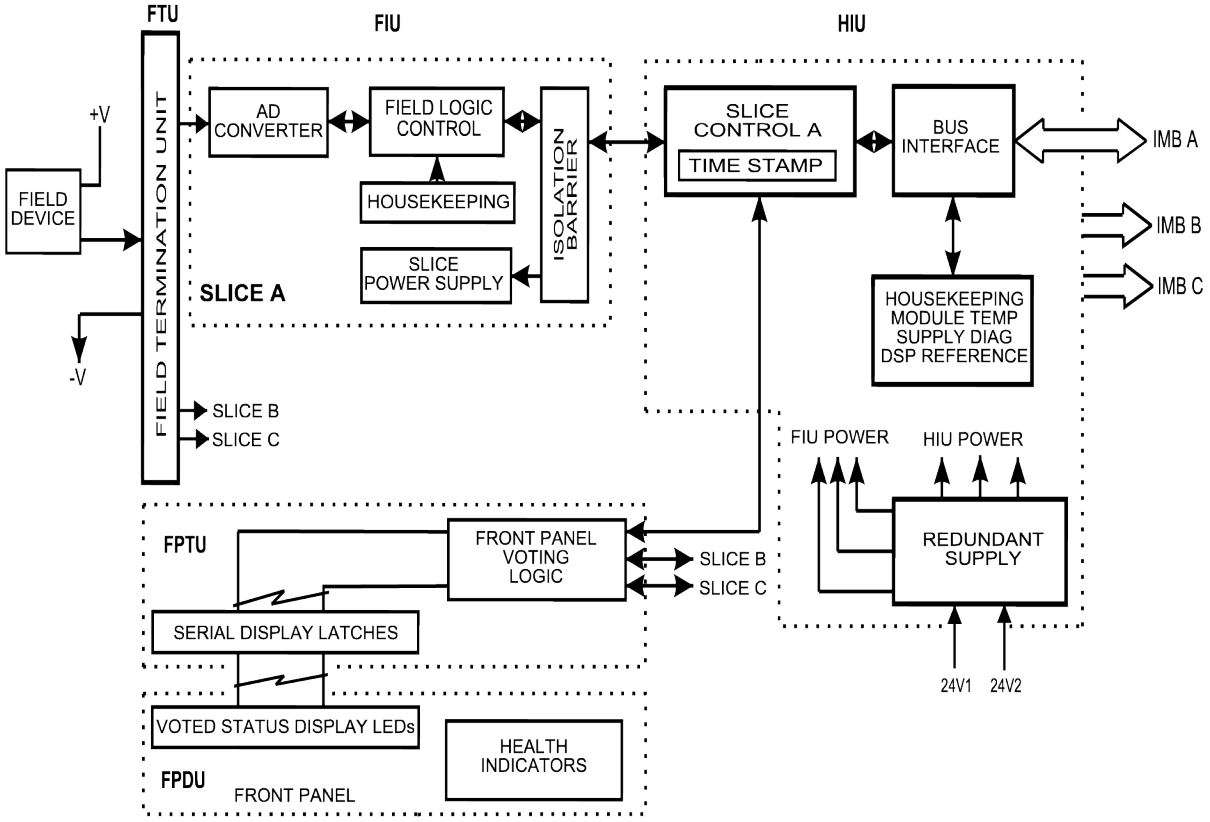


Figure 2: Functional Block Diagram

Field Termination Unit (FTU)

The Field Termination Unit (FTU) is the I/O Module assembly that connects all three FIUs to a field connector. The FTU primarily contains passive components necessary for front-end signal conditioning. When installed in a Trusted Controller or Expander Chassis, the FTU field connector mates to the Field I/O Cable Assembly attached at the rear of the Chassis.

The SmartSlot link is passed from the HIU to the field connections via the FTU. These signals go directly to the I/O cable assembly and maintain isolation from the I/O signals on the FTU. The SmartSlot link is the intelligent connection between Active and Standby Modules for coordination during Module replacement.

Field Interface Unit (FIU)

The Field Interface Unit (FIU) is the section of the Module that contains the specific circuits necessary to interface to the particular types of field I/O signals. Each Module has three FIUs, one per slice. For the TMR 24 Vdc Analog Input Module, the FIU contains an analog to digital converter (ADC) for each of the 40 field inputs.

The FIU receives isolated power from the HIU for logic. The FIU provides additional power conditioning for the operational voltages required by the

FIU circuitry. An isolated 6.25 Mbit/sec serial link connects each FIU to one of the HIU slices.

The FIU also measures a range of onboard "housekeeping" signals that assist in monitoring the performance and operating conditions of the Module. These signals include power supply voltages, current consumption, onboard reference voltages and board temperature.

Host Interface Unit (HIU)

The HIU is the point of access to the Inter Module Bus (IMB) for the Module. It also provides power distribution and local programmable processing power. The HIU is the only section of the I/O Module to directly connect to the IMB Backplane. The HIU is common to most Trusted I/O Module types and has type dependent and product range common functions. Each HIU contains three independent slices, commonly referred to as A, B, and C.

All interconnections between the three slices incorporate isolation to prevent any fault interaction between the slices. Each slice is considered a Fault Containment Region (FCR), as a fault on one slice has no effect on the operation of the other slices.

The HIU provides the following services common to the Modules in the family:

- High Speed Fault Tolerant Communications with the TMR Processor via the IMB interface.
- FCR Interconnect Bus between slices to vote coming IMB data and distribute outgoing I/O Module data to the IMB.
- Optically isolated serial data interface to the FIU slices.
- Redundant power sharing of dual 24 Vdc chassis supply voltage and power regulation for logic power to HIU circuitry.
- Magnetically isolated power to the FIU slices.
- Serial data interface to the FPU for Module status LEDs.
- SmartSlot link between Active and Standby modules for coordination during Module replacement.
- Digital Signal Processing to perform local data reduction and self-diagnostics.
- Local memory resources for storing Module operation, configuration, and field I/O data.
- Onboard housekeeping, which monitors reference voltages, current consumption and board temperature.

Front Panel Unit (FPU)

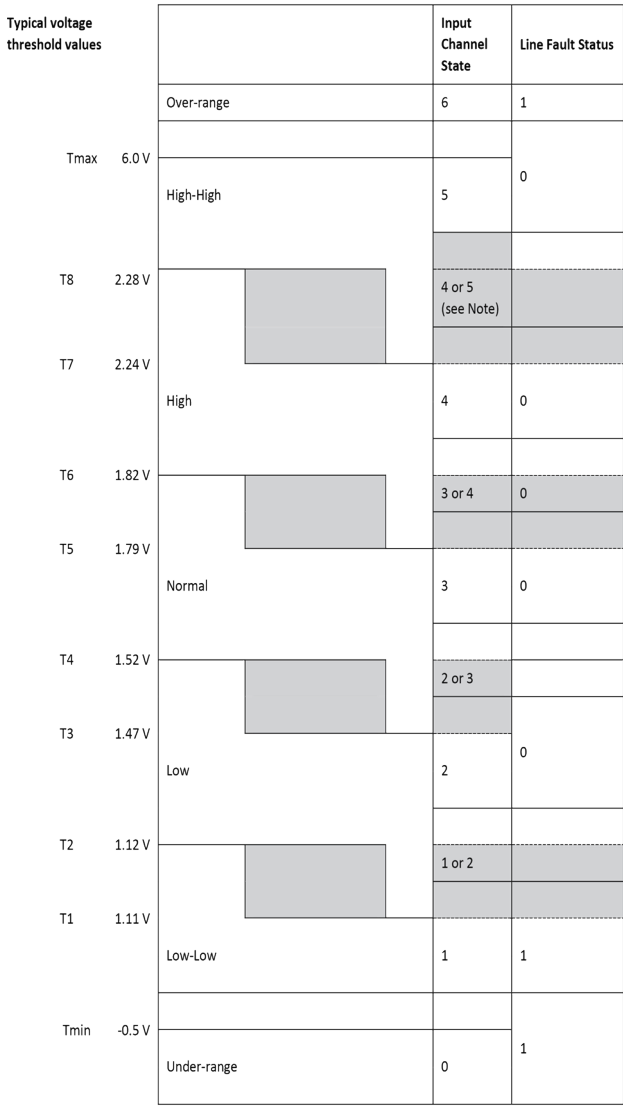
The Front Panel Unit (FPU) comprises a Front Panel Termination Unit (FPTU) and a Front Panel Display Unit (FPDU). The overall FPU contains the necessary connectors, switches, logic, and LED indicators for the Front Panel. For every type of Trusted I/O Module, the FPU contains the Slice Healthy, Active/Standby and Educated indicators (LEDs), and the module removal switches. Additional bicolor LEDs provide status indication for the individual

I/O signals. Serial data interfaces connect the FPU to each of the HIU slices to control the LED status indicators and monitor the module removal switches.

Line Monitoring Thresholds

The Module determines the contact state and line fault status by comparing the input voltage level to four user programmed thresholds and two fixed (minimum and maximum) thresholds. Hysteresis is provided on the thresholds by upscale and downscale values, corresponding to the thresholds for increasing and decreasing values respectively.

Table 1 Example Threshold Data (24 Vdc)



Note: The channel state value returned is dependent on the previous state value. If the input level is increasing, then the lower state value will be returned. If the input level is decreasing, the higher state value will be returned.

Default threshold values used for non-line monitored inputs are as follows (in raw units):

Default = 448, 576, 1344, 1472, 2240, 2368, 3520, 3648, 5120

Housekeeping

The Input Module automatically performs local measurements of several onboard signals that can be used for detailed troubleshooting and verification of Module operating characteristics. Measurements are made within each slice's HIU and FIU.

Fault detection and testing

From the IMB to the field connector, the Input Module contains extensive fault detection and integrity testing. As an input device, all testing is performed in a non-interfering mode. Data input from the IMB is stored in redundant error-correcting RAM on each slice portion of the HIU. Received data is voted on by each slice. All data transmissions include a confirmation response from the receiver.

Between the HIU and FIU, there are a series of optically isolated links for data and power. The data link is synchronized and monitored for variance. Both the FIU and HIU have onboard temperature sensors to characterize temperature-related problems.

The power supplies for both the HIU and FIU boards are redundant, fully instrumented and testable. Together, these assemblies form a Power Integrity Subsystem.

The module field input is connected to a single bit ADC known as the ΣΔ input circuit. These circuits, one per channel on each slice, produce a digital output that naturally transitions between on and off. Any failure in the circuit causes the output to saturate to stuck-on or stuck-off, which is automatically detected. As the conversion process is dynamic and not gated like traditional ADCs, failures are rapidly diagnosed and located.

By using the ΣΔ circuit, the analog path in the Module is short and does not involve many components. This results in analog failures being contained to a single channel on a single slice instead of causing a group of eight or more inputs to fail.

Sequence of Events characteristics

The Input Module automatically measures the field input voltage, compares the value to the configurable thresholds, and determines the state of the field input. An event occurs when the input transitions from one state to another. When an input changes state, the onboard real-time clock value is recorded. When the TMR Processor next reads data from the Input Module, the input state and real-time clock values are retrieved. The TMR Processor uses this data to log the input state change into the system Sequence of Events (SOE) log. The user may configure each input to be included in the system SOE log. Full details of SOE are contained in Trusted Sequence of Events and Process Historian Package Product Description, publication ICSTT-RM243 (PD-T8013).

Installation

Module insertion and removal

Before installation, visually inspect the module for damage. Ensure that the module housing appears undamaged and inspect the I/O connector at the back of the module for bent pins. If the module appears damaged or any pins are bent, do not install the module. Do not try to straighten bent pins. Return the module for replacement.

Ensure that the module is of the correct type.

Record the module type, revision and serial number of the module before installation.



WARNING: The module contains static sensitive parts. Static handling precautions must be observed. Specifically ensure that exposed connector pins are not touched. Under no circumstances should the module housing be removed.

To install the module:

1. Ensure that the field cable assembly is installed and correctly located.
2. Release the ejector tabs on the module using the release key. Ensure that the ejector tabs are fully open.
3. Holding the ejectors, carefully insert the module into the intended slot.
4. Push the module fully home by pressing on the top and bottom of the module fascia.
5. Close the module ejectors, ensuring that they click into their locked position.

The module should mount into the chassis with a minimum of resistance. If the module does not mount easily, do not force it. Remove the module and check it for bent or damaged pins. If the pins have not been damaged, try reinstalling the module.

Field cable selection

I/O cables suitable for use with the Trusted® TMR 24 Vdc Analog Input Module are detailed in these publications:

- Trusted I/O Companion Slot Cables Product Description, publication ICSTT-RM311 (PD-TC200)
- Trusted I/O SmartSlot Cables Product Description, publication ICSTT-RM313 (PD-TC500)

The publications listed above also detail the types of Field Termination Assembly (FTA) or Versatile Field Termination Assembly (VFTA) that may be used with this type of module.

Module pin-out connections

This table describes the module pin-out connections:

Table 2 Field Connector Pin-out

	C	B	A
1	SmartSlot Link C	SmartSlot Link B	SmartSlot Link A
2			
3	Chan 28 (+)	Chan 14 (+)	Chan 0 (+)
4	Chan 28 (+)	Chan 14 (+)	Chan 0 (+)
5	Chan 29 (+)	Chan 15 (+)	Chan 1 (+)
6	Chan 29 (+)	Chan 15 (+)	Chan 1 (+)
7	Chan 30 (+)	Chan 16 (+)	Chan 2 (+)
8	Chan 30 (+)	Chan 16 (+)	Chan 2 (+)
9	Return	Return	Return
10	Chan 31 (+)	Chan 17 (+)	Chan 3 (+)
11	Chan 31 (+)	Chan 17 (+)	Chan 3 (+)
12	Chan 32 (+)	Chan 18 (+)	Chan 4 (+)
13	Chan 32 (+)	Chan 18 (+)	Chan 4 (+)
14	Chan 33 (+)	Chan 19 (+)	Chan 5 (+)
15	Chan 33 (+)	Chan 19 (+)	Chan 5 (+)
16	Chan 34 (+)	Chan 20 (+)	Chan 6 (+)
17	Chan 34 (+)	Chan 20 (+)	Chan 6 (+)
18	Chan 35 (+)	Chan 21 (+)	Chan 7 (+)
19	Chan 35 (+)	Chan 21 (+)	Chan 7 (+)
20	Return	Return	Return
21	Chan 36 (+)	Chan 22 (+)	Chan 8 (+)
22	Chan 36 (+)	Chan 22 (+)	Chan 8 (+)
23	Chan 37 (+)	Chan 23 (+)	Chan 9 (+)
24	Chan 37 (+)	Chan 23 (+)	Chan 9 (+)
25	Chan 38 (+)	Chan 24 (+)	Chan 10 (+)
26	Chan 38 (+)	Chan 24 (+)	Chan 10 (+)
27	Chan 39 (+)	Chan 25 (+)	Chan 11 (+)
28	Chan 39 (+)	Chan 25 (+)	Chan 11 (+)
29	Chan 40 (+)	Chan 26 (+)	Chan 12 (+)
30	Chan 40 (+)	Chan 26 (+)	Chan 12 (+)
32	Chan 41 (+)	Chan 27 (+)	Chan 13 (+)
32	Chan 41 (+)	Chan 27 (+)	Chan 13 (+)

Trusted module polarization and keying

All Trusted modules have been Keyed to prevent insertion into the wrong position within a chassis. The polarization comprises two parts: the module and the associated field cable.

Each module type has been Keyed during manufacture. The organization responsible for the integration of the Trusted System must key the cable by

removing the keying pieces from the cable so that they correspond with the bungs fitted to the associated module before fitting.

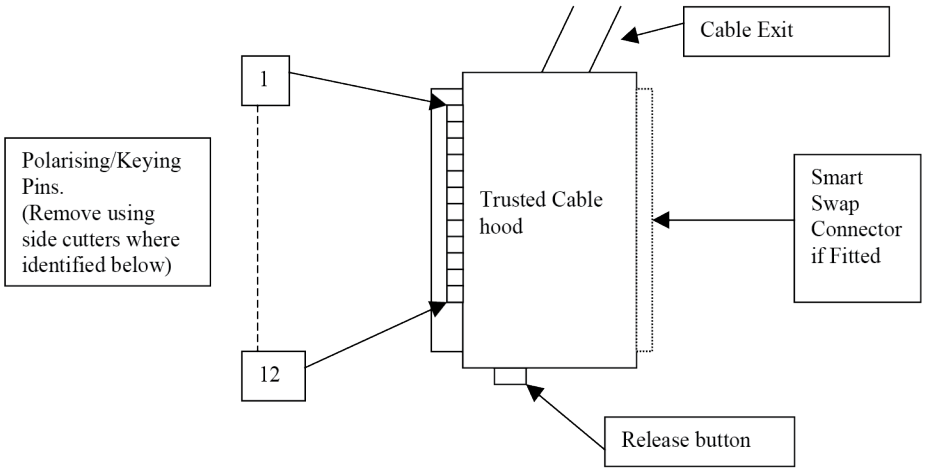


Figure 3: Module Polarization

For Cables with Companion Slot installations both keying strips must be polarized.

For this module (T8431) remove keying pins 1, 4, and 5.

Application

Module configuration

There is no configuration required to the physical Input Module. All configurable characteristics of the Module are performed using tools on the Engineering Workstation (EWS) and become part of the application or System.INI file that is loaded into the TMR Processor. The TMR Processor automatically configures the Input Module after applications are downloaded and during Active/Standby changeover.

The IEC 61131 TOOLSET provides the main interface to configure the Input Module. Details of the configuration tools and configuration sequence are provided in Trusted Toolset Suite Product Description, publication ICSTT-RM249 (PD-T8082). There are three procedures necessary to configure the Input Module. These are:

1. Define the necessary I/O variables for the field input data and module status data using the Dictionary Editor of the IEC 61131 TOOLSET.
2. Create an I/O Module definition in the I/O Connection Editor for each I/O Module. The I/O Module definition defines physical information, e.g. Chassis and Slot location, and allows variables to be connected to the I/O channels of the Module.
3. Using the Trusted® System Configuration Manager, define custom LED indicator modes, per-channel threshold levels and noise filtering, and other Module settings.

T8431 Complex Equipment Definition

The T8431 I/O Complex Equipment Definition includes eight I/O boards, referenced numerically by Rack number:

Table 3 Complex Equipment Definition

Rack	I/O Board	Description	Data Type	Direction	No. of channels
1	THRSHIN	OEM Parameters	-	-	-
		Field Input Status	Integer	In	9
2	STATE	Field Input State	Integer	In	40
3	AI	Field Input Engineering Unit	Integer	In	40
4	THRSHOUT	Threshold data	Integer	Out	11
5	LINE_FLT	Line Fault Status	Boolean	In	40
6	DISCREP	Channel Discrepancy	Integer	In	3
7	HKEEPING	Housekeeping Registers	Integer	In	51
8	INFO	I/O Module Information	Integer	In	11

There are two OEM parameters included in the first rack (THRSHIN Board). These OEM parameters define the primary module position; declaring the Module's chassis and slot location. There is no need to define the secondary

module position within the IEC 61131 TOOLSET. Where systems may be required to start-up with a Module in the secondary position as the Active Module, e.g. primary module is not installed when application is started, the secondary module's position should be declared in the module definition of the System Configuration Manager.

Table 4 OEM Parameters

OEM Parameter	Description	Notes
TICS_CHASSIS	The number of the Trusted Chassis where the primary I/O Module is installed	The Trusted Controller Chassis is 1, and Trusted Expander Chassis are 2 to 15.
TICS_SLOT	The slot number in the Chassis where the primary I/O Module is installed	The I/O Module slots in the Trusted Controller Chassis are numbered from 1 to 8. The I/O Module slots in the Trusted Expander Chassis are numbered from 1 to 12.

Rack 1: THRSHIN

This board allows the current thresholds for an analog input channel to be read by the application, under control of the THRSHOUT board (see Rack 4: THRSHOUT on page 24).

Table 5 Rack 1: Threshold Input Descriptions

Channel	Description
1	Channel number being read. Range 0 to 41.
2	States 2 > 1 falling threshold
3	States 1 > 2 rising threshold
4	States 3 > 2 falling threshold
5	States 2 > 3 rising threshold
6	States 4 > 3 falling threshold
7	States 3 > 4 rising threshold
8	States 5 > 4 falling threshold
9	States 4 > 5 rising threshold

THRSHIN reads in the Module threshold values controlled by THRSHOUT in Rack 4. See Table 1 for a graphical representation of the states and thresholds.

Rack 2: STATE

This board provides the majority voted numerical input state. This indicates within which threshold band the field input is in and Module channel fault status.

Table 6 Rack 2: STATE descriptions

Channel	Description
1	Field input channel 1 state
2	Field input channel 2 state
40	Field input channel 40 state

The numerical input state is returned as an integer value.

Table 7 Rack 2: STATE Bit Descriptions

Channel	Description
8-15	Internal channel fault on module
7	Unknown
6	Overrange
5	High-High
4	High
3	Normal
2	Low
1	Line fault
0	Underrange

The input channel has a value 7 (Unknown) when:

1. The input channel cannot be correctly measured by two or more slices of the TMR Input Module.
2. The TMR Processor detects a 2003 channel discrepancy between the three slices of the TMR Input Module.
3. The Module is simulated (not installed or the TMR Processor cannot communicate with 2003 slices of the Module).

Rack 3: AI

The AI board returns the engineering units for the associated field input.

Table 8 Rack 3: Channel Field Engineering Units

Channel	Description
1	Field input channel 1 voltage
2	Field input channel 2 voltage
40	Field input channel 40 voltage

The voltage is the median value taken from the triplicated Module. Field input current is converted to voltage using a 250 Ω resistor on a standard field termination assembly (FTA). This AI value may be used directly or scaled using the IEC 61131 TOOLSET conversion tables. The voltage is reported as 1024 counts per volt. To allow easy scaling for 4-20 mA inputs, zero volts reports as -1024, one volt reports as 0, and 5 volts reports as 4096.

Using a 250 Ω field loop configuration the following table represents normal operating values.

Table 9 Rack 3: Normal Operating Values

Voltage	Current	Engineering Unit
Open Circuit		-2048
0	0 mA	-1024
1	4 mA	0
2	8 mA	1024
3	12 mA	2048
4	16 mA	3072
5	20 mA	4096

Rack 4: THRSHOUT

This board allows the current thresholds for an analog input channel to be read or written by the application. The application can write new thresholds in the THRSHOUT board for a particular channel, and it can read the current thresholds from the THRSHIN board, under control of a channel in the THRSHOUT board.

Note that channels 0 and 41 are internal reference channels, and are not connected to the field. Channels 1 to 40 are field channels.

Table 10 Rack 4: THRSHOUT

Channel	Description
1	Write the threshold data for a particular input channel on channels 3 to 11 to the Module. The data is written on a rising edge 0 to 1.
2	Read the threshold data for a particular channel from the Module to the THRSHIN board. The data is read on a rising edge 0 to 1.
3	Channel number to write/read threshold data. Range 0 to 41.
4	States 2 > 1 falling threshold
5	States 1 > 2 rising threshold
6	States 3 > 2 falling threshold
7	States 2 > 3 rising threshold
8	States 4 > 3 falling threshold
9	States 3 > 4 rising threshold
10	States 5 > 4 falling threshold
11	States 4 > 5 rising threshold

Rack 5: LINE_FLT

This table describes Rack 5: LINE_FLT:

Table 11 Rack 5: LINE_FLT

Channel	Description
1	Field input channel 1 line fault
2	Field input channel 2 line fault
40	Field input channel 40 line fault

The line fault input state is reported as true (logic '1') for a line fault condition (open circuit, indeterminate, or short circuit condition). The logic state is the majority voted value.

Rack 6: DISCREP

This table describes Rack 6: DISCREP.

Table 12 Rack 6: DISCREP Bit Descriptions

Channel	Description
1	Discrepancy status inputs 1 to 16
2	Discrepancy status inputs 17 to 32
3	Discrepancy status inputs 33 to 40

Each of the words reports the discrepancy status of 16 input channels. The corresponding bit within the word is set to '1' when a discrepancy condition is detected on that input channel's input state (rack 2).

Rack 7: HKEEPING

This table describes Rack 7: HKEEPING.

Table 13 Rack 7: Housekeeping

Channel	Description				
	FCR		Units (Full Scale Range)		
1	A	24V2 Input Voltage	-32768	32767	mV
2	B				
3	C				
4	A	Internal supply voltage (post regulator)	-32768	32767	mV
5	B				
6	C				
7	A	Internal supply current (post regulator)	-32768	32767	mA
8	B				
9	C				
10	A	Input voltage (post isolation)	-32768	32767	mV
11	B				
12	C				

13	A	24V1 Input Voltage	-32768	32767	mV
14	B				
15	C				
16	A	HIU Board Temperature (Note: Temperature, ºC = input value / 256)	-32768	32767	-
17	B				
18	C				
19	A	Front Panel Load Current	-32768	32767	mA
20	B				
21	C				
22	A	SmartSlot Link Voltage	-32768	32767	mV
23	B				
24	C				
25	A	Reserved for FIU condensation sensor	0	0	-
26	B				
27	C				
28	A	FIU Internal Supply Voltage	-32768	32767	mV
29	B				
30	C				
31	A	FIU Internal Supply Current	-32768	32767	mA
32	B				
33	C				
34	A	FIU Unregulated input voltage	-32768	32767	mV
35	B				
36	C				
37	A	FIU Board Temperature (Note: Temperature, ºC = input value / 256)	-32768	32767	-
38	B				
39	C				
40	A	FIU Reference Voltage, DAC_X1	-32768	32767	mV
41	B				
42	C				
43	A	FIU Reference Voltage, DAC_X2	-32768	32767	mV
44	B				
45	C				
46	A	FIU Reference Voltage, DAC_X3	-32768	32767	mV
47	B				
48	C				
49	A	Diagnostic error code			
50	B				
51	C				

Each input within the housekeeping rack is reported as an integer. In general, the application engineer will not normally require these inputs. They are provided to aid fault finding and diagnosis and may be used for reporting and display purposes. If a slice is Fatal, then all reported housekeeping inputs are set to zero.

Rack 8: Information

This table describes Rack 8: INFO.

Table 14 Rack 8: INFO Descriptions

Channel	Description
1	Active Module chassis number
2	Active Module slot number
3	Active Module healthy
4	Active Module mode
5	Standby Module chassis number
6	Standby Module slot number
7	Standby Module healthy
8	Standby Module mode
9	Fault Containment Region (FCR) status
10	Primary Module is active
11	Active Module is simulated

The Active Module chassis and slot numbers indicate the position of the currently Active Module. These values will change to match the primary or secondary module position, depending on their active status, i.e. Active/Standby changeover will "swap" the values for the Active Module chassis and slot number channels with those in the Standby Module chassis and slot number channels. The chassis and slot numbers are set to zero if the Module is not present.

The Active and Standby Module healthy channel is returned as an integer, however only the least significant bit is used. A value of 0 indicates that a fault has been detected, a nonzero value indicates that the Module is healthy.

The Active and Standby Module mode is an integer indicating the current operating mode of the associated Module. The value indicates the current internal operating mode of the Module.

Table 15 Rack 8: INFO Bit Descriptions

Value	Module State
5	Shutdown
4	Maintain
3	Active
2	Standby
1	Configuration
0	Unknown, no module present

The FCR Status channel reports the fault status of the Active and Standby Modules. The value is bit-packed as shown below, the least significant byte is used with the most significant 8-bits set to zero:

Table 16 Rack 8: FCR Bit Descriptions

Bit Number							
7	6	5	4	3	2	1	0
Standby Module				Active Module			
Ejectors open	FCR C Healthy	FCR B Healthy	FCR A Healthy	Ejectors open	FCR C Healthy	FCR B Healthy	FCR A Healthy

The 'Primary Module is active' channel is set to nonzero if the primary module is the current Active Module, i.e. the Active Module is in the chassis and slot numbers defined within the OEM parameters.

The 'Active Module is simulated' channel is set to nonzero if the Active Module is being simulated, this will only be set if the Module is not present and the simulation enable has been set within the module's configuration in the System.INI file.

Sequence of Events configuration

Each Boolean Input Variable can be configured for automatic Sequence of Events (SOE) logging. This applies to the Input Status and Line Fault Status variables. A Boolean variable is configured for SOE during the variable definition in the Data Dictionary Editor. To select SOE, press the Extended Button in the Boolean Variable Definition Dialog Box to open the Extended Definition Dialog. Then check the box for Sequence of Events to enable the variable for automatic SOE logging.

During operation, the Input Module automatically reports time-stamped change of state information for the input data. The TMR Processor automatically logs change of state for configured SOE variables into the system SOE Log. The SOE Log can be monitored and retrieved using the SOE and Process Historian Package running on the EWS. This software package is described in Trusted Sequence of Events and Process Historian Package Product Description, publication ICSTT-RM243 (PD-T8013).

System.INI file configuration

There are many operating characteristics of the Input Module that can be customized for a particular application. The System Configuration Manager is a tool that allows the user to configure the specific operating characteristics for each Module. Descriptions of the items that may be configured for the Trusted 24 Vdc Analog Input Module T8431 are contained in Trusted Toolset Suite Product Description, publication ICSTT-RM249 (PD-T8082).

Certain characteristics apply to the entire Module and are considered Module Configurable Items. Other characteristics apply to individual input channels and are considered Channel Configurable Items. There are specific default settings for each of the configurable items. If the default settings are appropriate for a given application, customization of the module definition in the System Configuration Manager is not required.

Operation

Front panel

Status LEDs on the front of the Module provide visual indications of the module's operational status and field input status. Each LED is a tri-color LED of which for normal operation, only two colors are used; red and green. At the top and bottom of each Module is an ejector lever that is used to remove the Module from the Chassis. Limit switches detect the open/closed position of the ejector levers. The ejector levers are normally latched closed when the Module is firmly seated into the Controller or Expander Chassis.

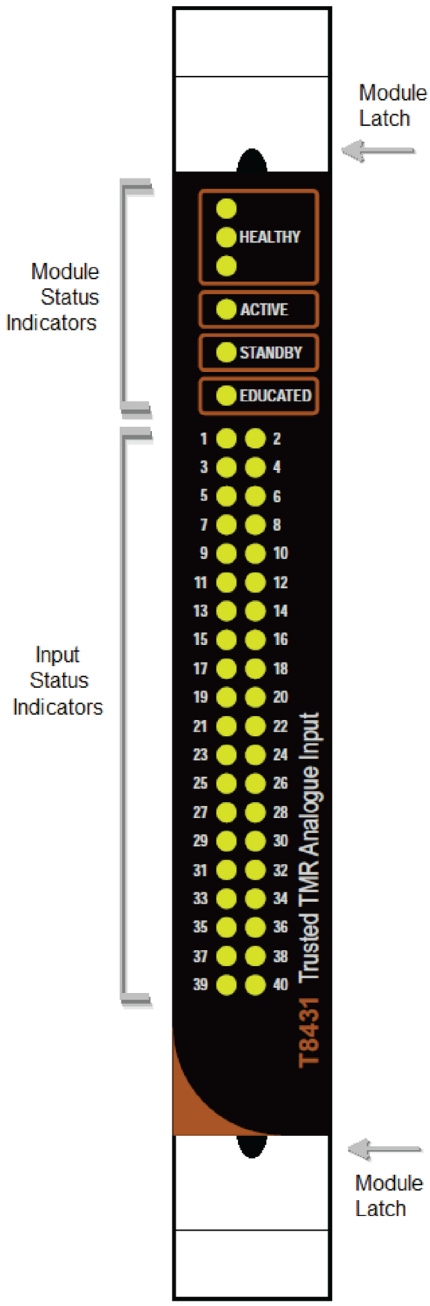


Figure 4: Module Front Panel

Module status LEDs

There are six module status LEDs on the Module Front Panel; three Healthy, one Active, one Standby, and one Educated. The Healthy indicators are controlled directly by each module slice. The Active, Standby, and Educated indicators are controlled by the FPU. The FPU receives data from each of the module slices. The FPU performs a 2003 vote on each data bit from the slices and sets the indicators accordingly.

The module status LED states and their meanings are described as follows:

Table 17 Module Status Indicators

LED	State	Description
Healthy	Off	No power applied to the module.
	Amber	Slice is in the startup state (momentary after installation or power-up).
	Green	Slice is healthy.
	Red - flashing	Fault present on the associated slice but the slice is still operational, or one 24V feed to the chassis has failed.
	Red (momentary)	On installation – power applied to the associated slice.
	Red	The associated slice is in the fatal state. A critical fault has been detected and the slice disabled.
Active	Off	Module is not in the Active state.
	Green	Module is in the Active (or Maintain) state.
	Red - flashing	Module is in the shutdown state if the Standby LED is off.
	Red - flashing	Module is in the fatal state if the Standby LED is also flashing.
Standby	Off	Module is not in the Standby state.
	Green	Module is in the Standby state.
	Red - flashing	Module is in the fatal state. The Active LED will also be flashing red.
Educated	Off	Module is not educated.
	Green	Module is educated.
	Green - flashing	Module is recognized by the Processor but education is not complete.
	Amber - flashing	Active/Standby changeover in progress.

I/O status LEDs

There are 40 input channel status LEDs on the Module Front Panel, one for each field input. These indicators are controlled by the FPU. The FPU receives data from each of the module slices. The FPU performs a 2003 vote on each data bit from the slices and sets the indicators accordingly.

The input status LED mode is dependent upon the voltage level of the field I/O signal. Each field input voltage is measured and compared to six threshold levels (four configurable and two fixed) which produce seven threshold bands. Each threshold band can be defined to have a particular indicator mode: off, green, red, flashing green, or flashing red.

The configurable voltage thresholds and LED modes allow users to customize the input measurement and status indications to suit individual application requirements. Without customization, the default indicator modes are suitable for analog inputs as described below:

Table 18 Default I/O Status Indicators

Channel	Description
Off	'Normal' (states 1,2,3)
Green - steady	'High alarm' (states 4,5)
Green – flashing	Over-range (state 6)
Red-flashing	Under-range (state 0) or Channel Fault (8 to 15)



Tip: The LEDs indicating channel status may be configured to suit user requirements by implementing the procedure for configuring the System.INI file detailed in Trusted Toolset Suite Product Description, publication ICSTT-RM249 (PD-T8082).

Fault finding and maintenance

Fault reporting

Input Module faults are reported to the user through visual indicators (LEDs) on the Front Panel of the Module. Faults are also reported via status variables that may be automatically monitored in the application programs, and external system communications interfaces. There are generally two types of faults that must be remedied by the user; external wiring and module faults. External wiring faults require corrective action in the field to repair the fault condition. Module faults require replacement of the Input Module.

Field wiring faults

The input circuits of the Module may be used to detect field wiring faults in addition to alarm states. To achieve this, line monitoring components must be fitted to the field device.

By comparing the input signal from the field with pre-configured alarm thresholds, the Module can automatically detect field wiring faults. When a field loop develops a line fault, the input channel status LED will adopt the steady red state (default setting). The corresponding input state will be reported and the line fault status for that channel will be set to '1'. All other input channels will be unaffected, except in the case of common cause wiring faults in the field.

Once the field wiring fault has been identified and corrected, the input status and the input status LED will display the normal status of the field device and field wiring.

Module faults

Extensive diagnostics provide the automatic detection of module faults. The TMR architecture of the Input Module and the diagnostics performed ensure the validity of all critical circuits. Using the TMR architecture provides a Fault Tolerant method to withstand the first fault occurrence on the Module and continue normal input measurements without interruption in the system or process. Faults are reported to the user through the Healthy status indicators on the Front Panel of the Module and through the INFO and HKEEPING variables. Under normal operations all three Healthy Indicators are green. When a fault occurs, one of the Healthy Indicators will be flashing red. It is recommended that this condition is investigated and if the cause is within the Module, it should be replaced.

Module replacement activities depend on the type of spare module configuration chosen when the system was configured and installed. The Module may be configured with a dedicated Companion Slot or with a SmartSlot for a spare replacement module.

Companion slot

For a Companion Slot configuration, two adjacent slots in a Trusted® Chassis are configured for the same input module function. One slot is the primary slot and the other a unique secondary (or spare) slot. The two slots are joined at the rear of the Trusted Chassis with a double-wide I/O Interface Cable that connects both slots to common field wiring terminations. During normal operations, the primary slot contains the Active Module as indicated by the Active indicator on the Front Panel of the Module. The secondary slot is available for a spare Module that will normally be the Standby Module as indicated by the Standby indicator on the Front Panel of the Module.

Depending on the installation, a hot-spare Module may already be installed, or a module blank will be installed in the standby slot. If a hot-spare Module is already installed, transfer to the Standby Module occurs automatically when a module fault is detected in the Active Module. If a hot-spare is not installed, the system continues operating from the Active Module until a spare Module is installed.

SmartSlot

For a SmartSlot configuration, the secondary slot is not unique to each primary slot. Instead, a single secondary slot is shared among many primary slots. This technique provides the highest density of Modules to be fitted in a given physical space. At the rear of the Trusted Chassis, a single-wide I/O Cable connects the secondary slot directly to the I/O Cable connected to the failed primary module. With a spare Module installed in the SmartSlot and the SmartSlot I/O Cable connected to the failed primary module, the SmartSlot can be used to replace the failed primary module.

Input Module Smart Slot jumper cable TC-306-02

SmartSlot between Chassis can be performed if the Chassis are version 2 (or higher). These have the connector fitted to enable connection of a TC-006 that ensures the 0 Volt of each Chassis is at the same potential.

Cold Start

If an I/O Module has shut down (due, for example, to two existing faults), the three Healthy LEDs will be red, the Active and Standby LEDs will be flashing red and the Educated LED will be flashing amber. The I/O functions provided by this Module will have been lost if a hot swap partner has not taken over control. The Module can only be restarted by removing it from its slot and reinserting it.

If an I/O Module is inserted into a functional system slot that previously had no Active Module (e.g. removing and reinserting as above), then the Processor will educate the Module once it has booted. Once educated, the Educated LED will be steady green and the Active LED will be red flashing.

Input Modules will now be reading and reporting their inputs. Output Modules have not yet energized their outputs. To activate outputs and to set

the Module's Active LED and the Processor's System Healthy LED steady green, press the Processor Reset push button.

Input Channel Calibration Check

It is recommended that a check is carried out at two yearly intervals on the input channel calibration. This check will detect long-term drift and any inaccuracy as a result. Refer to Appendix F of Trusted TMR Safety Manual T8094, publication ICSTT-RM459.

Transfer between Active and Standby Modules

The TMR Processor is responsible for managing a pair of I/O Modules through an Active/Standby changeover. The following rules apply to Active/Standby changeovers, though the TMR Processor and not the I/O Module enforces them:

- The user must define the primary, and optionally the secondary, I/O Module location for each I/O Module pair. Each primary module location must be unique and is defined as part of the complex equipment definition within the IEC 61131 TOOLSET. Secondary module locations can be unique or shared between multiple secondary modules and are defined within the module's section within the System.INI file. The system will automatically determine the secondary module position if the primary module is installed and is operable.
- On initial startup, if the primary module is installed, it will become the Active Module by default. If the secondary module has been defined within the System.INI file and no primary module is present, and if the secondary module location is unique, the secondary module will become the Active Module by default. If the secondary module is installed with no primary module present, and the secondary module location is not unique (as in a SmartSlot configuration), then NO Module for that Module pair will become Active.
- In order for a Module to become the Active Module, the TMR Processor will verify that the Module is the correct I/O Module type and that both module removal switches are closed. At this point, the I/O Module is configured and eventually placed in the Active state.
- A module in the Active state should never be removed.
- When a fault occurs on the Active Module, the TMR Processor will be informed. Once it becomes aware of the fault, the TMR Processor will attempt an Active/Standby changeover.
- An Active/Standby changeover starts with the TMR Processor checking to see if a Standby I/O Module is installed. If no Standby I/O Module is available, the TMR Processor will continue to use the Active Module and will continue to check for an available Standby I/O Module. Once a Standby Module is found, the TMR Processor will verify that the I/O Module is of the correct type, that both module removal switches are closed, and that the I/O Module is a part of the correct module pair by using the SmartSlot link. At this point, the TMR Processor will configure the Standby I/O Module with the same configuration information as the currently Active I/O Module and place the Standby

I/O Module into the Standby state. The Active Module is then placed in the Maintain state (which suspends field loop testing), and any module-specific changeover data is transferred. The Educated light flashes amber before the Active/Standby changeover takes place, to indicate transfer of dynamic change over data (COD). The previous Standby Module then becomes the Active Module and the original Module becomes Standby. If the currently Active Module does not successfully complete the self-tests, the TMR Processor will revert it to the Standby state, and the Module in the Maintain state will revert to the Active state.

- When both module removal switches are opened on an Active Module, regardless of the module fault status, the TMR Processor will treat it as a request to perform an Active/Standby changeover.

Under normal conditions, an Active/Standby changeover will only occur if the new Active Module is fault free. Under some circumstances, it is desirable to be able to force a changeover to a known faulted module. This can be accomplished by opening the module removal switches on the currently Active Module and pressing the reset push button on the TMR Processor. This will force the changeover to proceed even if the new Active Module is not fault free.

Specifications

This table lists the module specifications:

Item	Description
Backplane (IMB) Supply	
Voltage	20 Vdc to 32 Vdc
Power	20 W
Field Supply	N/A
Maximum Power Dissipation	20 W
Module Location	T8100, T8300 I/O Module Slot
Isolation	
Field Common	50 V Reinforced (continuous)[1] 250 V Basic (fault)[2] [Type tested at 2436 Vdc for 60 s].
Channel to Channel	None
Fusing	None
Number of Inputs	40
Input	
Impedance (FTA)	250 Ohm
Impedance (module)[3]	16.967 K Ohm
Current	0 mA – 22 mA
Voltage	0 Vdc – 5.5 Vdc
Thresholds	Configurable
Resolution (LSB)	3.906 µA
Safety Accuracy	±200 µA
Calibration Accuracy[4]	±0.15 %
Intrinsic Safety	None - External barrier required
Sequence of Events	
Event Resolution (LSB)	1 ms
Time stamp Accuracy	±10 ms
Operating Temperature	0 °C to +60 °C (+32 °F to +140 °F)
Storage Temperature	-25 °C to +70 °C (-13 °F to +158 °F)
Relative Humidity – Operating and Storage	10% – 95%, noncondensing
Environmental Specifications	Refer to Trusted 8000 Series International Safety and Environmental Approvals, publication ICSTT-TD003
Dimensions	
Height	266 mm (10.5 in)

[1] 50 Vrms Secondary circuit derived from Mains, OVC II up to 300V.

[2] 250 Vrms Mains circuit, OVC II up to 300V. Exposure to voltages at these levels shall be temporally constrained consistent with the system MTTR.

[3] In the case where partner modules are fitted then the effective Module input impedance is halved.

[4] Refer to T8094 Trusted Safety Manual for guidance on calibration maintenance.

Item	Description
Width	31 mm (1.2 in)
Depth	303 mm (12.0 in)
Weight	1.149 kg (2.5 lb)

History of changes

This appendix contains the new or updated information for each revision of this publication. These lists include substantive updates only and are not intended to reflect all changes. Translated versions are not always available for each revision.

Issue 19, August 2021

Change
Updated link for TechConnect℠ Support Contract Access Level and Features. Removed instruction for using By Product when searching Knowledgebase.
Updated branding.

Issue 18D, June 2018

Change
Updated Specification Table

Issue 17, March 2017

Change
Front Panel image (Figure 4) updated to show new label. In Specifications section, "Field Common Isolation" changed to "Field Common Insulation".

Issue 16, June 2016

Change
Rebranded and reformatted with correction to Relative Humidity Range and Operating Temperature statement in the Specification Section, also any typographical errors

Issue 15, April 2010

Change
Rack 7 minor change

Issue 14, November 2009

Change
Calibration checking information added

Issue 13, December 2008

Change
Channel LEDs

Issue 12, September 2007

Change
Threshold boards

Issue 11, December 2006

Change
Weights & Dims

Issue 10, September 2006

Change
Corrections

Issue 9, August 2006

Change
Corrections

Issue 8, June 2005

Change
Reformat Sect 3.2.3 Table 9 Bit ref changed 0-9 & 10-14 0-20mA added Range +/-64 changed to 32

Rockwell Automation support

Use these resources to access support information.

Technical Support Center	Find help with how-to videos, FAQs, chat, user forums, and product notification updates.	rok.auto/support
Knowledgebase	Access Knowledgebase articles.	rok.auto/knowledgebase
Local Technical Support Phone Numbers	Locate the telephone number for your country.	rok.auto/phonesupport
Literature Library	Find installation instructions, manuals, brochures, and technical data publications.	rok.auto/literature
Product Compatibility and Download Center (PCDC)	Get help determining how products interact, check features and capabilities, and find associated firmware.	rok.auto/pcdc

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Waste Electrical and Electronic Equipment (WEEE)



At the end of life, this equipment should be collected separately from any unsorted municipal waste.

Rockwell Automation maintains current product environmental information on its website at rok.auto/pec.

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