MANUFACTURER DOCUMENT PACKAGE

Manufacturer's Manual

Reference package for procurement and maintenance review

ICS TRIPLEX

T8431CX

40-CHANNEL TMR ANALOG INPUT

Used with the applicable Trusted TMR analog I/O configuration.

REFERENCE PACKAGE

OFFICIAL DOCUMENT

Selected official manufacturer pages follow this cover.

Source: Rockwell Automation ICSTT-RM273Q-EN-P, August 2021; T8431 family hardware.



Trusted TMR 24 Vdc Analog Input Module 40 Channel

PD-T8431 Issue 19

Rockwell Automation Publication ICSTT-RM273Q-EN-P - August 2021
Supersedes PD-T8431 Issue 18 June 2018

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.

In no event will Rockwell Automation, Inc. be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams.

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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).

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).

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.

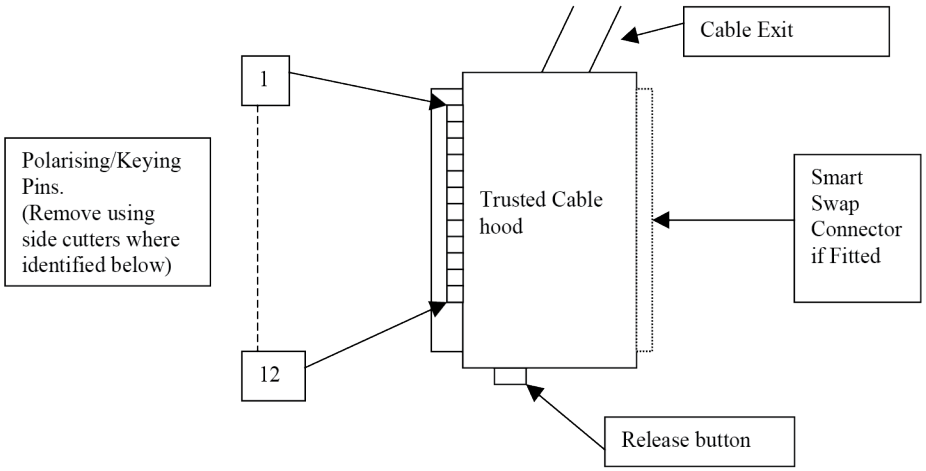


Figure 3: Module Polarization

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

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.

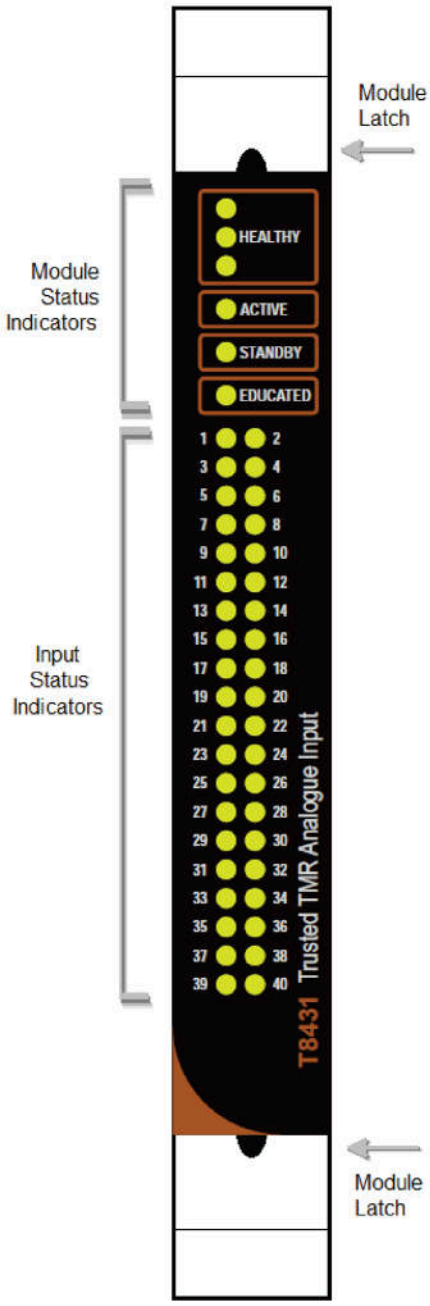


Figure 4: Module Front Panel

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)

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

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)