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.

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.

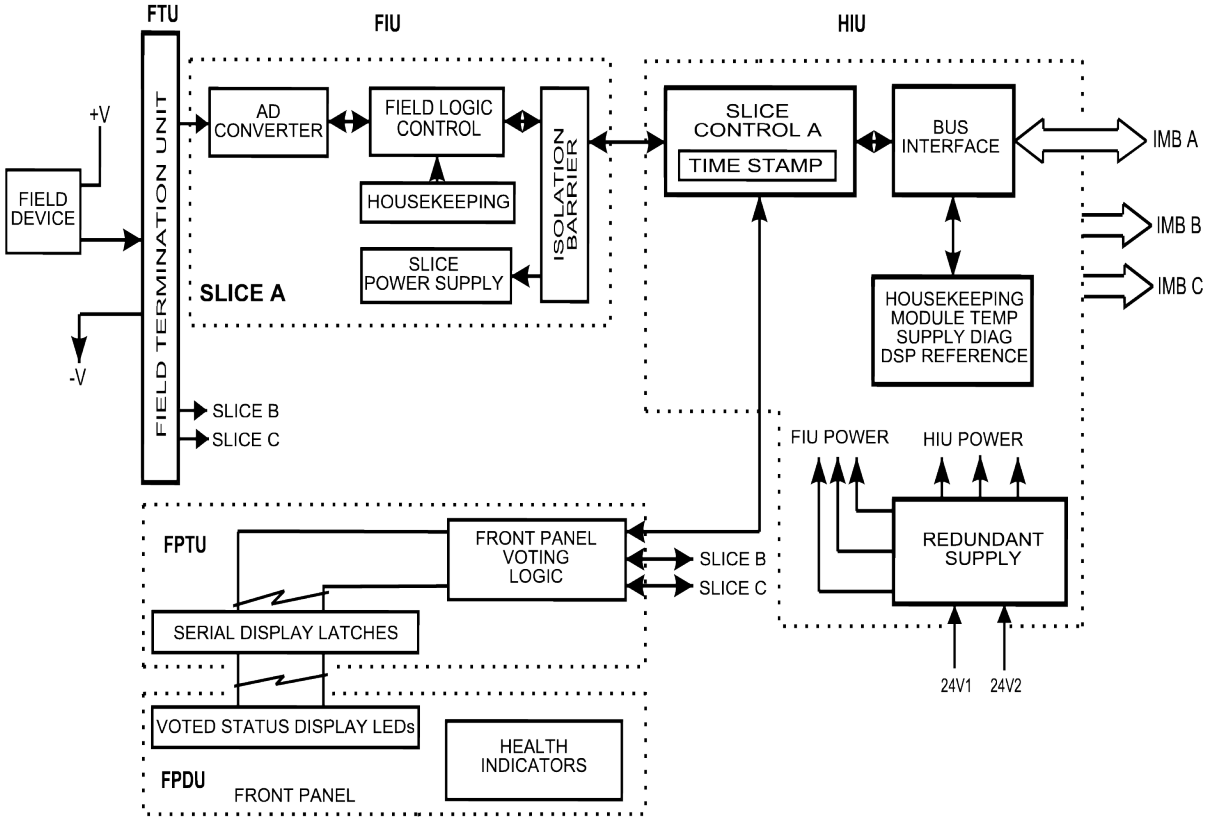


Figure 2: Functional Block Diagram

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.

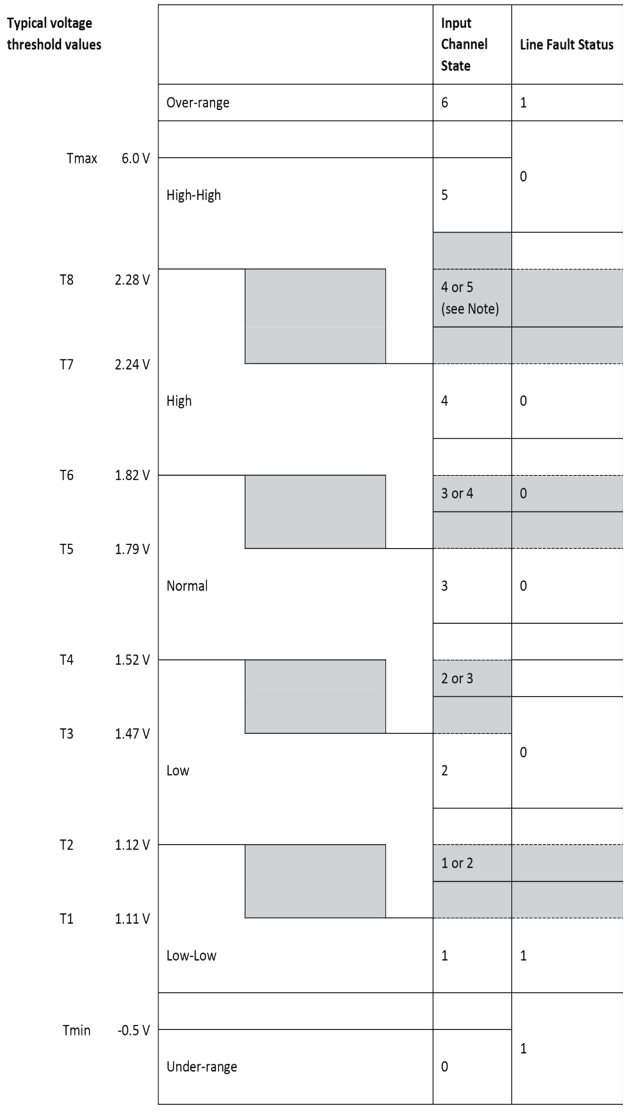
The FIU receives isolated power from the HIU for logic. The FIU provides additional power conditioning for the operational voltages required by the

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.

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				

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)

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.