# Trusted TMR 24 Vdc Zone Interface Module 40 Channel

## Product Overview

The Trusted® TMR Zone Interface Module has been designed to provide a configurable interface specifically for use in Fire and Gas protection systems. The Module interfaces to up to 40 Fire and Gas field device inputs or actuators. Each of the 40 I/O Channels can be individually configured as Analogue Input, Digital Input or Digital Output to provide all of the interfaces needed to protect one or more Fire and Gas Zones. Interfacing to the field devices is through a Versatile Field Termination Assembly type 8842, which provides the field loop conditioning for each of the types of signal, and enables the connection of reset signals for latching type detectors without the need for external hardware. The Module is separated into 5 power groups each with 8 channels. Power groups can be combined together to provide a configurable number of channels for each Fire/Gas Zone. All of these functions provide data to the Trusted TMR System which acts as the logic solver. This Module is not approved for direct connection to hazardous areas and should be used in conjunction with Intrinsic Safety Barrier devices.

Triplicated diagnostic tests are performed throughout the Module, including measurements for current and voltage on each portion of voted input or output channels. Tests are also performed for stuck on and stuck off failures. All inputs are treated as analogue and are fully tested. Fault tolerance is achieved through a Triple Modular Redundant (TMR) architecture within the Module for each of the 40 channels.

## Features:

- 40 Triple Modular Redundant selectable input/output points per Module.
- Inputs interface to 4-20 mA gas detectors, Fire and Heat detectors, Break Glass units etc.
- Programmable Field Device Reset signals (up to 5 individual resets).
- Two or Three Wire Field devices through 8842.
- Fuse Protection of Inputs and Outputs through 8842, external to the Module.
- High Power Digital Outputs to interface to Dampers, Extinguishant Release, Fire pumps etc.
- 5 Isolated Power Groups to allow flexible and efficient field configurations.

- Comprehensive automatic diagnostics and self-test.
- Automatic line monitoring per point to detect faults in field wiring and loads.
- 2500 V impulse withstand opto/galvanic isolation barrier.
- Automatic over-current protection (per channel), no external fuses required.
- On-board Sequence of Events (SOE) reporting with 1 ms resolution.
- Module can be hot-replaced on-line using dedicated Companion (adjacent) Slot or SmartSlot (one spare slot for many Modules) configurations.
- Front Panel output status Light Emitting Diodes (LEDs) for each channel indicate 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.

# 1. Description

The TMR Zone Interface 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 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).

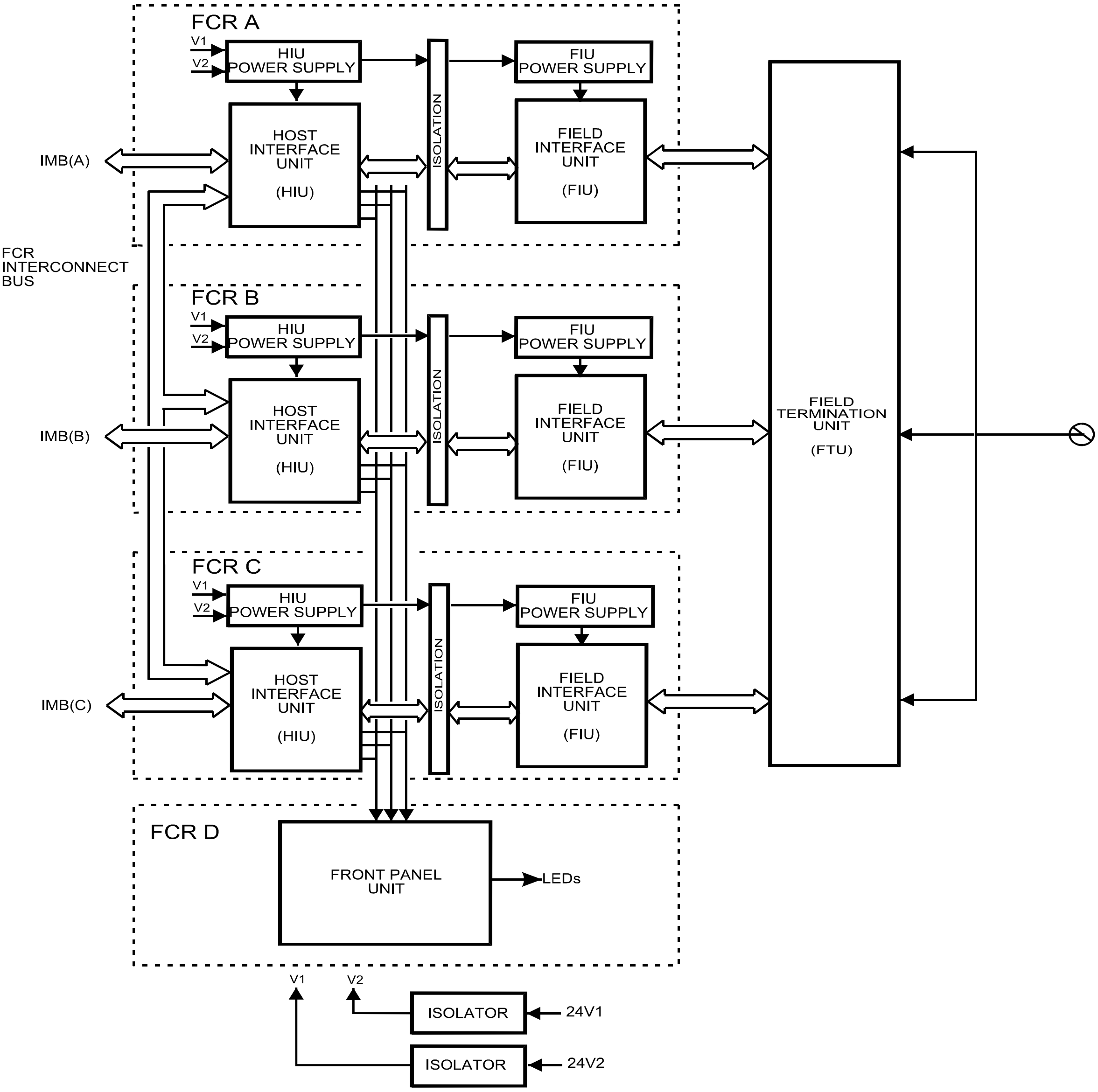

Figure 1 Module Architecture

All High Integrity I/O Modules are made up of 4 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 block diagram of the Trusted Zone Interface Module.

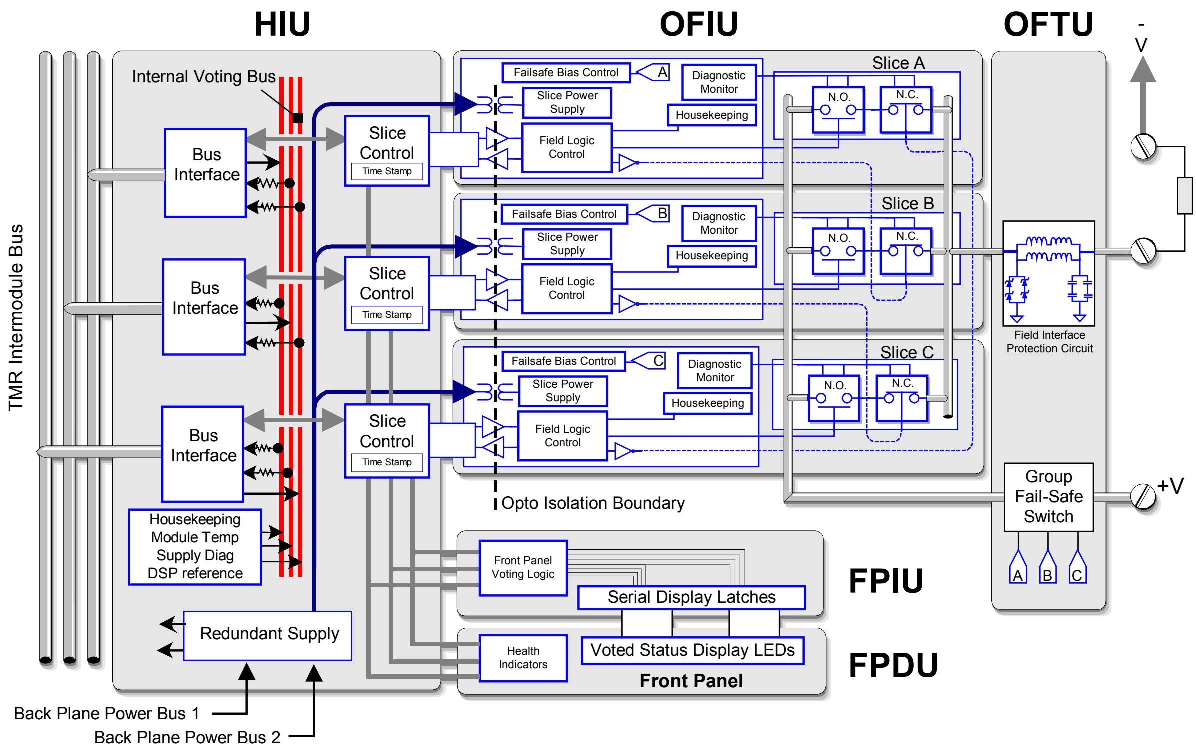

Figure 2 Function Block Diagram

## 1.1. Field Termination Unit (FTU)

The Field Termination Unit (FTU) is the section of the I/O Module that connects all three FIUs to a single field interface. The FTU provides the Group Fail Safe switches and passive components necessary for signal conditioning, over-voltage protection, and EMI/RFI filtering. When installed in a Trusted Controller or Expander Chassis, the FTU field connector interconnects 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 field connector and maintain isolation from the I/O signals on the FTU. The SmartSlot link is the intelligent connection between Active and Standby Modules for co-ordination during Module replacement.

## 1.2. 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 Zone Interface Module, the FIU contains one stage of the output switch structure, and analogue to digital (ADC) monitoring circuits for each of the channels Two additional ADC circuits provide optional monitoring of the external field I/O supply voltage.

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 on-board "housekeeping" signals that assist in monitoring the performance and operating conditions of the Module. These signals include power supply voltages, current consumption, on-board reference voltages and board temperature.

## 1.3. 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 high integrity I/O 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 incoming IMB data and distribute outgoing I/O Module data to the IMB.
- Galvanically 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 co-ordination 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.
- On-board housekeeping, which monitors reference voltages, current consumption and board temperature.

## 1.4. Front Panel Unit (FPU)

The Front Panel Unit (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), also the Module removal switches. Additional bi-colour 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.

## 1.5. Input Line Monitoring Thresholds

Whether selected as a digital or an analogue input, the Module measures the voltage applied to each input and compares this with four user programmed thresholds and two fixed (minimum and maximum) thresholds. These may be used within the application to signal a field device state. Hysteresis is provided on the thresholds by upscale and downscale values, corresponding to the thresholds for increasing and decreasing values respectively. The analogue voltage reading is also provided to the application for conversion to engineering units and/or direct trip derivation.

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

Default = -5000, -5000, 5000, 5000, 7500, 7500, 11750, 11750

## 1.6. Housekeeping

The Zone Interface Module automatically performs local measurements of several on-board signals that can be used for detailed troubleshooting and verification of Module operating characteristics. Measurements are made within each slice’s HIU and FIU.

## 1.7. Fault Detection and Testing

Extensive diagnostics provide the automatic detection of Module faults. The TMR architecture of the Output Module and the diagnostics performed verify 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 output controls 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 information reported to the TMR Processor. 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 be 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.

From the IMB to the field connector, the I/O Module contains extensive fault detection and integrity testing. Most 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.

Periodically, the TMR Processor commands the on-board Digital Signal Processors (DSPs) to perform a Safety Layer Test (SLT). The SLT results in the DSP verifying with the TMR Processor its ability to process data with integrity. In addition, the DSP uses Cyclical Redundancy Checks (CRC) to verify the variables and configuration stored in Flash memory.

Between the HIU and FIU are a series of galvanically isolated links for data and power. The data link is synchronized and monitored for variance. Both FIU and HIU have on-board 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 Sub-system.

## 1.8. Sequence of Events Characteristics

The Module automatically measures the field voltage and current to determine the state of each channel. An event occurs when the channel transitions from one state to another. When a channel changes state, the on-board timer value is recorded. When the TMR Processor next reads data from the Module, the channel state and real-time clock value are retrieved. The TMR Processor uses this data to log the state change into the system Sequence of Events (SOE) log.

The user may configure each channel to be included in the system SOE log. Full details of SOE are contained in Trusted Sequence of Events and Process Historian Package, publication ICSTT-RM243 (PD-T8013).

## 1.9. Output Switch Structure

The Zone Interface Module provides a TMR switch topology where the load is driven by a total of three fully monitored, fail safe (6 element) switch channels, one physically resident on each OFIU in the Module. Any single switch or entire slice failure is designed to leave two of the three fail safe switch channels operational to power the load.

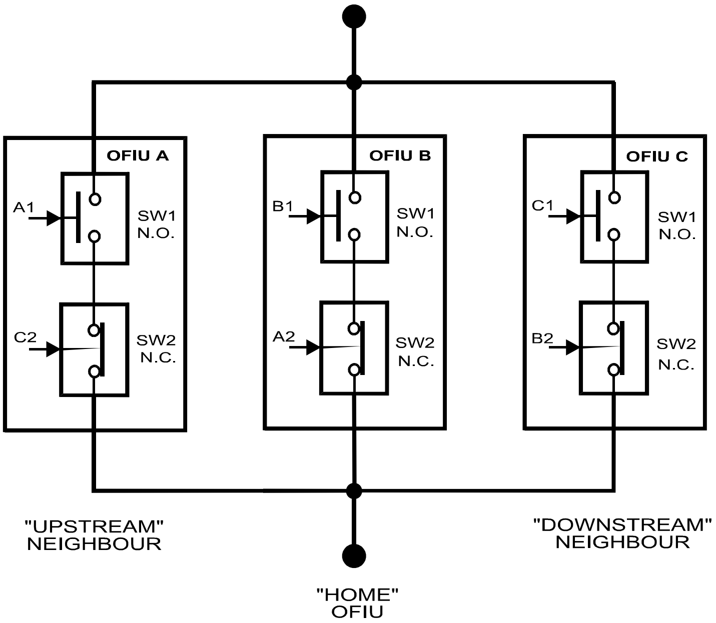

**Figure 3 Output Switch Structure**

The upper switches as shown in Figure 3 are denoted as N.O. (Normally Open), and are controlled by the FIU on which they are physically resident.[1] The lower switches are depicted as N.C. (Normally Closed), and are controlled by the "upstream" neighbouring FIU.[2]

**Note**: In this context, N.O. is defined as being in the off state in the absence of control signal power, and similarly, N.C. is the on state in the absence of control signal power. These switches are constructed from enhancement mode MOSFETs and are both guaranteed to be off in the absence of Module power to create gate voltage signals to bias them on3 (unlike electromechanical relays for example).

The reason that the lower switches are specified to be on in the absence of control signal power is to allow two channels to power the load should an entire slice fail. Even if an entire slice fails, the surviving output circuits will carry the necessary control. The structure of each FIU output is shown below:

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[1] Their "home" FIU.

[2] The home FIU, supplies an independent control signal for the "downstream" FIU FSS.

[3] For an un-faulted transistor.

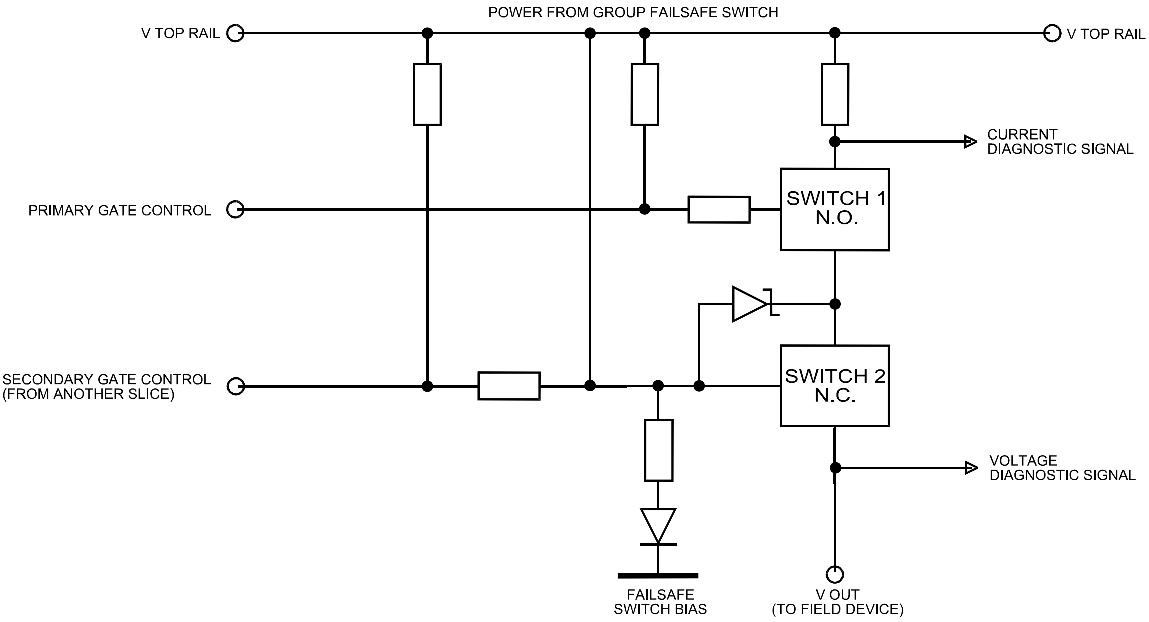

**Figure 4 Simplified Switch Circuit Diagram**

A resistor provides a means of continuously monitoring the switch current. A signal transistor is used to drive the gate of Switch 2. It provides Switch 2 with a negative gate voltage, to minimize it's on resistance, and serves to hold Switch 2 on in the event that the secondary gate control loses power.

The Zener diode between the gate of Switch 2 and source is only required to protect the gate from large voltage spikes on the drain that might capacitively couple through when Switch 1 and Switch 2 are in the off state.

The resistors in series with the gate of Switch 1 and the signal transistor serve to protect the drive logic in the event of a malicious switch failure. The pull-up resistors define the gate voltages in the absence of power.

### 1.9.1. Switch Diagnostics

During normal operation, Switch 1 and Switch 2 are maintained on. In this state, Switch 1 and Switch 2 exhibit a low resistance.

To determine the ability of the system to control the load via Switch 1 and Switch 2, their gate voltages are modulated, one at a time. As the gate voltages are modulated, the monitoring signals synchronously change in a predictable fashion. The local DSP analyses the relative amplitude and phase of these small AC signals, to determine the on resistance and threshold voltages of each switch.

The current to the load does not need to be completely interrupted in order to obtain a level of confidence in the ability of the transistors to turn off. For the TMR switch configuration in the on state, only one fail safe switch at a time needs to be modulated, while the other two bear the load current.

### 1.9.2. Short Circuit Protection

Output channels are classified as protected under IEC 61131-2, specifically ‘Protected Outputs Requirements’.

In a fuse-free design such as in the Trusted System, the Module is required to respond rapidly in the event of an over-current or over-power situation. In fact, this protection scheme offers advantages to fuses in both automatic recovery and speed of action.

The topology of the channel provides a natural limit to the instantaneous current flow, giving the Module time to respond. Furthermore, the over-current protection circuitry is inherently self-testable, since the threshold can be set to a programmable value.

The P-channel architecture of Switch 1 and Switch 2 has an open-drain output structure. Under short-circuit conditions the maximum instantaneous current with a 24 V field voltage is naturally limited to less than 5 A per channel. This is because high output currents cause the gate-source voltages of the two transistors to be reduced, tending to turn them off.

The output current is monitored by the DSP. Sustained over current conditions cause the DSP to de-energise the associated output. Once the fault has been corrected, the latched de-energised state can be cleared by operating the system Fault Reset button or by transitioning the commanded channel state.

The output also includes a non-replaceable fusible link for absolute protection.

### 1.9.3. Group Fail Safe Switches

To support safe operation, the Zone Interface Module is equipped with a series of switches that provide source power to a group of 8 channels. The Module Group Fail Safe Switch (GFSS) is intended as a final control switch which can de-energise any outputs that cannot be de-energised in the normal way. For safety, the presence of two or more faults within the Module will cause the Group Fail Safe Switches to de-energise. This de-energises all of the outputs in its group.

The GFSS has three switches in parallel, each controlled by one 'slice' of the group. This means that if one slice determines from the states that an output is not de-energised when it should be, then it can command its own GFSS and those of the other slices’ GFSS to de-energise. This results in two of the three elements of the GFSS structure to de-energise, leaving only one GFSS element energised. If two slices do the same thing then the last GFSS will de-energise. For example, this would occur if two or more switch elements fail in a 'stuck-on' state such that the output cannot de-energise.

The GFSS control signal is generated by a charge pump driven from the comms clock to the slice power group. If the clock fails then the GFSS bias collapses. This means that even if the ability of the slice to communicate with a power group is lost, the GFSS can still be de-energised by stopping the comms clock. If a slice fails, the watchdog on the HIU will time out and reset the slice. This will shutdown the FIU power supply and the associated GFSS control signal will also de-energise.

## 1.10. Output Line Monitoring States

When a channel is selected as an output, the Module automatically monitors channel current and voltage to determine the state. The numerical output state and line fault status are reported back to the application and are represented below.

| **Description** | **Numerical Output State** | **Line Fault Status** |
|---|---|---|
| Field Short Circuit | 5 | 1 |
| Output Energised (On) | 4 | 0 |
| No Load, Field Open Circuit | 3 | 1 |
| Output De-energised (Off) | 2 | 0 |
| No Field Supply Voltage | 1 | 1 |

**Table 1 Line Monitoring Fault Status**

## 1.11. Input Interfaces

Each channel selected as an input is provided with three ADC converters which monitor the voltage at the input connection. These are the same ADC converters which are used to determine channel state in the output configuration. Each input is a high impedance channel and measures from 0 to 30V. If current is to be measured, the input must be conditioned with an external resistor. This resistor is mounted on the T8842 Versatile Field Termination Assembly. The Module uses its TMR architecture to provide fault tolerance in the event of a hardware failure. Dynamic testing of the input path is provided to support safe operation within the TMR structure.

Note that 24 V field power is required for a Zone Interface Module even if all channels are configured as volt-free inputs. This may be connected via the plug at the Chassis end of the cable to a T8290 or T8297 Distribution Unit (for cables without power wires) or at the Versatile Field Termination Assembly (VFTA) (for integral power cables).

## 1.12. Field Interface Selection

For details of the recommended field interface circuit configurations, please refer to the product description for the T8842 Versatile Termination Assembly.

# 6. Specifications

| | |
|---|---|
| **Backplane (IMB) Supply** | |
| Voltage | 20 Vdc to 32 Vdc |
| Power | 27 W |
| **Field Supply** | |
| Voltage | 18 Vdc to 32 Vdc |
| Current | 2 A per channel maximum (3). |
| Module Location | T8100, T8300 I/O Module Slot |
| **Isolation** | |
| Power Group to Power Group | 50 V Reinforced (continuous) (1)<br>[Type tested at 1411 Vdc for 60 s]. |
| Field Common | 50 V Reinforced (continuous) (1)<br>250 V Basic (fault) (2)<br>[Type tested at 2436 Vdc for 60 s]. |
| Channel to Channel (within Power Group) | None |
| Fusing | Not user serviceable |
| Number of Channels | 40 |

| | |
|---|---|
| **Output** | |
| Output Off State Resistance | 33 kΩ |
| Output On State resistance | 1.6 Ω |
| Current Rating (Continuous) | 2 A per channel maximum (3). |
| Minimum On State Load Current | 50 mA |
| Field Voltage Range | 18 Vdc to 32 Vdc |
| Measurement Range | 0 Vdc to +32 Vdc |
| Maximum Withstanding | -1 to +40 Vdc |
| Maximum Capacitance | at least 2800 µF at 2 A |
| Turn-on/off Delay | 5 ms |
| **Input** | |
| Impedance | 33 kΩ |
| Analogue Resolution | 12 Bit |
| Calibration Accuracy | 0 V to VFIELD-4 V = 0.12 V<br>VFIELD – 4 V to VFIELD = 0.48 V |
| Safety Accuracy | 0.25 V |
| Output Short Circuit Protection | Electronic latching |
| 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 %, non-condensing |
| Environmental Specifications | Refer to Document ICSTT-TD003 |

| | |
|---|---|
| **Dimensions** | |
| Height | 266 mm (10.5 in) |
| Width | 31 mm (1.2 in) |
| Depth | 303 mm (12 in) |
| Weight | 1.3 kg (2.7 lb) |

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

Note 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.

Note 3) Total current per Power Group is 8A for ambient temperature T, for 0 °C < T < 50 °C, and is 6A for 0 °C < T < 60 °C.