1.1. Overview

The TMR Expander Processor is a fault tolerant design based on TMR architecture arranged in a lock-step configuration. Figure 1 shows, in simplified terms, the basic structure of the TMR Expander Processor.

The Module has three main fault containment regions (FCR A, B and C). Each of the main FCRs contains interfaces to the Expander Bus and Inter-Module Bus (IMB), an active/standby interface to the other TMR Expander Processor in the Chassis, control logic, communications transceivers and power supplies.

Communication between the Module and the TMR Processor is via the TMR Expander Interface Module and the triplicated Expander Bus. The Expander Bus is triplicated, point-to-point architecture. Each channel of the Expander Bus comprises separate command and response media. Voting is provided at the Expander Bus Interface to ensure that cable faults are tolerated, and the remainder of the Expander Processor operates in a fully triplicated mode, even in case of cable faults occurring.

Communication between the Module and the I/O Modules in the Expander Chassis is via the IMB on the Backplane of the Expander Chassis. The IMB is identical to that within the Controller Chassis, providing the same fault tolerant, high bandwidth communications between the Interface Modules and the TMR Processor. As with the Expander Bus Interface all transactions are voted, localising faults to the IMB should they occur.

A fourth FCR (FCR D) provides the non-critical monitoring and display functions and is also part of the inter-FCR Byzantine voting structure.

Isolation is provided between FCRs wherever interfaces are required, to ensure that faults cannot propagate between them.

1.2. Power Distribution

The TMR Expander Processor Module derives its internal voltages from dual redundant +24 Vdc power supplied via the module connector from the Trusted Expander Chassis Backplane. Each FCR derives the required supplies independently.

2. Installation

CAUTION:

The Expander Processor Module always resides in one of the two Processor (left most - PL1 and PL2) slots within the Expander Chassis. The Expander Processor must NOT be installed in any other module locations, as this may cause damage to the Module.

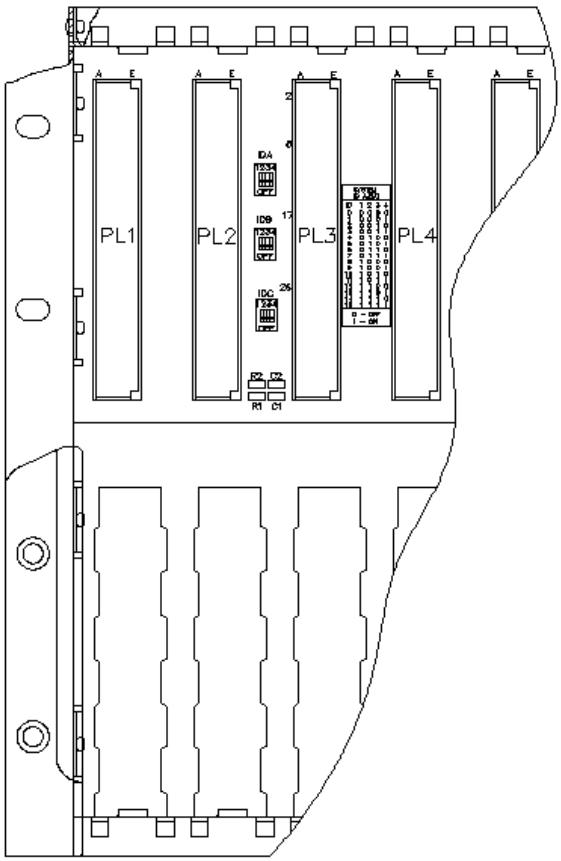


Figure 2 Expander Processor Slots

The two Processor slots must be interconnected using the Cable Hood Assembly shown below.

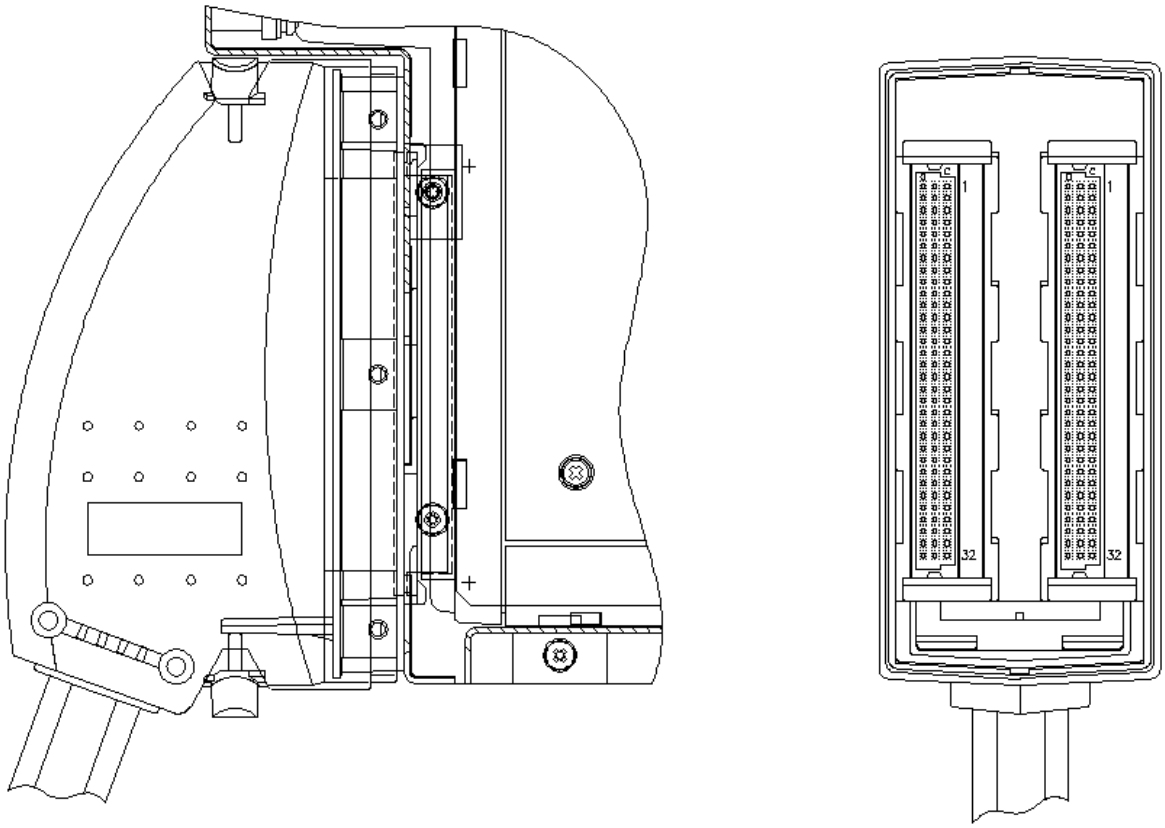


Figure 3 Expander Processor Cable

The Expander Processor Modules are connected to the Expander Interface Modules by the Expander Interface Hot Link Cable TC-301 via the Trusted Expander Interface Adapter Unit T8312.

Remote Expander Processor Modules are connected to the Trusted Fibre Optic Tx/Rx Unit T8314 by the Fibre Tx/Rx Unit to Expander Processor (Remote Expanders) Cable TC-303.

The connection to the Trusted Fibre Optic Tx/Rx Unit from the Expander Interface Modules is via the Trusted Expander Interface Adapter Unit using the Expander Interface Adapter to Fibre Tx/Rx Unit (Remote Expanders) Cable TC-302.

2.1. Module Insertion/Removal

CAUTION:

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.

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.

If the module is to reside in a new chassis, or the system is being configured for the first time, ensure that the chassis address has been set correctly before installing the modules. See Expander Chassis Product Description (PD-T8300) for further details.

To install the module:

1. Ensure that the cable assembly is 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.

2.2. Module Replacement

The replacement module must be inserted in the vacant Processor slot, ensuring that the module is correctly located and the ejector tabs are closed (see Module Insertion and Removal). The newly installed module will perform its power-up sequence.

Ensure that the Light Emitting Diode (LED) indicators on the newly installed module are as follows:

LED 1	Healthy A	Steady Green
LED 2	Healthy B	Steady Green
LED 3	Healthy C	Steady Green

If the original module has reported faults, the TMR Processor may automatically initiate the changeover to the newly installed module. Manual changeover may be initiated either using the ejector tabs on the original module or using commands via the diagnostic interface. To initiate the changeover using the ejector tabs use the following sequence:

1. Release both the top and bottom ejector tabs on the original module using the ejector release tool. DO NOT remove the module.

3. Application

3.1. Message Forwarding

The primary function of the Expander is to provide a method of extending the IMB beyond a single Processor Chassis. The active TMR Expander Interface Module receives messages from the Processor Chassis IMB/Backplane and forwards them to the Expander Bus when its slot position is enabled. Similarly, the active TMR Expander Processor Module forwards all messages received from the Expander Bus to the Expander Chassis IMB.

Messages addressed to the Expander Processor Module itself, i.e. those command messages with chassis and slot address fields matching those of the Module, result in the message being handled locally and the appropriate response message being generated. For other command messages the response message received by the active Expander Processor from the addressed module is passed to the Expander Bus and hence to the TMR Expander Interface Module. The active TMR Expander Interface Module then passes the message to the Processor Chassis IMB, subject to the prevailing IMB control signals.

The messages received from the Controller Chassis IMB at the TMR Expander Interface Module are re-synchronised and majority voted before being passed to the triplicated Expander Bus. Similarly, messages received by the TMR Expander Processor Module from the Expander Chassis IMB are re-synchronised and majority voted before onward transmission.

Messages received from the Expander Bus at both the TMR Expander Interface Module and TMR Expander Processor Module are re-synchronised and majority voted (Byzantine voted) before being passed to the associated IMB.

Errors in messages are corrected, and therefore masked using this method. This, however, makes it important that discrepancies in faults in these signals are detected and the information made available for fault reporting purposes to avoid latent fault issues.

3.2. Control Signal Forwarding

The active TMR Expander Interface Module continually monitors and transmits the state of the following signals:

- Power Failure Warning
- System Watchdog
- Command Response Control

All three signals are fully triplicated. These signals are distributed to all of the attached Expander Busses. The TMR Expander Processor Modules forward the received state of these

signals to the Expander Chassis IMB. The direction of these signals is always from TMR Processor to TMR Expander Interface to TMR Expander Processor to Interface (I/O) Module.

As with the message forwarding, these signals are re-synchronised and majority voted, i.e. Byzantine voted at the TMR Expander Interface and TMR Expander Processor Modules. The signals are synchronous within the Expander Chassis even in the case of a fault within the Processor Chassis.

3.3. Interface Module Selection

The active TMR Expander Processor Module monitors the received command messages and decodes chassis and slot information where the message's chassis number matches that set by the local switches.

3.4. IMB Power Generation

The TMR Expander Processor Modules (both active and standby) generate three independent IMB power supplies. These supplies are provided via a diode to the IMB/backplane. These supplies are used to power the triplicated IMB interfaces within the Interface Modules within the Expander Chassis.

These supplies have a common return, commoned with the module's internal 0 V. Failure of any of these supplies will not affect the remaining supplies. Similarly, overload conditions on a supply will not affect the continued operation of the other supplies.

3.5. IMB Clock Generation

The active TMR Expander Processor Module provides synchronised IMB clock signals at the standard IMB rate of 12.5M symbols/second. To minimise clock loading, the IMB connection provides independent signals for odd and even module positions and for the other TMR Expander Processor Module. All of these signals are driven synchronously.

3.6. 24 V Supply Monitoring

The TMR Expander Processor Modules monitor each of the 24 V supplies and generates status information accessible by the TMR Processor.

3.7. Module Information

The following information is recorded by the TMR Expander Processor Module and made available to the TMR Processor.

- Expander Bus link quality, including receive error counts for each communications link and link status.

- Received message error, on a per link/FCR basis, including frame error, checksum error and discrepancy.
- HIFT Clock, master and slave clock status, and master/slave switching.
- FCR watchdog status.
- Current active/standby status.
- IMB status information.
- 24 V supply levels.
- Module type code and serial number.
- Module removed flap status.

3.8. Communication Busses

3.8.1. Expander Bus

Each TMR Expander Processor Module contains a Bus Interface, isolation components and transceivers to the Expander Bus. The triplicated Expander Bus provides communication interconnection between the TMR Processor Chassis and the Expander Chassis at a data transfer rate of 1.5 Gbps via unshielded twisted pair (UTP) cables.

3.8.2. Inter-Module Bus

Each TMR Expander Processor Module FCR contains a Bus Interface to the Inter-Module Bus. The triplicated Inter-Module Bus provides communication interconnection between modules in the TMR Expander Chassis, at a data transfer rate of up to 12.5 Mbps.

The Inter-Module Bus handles the following triplicated signals:

Data	-	8-bit, bi-directional bus.
Control	-	Bus clocks, module enables and bus direction control.
System Watchdog	-	System Watchdog signal to the I/O Modules.
Power Fail	-	System power fail warning to I/O Modules.
Slot	-	Indicating the left or right Trusted TMR Expander Processor slot position to the Trusted TMR Processor.
Chassis ID	-	a 4-bit code indicating the chassis number or id.

3.9. Module Configuration

The Expander Processor requires no configuration to the Module itself. The Module provides status information that is available to the application programmer. The **IEC 61131 TOOLSET** provides the interface to configure and use this status information.

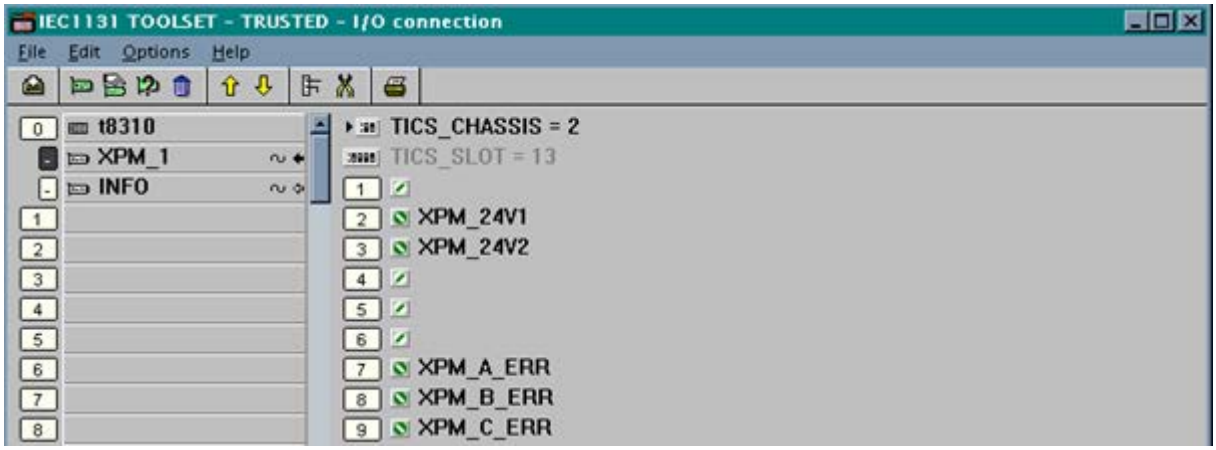


Figure 5 Module Configuration

3.10. I/O Complex Equipment Definition T8310

Each Module fitted in a Trusted System requires an entry in the I/O Connection table, specifying its chassis and slot number. The I/O Complex Equipment Definition allows control of the Module's functions, and provides information on its status. For information on editing the I/O Connection table, refer to PD-T8082. The definition for this Module is described below.

OEM PARAMETERS

OEM parameter	Valid numbers	Description
TICS_CHASSIS TICS_SLOT	2 – 15 13 and 14 (Expander Chassis)	The TICS chassis & slot number where the T8310 module is placed. Expander Processor Modules cannot be placed in a Processor Chassis. By definition, the primary module is placed in the left-hand slot (13) and the secondary in the right-hand slot (14).

CONFIGURATION

Physical Module:

RACK 1: [XPM_0]	16 ANALOGUE inputs	Channel 1: Not used Channel 2: 24 Vdc Feed 1 Channel 3: 24 Vdc Feed 2 Channel 4: Not used Channel 5: Not used

4.5. Module Status LEDs

LED	State	Description
Healthy	On Steady Green Flashing Red	The Module is healthy. Fault on the corresponding Channel.
Active	Green	Module is in the Active state.
Standby	On Steady Green	Module is in the Standby state.
Communications Activity	Off Green Red	No activity or failed. Receive activity. Transmit activity.

Table 3 Module Status Indicators

When the Module is in standby, no Transmit activity (Red LED) will be observed.

Table 3-1 - Central Modules

Functions/Module	IEC 61508 Certified Configuration	Conditions
Peer to Peer Software board definitions dxpai16, dxpao16, dxpdi128, dxpdo128, dxpai128 & dxpao128	Certified for use over single or multiple communication networks	Certified as safety-related and can be used for safety critical communications up to SIL 3 applications provided two separate Dxpai16 & Dxpao16, Dxpdi128 & Dxpdo128, or Dxpai128 & Dxpao128 software board definition pairs are defined and used for safety values. The safety values from the duplicate software board definitions must be compared, with equivalency verified, within the receiving application.
Trusted TMR Interface 8160	Non-interfering	Certified as non-interfering to the Trusted controller but retains DIN19250/AK5 certification of the original Regent and Regent+Plus I/O system (refer to Appendix A) when used to migrate applications to the Trusted Controller in accordance with this manual, publication ICSTT-RM255 (PD-T8160), and taking account of guidance in NAMUR 126.
SC300E Bridge Module 8161	Non-interfering	Certified to SIL 3 IEC 61508 Ed 1 of the original SC300E system (refer to Appendix B) when used to migrate applications to the Trusted Controller in accordance with this manual and publication ICSTT-RM403 (PD-8161) and taking into account of guidance in NAMUR 126.
CS300 Bridge Module 8162	Non-interfering	Certified as non-interfering to the Trusted controller but retains DIN19250/AK6 certification of the original CS300 system (refer to Appendix C on page 99) when used to migrate applications to the Trusted Controller in accordance with this manual and publication ICSTT-RM404 (PD-8162), and taking account of guidance in NAMUR 126.
Trusted Communication Interface T8150 / T8151 / T8151B / T8151C	Not safety-related but interference free	Certified as non-interfering safety-related and can be used for safety-critical communication up to SIL 3 as part of the black channel in single or dual module configurations.
Trusted Expander Modules (XIM / XPM) T8310 / T8310C / T8311 / T8311C	Not safety-related but interference free 2oo3	Certified as non-interfering safety-related and can be used for safety-critical communication up to SIL 3 as part of the gray channel in single module or active/standby configurations.
Trusted Fiber TX/RX Unit T8314 / T8314C	Not safety-related but interference free 2oo3	Certified as non-interfering safety-related and can be used for safety-critical communication up to SIL 3.

Note: Module numbers ending in "C" are conformal coated versions. Conformal coated printed circuit boards in these modules are coated during manufacture. The coating meets defense and aerospace requirements and is approved to US MIL Specification MIL-1-46058C, which meets the requirement for IPC-CC-830. The coating is also UL-recognized.

Table 3-2 - Input Modules High Density I/O

Functions/Module	IEC 61508 Certified Configuration	Conditions
Trusted Digital Inputs T8403, Triplicated, 24V DC T8423, Triplicated, 120V DC T8425, Triplicated, 120V DC	Internal 2oo3 (2oo3 implemented in a single module)	De-energize to trip: certified up to SIL 3. Energize to trip: certified only for applications that fulfill the requirements under Energize to trip configurations on page 42.