

Technical Product Guide

Tricon v10 Systems

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Preface

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| | | |
|------------|------------------|-----------------------------|
| Telephone: | Toll-free number | 866-746-6477 |
| | Toll number | 508-549-2424 (outside U.S.) |
| Fax: | Toll number | 508-549-4999 |

The Tricon fault-tolerant controller is based on a Triple-Modular Redundant (TMR) architecture.

Introduction

What Is Fault-Tolerant Control?

A fault-tolerant control system identifies and compensates for failed control system elements and allows repair while continuing an assigned task without process interruption. A high-integrity control system such as the Tricon™ controller is used in critical process applications that require a significant degree of safety and availability.

What Is the Tricon Controller?

The Tricon is a state-of-the-art controller that provides fault tolerance by means of Triple-Modular Redundant (TMR) architecture. TMR integrates three isolated, parallel control systems and extensive diagnostics in one control system. The system uses two-out-of-three voting to provide high-integrity, error-free, uninterrupted process operation.

The Tricon controller uses three identical channels. Each channel independently executes the control program in parallel with the other two channels. Specialized hardware/software voting mechanisms qualify and verify all digital inputs and outputs from the field, while analog inputs are subject to a mid-value selection process.

Because each channel is isolated from the others, no single-point failure in any channel can pass to another. If a hardware failure occurs on one channel, the other channels override it. Meanwhile, the faulting module can easily be removed and replaced, while the



The Tricon Fault-Tolerant Controller

controller is online, without interrupting the process.

Setting up control programs is simplified with the triplicated Tricon system, because it operates as a single control system from the user's point of view. The user terminates sensors and actuators at a single wiring terminal and programs the Tricon controller with one

set of control program logic. The Tricon controller manages the rest!

Extensive diagnostics on each channel, module, and functional circuit immediately detect and report operational faults by means of indicators or alarms.

All diagnostic fault information is accessible by the control program and the operator. The program or the operator can use diagnostic data to modify

Introduction

control actions or direct maintenance procedures.

Other key features of the Tricon controller that ensure the highest possible system integrity are:

- Ability to operate with three, two, or one Main Processors before shutdown
- Fully implemented and transparent triplication
- Comprehensive system diagnostics
- Complete range of I/O modules
- Dual and single I/O modules for safety-critical points with a limited need for availability
- Remote I/O up to 7.5 miles (12 kilometers) away from the MPs
- Simple, online module repair
- Unsurpassed reliability and availability

What Are Typical User Applications?

Each day the Tricon controller supplies increased safety, reliability, and availability to a worldwide installed base. The following are a few typical applications. For more information on how a Tricon controller can add value to your applications, ask your sales representative for additional documentation and customer references.

Emergency Safety Shutdown (ESD)

The Tricon controller provides continuous protection for safety-critical units in refineries, petrochemical/chemical plants, and other industrial processes. For example, in reactor and compressor units, plant-trip signals—for pressure, product feed rates, expander pressure equalization and temperature—are monitored, and shutdown actions taken if an upset condition occurs. Traditional

shutdown systems—implemented with mechanical or electronic relays—provide shutdown protection but can also cause dangerous nuisance trips.

The Tricon controller increases system integrity, providing automatic detection and verification of field sensor integrity, integrated shutdown and control functionality, and direct connection to the supervisory data highway for continuous monitoring of safety-critical functions.

Boiler Flame Safety

Process steam boilers function as a critical component in most refinery applications. Protection of the boiler from upset conditions, safety interlock for normal startup and shutdown, and flame-safety applications are combined by one integrated Tricon system. In traditional applications, these functions had to be provided by separate, non-integrated components. But with the fault-tolerant, fail-safe Tricon controller, the boiler operations staff can use a critical resource more productively while maintaining safety at or above the level of electromechanical protection systems.

Turbine Control Systems

The control and protection of gas or steam turbines requires high integrity as well as safety. The continuous operation of the fault-tolerant Tricon controller provides the turbine operator with maximum availability while maintaining equivalent levels of safety. Speed control as well as start-up and shutdown sequencing are implemented in a single integrated system. Unscheduled outages are avoided by using *hot-spares* for the I/O modules. If a fault occurs in a module, a replacement module is automatically activated without operator intervention.

Offshore Fire and Gas Protection

The protection of offshore platforms from fire and gas threats requires continuous availability as well as reliability. The Tricon controller provides this availability through *online replacement* of faulty modules. Faults in individual modules, field wiring, and sensors are managed automatically by built-in diagnostics. Analog fire and gas detectors are connected directly to the Tricon, eliminating the need for trip amps. An operator interface monitors fire and gas systems as well as diagnostics for the Tricon controller and its attached sensors. Traditional fire and gas panels can be replaced with a single integrated system, saving costly floor space while maintaining high levels of safety and availability.

What Is TriStation 1131?

TriStation™ 1131 Developer's Workbench is an integrated tool for developing, testing and documenting control programs that execute in the Tricon controller. The TriStation 1131 software complies with the IEC 61131 International Standard for Programmable Controllers and follows the Microsoft® Windows® guidelines for graphical user interfaces.

What About Communication Capabilities?

Optional modules enable the Tricon controller to communicate with other Triconex® controllers and with other hosts such as:

- Modbus masters and slaves
- Distributed Control Systems (DCS)
- Operator workstations
- Host computers using Ethernet (802.3) protocol

For more information, see “Communication Capabilities” on page 67.

The Tricon controller is designed with a fully triplicated architecture throughout, from the input modules through the Main Processors (MPs) to the output modules.

Theory of Operation

Triple Modular Redundant (TMR) architecture ensures fault tolerance and provides error-free, uninterrupted control in the presence of either hard failures of components or transient faults from internal or external sources.

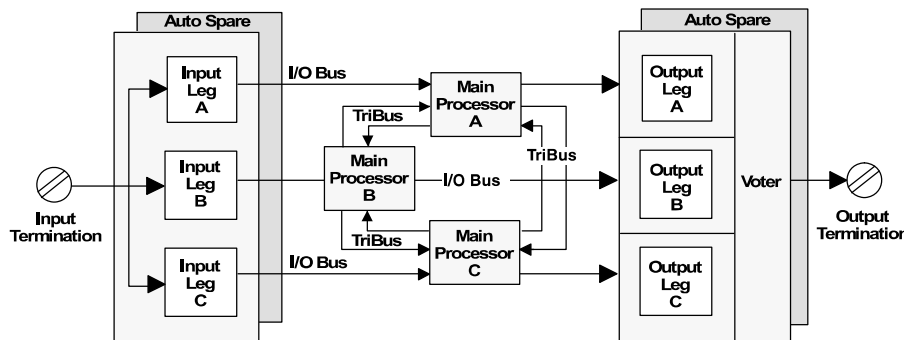
Every I/O module houses the circuitry for three independent channels. Each channel on the input modules reads the process data and passes that information to its respective Main Processor. The three Main Processors communicate with each other using a proprietary high-speed bus system called the TriBus.

sate for errors that occur between the Main Processor and the final output driven to the field.

Each I/O slot can contain two identical I/O modules, which means if a fault is detected on one module, control is automatically switched to the healthy module. A faulty module can also be replaced online when only one module is installed in the slot. In this case, a healthy module is inserted in the spare slot and the control is switched to this module, which allows the faulty module to be pulled and sent for repair.

As each input module is polled, the appropriate channel of the I/O bus transmits new input data to the Main Processor. The input data is assembled into a table in the Main Processor and is stored in memory for use in the hardware voting process.

The individual input table in each Main Processor is transferred to its neighboring Main Processors over the TriBus. During this transfer, hardware voting takes place. The TriBus uses a direct memory access programmable device to synchronize, transmit, vote, and compare data among the three Main Processors.



Simplified Tricon System Architecture

Once per scan, the Main Processors synchronize and communicate with their neighbors over the TriBus. The TriBus votes digital input data, compares output data, and sends copies of analog input data to each Main Processor. The Main Processors execute the control program and send outputs generated by the control program to the output modules. The Tricon controller votes the output data on the output modules as close to the field as possible to detect and compen-

Main Processor Modules

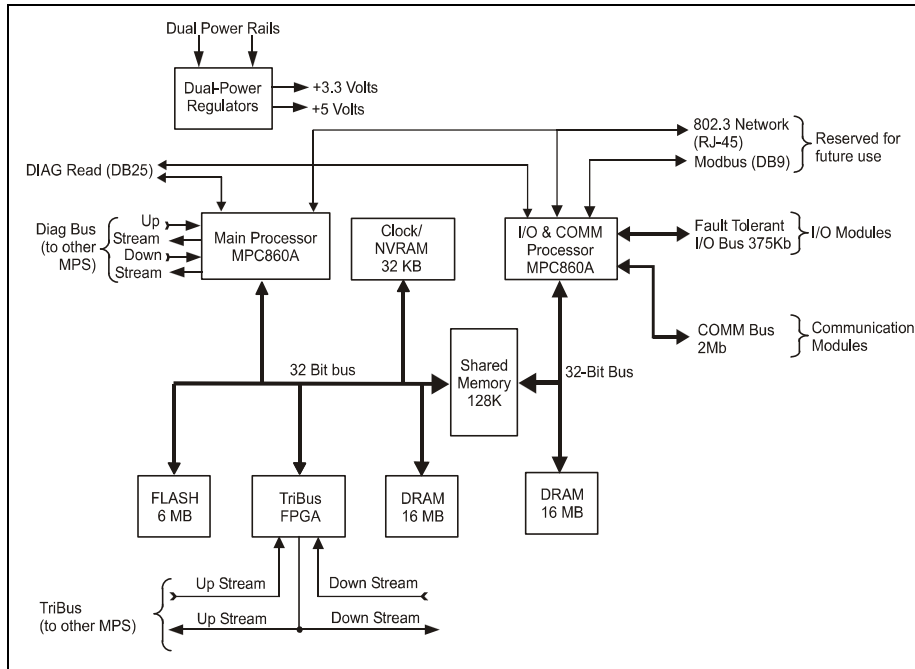
A Tricon controller contains three Main Processor modules. Each Main Processor controls a separate channel of the system and operates in parallel with the other Main Processors. A dedicated I/O Processor on each Main Processor manages the data exchanged between the Main Processor and the I/O modules. A triplicated I/O bus, located on the chassis backplane, extends from chassis to chassis by means of I/O bus cables.

If a disagreement occurs, the signal value found in two out of three tables prevails, and the third table is corrected accordingly. One-time differences which result from sample timing variations are distinguished from a pattern of differing data. Each Main Processor maintains data about necessary corrections in local memory. Any disparity is flagged and used at the end of the scan by the Tricon controller built-in fault analyzer routines to determine whether a fault exists on a particular module.

The Main Processors put corrected data into the control program. The 32-bit main microprocessor executes the control program in parallel with the neighboring Main Processor modules.

The control program generates a table of output values which are based on the table of input values according to customer-defined rules built into the control program. The I/O Processor on

Theory of Operation



Main Processor (Model 3008) Architecture

each Main Processor manages the transmission of output data to the output modules by means of the I/O bus.

Using the table of output values, the I/O Processor generates smaller tables, each corresponding to an individual output module in the system. Each small table is transmitted to the appropriate channel of the corresponding output module over the I/O bus. For example, Main Processor A transmits the appropriate table to Channel A of each output module over I/O Bus A. The transmittal of output data has priority over the routine scanning of all I/O modules. The I/O Processor manages the data exchanged between the Main Processors and the communication modules using the communication bus which supports a broadcast mechanism.

Main Processors receive power from dual Power Modules and power rails in the Main Chassis. A failure on one

Power Module or power rail does not affect system performance.

Bus Systems and Power Distribution

Three triplicated bus systems are etched on the chassis backplane: the TriBus, the I/O bus, and the communication bus.

TriBus

The TriBus consists of three independent serial links which synchronizes the Main Processors at the beginning of a scan, and performs either of these functions:

- Transfers I/O, diagnostic, and communication data.
- Compares data and flags disagreements of output or memory data from the previous scan.

An important feature of Tricon controller architecture is the use of a single transmitter to send data to both the upstream and downstream Main

Processors, which ensures the same data is received by the upstream processor and downstream processor.

I/O Bus

Each I/O module transfers signals to or from the field through its associated field termination assembly. Two positions in the chassis tie together as one logical slot. Termination cables are tied to panel connectors at the top of the backplane. Each connection extends from the termination module to both active and hot-spare I/O modules, which means both the active module and the hot-spare module receive the same information from the field termination wiring.

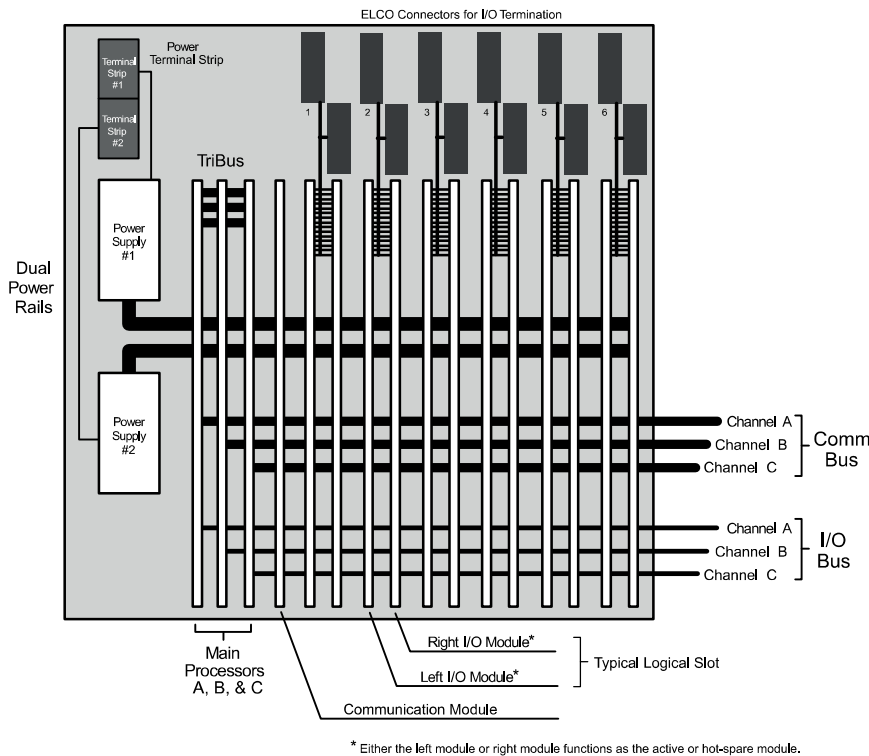
The triplicated I/O bus transfers data between the I/O modules and the Main Processors at 375 kilobits per second. The I/O bus is carried along the bottom of the backplane. Each channel of the I/O bus runs between one Main Processor and the corresponding channels on the I/O module. The I/O bus extends between chassis using a set of three I/O bus cables.

Communication Bus

The communication (COMM) bus runs between the Main Processors and the communication modules at 2 megabits per second.

Power Distribution

Power for the chassis is distributed across two independent power rails and down the center of the backplane. Each module in the chassis draws power from both power rails through dual power regulators. There are four sets of power regulators on each input and output board: one set for each channel (A, B, and C) and one set for the status indicators.



Tricon Bus Systems and Power Distribution

Field Signals

Each I/O module transfers signals to or from the field through its associated field termination panel. Two positions in the chassis tie together as one logical slot. The first position holds the active I/O module and the second position holds the hot-spare I/O module. Termination cables are connected to the top of the backplane. Each connection extends from the termination panel to both active and hot-spare I/O modules. Therefore, both the active module and the hot-spare module receive the same information from the field termination wiring.

Digital Input Modules

The Tricon controller supports two basic types of Digital Input Modules: TMR and Single. The following paragraphs describe Digital Input Modules

in general, followed by specifics for TMR and Single modules.

Every Digital Input Module houses the circuitry for three identical channels (A, B, and C). Although the channels reside on the same module, they are completely isolated from each other and operate independently. A fault on one channel cannot pass to another. In addition, each channel contains an 8-bit microprocessor called the I/O communication processor, which handles communication with its corresponding Main Processor.

Each of the three input channels asynchronously measures the input signals from each point on the input module, determines the respective states of the input signals, and places the values into input tables A, B, and C respectively. Each input table is regularly interrogated over the I/O bus by the I/O

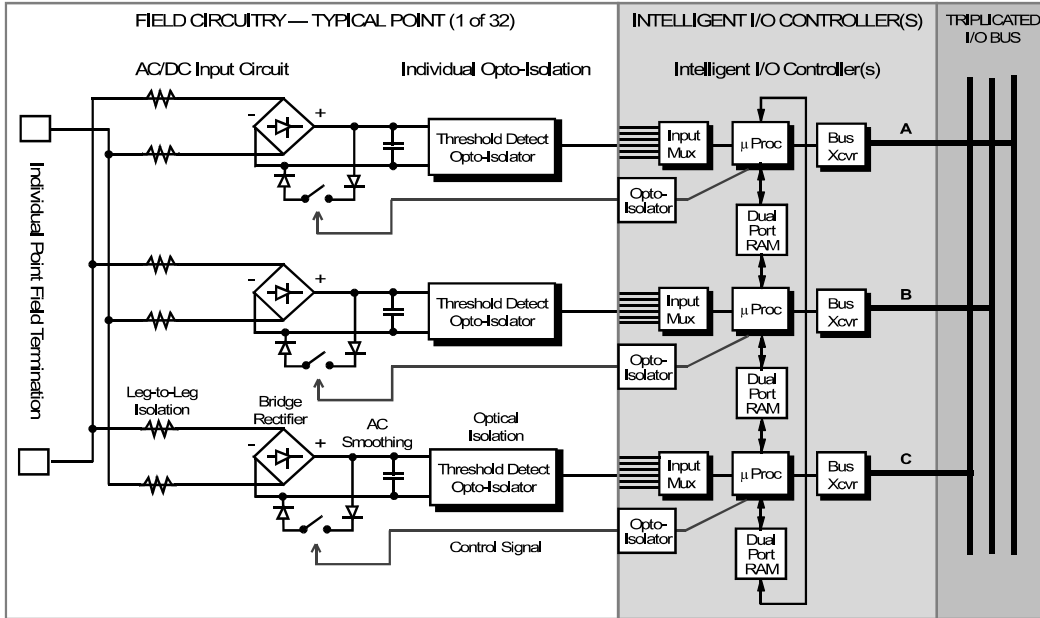
communication processor located on the corresponding Main Processor. For example, Main Processor A interrogates Input Table A over I/O Bus A.

On TMR Digital Input Modules, all critical signal paths are 100 percent triplicated for guaranteed safety and maximum availability. Each channel conditions signals independently and provides isolation between the field and the Tricon controller. (The Model 3504E High-Density Digital Input Module is an exception—it has no channel-to-channel isolation.)

DC models of the TMR Digital Input Modules can self-test to detect stuck-ON conditions where the circuitry cannot tell whether a point has gone to the OFF state. Because most safety systems use a de-energize-to-trip setting, the ability to detect the Off state is an important feature. To test for stuck-ON inputs, a switch within the input circuitry is closed to allow a zero input (Off) to be read by the optical isolation circuitry. The last data reading is frozen in the I/O Processor while the test is running.

On Single Digital Input Modules, only those portions of the signal path which are required to ensure safe operation are triplicated. Single modules are optimized for those safety-critical applications where low cost is more important than maximum availability. Special self-test circuitry detects all stuck-On and stuck-Off fault conditions within the non-triplicated signal conditioners in less than half a second. This is a mandatory feature of a fail-safe system, which must detect all faults in a timely manner and, upon detection of an input fault, force the measured input value to the safe state. Because the Tricon is optimized for de-energize-to-trip applications, detection of a fault in the input circuitry forces to Off (the de-energized state) the value reported to the Main Processors by each channel.

Theory of Operation



Architecture of TMR Digital Input Module with Self-Test (DC Model)

channels B and C, or channels A and C command them to close—in other words, 2-out-of-3 drivers voted On. The quadruplicated voter circuitry provides multiple redundancy for all critical signal paths, guaranteeing safety and maximum availability.

Each type of Digital Output Module executes a particular Output Voter Diagnostic (OVD) for every point. Loopback on the module allows each microprocessor to read the output value for the point to determine whether a latent fault exists within the output circuit.

Digital Output Modules

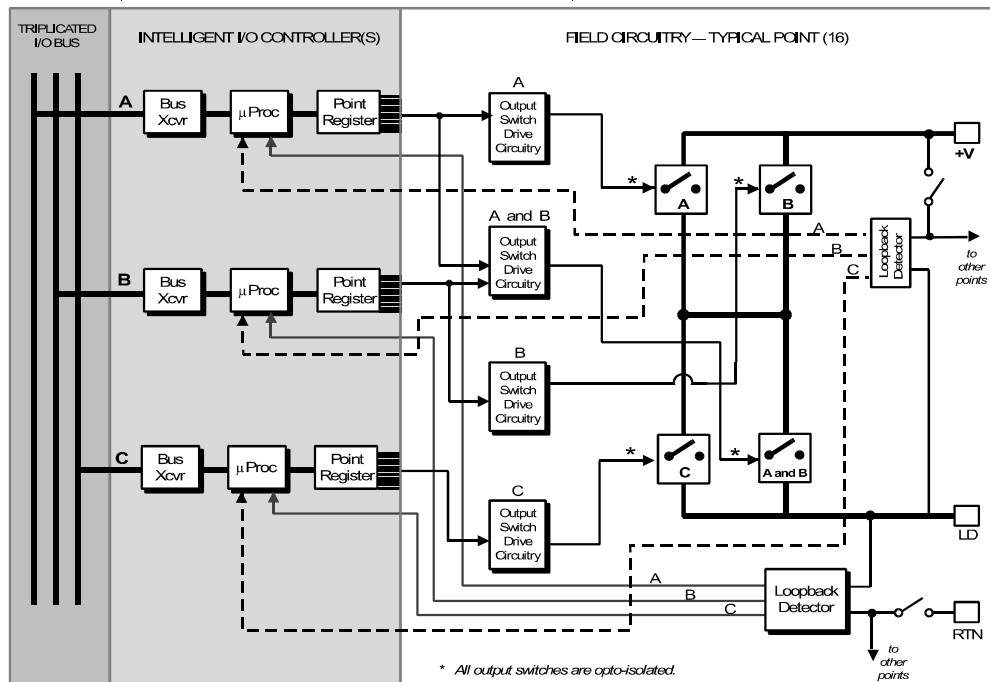
There are four basic types of Digital Output Modules: dual, supervised, DC voltage and AC voltage.

The following paragraphs describe Digital Output Modules in general, followed by specifics for the four types.

Every Digital Output Module houses the circuitry for three identical, isolated channels. Each channel includes an I/O microprocessor which receives its output table from the I/O communication processor on its corresponding Main Processor. All of the Digital Output Modules, except the dual DC modules, use a patented quadruplicated output circuitry, referred to as *Quad Voter*, which votes on the individual output signals just before they are applied to the load. This

voter circuitry is based on parallel-series paths which pass power if the drivers for channels A and B, or

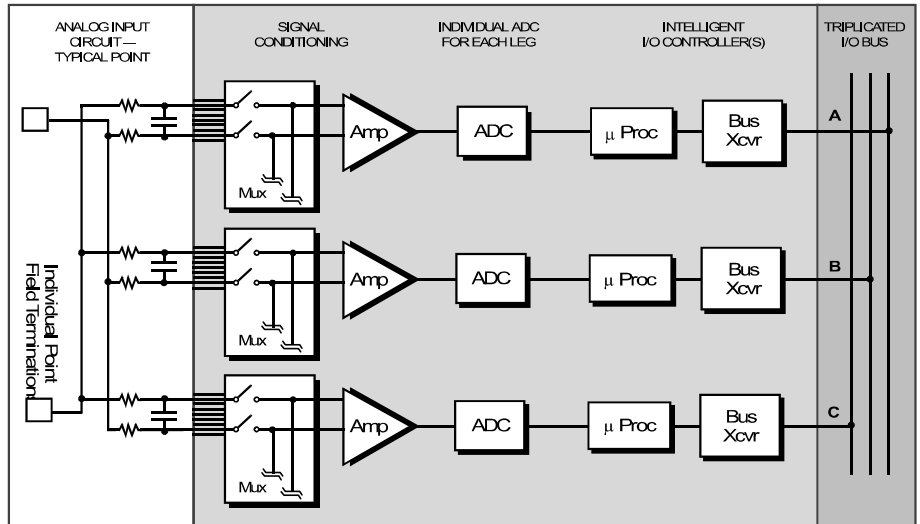
point to determine whether a latent fault exists within the output circuit.



Architecture of 16-Point Supervised Digital Output Module

Analog Input Modules

On an Analog Input Module, each of the three channels asynchronously measures the input signals and places the results into a table of values. Each of the three input tables is passed to its associated Main Processor module using the I/O bus. The input table in each Main Processor is transferred to its neighbors across the TriBus. The middle value is selected by each Main Processor, and the input table in each Main Processor is corrected accordingly. In TMR mode, the mid-value data is used by the control program; in duplex mode, the average is used.



Architecture of TMR Analog Input Module

Each Analog Input Module is automatically calibrated using multiple reference voltages read through the multiplexer. These voltages determine the gain and bias that are required to adjust readings of the analog-to-digital converter (ADC).

Analog Input Modules and termination panels are available to support a wide variety of analog inputs, in both isolated and non-isolated versions: 0-5 VDC, -5 to +5 VDC, 0-10 VDC, 4-20 mA, thermocouples (types K, J, T, E), and resistive thermal devices (RTDs).

Analog Output Module

The Analog Output Module receives three tables of output values, one for each channel from the corresponding Main Processor. Each channel has its own digital-to-analog converter (DAC). One of the three channels is selected to drive the analog outputs. The output is continuously checked for correctness by “loop-back” inputs on each point which are read by all three microprocessors. If a fault occurs in the driving channel, that channel is declared faulty and a new channel is selected to drive the field device. The

designation of “driving channel” is rotated among the channels, so that all three channels are tested.

Field Terminations

Various termination options are available for field wiring of the Tricon chassis, including external termination panels (ETPs) and fanned-out cables.

An ETP is an electrically-passive printed circuit board to which field wiring is easily attached. An ETP passes input signals from the field to an input module or passes signals generated by an output module directly to field wiring, thereby permitting removal or replacement of the input or output module without disturbing field wiring.

A fanned-out cable is a lower-cost alternative to an ETP when using Digital Input Modules or Digital Output Modules. One end of a fanned-out cable connects to the Tricon controller backplane and the other end provides 50 fanned-out leads, each individually labeled with a pin number that matches the connector signals.

Communication Modules

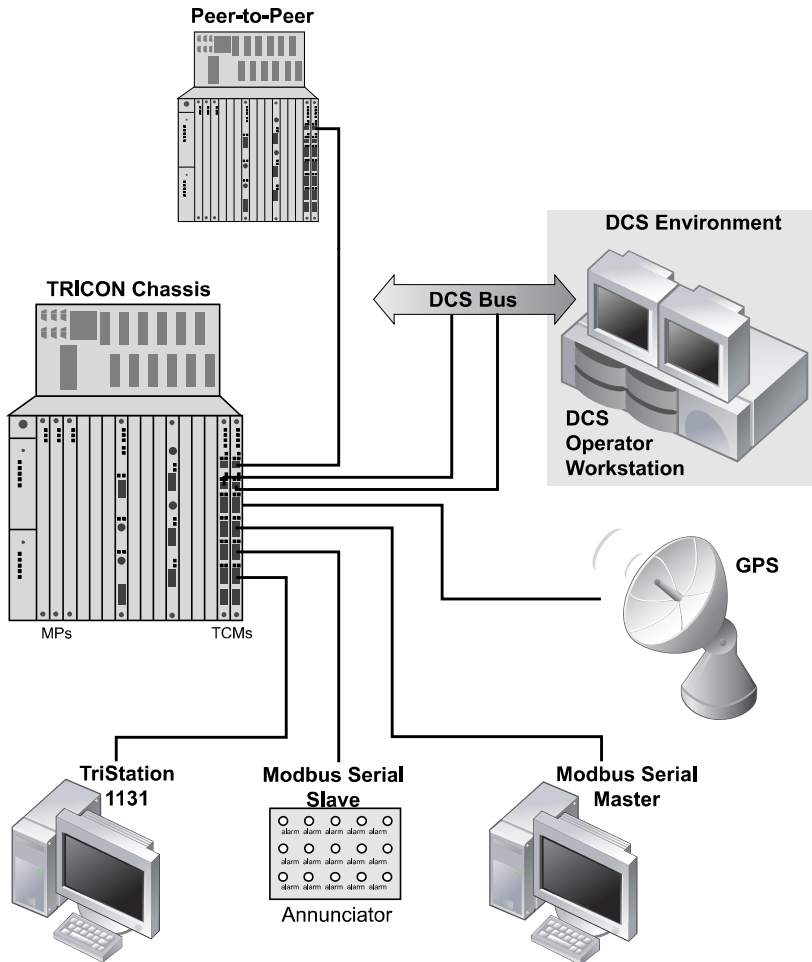
By means of the communication modules described in this section, the Tricon controller can interface with Modbus masters and slaves, other Triconex controllers in a Triconex peer-to-peer network, external hosts on Ethernet networks, and Honeywell™ and Foxboro® distributed control systems (DCS). The Main Processors broadcast data to the communication modules across the communication bus. Data is typically refreshed every scan; it is never more than two scan-times old. For more information, see “Communication Capabilities” on page 67.

Tricon Communication Module (TCM)

The Tricon Communication Module (TCM) enables a Tricon controller to communicate with Modbus devices (masters or slaves), a TriStation 1131 PC, a network printer, other Triconex controllers, and other external devices on Ethernet networks.

Each TCM has four serial ports, two Ethernet network ports, and one debug port (for Invensys use).

Theory of Operation



Sample of the TCM Communication Capabilities

A single Tricon controller supports up to four TCMs, which reside in two logical slots. This arrangement provides a total of sixteen serial ports and eight Ethernet network ports.

Enhanced Intelligent Communication Module (EICM)

The EICM enables a Tricon controller to communicate with Modbus devices (masters or slaves), with a TriStation 1131 PC, and with a printer. The four serial ports are uniquely addressed and can be used for Modbus or TriStation communication at speeds up to 19.2 kilobits per second. A single Tricon High-Density controller supports up to

two EICM modules which reside in one logical slot. This arrangement provides a total of six Modbus ports, two TriStation ports, and two printer ports.

Network Communication Module (NCM)

The NCM supports Ethernet (802.3) communication at 10 megabits per second for Triconex-proprietary protocols and applications.

The NCM also supports OPC Server which can be used by any OPC client. In addition, users can write their own applications using the TSAA protocol.

The NCMG enables time synchronization to a GPS device.

Hiway Interface Module (HIM)

The HIM acts as an interface between a Tricon controller and a Honeywell TDC-3000 Distributed Control System (DCS) by means of the Hiway Gateway and Local Control Network (LCN). The HIM enables higher-order devices, such as computers and operator workstations, to communicate with the Tricon.

Safety Manager Module (SMM)

The SMM acts as an interface between a Tricon controller and a Honeywell Universal Control Network (UCN), one of three principal networks of the TDC-3000 DCS. The SMM appears to the TDC-3000 as a safety node on the Universal Control Network (UCN), allowing the Tricon controller to manage process-critical points within the overall TDC-3000 environment. The SMM transmits all Tricon aliased data and diagnostic information to TDC-3000 operator workstations in display formats that are familiar to Honeywell operators.

Advanced Communication Module (ACM)

The ACM acts as an interface between a Tricon controller and a Foxboro Intelligent Automation (I/A) Series DCS. The ACM appears to the Foxboro system as a safety node on the I/A Series[®] Nodebus, allowing the Tricon controller to manage process-critical points within the overall I/A DCS environment. The ACM transmits all Tricon aliased data and diagnostic information to I/A operator workstations in display formats that are familiar to Foxboro operators.

See "Product Specifications" on page 17 for specifications of the TCM, EICM, NCM, SMM, HIM, and ACM.

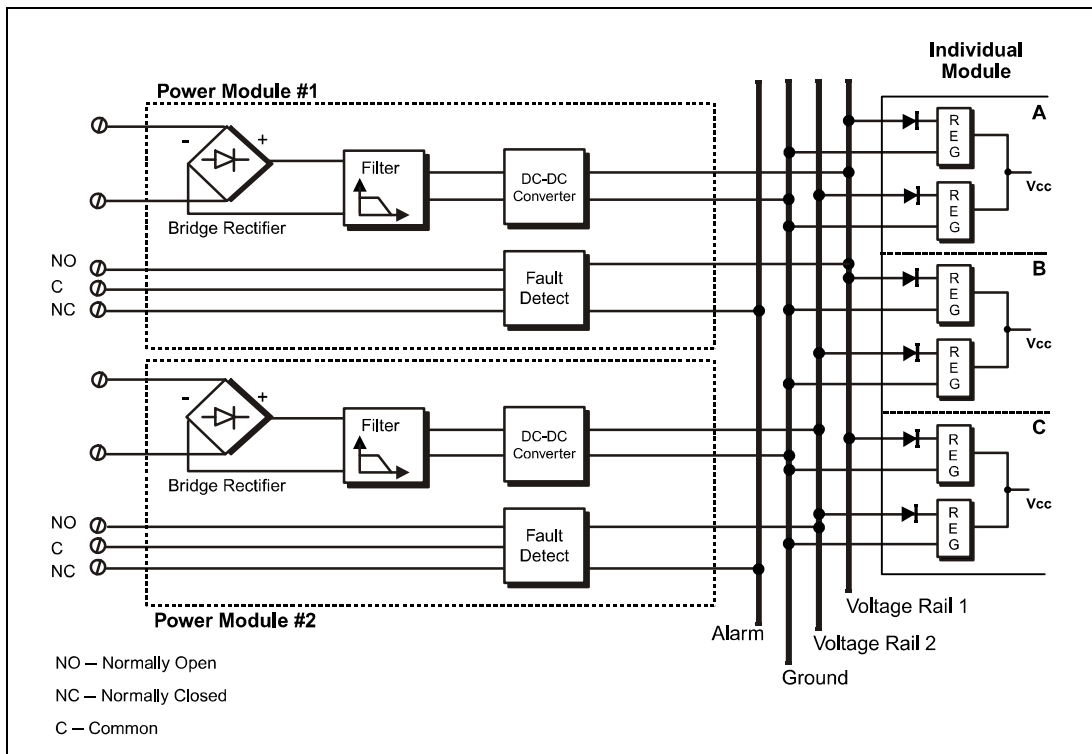
HART Communication

Highway Addressable Remote Transducer protocol (HART™) is a bi-directional industrial field communication protocol used to communicate between intelligent field instruments and host systems over 4-20 mA instrumentation wiring. Invensys offers these components to enable HART communication between HART devices in the field and Configuration and Asset Management Software running on a PC:

- Model 2770H HART Analog Input Interface Module
- Model 2870H HART Analog Output Interface Module

Power Modules

Each Tricon chassis houses two Power Modules arranged in a dual-redundant configuration. Each module derives power from the backplane and has independent power regulators for each channel. Each can support the power requirements for all the modules in the chassis in which it resides, and each feeds a separate power rail on the chassis backplane. The Power Modules have built-in diagnostic circuitry which checks for out-of-range voltages and over-temperature conditions. A short on a channel disables the power regulator rather than affecting the power bus.



Architecture of Power Module Subsystem

A Tricon system consists of one Main Chassis and up to fourteen additional chassis.

System Configuration

A Tricon system is composed of a Main Chassis and up to 14 Expansion or Remote Expansion (RXM) Chassis. The maximum system size is 15 chassis supporting a total of 118 I/O modules (maximum including spares), interface modules, and communication modules that interface with OPC clients, Modbus devices, other Tricon controllers, and external host applications on Ethernet (802.3) networks, as well as Foxboro and Honeywell distributed control systems (DCS).

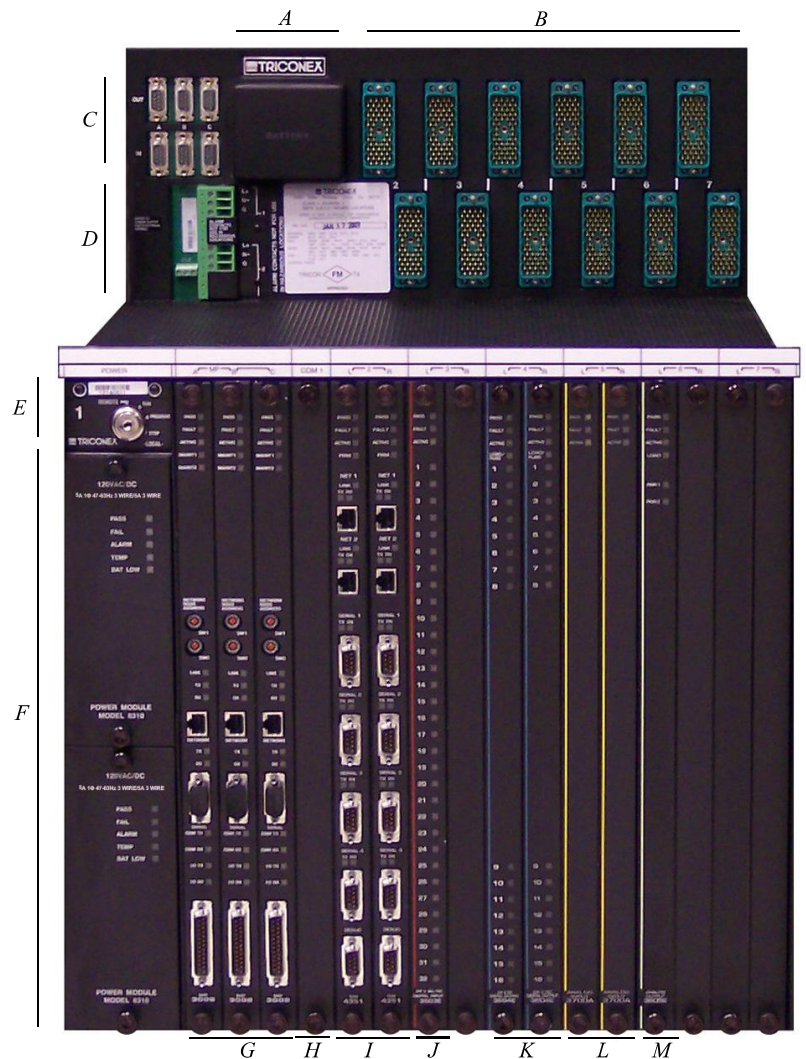
The following sections provide guidelines for chassis layout and system configuration.

Chassis Layout

Two power supplies reside on the left side of all chassis, one above the other. In the Main Chassis, the three Main Processors are immediately to the right. The remainder of the chassis is divided into six logical slots for I/O and communication modules and one COM slot with no hot-spare position. Each logical slot provides two physical spaces for modules, one for the active module and the other for its optional hot-spare module.

The layout of an Expansion Chassis is similar to that of the Main Chassis, except that Expansion Chassis provide eight logical slots for I/O modules. (The spaces used by the Main Processors and the COM slot in the Main Chassis are now available for other purposes.)

The Main and Expansion Chassis are interconnected by means of triplicated



- | | | |
|--------------------------------|----------------------------|-----------------------------|
| A. Memory backup battery | F. Redundant Power Modules | K. DO module with hot-spare |
| B. Connectors for terminations | G. Three Main Processors | L. AI module with hot-spare |
| C. I/O expansion ports | H. COM slot (empty) | M. AO module without spare |
| D. Power terminals | I. Two TCMs | |
| E. Keyswitch | J. DI module without spare | |

Sample Layout of a Tricon Chassis

System Configuration

I/O bus cables. The maximum I/O bus cable length between the Main Chassis and the last Expansion Chassis is 100 feet (30 meters), but in restricted applications the length can be greater. (Please contact the Invensys Global Customer Support (GCS) center for assistance when configuring a system that exceeds 100 feet (30 meters) of I/O bus cable length.)

RXM Chassis are used for systems in which the total cable distance between the first chassis and the last chassis exceeds the distance which can be supported by copper. Each RXM Chassis houses a set of three RXM Modules in the same position as the Main Processors in the Main Chassis. Six remaining logical slots are available in an RXM Chassis and one blank (unused) slot.

Online Module Repair

The logical slot arrangement of a Tricon chassis provides two approaches to the online repair of faulting modules: the *hot-spare* method and *online module replacement*.

With the hot-spare method, a logical slot contains two identical I/O modules. While one module is active, the other module is powered but inactive. The Tricon system cycles control between the two healthy I/O modules approximately every hour, so that each undergoes complete diagnostics on a regular basis. If a fault is detected on one module, the Tricon system automatically switches control to the other module, allowing the system to maintain three healthy channels continuously. The faulty module can then be removed and replaced.

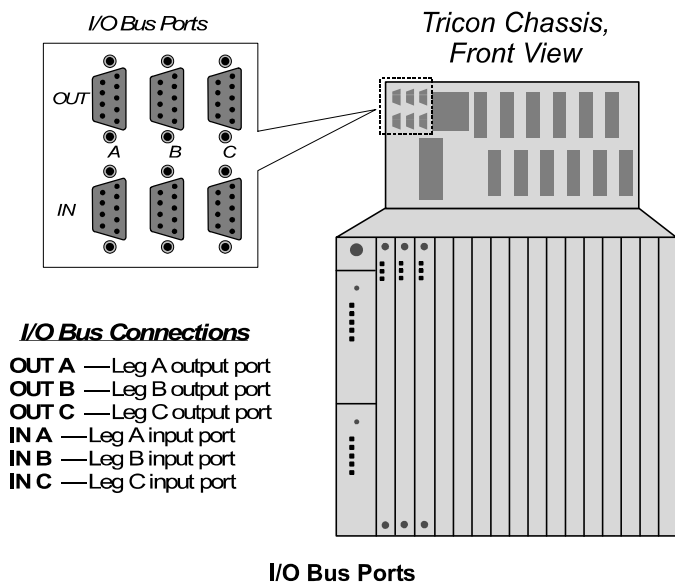
Alternatively, a module can be replaced online even when only one I/O module is normally installed in a logical slot. If a fault occurs, the Fault indicator turns on, but the module remains active on two channels. A replacement module is then inserted into the unused space in the slot. The Tricon system will grant control to this second I/O module after it passes a diagnostic test. Once the replacement I/O module becomes active, the faulty module can be removed. This repair method demonstrates the Tricon controller's ability to

automatically transition from triplicated to dual control and back again without process interruption.

A Tricon system should include at least one hot-spare module in place for each type of I/O module in the system. With this arrangement, hot-spare modules are tested regularly and can be used for online module replacement anywhere in the system.

I/O Bus Connections

The I/O Bus Ports figure shows the three sets of RS-485 I/O bus ports (IN and OUT) on each chassis. Additional chassis may branch out from the Main Chassis by means of the I/O bus ports, up to a maximum of 14. There are six ports—two sets of three for triplicated serial communication—located on a panel in the upper left corner of the backplane. One set of three I/O bus cables is required for each Expansion Chassis, and for each RXM Chassis that houses a primary RXM Module set. (Remote RXM Chassis are connected to the primary RXM Chassis with fiber-optic cables.) Communication across the I/O bus cables (and the RXM fiber-optic cables) is at 375 kilobits per second, the same rate as the internal I/O bus on the backplane of each chassis.



System Configuration Guidelines

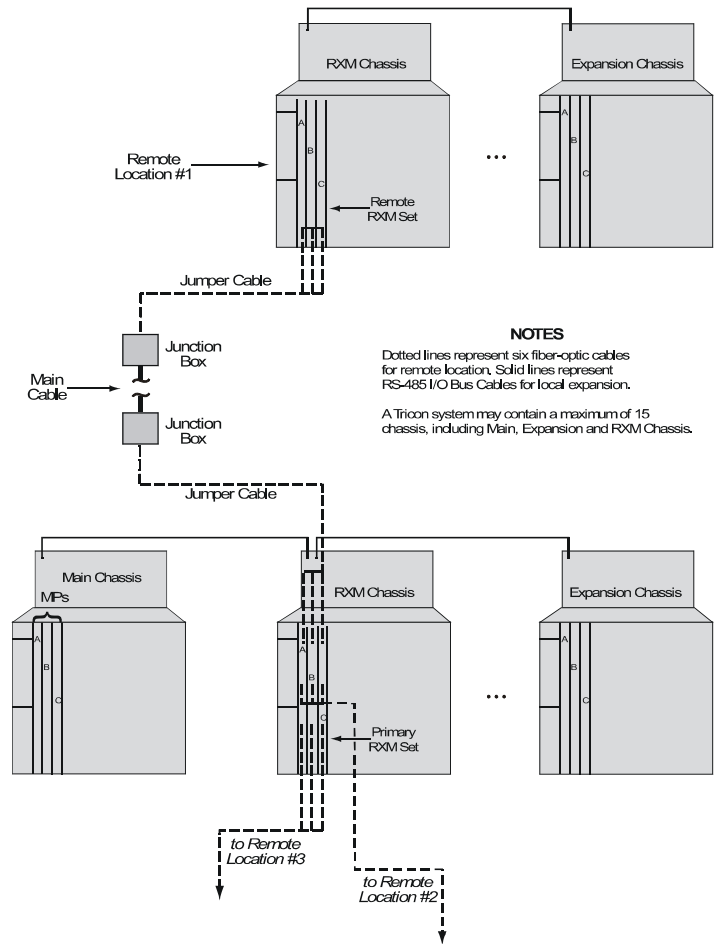
A Tricon system must have a Main Chassis, and may have up to 14 Expansion or Remote Expansion (RXM) Chassis. The following configuration guidelines apply.

Main Chassis Configuration Guidelines

- There is one Main Chassis with a chassis address of 1.
- The Main Chassis must contain three Model 3008 Main Processors for Tricon v10 and later systems.
- The Main Chassis must house two Power Modules.
- The Main Chassis provides six logical slots for user-selected modules and one COM slot.
- A v10 low-density configuration includes a v5–v8 chassis with v10 Main Processors, communication, and I/O modules.

Expansion Chassis Configuration Guidelines

- Expansion Chassis are used when the total I/O bus cable length for the system is less than 100 feet (30 meters) for each channel.
- Each Expansion Chassis must have a unique address between 2 and 15. This address must not be used by any other chassis.
- Each Expansion Chassis must house two Power Modules.
- One set of triplicated I/O bus cables is used to interconnect channels A, B, and C between Expansion Chassis.
- Each Expansion Chassis provides eight logical slots.



System Configuration with Three Remote Locations

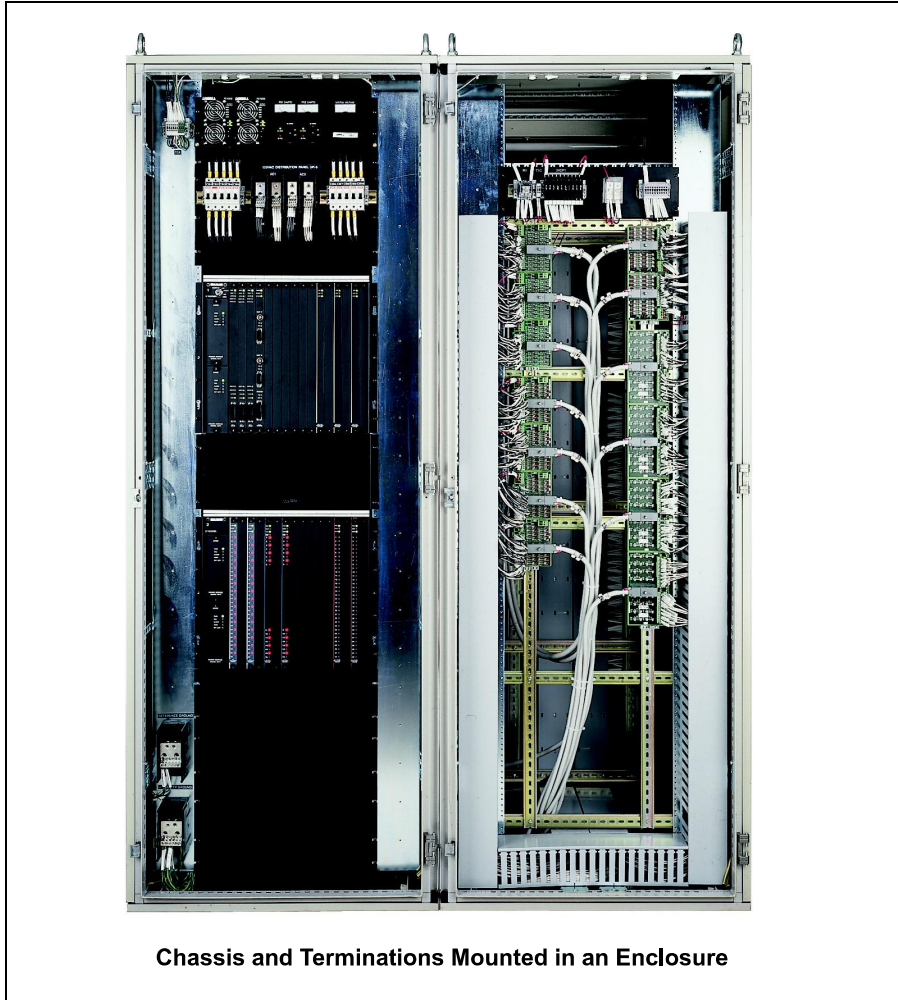
RXM Chassis Configuration Guidelines

- RXM Chassis must be used when the total I/O bus cable length for the system is greater than 100 feet (30 meters) for each channel.
- Each RXM Chassis must have a unique address between 2 and 15. This address must not be used by any other chassis.
- One RXM Chassis must be located within 100 feet (30 meters) of the Main Chassis. This RXM Chassis must house the primary RXM Module set. Up to three primary RXM Module sets are normally

supported. Contact Invensys regarding other configurations.

- Each primary RXM Module set can support up to three remote sites, each up to 7.5 miles (12 kilometers) away.
- One RXM Chassis must be located at each remote site. This RXM Chassis must house a remote RXM Module set.
- A primary RXM Module set and a remote RXM Module set are connected by six fiber-optic cables which transmit and receive signals for channels A, B, and C.

System Configuration



Chassis and Terminations Mounted in an Enclosure

- RXM Chassis can be connected to local Expansion Chassis using I/O bus cables.
- Each RXM Chassis must contain two Power Modules.
- Each RXM Chassis provides six logical slots for I/O modules and one blank (unused) slot.

Communication Module Configuration Guidelines

The following rules apply to the TCM, EICM, NCM, HIM, SMM, and ACM in a Tricon system:

- A TriStation 1131 PC communicates with a Tricon controller through a TCM, EICM, NCM or ACM, so at least one of these modules must be installed in the Main Chassis or Chassis 2.
- One logical slot is available for EICMs or ACMs, respectively. Matched pairs of these modules can be installed in both the left and right positions of one logical slot.
- Up to two logical slots can be configured for NCMs. Matched pairs of NCMs can be installed in the left and right positions of each logical slot. If only one logical slot is used, the slot can be in the Main Chassis or Chassis 2. If two logical slots are used, they must be Slot 6 and 7 in the Main Chassis, and Peer-to-Peer cannot be used.
- Up to two logical slots can be configured for TCMs. Matched pairs of TCMs can be installed in the left and right positions of each logical slot, and they can be located in the Main Chassis or Chassis 2.

- Up to three logical slots can be configured for SMMs. A matched pair of SMMs can be installed in the left and right positions of each logical slot. All three slots must be in the Main Chassis or Chassis 2.
- Up to two logical slots can be configured for HIMs. Both slots must be in the Main Chassis.
- The COM slot can be configured only for the EICM, TCM, or NCM.
- You cannot install an NCM and a TCM in the same Tricon system. You also cannot install an EICM and a TCM in the same system.
- Model 4351A, 4351B, 4352A, and 4352B TCMs cannot be installed into a system with Model 4351 or 4352 TCMs, even if they are installed in different chassis.
- If communication modules are housed in Chassis 2, this chassis must be connected directly to the Main Chassis using I/O COMM cables (Model 9001) rather than standard I/O bus cables.
- Chassis 2 can be an I/O Expansion Chassis or a primary RXM Chassis.

Chassis Power Limitations

To maintain the safety and reliability of the Tricon controller, each system must be configured for operation under a worst-case scenario. These circumstances include operation with only one functional power supply at 140° F (60° C), ambient. (See “Power Modules” on page 32 for detailed specifications). Under these conditions, the power supply is rated to deliver 175 watts. The table to the right lists the logic power consumption per module in watts.

| Module Type | Watts Consumed |
|------------------------------------|----------------|
| ACM | 15 |
| Analog Input | 10 |
| Analog Input, Models 3720 and 3721 | 12 |
| Analog Input, Isolated | 15 |
| Analog Input, High-Density | 10 |
| Analog Output | 15 |
| Analog Output, Bipolar | 20 |
| Digital Input, High-Density | 10 |
| Digital Input, Single | 10 |
| Digital Input, TMR | 10 |
| Digital Output, AC | 10 |
| Digital Output, DC | 10 |
| Digital Output, Dual | 10 |
| Digital Output, Supervised | 15 |
| EICM | 10 |
| HART Analog Input Interface | 5 |
| HART Analog Output Interface | 5 |
| HIM | 10 |
| Main Processor, Model 3008 | 10 |
| NCM | 20 |
| Power Module | n/a |
| SMM | 20 |
| TCM | 7 |
| Thermocouple Input, Isolated | 15 |
| Thermocouple Input, Non-Isolated | 10 |
| Pulse Input | 20 |
| Pulse Totalizer | 10 |
| RXM | 5 |
| Relay Output | 15 |

| Voltage | Description | Type | Model No. | Points | For Details, See |
|------------------------------|--------------------------------------|------|-------------|---------|------------------|
| 0–5 VDC | Single-Ended | TMR | 3720 | 64 | page 49 |
| 0 to 5 or –5 to +5 VDC | Differential, DC Coupled | TMR | 3721 | 32 | page 49 |
| Analog Output Modules | | | | | |
| 4–20 mA | Current Loop, DC Coupled | TMR | 3805E/3805H | 8 | page 50 |
| 4–20 mA and 20–320 mA | Current Loop, DC Coupled | TMR | 3806E | 6 and 2 | page 50 |
| –60 to 60 mA | Bipolar, Commoned Return, DC Coupled | TMR | 3807 | 4 | page 50 |

Tricon Equipment Certified for Use in Marine Environments

Bureau Veritas (BV) has certified specific Tricon products as being in full compliance with the following internationally recognized standard and qualified for use in marine environments:

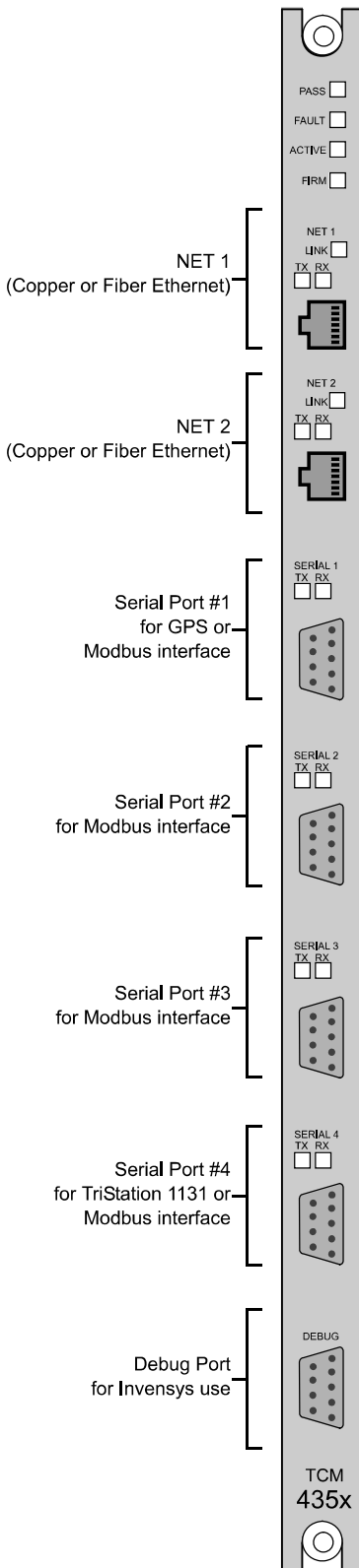
BV NR467:2011, Part C, Ch 2-3 Rules for the Classification of Steel Ships; Part C - Machinery, Electricity, Automation and Fire Protection; Chapters 2-3

Bureau Veritas Environmental Category, EC Code: 31C

The following table lists the model numbers of Tricon equipment certified for use in marine environments and identifies the standard model to see for information about the equipment. All of the information (specifications, simplified schematics, installation guidelines, and so on) for standard equipment also applies to marine equipment. Additionally, refer to the *Planning and Installation Guide for Tricon v9–v10 Systems* for application-specific installation instructions.

| Model Number | Description | See This Standard Model |
|--|---|-------------------------|
| Modules and Chassis^a | | |
| 8110C | Main Chassis | 8110 |
| 8111C | Expansion Chassis | 8111 |
| 8112C | Remote Expansion Chassis | 8112 |
| 8310C | High-Density Power Module, 120 V | 8310 |
| 8311C | High-Density Power Module, 24 VDC | 8311 |
| 8312C | High-Density Power Module, 230 VAC | 8312 |
| 3008C | Enhanced Main Processor III, 16 Mb | 3008 |
| 4200C | Remote Extender Module | 4200 |
| 4200-3C | Remote Extender Module (Set) | 4200-3 |
| 4201C | Remote Extender Module | 4201 |
| 4201-3C | Remote Extender Module (Set) | 4201-3 |
| 4351BC | Tricon Communication Module (TCM), copper | 4351B |
| 4352BC | Tricon Communication Module (TCM), fiber-optic | 4352B |
| 4353C | Tricon Communication Module (TCM), Embedded OPC Server, copper | 4353 |
| 4354C | Tricon Communication Module (TCM), Embedded OPC Server, fiber-optic | 4354 |
| 3703EC | AI, 0–5 VDC or 0–10 VDC, differential, isolated, TMR, 16 pts. | 3703E |
| 3721C | AI, 0–5 VDC or –5 to +5 VDC, differential, DC-coupled, TMR, 32 pts. | 3721 |
| 3700AC | AI, 0–5 VDC, non-commoned, differential, DC-coupled, TMR, 32 pts. | 3700A |
| 3720C | AI, 0–5 VDC, single-ended, 64 pts. | 3720 |

Product Specifications



Alias numbers must also be used when host computers access the Tricon controller through other communication modules. See “Communication Capabilities” on page 67 for more information.

TCM Models 4353 and 4354 have an embedded OPC server on NET 2, which allows up to 10 OPC clients to subscribe to data collected by the OPC Server. The embedded OPC Server supports the Data Access 2.05 standard and the Alarms and Events 1.10 standard.

Each TCM contains two network ports—NET 1 and NET 2. Models 4351A, 4351B, and 4353 have two copper Ethernet (802.3) ports and Models 4352A, 4352B, and 4354 have two fiber-optic Ethernet ports.

On TCM Models 4351A, 4351B, 4352A, and 4352B, NET 1 and NET 2 support the TCP/IP, Modbus TCP/IP Slave/Master, TSAA, TriStation, SNTP, and Jet Direct (for network printing) protocols. NET 1 also

supports the Peer-to-Peer (UDP/IP) and Peer-to-Peer Time Synchronization protocols.

On TCM Models 4353 and 4354, NET 2 supports only the embedded OPC server, TriStation, and SNTP protocols, while NET 1 supports all of the listed protocols except the embedded OPC server.

A single Tricon system supports a maximum of four TCMs, which must reside in two logical slots. Different TCM Models cannot be mixed in one logical slot. Each Tricon system supports a total of 32 Modbus masters or slaves—this total includes network and serial ports. The hot-spare feature is not available for the TCM, though you *can* replace a faulty TCM while the controller is online.

TCM Specifications

| Model Number | 4351A, 4351B, 4352A, 4352B, 4353, 4354 | |
|----------------------------|--|--|
| Serial ports | 4, RS-232/RS-485 ports, DB-9 connectors | |
| Network ports | 2, 10/100BaseT Ethernet ports, RJ-45 connectors (Models 4351A, 4351B, 4353) 2, fiber-optic mode Ethernet ports, MT-RJ connectors with 62.5/125 um fiber cables (Models 4352A, 4352B, 4354) | |
| Port isolation | 500 VDC | |
| Protocols | TriStation, Modbus, TCP/IP, ICMP, SNTP, TSAA (with support for IP Multicast), Trimble GPS, Embedded OPC Server (Models 4353 and 4354), Peer-to-Peer (UDP/IP), Peer-to-Peer Time Synchronization, Jet Direct (network printing) | |
| Modbus functions supported | 01 — Read Coil Status 02 — Read Input Status 03 — Read Holding Registers 04 — Read Input Registers 05 — Modify Coil Status | 06 — Modify Register Content 07 — Read Exception Status 08 — Loopback Diagnostic Test 15 — Force Multiple Coils 16 — Preset Multiple Registers |
| Communication speed | Copper Ethernet ports: 10/100 Mbps (Model 4353 supports only 100 Mbps) Fiber Ethernet ports: 100 Mbps Serial ports: up to 115.2 Kbps per port | |
| Status Indicators | PASS, FAULT, ACTIVE, FIRM LINK— 1 per network port, TX (Transmit) — 1 per port, RX (Receive) — 1 per port | |

Communication Capabilities

workstation software (PC-based or mini-computer-based) support Modbus RTU and ASCII protocol, as do most DCS vendors, by means of a network-bridging device.

Because the TCM and the EICM can operate as a Modbus master or slave (the EICM can simultaneously act as both), the productivity of the Tricon controller can be expanded in a low-cost manner for non-critical I/O. When the TCM or the EICM operates as the master, it can control slave devices such as annunciators, bypass switches on non-critical PLCs, or other Tricon controllers. When the TCM or the EICM operates as a slave, a computer on the network is the master—this can be a DCS, an operator workstation, or any general-purpose computer programmed to support Modbus devices.

TCM and EICM users can select the RS-232 point-to-point interface for one master and one slave, or the RS-485 interface for one master and up to 32 slaves. The RS-485 network trunk can be one or two twisted-pair wires up to a maximum of 4,000 feet (1,200 meters).

While the TCM and the EICM are appropriate for many applications, Invensys offers alternate communication methods when fast response time or a large amount of data throughput is required.

Networking with Ethernet

The Tricon controller supports Ethernet (802.3) communication through the NET 1 and NET 2 ports on the Tricon Communication Module (TCM), and the NET 2 ports on the Advanced Communication Module (ACM) and the Network Communication Module (NCM). All of these modules support Triconex applications, user-written applications, and “open” networking

| Protocols | TCM | EICM | NCM | ACM |
|--|-----|------|-----|-----|
| Peer-to-Peer | ✓ | — | ✓ | — |
| Time Synchronization | ✓ | — | ✓ | — |
| Trimble GPS (TAIP) | ✓ | — | — | — |
| SNTP | ✓ | — | — | — |
| Network Printing using Jet Direct | ✓ | ✓ | — | — |
| TriStation | ✓ | ✓ | ✓ | ✓ |
| Tricon System Access control program (TSAA) | ✓ | — | ✓ | ✓ |
| Protocols for User-Written Applications | | | | |
| Modbus RTU and ASCII | ✓ | ✓ | — | — |
| Modbus TCP | ✓ | — | — | — |
| TCP-IP/TCP-UDP | ✓ | — | ✓ | ✓ |
| Triconex Applications | | | | |
| Sequence of Events | ✓ | — | ✓ | ✓ |
| DDE Server | ✓ | — | ✓ | ✓ |
| TriStation 1131 | ✓ | ✓ | ✓ | ✓ |
| Enhanced Diagnostic Monitor | ✓ | — | — | — |
| OPC Server for Triconex ^a | ✓ | — | ✓ | — |

Protocols and Applications for Networking

NOTES

^aTCM Models 4351A, 4351B, 4352A, and 4352B, and NCMs rely on an external Matrikon OPC Server. TCM Models 4353 and 4354 have an Embedded OPC Server.

See page 33, page 35, page 37, and page 38 for network port usage on the TCM, EICM, NCM, and ACM

with external systems by means of TCP-IP/UDP-IP protocol.

In addition, the TCM and NCM support the Triconex Peer-to-Peer and Time Synchronization protocols on the NET 1 port. The TCM and NCM also support a fully redundant OPC capability. The table above lists the protocols and applications that can be used with the TCM, NCM, and ACM.

To maximize safety, the Tricon system offers module, media, and workstation redundancy. Module/media redundancy is achieved by installing two TCMs, NCMs, or ACMs in the same logical slot and connecting their network nodes with two sets of cables. This arrangement permits continuous operation in case of broken cables,

intermittent cable connections, port failures, or TCM/ NCM/ACM failures.

External host redundancy is obtained by connecting a spare external host machine to the network. If the primary host fails, it can be shut down and the control program restarted on the spare host. All Triconex applications use PCs as external hosts, so all of the applications could be loaded on the primary and spare hosts without requiring any other PCs.

Triconex Protocols

A protocol is a set of rules for exchanging data between two or more devices. In a Peer-to-Peer protocol, any device on the network can initiate a data transfer operation. In a master/slave protocol, only the master can initiate a

data exchange. Invensys has developed one peer-to-peer protocol and three master/slave protocols (Time Synchronization, TriStation, and TSAA) to support different types of applications. All of the following Triconex protocols support a maximum of 31 Tricon controllers on a network. Please contact Invensys for application guidelines and potential performance limitations.

Peer-to-Peer

Peer-to-Peer protocol allows Tricon controllers to exchange small amounts of safety and process information on the proprietary network. For information about using the Peer-to-Peer Send and Recv functions in applications, see the *TriStation 1131 Developer's Guide*.

Time Synchronization

Time Synchronization is a master/slave protocol used to maintain a consistent time base for all Tricon controllers connected to each other by means of TCMs or NCMs.

TriStation

The TriStation protocol is a master/slave protocol in which the master (the TriStation 1131 PC) communicates with the slave (the Tricon controller) over an Ethernet network. Although the TriStation protocol supports a maximum of 31 Tricon controllers, the master can

communicate with only one slave at a time.

TSAA

The Tricon System Access control program (TSAA) protocol is a master/slave protocol in which the master (the external host) communicates with one or more slaves (Tricon controllers) over an open network. TSAA specifies the interfaces, commands and data structures used to develop applications that send and receive data to and from Tricon controllers.

TSAA can be used to develop these types of applications:

- Control (read/write) applications such as an operator interface that requires access to Tricon controller status and the ability to write data to the Tricon controller.
- Monitor (read only) applications such as a Sequential Events Recorder, Event Logger or status display that retrieves data from the Tricon controller.

For more information about TSAA, see the *Communication Guide for Tricon v9–v10 Systems*.

Triconex Applications

Invensys offers several applications for Ethernet (802.3) networks, all of which use a PC as the external host. These

applications are briefly described in the table below.

The Tricon controller offers considerable flexibility and functionality in the area of data communication, and can readily be configured to match control program requirements. Invensys is continually striving to advance the state of the art in safety systems. High-speed, redundant network communication is another example of that commitment.

Foxboro's Intelligent Automation Series System

Invensys offers the *Advanced Communication Module (ACM)* for tightly-integrated interfacing with Foxboro's Intelligent Automation (I/A) Series Nodebus. The ACM communicates process information at full network data rates for use anywhere on the I/A Series system, transmitting all Tricon aliased data and diagnostic information to operator workstations in display formats that are familiar to Foxboro operators.

The ACM makes the following functions available to the I/A Series:

- Handles critical I/O points and passes results to the I/A Series
- Processes Tricon controller alarms and propagates them to user-defined

| Triconex Application | Description |
|--------------------------------------|--|
| TriStation 1131 | Allows development, testing, and monitoring of applications for the Tricon controller. |
| Sequence of Events (SOE) | Retrieves events (state changes of discrete variables) from Tricon controllers on a network. For system maintenance and shutdown analysis. |
| Enhanced Diagnostic Monitor | Allows monitoring the hardware and application status of Tricon controllers. |
| DDE Server | Allows Windows-based DDE client applications such as Microsoft [®] Excel [®] to read and write Tricon aliased data. |
| OPC Server for Triconex ^a | Allows OPC clients to have read and write access to Triconex controller program variables. Requires the Network Communication Module (NCM) or the Tricon Communication Module (TCM). |

^aTCM Models 4351A, 4351B, 4352A, and 4352B, and NCMs rely on an external Matrikon OPC Server. TCM Models 4353 and 4354 have an embedded OPC Server.