Technical Product Guide
Tricon Systems

Preface

DISCLAIMER

TECHNICAL SUPPORT

Customers in the U.S. and Canada can obtain technical support from the Customer Satisfaction Center (CSC) at the numbers below. International customers should contact their regional support center.

Telephone:	Toll-free number	866-746-6477
	Toll number	508-549-2424 (outside U.S.)
Fax:	Toll number	508-549-4999
E-mail:	ips.csc@ips.invensys.com	

The Tricon is a fault-tolerant controller based on a Triple-Modular Redundant (TMR) architecture.
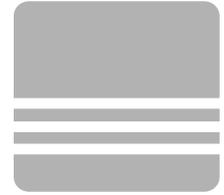
What is Fault-Tolerant Control?

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 is used in critical process applications that require a significant degree of safety and availability.

What is the Tricon?

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 with no single point of failure.

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 does occur 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 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.

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Introduction

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

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

- No single point of failure
- Ability to operate with 3, 2 or 1 Main Processor 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 MPs
- Simple, online module repair
- Unsurpassed reliability and availability

What are Typical User Applications?

Each day the Tricon 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 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 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 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?

TriStation 1131 Developer's Workbench is an integrated tool for developing, testing and documenting control programs that execute in the Tricon controller. TriStation 1131 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 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

The Tricon is designed with a fully triplicated architecture throughout, from the input modules through the main processors (MPs) to the output modules.
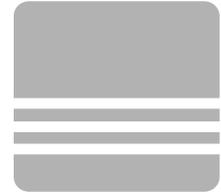
Fault tolerance in the Tricon is achieved by means of a Triple-Modular Redundant (TMR) architecture. The Tricon provides error-free, uninterrupted control in the presence of either hard failures of components, or transient faults from internal or external sources.

The Tricon is designed with a fully triplicated architecture throughout, from the input modules through the main processors to the output modules. Every I/O module houses the circuitry for three independent channels, which are also referred to as legs. 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.

Once per scan, the three main processors synchronize and communicate with their two neighbors over the TriBus. The Tricon 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 output data is voted on the output modules as close to the field as possible, which enables the Tricon to detect and compensate for any errors that might occur between the voting and the final output driven to the field.

For each I/O module, the system can support an optional hot-spare module

which takes control if a fault is detected on the primary module during operation. The hot-spare position can also be used for online system repairs.

Main Processor Modules

A Tricon system contains three main processor (MP) modules to control three separate channels of the system. Each main processor operates in parallel with the other two main processors, as a member of a triad.

A dedicated I/O and COMM processor on each main processor manages the data exchanged between the main processors and the I/O modules. A triplicated I/O bus is located on the chassis backplane and is extended from chassis to chassis by means of I/O bus cables.

As each input module is polled, the new input data is transmitted to the main processor over the appropriate channel of the I/O bus. The input data from each input module is assembled into a table in the main processor and 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 proprietary TriBus. During this transfer, hardware voting takes place. The TriBus uses a direct memory access (DMA) programmable device to synchronize, transmit, vote and compare data among the three main processors.
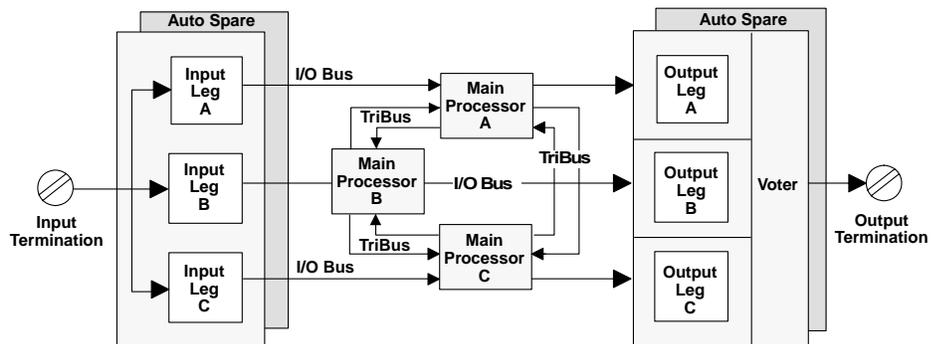
Simplified Tricon Architecture

If a disagreement is discovered, 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 can be distinguished from a pattern of differing data. The three independent main processors each maintain data about necessary corrections in local memory. Any disparity is flagged and used at the end of the scan by the built-in Fault Analyzer routines to determine whether a fault exists on a particular module.

Theory of Operation

After the TriBus transfer and input data voting have corrected the input values, these corrected values are used by the main processors as input to the user-written control program. (The control program is developed in the TriStation software and downloaded to the main processors.) The 32-bit main microprocessor executes the user-written control program in parallel with the neighboring main processor modules.

The user-written control program generates a table of output values based on the table of input values, according to the rules built into the control program by the customer. The I/O processor on 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 appro-priate 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 and COMM processor manages the data exchanged between the main processors and the communication modules using the communication bus, which supports a broadcast mechanism.

The model 3008 Main Processors provide 16 megabytes of DRAM, which is used for the control program, sequence-of-events data, I/O data, diagnostics and communication buffers.

In the event of an external power failure, the integrity of the user-written program and the retentive variables is protected for a minimum of six months.

The main processor modules receive power from dual power modules and power rails in the main chassis. A failure on one power module or power rail will not affect the performance of the system.

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.

The TriBus consists of three independent serial links which operate at 25 megabits per second. The TriBus synchronizes the main processors at the beginning of a scan. Then each main processor sends its data to its upstream and downstream neighbors. The TriBus performs one of two functions with the data:

- Transfer of data only—for I/O, diagnostic and communication data.

  - Comparing data and flagging disagreements—for the previous scan's output data and memory of user-written control program.

An important feature of the Tricon's fault-tolerant architecture is the use of a single transmitter to send data to both the upstream and downstream main processors. This ensures receipt of the same data by the upstream processor and downstream processor.
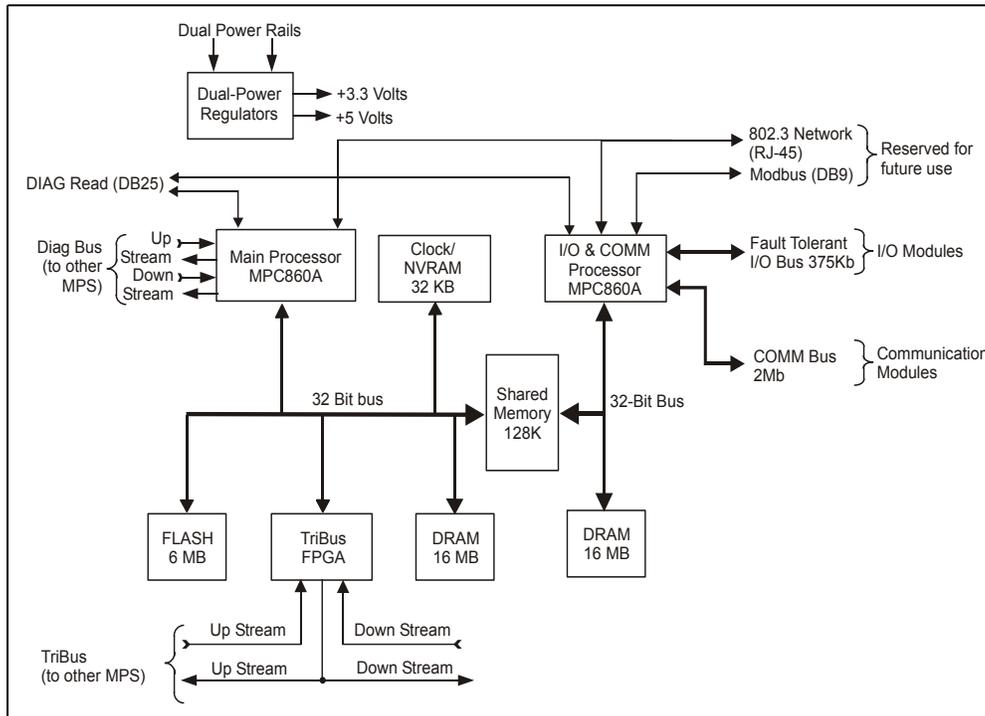
Main Processor (Model 3008) Architecture

I/O Bus

The triplicated I/O bus transfers data between the I/O modules and the main processors at 375 kilobits per second. The triplicated I/O bus is carried along the bottom of the backplane. Each channel of the I/O bus runs between one of the three main processors and the corresponding channels on the I/O module.

The I/O bus can be extended 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 for the chassis is distributed across two independent power rails down the center of the backplane. Every 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 module: one set for each of the channels A, B and C and one set for the status-indicating LED indicators.

Field Signals

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. 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 module 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.
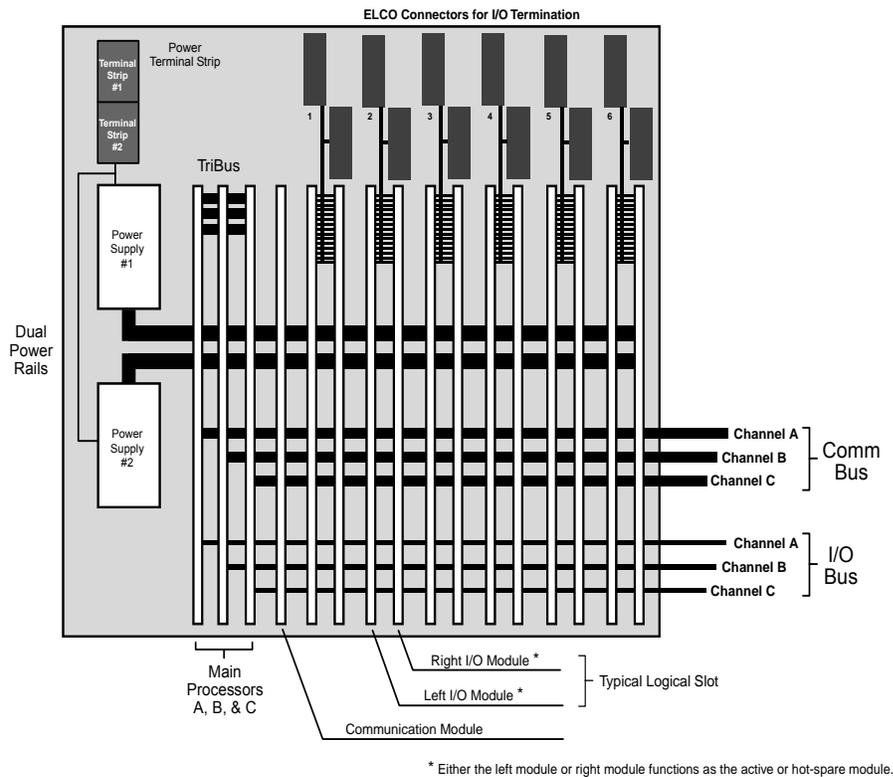
Backplane of the Main Chassis

* Either the left module or right module functions as the active or hot-spare module.

Digital Input Modules

The Tricon 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 termina-

tion 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 module. 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. (The 64-point 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

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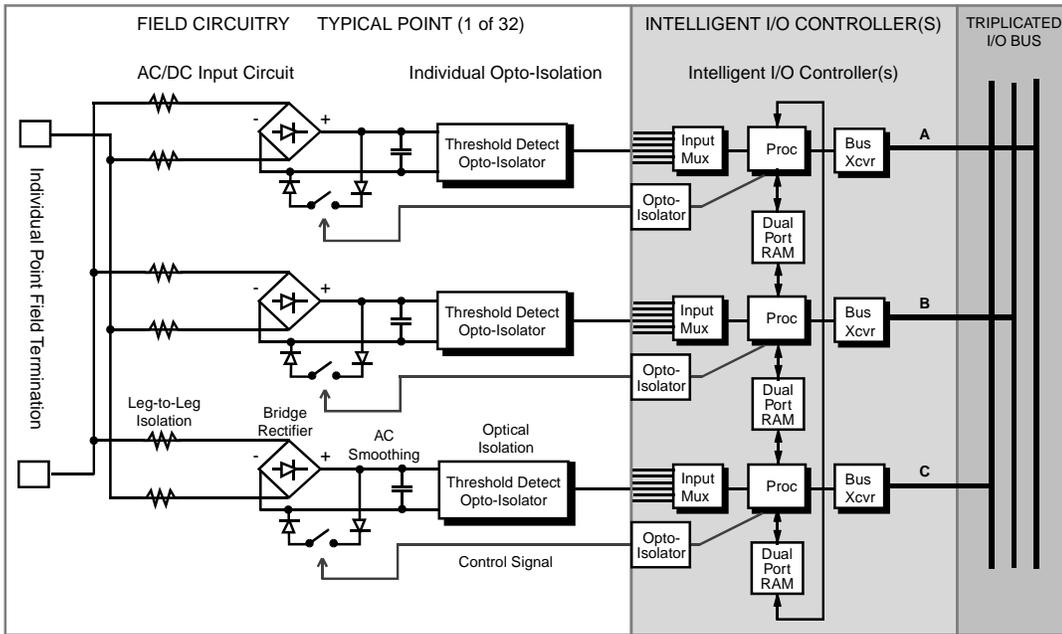
Architecture of TMR Digital Input Module with Self-Test (DC Model)

tory 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.

cannot tell whether a point has gone to the OFF state. Since most safety systems are set up with a de-energize-to-trip capability, the ability to detect stuck-ON points 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 isolation circuitry. The last data reading is frozen in the I/O communication 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 manda-

Digital Output Modules

There are four basic types of digital output modules: dual, supervised, DC voltage and AC voltage. The following
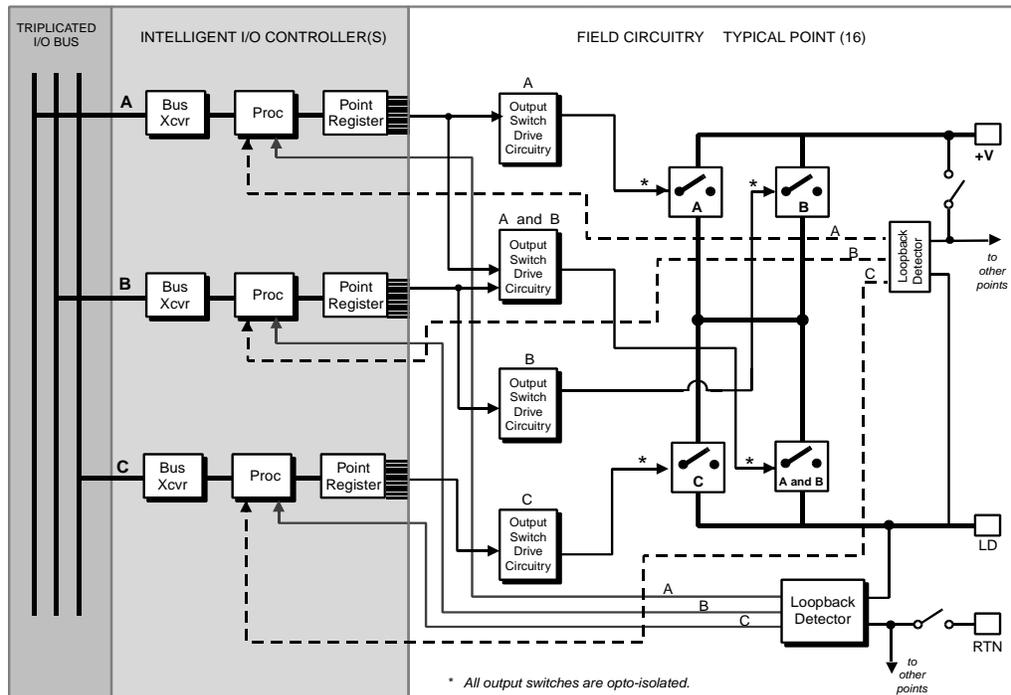
**Architecture of 16-Point Supervised Digital Output Module**

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 micro-processor 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 special quadruplicated output circuitry 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 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. Loop-back 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.

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 corresponding I/O bus. The input table in each main processor module is transferred to its neighbors across the Tricon. The middle value is selected by each main processor, and
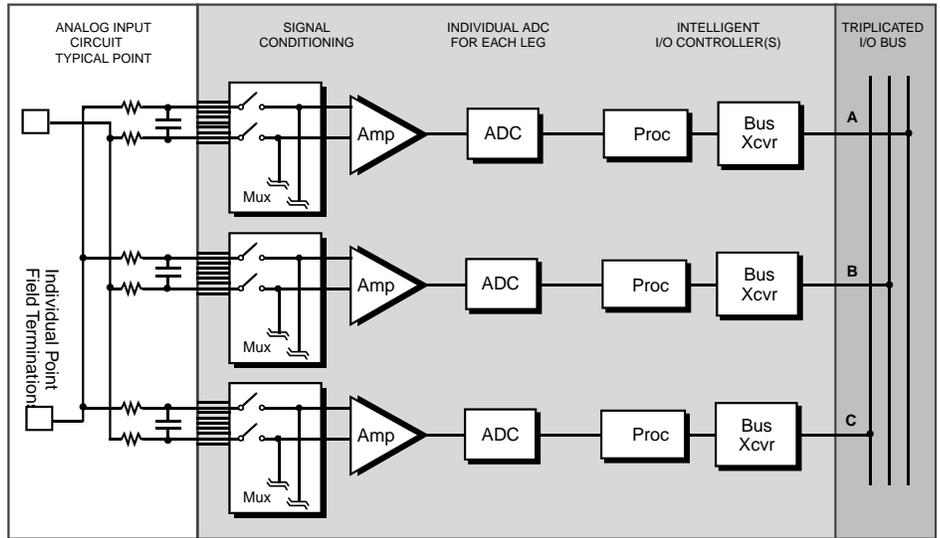
Architecture of TMR Analog Input Module

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.

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 micropro-cessors. 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
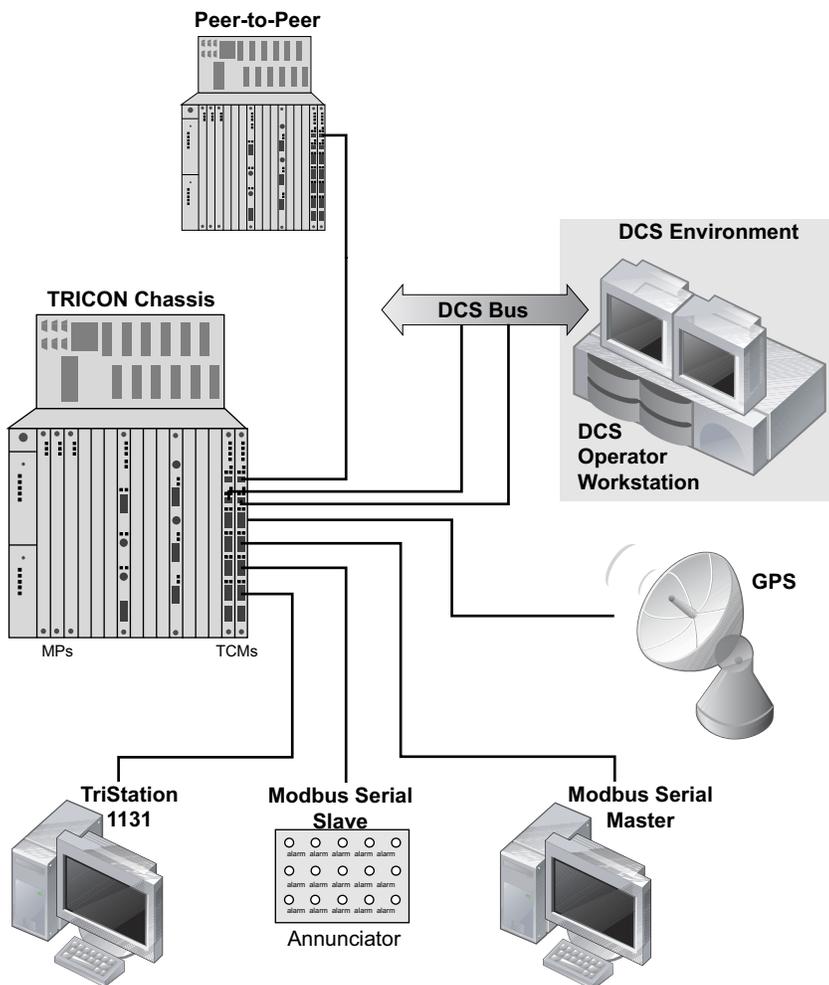
Sample of the TCM Communication Capabilities

input or digital output modules. One end of a fanned-out cable connects to the Tricon 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 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 59.

Tricon Communication Module (TCM)

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

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

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)

Supports RS-232, RS-422, and RS-485 serial communication with external devices at speeds up to 19.2 kilobits per second. The EICM provides four serial, opto-isolated ports which can interface with Modbus masters, slaves, or both; or a TriStation. The module also provides a Centronics-compatible parallel port.

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 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 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.

Power Supply 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.
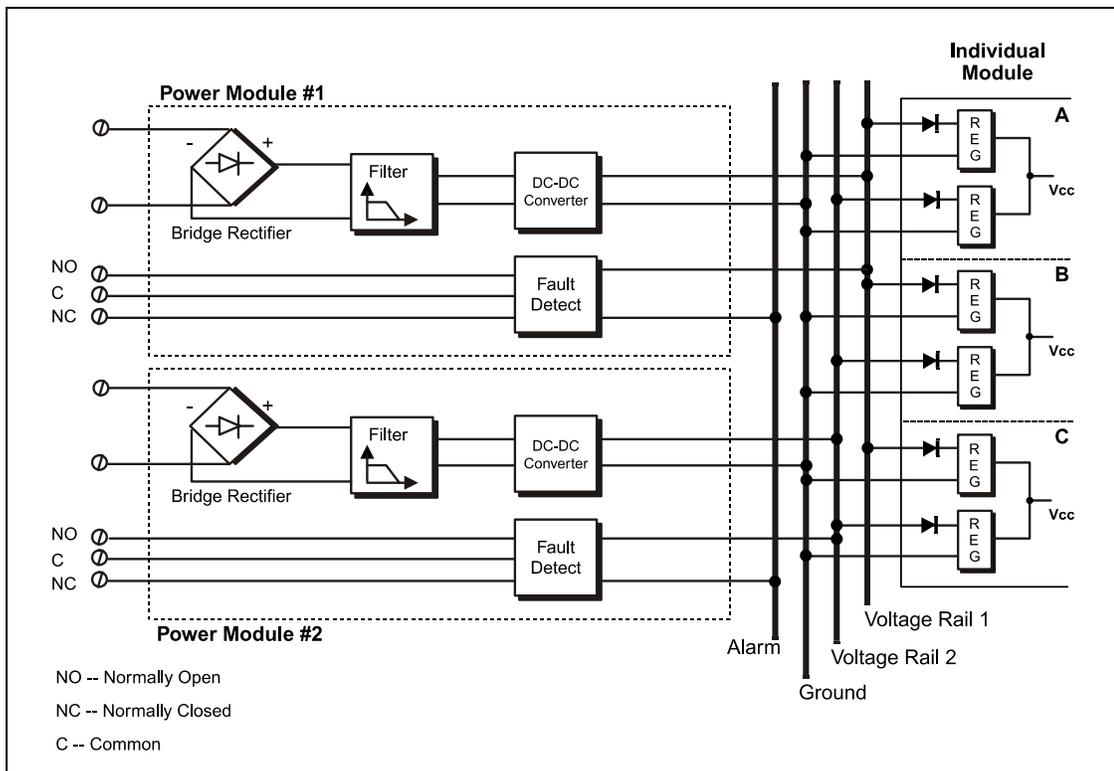
Architecture of Power Subsystem

Notes

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 and communication modules that interface with OPC clients, Modbus devices, other Tricons, 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 I/O bus cables. The maximum I/O bus cable length between the main chassis
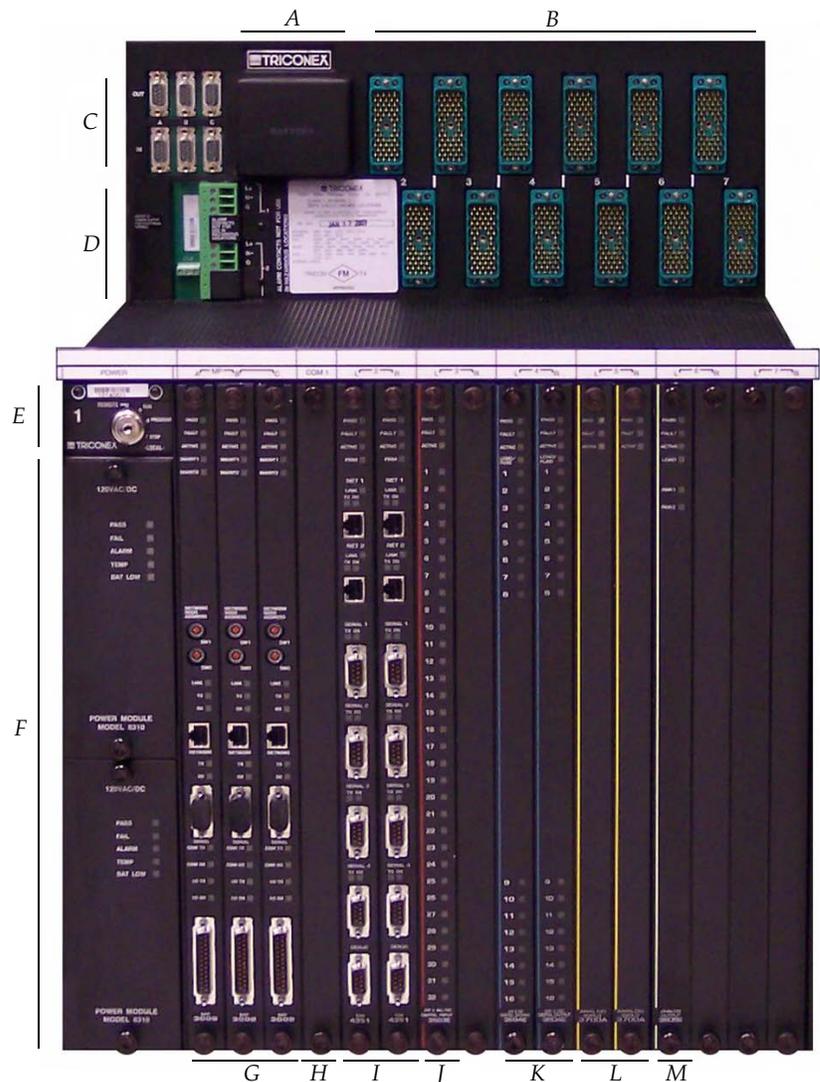
A. Memory backup battery	F. Redundant Power Modules
B. Connectors for terminations	G. Three Main Processors
C. I/O expansion ports	H. COM slot (empty)
D. Power terminals	I. Two TCMs
E. Keyswitch	J. DI module without spare

K. DO module with hot-spare
L. AI module with hot-spare
M. AO module without spare

Sample Layout of a Tricon Chassis

System Configuration

and the last expansion chassis is normally 100 feet (30 meters), but in restricted applications the length can be up to 1,000 feet (300 meters). (Please consult your Triconex Customer Support representative for assistance when configuring a system that exceeds 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 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 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 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 figure on this page 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.

I/O Bus Ports

Tricon Chassis, Front View

I/O Bus Connections

OUT A — Leg A output port
OUT B — Leg B output port
OUT C — Leg C output port
IN A — Leg A input port
IN B — Leg B input port
IN C — Leg C input port

I/O Bus Ports
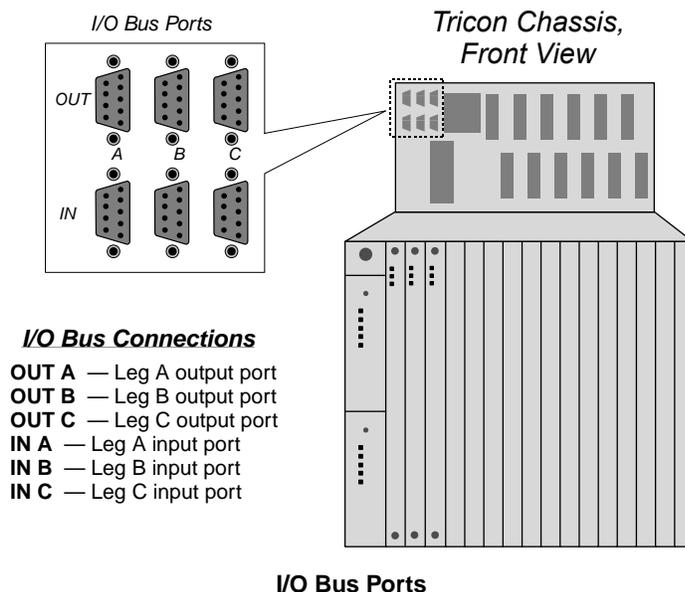
System Configuration Guidelines

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 v9.6 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 v9 low-density configuration includes a v5–v8 chassis with v9 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.

NOTES

Dotted lines represent six fiber-optic cables for remote location. Solid lines represent RS-485 I/O Bus Cables for local expansion.

A Tricon system may contain a maximum of 15 chassis, including Main, Expansion and RXM Chassis.
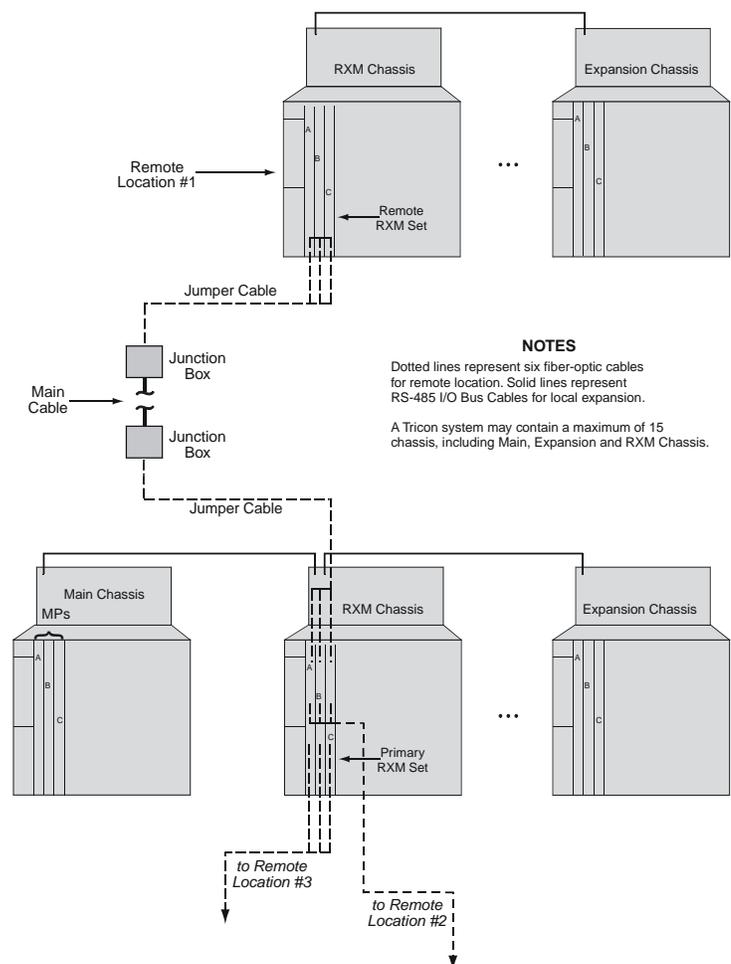
System Configuration with Three Remote Locations

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 3 primary RXM module sets are normally supported.

Contact Triconex regarding other configurations.

- Each primary RXM module set can support up to 3 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 6 fiber-optic cables which transmit and receive signals for channels A, B and C.

System Configuration
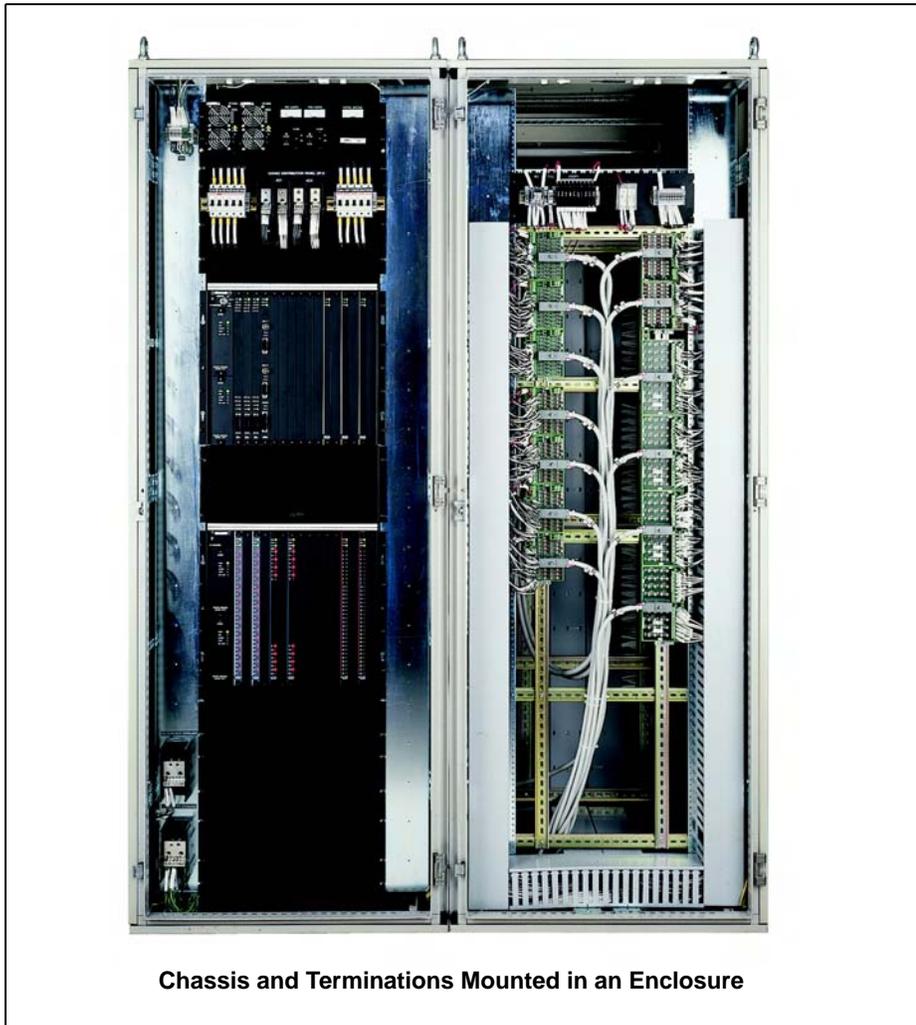
Chassis and Terminations Mounted in an Enclosure

- RXM chassis can be connected to local expansion chassis using I/O bus cables.

- Each RXM chassis must contain 2 power modules.

- Each RXM chassis provides 6 logical slots for I/O modules and 1 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 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.

- 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, 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 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, Isolated	15
Analog Input, High Density	10
Analog Output	15
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
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

Notes

The Tricon supports a comprehensive range of modules to meet customers' needs.
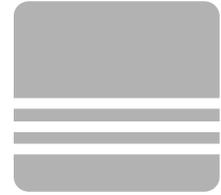
Product Specifications

The Triconex product family includes a comprehensive range of modules. This section includes: a summary of the system components and their uses, a table that lists standard products and their model numbers, and a summary of specifications for each standard product in the Tricon family

See the *Tricon Planning and Installation Guide* for complete information.

Summary of Tricon Components

Chassis

- *Main Chassis*—houses main processors, memory back-up batteries, communication modules and I/O modules.
- *Expansion Chassis*—for additional I/O modules up to 100 feet (30 meters) away from the main chassis. In restricted applications, operation up to 1,000 feet (300 meters) is supported.
- *RXM Chassis*—for I/O modules up to 7.5 miles (12 kilometers) away from the main chassis.
- *Mechanical Keying*—Each slot in the Tricon is mechanically keyed to correspond with a specific type of module. This prevents the installation of modules into improper slots.

For chassis mounting and enclosure specifications, see .

Power Supply Modules

- Provide logic power to modules in the main, expansion or RXM chassis. Available in 24 VDC, 115 VAC and 230 VAC versions. The power rating of each power supply is 175 watts at 140 ° F (60° C).

Main Processors

The main processors execute the system diagnostics and the user-written control program.

Communication Modules

- *Tricon Communication Module (TCM)* supports a number of Triconex protocols and applications and user-written applications on Ethernet (802.3) networks, including TriStation, Modbus TCP and OPC. It also supports RS-232 and RS-485 serial communication with Modbus devices, TriStation, and GPS for time synchronization.

- *Enhanced Intelligent Communication Module (EICM)* supports RS-232, RS-422 and RS-485 serial communication with Modbus devices and TriStation.

- *Network Communication Module (NCM)* supports a number of Triconex protocols and applications and user-written applications on Ethernet (802.3) networks, including TriStation.

- *Safety Manager Module (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.

- *Hiway Interface Module (HIM)* acts as an interface between a Tricon controller and a Honeywell TDC 3000 Hiway Gateway and Local Control Network (LCN).

- *Advanced Communication Module (ACM)* allows a Tricon controller to interface with a Foxboro Industrial Automation (I/A) Series DCS and TriStation.

Fiber-Optic Remote Extender Modules (RXM)

For operation of Expansion Chassis up to 7.5 miles (12 kilometers) away from the Main Chassis, with exceptional immunity against electro-static and electro-magnetic interference.

I/O Modules

- *Digital Input Modules* receive discrete signals of these nominal voltages: 115 VAC/VDC, 48 VAC/VDC, and 24 VAC/VDC. All voltages are available in TMR modules. Non-TMR modules are available in 24 VDC and 48 VDC only. Speed input and totalization modules are also available.

- *Supervised Digital Output Modules* produce discrete output signals of these nominal voltages, with diagnostic coverage of the field circuit and load device: 115 VAC, 120 VDC, 48 VDC and 24 VDC.

- *Digital Output Modules* produce discrete output signals of these nominal voltages: 115 VAC, 120 VDC, 24 and 48 VDC. Dual output modules are also available.

- *Analog Input Modules* receive analog signals of these types: 0-5 VDC, -5 to +5 VDC, 0-10 VDC and Thermocouple types J, K, T and E. Available in both isolated and DC-coupled versions.

- *Analog Output Module* drives eight 4-20 mA analog output signals. The high-current AO module includes 6 points at 4-20 mA and 2 points at 20-320 mA.

Product Specifications

Standard Tricon Products

Description	Model No.	See
Chassis Assemblies		
Main Chassis, High Density Configuration, includes the Tricon printed manuals	8110	page 13, page 21
Expansion Chassis, High Density Configuration	8111	page 13, page 21
Remote Expansion Chassis, High Density Configuration	8112	page 13, page 21
I/O Bus Expansion Cables (Set of 3)	9000[1]	page 12
I/O-COMM Bus Expansion Cables (Set of 3)	9001	page 12, page 21
Blank I/O Slot Panel	8105	page 22
Power Modules		
120 VAC/VDC – 175-Watt Power Module	8310	page 24
24 VDC – 175-Watt Power Module	8311	page 24
230 VAC – 175-Watt Power Module	8312	page 24
Main Processor Modules		
3008 Main Processor, 16 megabytes DRAM	3008	page 25
Communication Hardware and Software		
Tricon Communication Module (TCM), Ethernet (802.3) and serial (RS-232/RS-485) ports	4351A, 4352A, 4353, 4354	page 26
Enhanced Intelligent Communication Module (EICM), serial (RS-232/RS-422/RS-485) ports	4119, 4119A	page 27
Safety Manager Module (SMM), Honeywell UCN Interface	4409	page 28
Network Communication Module (NCM), Ethernet (802.3) ports	4329, 4329G	page 29
Advanced Communication Module (ACM), Foxboro I/A Series Nodebus Interface	4609	page 30
Hiway Interface Module (HIM), Honeywell Data Hiway Interface	4509	page 31
Triconex DDE Server Software	7523-1	page 61
Network Accessory Kit (Ethernet thin cable, connectors and terminators)	7600-3	n/a
Remote Extender Modules		
Primary RXM, Multi-Mode Fiber Optics, Set of 3 Modules	4200-3	page 32
Remote RXM, Multi-Mode Fiber Optics, Set of 3 Modules	4201-3	page 32
Primary SRXM, Single-Mode Fiber Optics, Set of 3 Modules	4210-3	page 32
Remote SRXM, Single-Mode Fiber Optics, Set of 3 Modules	4211-3	page 32
TriStation Software		
TriStation 1131 v4.1.x Software License with printed manuals	Contact Triconex for current model number	page 63
TriStation 1131 v3.1.3 Software License with printed manuals	7244-4	page 63
CEMPLE Language Editor, v3.1.3	7224-4	page 67
Documentation Sets		
Tricon Planning and Installation, Field Terminations, and Communication printed manuals	Contact Triconex for current model number	
Triconex User Documentation, includes all manuals in PDF format (CD-ROM)	Contact Triconex for current model number	

1. I/O Bus Expansion Cables are available in custom lengths. Please contact Triconex for more information.

Tricon I/O Modules

Voltage	Description	Type	Model No.	Points	For Details, See
Digital Input Modules					
115 VAC/VDC	Opto-Isolated, Non-Commoned	TMR	3501E/3501T	32	page 33
48 VAC/VDC	Commoned in Groups of 8, Self-Test	TMR	3502E	32	page 33
24 VAC/VDC	Commoned in Groups of 8, Self-Test	TMR	3503E	32	page 33
24/48 VDC	High Density, DC Coupled	TMR	3504E	64	page 34
24 VDC	Low Threshold with Self-test, Commoned	TMR	3505E	32	page 33
24 VDC	Single, Opto-Isolated, Commoned	Single	3564	64	page 34
Pulse Input	Differential, AC Coupled	TMR	3511	8	page 35
Pulse Totalizer	Opto-isolated, Non-commoned	TMR	3515	32	page 36
Digital Output Modules					
115 VAC	Opto-Isolated, Non-commoned	TMR	3601E/3601T	16	page 37
120 VDC	Opto-Isolated, Non-commoned Opto-Isolated, Commoned	TMR	3603B, 3603E/3603T	16	page 37
24 VDC	Opto-Isolated, Non-commoned	TMR	3604E	16	page 37
48 VDC	Opto-Isolated, Non-commoned	TMR	3607E	16	page 37
115 VAC	Galvanically Isolated, Commoned., Supv.	TMR	3611E	8	page 39
48 VDC	Galvanically Isolated, Commoned, Supv.	TMR	3617E	8	page 39
120 VDC	Opto-Isolated, Commoned, Supervised	TMR	3623/3623T	16	page 38
24 VDC	Opto-Isolated, Commoned, Supervised	TMR	3624	16	page 38
24 VDC	Supervised/Non-Supervised, Commoned	TMR	3625	32	page 38
24 VDC	Opto-Isolated, Commoned	Dual	3664	32	page 40
24 VDC	Opto-Isolated, Commoned	Dual	3674	32	page 40
Relay Output	Non-triplicated, Normally Open	Non-triplicated	3636R/3636T	32	page 35
Analog Input Modules					
0-5 VDC	Differential, DC Coupled	TMR	3700A	32	page 41
0-10 VDC	Differential, DC Coupled	TMR	3701	32	page 41
0-5, 0-10 VDC	Differential, Isolated	TMR	3703E	16	page 41
0-5, 0-10 VDC	High-Density, Differential, DC Coupled	TMR	3704E	64	page 41
Thermocouple	Differential, DC Coupled	TMR	3706A	32	page 44
Thermocouple	Differential, Isolated	TMR	3708E	16	page 44
0–5 VDC	Single-Ended	TMR	3720	64	page 41
0 to 5 or −5 to +5 VDC	Differential, DC Coupled	TMR	3721	32	page 41
Analog Output Modules					
4-20 mA	Current Loop, DC Coupled	TMR	3805E	8	page 43
4-20 mA and 20-320 mA	Current Loop, DC Coupled	TMR	3806E	6 and 2	page 43

Product Specifications

General Environmental and EMC Specifications

Other than the optional conformal coating of all PCB assemblies, the Tricon is not explicitly protected against dust, corrosive atmospheres or falling debris. Atmospheric and airborne-particle protection must be provided by housing the Tricon in an appropriate NEMA-rated enclosure.

Operating Temperature	32° to 140° F (0° to 60° C), ambient, as measured at the bottom of the chassis, per IEC 60080-2-l Test Nb
Storage Temperature	-40° to 167° F (-40° to 75° C), per IEC 60068-2-14, Test Na
Relative Humidity	5% to 95%, non-condensing, per IEC 60068-2-2, Test Bb, and IEC 60068-2-3 test Db
Sinusoidal Vibrations per Axis	2 G @ 10 to 150 Hz, per IEC 60068-2-6, Test Fc
Shock	15 G for 6-11 ms in each axis, per IEC 60068-2-27
Electrostatic Discharge	IEC 61000-4-2, 4 kV air, 8kV contact
Conducted Susceptibility	IEC 61000-4-4, Fast Transient/Burst, 2 kV power, 1kV signal lines and IEC 61000-4-5, Surge Withstand, 2 kV CM AC power lines, etc. IEC 61000-4-6, RFI, 0.15-80 MHz, 10V
Radiated Susceptibility	IEC 61000-4-3, 26-1000 MHz, 10V/m and IEC 61000-4-8, 50-60 Hz, 30A/m
Conducted Emissions	CISPR 16, Class A, 0.15-30MHz, 73-79db when installed per the guidelines of the P&I Guide.
Radiated Emissions	CISPR 11, Class A, 30-1000 MHz @ 10m, 4-47 db when installed per the guidelines of P&I Guide.

International Approvals

The Tricon controller has been certified as complying with multiple internationally recognized standards by the following internationally recognized certification agencies, these certifications have qualified the Tricon for use around the world in safety critical applications. Test reports from the various certification agencies are available upon request.

TÜV Rheinland — TÜV has certified that the Tricon v9 and v10 controllers are in full compliance with the internationally recognized standards listed below, and thus are qualified for use in the following applications and jurisdictions.
- Emergency safety shut-down or other critical control applications requiring SIL 1-3 certification per the functional safety requirements of IEC 61508 9 (only Tricon v9.6 or later)
- Emergency safety shut-down or other critical control applications requiring AK 1-AK6 certification per the functional safety requirements of DIN V 19250 and DIN V VDE 0801 (only Tricon v9.x)
- Fire and gas detection applications requiring certification per the requirements of EN 54
- Fire and gas detection applications requiring certification per the requirements of NFPA 72 (only Tricon v9.6 or later)
- Burner management applications requiring certification per the requirements of DIN VDE 0116
- Burner management applications requiring certification per the requirements of NFPA 8501 or NFPA 8502 (only Tricon v9.6 or later)
- All applications in the European Union or other jurisdictions requiring compliance with the EMC Directive No. 89/336/EEC and Low Voltage Equipment Directive No. 72/23/EEC
- All applications in the European Union or other jurisdictions requiring compliance with the ATEX Directive No. 94/9/EC for Zone 2, Group IIB hazardous locations
- Environmental, health, and safety applications in semiconductor manufacturing facilities per the requirements of SEMI S2

For hazardous location applications, see the *Tricon Planning and Installation Guide* for application-specific installation instructions.

Canadian Standards Association (CSA) — CSA has certified that the Tricon v10 controller is in full compliance with the internationally recognized electrical safety standards and is qualified for general use in North American and other jurisdictions requiring compliance with these standards.

Factory Mutual Research (FM) — Factory Mutual has certified that the Tricon v10 controller is in full compliance with the international recognized standards and is qualified for use in Class I, Division 2 Temperature T4, Groups A, B, C, and D hazardous indoor (or outdoor in a NEMA 4 cabinet) locations. For hazardous location applications, see the *Tricon Planning and Installation Guide* for application-specific installation instructions.

European Union CE Mark — Based upon the independent TÜV evaluation and test results, Triconex has certified the Tricon controller is suitable to use in the European Union and all other jurisdictions requiring compliance with the European Union EMC Directive No. 89/336/EEC and Low Voltage Equipment Directive No. 72/23/EEC, see Certificate of Compliance for details. For hazardous location applications, see the *Tricon Planning and Installation Guide* for application-specific installation instructions.

U.S. Nuclear Regulatory Commission (NRC) — The NRC has certified that the Tricon controller is suitable for use in nuclear 1E applications within the limitations and guidelines referenced in the NRC Safety Evaluation Report (SER) ML013470433, *Review of Triconex Corporation Topical Reports 7286-545, "Qualification Summary Report"* and *7286-546, "Amendment 1 To Qualification Summary Report," Revision 1.* This report is available from the NRC via the Agency Document Access and Management System (ADAMS) Web site. This qualification was based upon EPRI TR-107330, *Generic Requirements Specification for Qualifying a Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants.* For details on models and revisions qualified for 1E applications, please contact Invensys Nuclear by calling toll-free 866-703-6300, toll 949-885-0885, or visit the Invensys Nuclear Web site at http://www.invensysnuclear.com.

Chassis Options

A Tricon system is made up of one or more chassis assemblies which contain I/O and communication modules. The first chassis of a system is called the main chassis (model 8110). To enlarge a system, expansion chassis (model 8111) and/or RXM chassis (model 8112) can be added. (See "System Configuration" on page 11 for details.)

I/O Expansion Bus

Each chassis has six RS-485 I/O expansion bus ports at the top left corner of the backplane. There are two sets of ports for channels A, B, and C, providing for two triplicated serial communications paths between chassis. One set of cables is required for each expansion chassis and for the RXM chassis which houses the primary RXM module set. The standard length of a cable set (model 9000) is 6 feet—longer cables are available if needed.

The triplicated I/O bus transfers data between the I/O modules and the main processors at 375 kilobits per second. The communication bus runs between the main processors and the communication modules at 2 megabits per second.
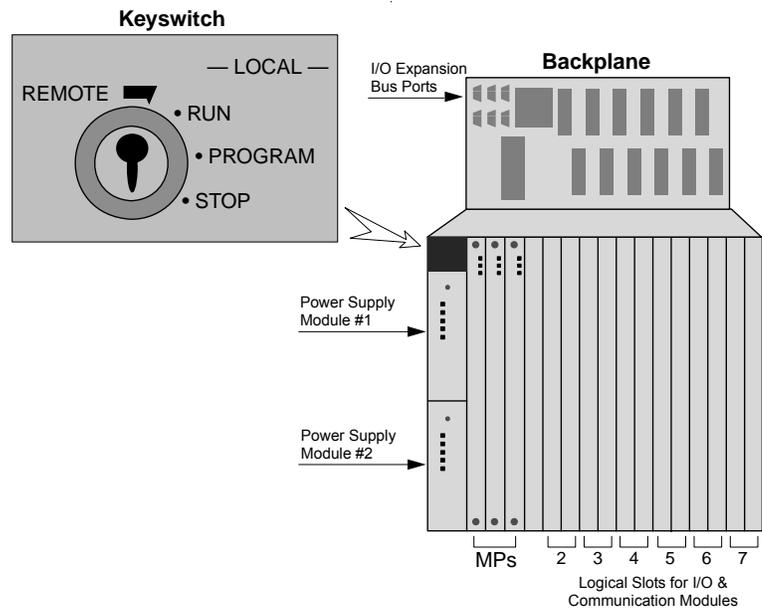
Keyswitch for System Control

The main chassis has a four-position keyswitch which controls all the chassis in the system. The keyswitch setting is readable by Tricon controllers, TriStation software, and the control programs. Switch settings are:

RUN—Normal operation with read-only capability. The main processors execute the previously-loaded control program. Attempts to modify program variables by TriStation, Modbus masters or external hosts are rejected. However, an control program may call gated access functions to enable external host writes during a designated window of time.

PROGRAM—For program loading and checkout. Allows control of the Tricon system from the TriStation platform, including Download All and Download Change. Also allows writes to program variables by external hosts.

STOP—Stops reading inputs, forces non-retentive digital and analog outputs to 0, and halts the control program. (Retentive outputs retain the value they had before the keyswitch was turned to STOP.) The STOP setting can be used for installation and service of process-related equipment, *but is not required for service of the Tricon.*

REMOTE—Allows writes to program variables by TriStation and external hosts. (Download All and Download Change by TriStation are not allowed.) Modification of program logic is not allowed.

Mechanical Specifications

These specifications apply to Main, Expansion and RXM Chassis; Power Supply Modules; and other modules where indicated.

Overall Dimensions	19 in wide by 22.75 in high by 17.75 in deep (48.3 cm by 57.8 cm by 45.1 cm)
Chassis Fabrication	Black zinc-plated and welded cold-rolled steel
Approximate Weights	
Main or Expansion Chassis	54.0 lbs. (24.5 kg.)
Power Module	7.2 lbs. (3.3 kg.)
Main Processor	4.7 lbs. (2.1 kg.)
I/O Module	4.7 to 6.0 lbs. (2.1 kg. to 2.7 kg)
Communication Module	5.0 lbs. (2.3 kg.)
16-point Termination Panel	.09 lbs. (.04 kg.)
32-point Termination Panel	2.1 lbs. (.95 kg.)

Product Specifications

Chassis and Mounting Specifications

The Tricon system can be rack-mounted or panel-mounted in an industry-standard NEMA enclosure as described on the next page. Cabinets can optionally be equipped with base and casters. Multiple cabinets can be bolted together on the sides, but sufficient clearance must be allowed to fully open their front and rear doors.

Slot Covers

All unused slots in a chassis should be filled with Blank I/O Slot Panels (model 8105) to maintain proper air flow.

Heat Management

When mounting Tricon chassis into vented or non-vented enclosures, the integration engineer must make provisions for sufficient heat management.

Triconex recommends the installation of baffles (Triconex part number 2000361-001), as shown on page 23. For temperatures above 122° F (50° C), other heat management provisions must be implemented, such as:

• Louvers and pagoda top

• Enlarged front and rear louvers with raised pagoda top

• Lower density filters

• Redundant fans (running all the time) with appropriate louvers and pagoda top

• Failure detection circuitry
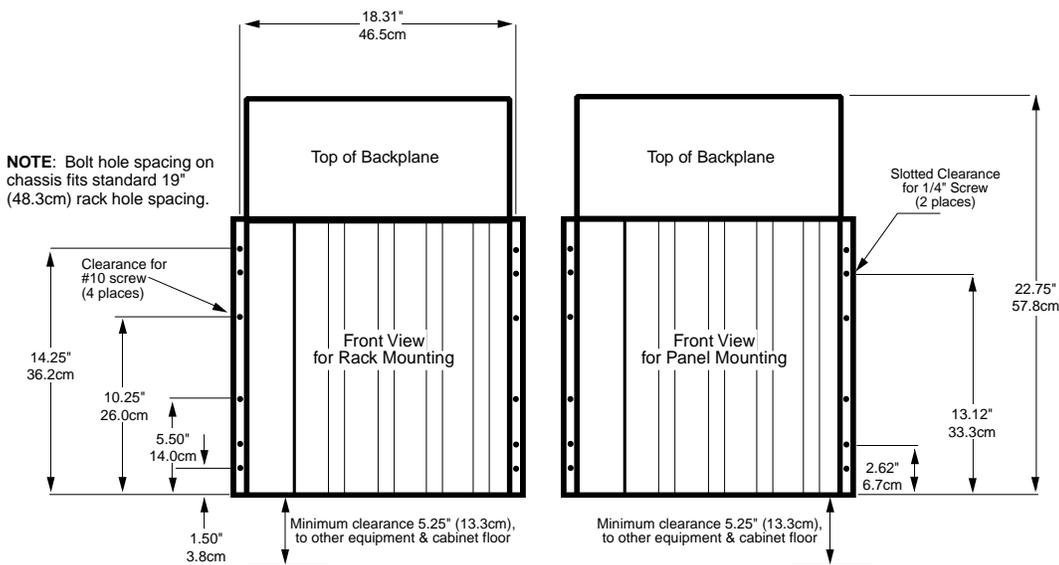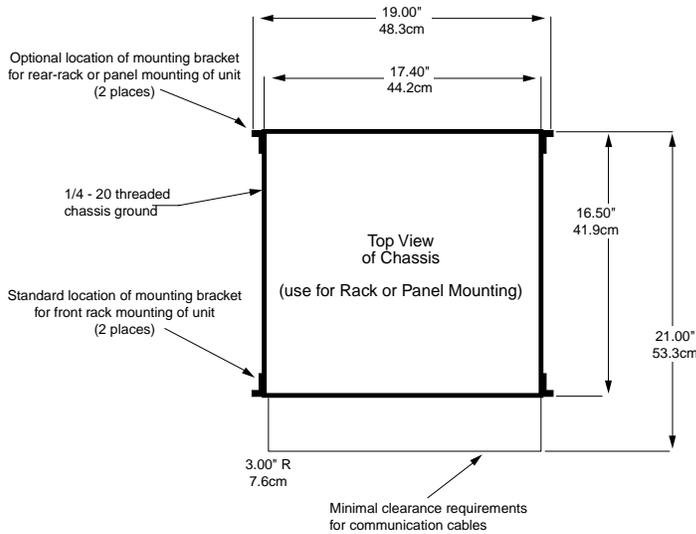
Dimensions and Clearances for Rack and Panel Mounting

31.5"
(800 mm)

Field Power Supply

A/C Distribution
Panel

Tricon
Main
Chassis

Tricon
Expansion
Chassis

3.5" minimum
(89 mm minimum)

FRONT VIEW

31.5"
(800 mm)

Baffle

1.75"
(44.5 mm)
minimum

Tricon
Chassis
(side view)

4.0" minimum
(102 mm minimum)

SIDE VIEW

31.5"
(800 mm)

DC Distribution
Panel

Analog Input/
Digital Input
External
Termination
Panel
4.5" x 10"
(114 mm x 254 mm)

Wire Duct

Wire Duct

16-point
Digital Output
External
Termination
Panel
4.5" x 5.0"
(114 mm x 127 mm)

86.0"
(2,200 mm)

REAR VIEW

Typical Dimensions and Clearances for Chassis Installation with External Terminations

NOTE

This drawing shows a typical set-up for external termination panels—other set-ups are possible.
Please contact the Triconex Customer Satisfaction Center for details.

Mounting Tricon Chassis in Enclosures

Triconex will mount Tricon chassis in any of the industry-standard enclosures listed below. (Please contact Triconex regarding other enclosures, available for additional engineering and documentation charges.) See page 14 for a photograph of Tricon chassis and terminations mounted in a sample enclosure.

Enclosures Typically Supported by Triconex*

Type	Width	Depth	Height
Rittal NEMA 12	31.5 inches (800 mm)	31.5 inches (800 mm)	86.0 inches (2,200 mm)
	31.5 inches (800 mm)	31.5 inches (800 mm)	78.0 inches (2,000 mm)
MarkHon NEMA 1	31.5 inches (800 mm)	31.5 inches (800 mm)	85.0 inches (2,160 mm)

* Other sizes are available. Please contact Triconex for more information.

Product Specifications

Power Modules

Each Tricon chassis is equipped with two power modules—either one is fully capable of running the Tricon at full load and rated temperature. Each power module can be replaced online. The power modules, located on the left side of the chassis, convert line power to DC power appropriate for all Tricon modules. Terminal strips for system grounding, incoming power and hardwired alarms are located on the lower left corner of the backplane. Incoming power should be rated for a minimum of 240 watts per power supply.

The power module alarm contacts are actuated when:

- A module is missing from the system
- The hardware configuration conflicts with the control program's logical configuration
- A module fails
- A main processor detects a system fault
- Primary power to a power module fails
- A power module has a "Low Battery" or "Over Temperature" warning

Front Panel of Power Module:
(located on lower left side of chassis)
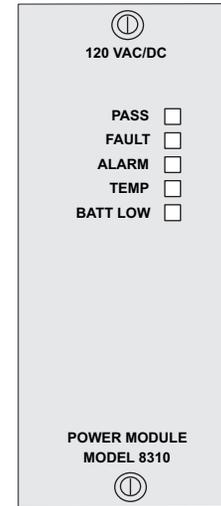
Power Module Specifications

Isolation	>1000 VAC or 1500 VDC, Input to Output
Input Terminations	Protected by safety cover
	Accepts three 12-gauge wires (3.310mm^2): neutral, hot, and protective earth (chassis ground)
Over-Temp. Sensor	Temperature warning monitor—trips when internal temp. is greater than 181° F (83°C); this typically occurs at ambient temperature 140°F (60°C) or higher
Alarm Contacts	Normally open, normally closed and common
	Each contact supports 120 VAC @ 1 amp
	Accepts 12-gauge (3.310mm^2) wire
	Protected by safety cover
Input Power Required	240 watts minimum per Power Module
Output Power	175 watts at 140°F (60°C)
Output Voltage	6.5 VDC, ±1% under all operating conditions
Output Current	27 amps maximum at 140°F (60°C) ambient

Terminal Strip for Power Module:
(located on backplane above the Power Module)
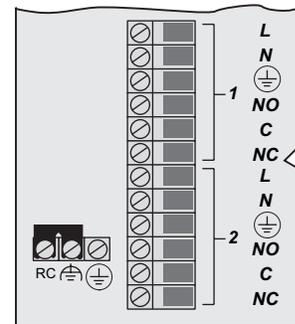
Power Module Model	8310	8311	8312
Chassis Type	Main/Expansion/RXM	Main/Expansion/RXM	Main/Expansion/RXM
Nominal Voltage	120 VAC/VDC	24 VDC	230 VAC
Input VAC @ 47-63 Hz	85-140	n/a	185-285
Input VDC	95-180	22-31	n/a
Fuse Rating and Type	5 amps, time-delay	15 amps, time-delay	2.5 amps, time-delay
Output Hold Time (nominal to 0 volts)	20 ms minimum	2.8 ms minimum	20 ms minimum
Diagnostic Indicators	PASS, FAULT, ALARM, TEMP, BAT LOW	PASS, FAULT, ALARM, TEMP, BAT LOW	PASS, FAULT, ALARM, TEMP, BAT LOW

Main Processor Modules

Model 3008 Main Processors are available for Tricon v9.6 and later systems. For detailed specifications, see the *Planning and Installation Guide for Tricon Systems*.

Three MPs must be installed in the main chassis of every Tricon system. Each MP independently communicates with its I/O subsystem and executes the user-written control program.

Sequence of Events (SOE) and Time Synchronization

During each scan, the MPs inspect designated discrete variables for state changes known as *events*. When an event occurs, the MPs save the current variable state and time stamp in the buffer of an SOE block.

If multiple Tricon systems are connected by means of NCMs, the time synchronization capability ensures a consistent time base for effective SOE time-stamping. See page 70 for more information.

Diagnostics

Extensive diagnostics validate the health of each MP, I/O module and communication channel. Transient faults are recorded and masked by the hardware majority-voting circuit. Persistent faults are diagnosed and the errant module is hot-replaced.

MP diagnostics perform these tasks:

- Verify fixed-program memory and static RAM

- Test all basic processor and floating-point instructions and operating modes

- Validate user memory by means of the TriBus hardware-voting circuitry

- Verify the shared memory interface with each I/O communication processor and channel

- Verify handshake and interrupt signals between the CPU, each I/O communication processor and channel

- Check each I/O communication processor and channel microprocessor, ROM, shared memory access and loopback of RS-485 transceivers

- Verify the TriClock and TriBus interfaces

Physical Description of Model 3008 Main Processors

Feature	Description
Microprocessor	Motorola MPC860, 32 bit, 50 MHz
Memory	• 16 MB DRAM (non-battery backed-up) • 32 KB SRAM, battery backed-up • 6 MB Flash PROM
Tribus Communication Rate	• 25 megabits per second • 32-bit CRC protected • 32-bit DMA, fully isolated
I/O Bus and Communication Bus Processors	• Motorola MPC860 32 bit 50 MHz

Indicators on Main Processors

PASS	Module has passed self-diagnostic tests
FAULT	Module has a fault and should be replaced
ACTIVE	Module is executing the user-written control program
MAINT1	Maintenance indicator 1
MAINT2	Maintenance indicator 2
COM TX	Transmitting data across COMM bus
COM RX	Receiving data from COMM bus
I/O TX	Transmitting data across I/O bus
I/O RX	Receiving data from I/O bus
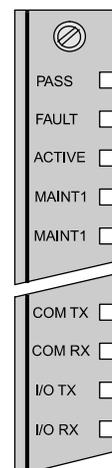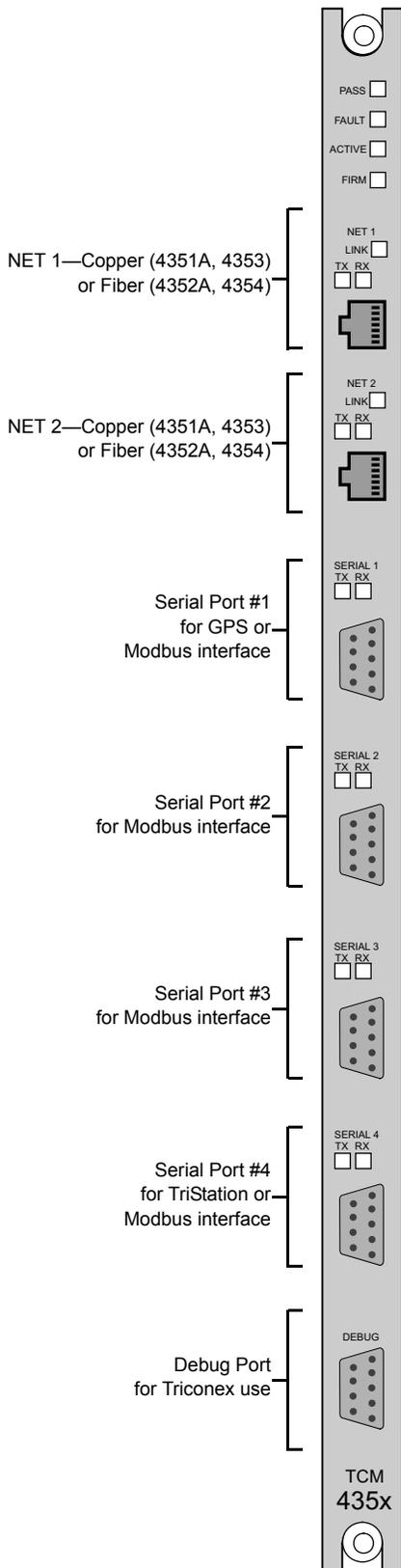
Tricon Communication Module

The Tricon Communication Module (TCM), which is compatible with only Tricon v10.0 and later systems, allows the Tricon to communicate with TriStation, other Tricon or Trident controllers, Modbus master and slave devices, and external hosts over Ethernet networks.

Each TCM contains four serial ports, two network ports, and one debug port (for Triconex use).

Each serial port is uniquely addressed and can be configured as a Modbus master or slave. Serial port #1 supports either the Modbus or the Trimble GPS interface. Serial port #4 supports either the Modbus or the TriStation interface. Each TCM supports an aggregate data rate of 460.8 kilobits per second, for all four serial ports.

Programs for the Tricon use variable names as identifiers but Modbus devices use numeric addresses called *aliases*. Therefore, an alias must be assigned to each Tricon variable name that will be read by or written to a Modbus device. An alias is a five-digit number which represents the Modbus message type and the address of the variable in the Tricon. An alias number is assigned in TriStation.

Any standard Modbus device can communicate with the Tricon through the TCM, provided that aliases are assigned to the Tricon variables. Alias numbers must also be used when host computers access the Tricon through other communication modules. See "Communication Capabilities" on page 59 for more information.

Each TCM contains two network ports—NET 1 and NET 2. Models 4351A and 4353 have two copper Ethernet (802.3) ports and Models 4352A and 4354 have two fiber-optic Ethernet ports. 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 and Peer-to-Peer Time Synchronization protocols.

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.

Figure labels

NET 1—Copper (4351A, 4353) or Fiber (4352A, 4354)

NET 2—Copper (4351A, 4353) or Fiber (4352A, 4354)

Serial Port #1 for GPS or Modbus interface

Serial Port #2 for Modbus interface

Serial Port #3 for Modbus interface

Serial Port #4 for TriStation or Modbus interface

Debug Port for Triconex use

PASS
FAULT
ACTIVE
FIRM

NET 1 LINK TX RX

NET 2 LINK TX RX

SERIAL 1 TX RX

SERIAL 2 TX RX

SERIAL 3 TX RX

SERIAL 4 TX RX

DEBUG

TCM 435x

TCM Specifications

Model Number	4351A, 4352A, 4353, 4354	
Serial ports	4, RS-232/RS-485 ports, DB-9 connectors	
Network ports	2, 10/100BaseT Ethernet ports, RJ-45 connectors (model 4351A and 4353) 2, fiber-optic mode Ethernet ports, MTRJ connectors with 62.5/125 um fiber cables (model 4352A and 4354)	
Port isolation	500 VDC	
Protocols	TriStation, Modbus, TCP/IP, ICMP, SNTP, TSAA, Trimble GPS, Peer-to-Peer, Peer-to-Peer Time Synchronization, Jet Direct (network printing)	
Modbus functions supported	01 — Read Coil Status	06 — Modify Register Content
	02 — Read Input Status	07 — Read Exception Status
	03 — Read Holding Registers	08 — Loopback Diagnostic Test
	04 — Read Input Registers	15 — Force Multiple Coils
	05 — Modify Coil Status	16 — Preset Multiple Registers
Communication speed	Copper Ethernet ports: 10/100 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	

Enhanced Intelligent Communication Module

The model 4119A Enhanced Intelligent Communication Module (EICM) allows the Tricon to communicate with Modbus masters and slaves, TriStation and printers.

For Modbus connections, the EICM user 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).

Each EICM contains four serial ports and one parallel port which can operate concurrently. Each serial port can be configured as a Modbus master with up to seven Modbus masters per Tricon chassis. A single Tricon system supports a maximum of two EICMs, which must reside in one logical slot. (The hot-spare feature is not available for the EICM, though you can replace a faulty EICM while the controller is online.) Each serial port is uniquely addressed and supports either the

Modbus or TriStation interface. Modbus communication can be performed in either RTU or ASCII mode. The parallel port provides a Centronics interface to a printer.

Each EICM supports an aggregate data rate of 57.6 kilobits per second (for all four serial ports).

Programs for the Tricon use variable names as identifiers but Modbus devices use numeric addresses called *aliases.* Therefore an alias must be assigned to each Tricon variable name that will be read by or written to a Modbus device. An alias is a five-digit number which represents the Modbus message type and the address of the variable in the Tricon. An alias number is assigned in TriStation.

Any standard Modbus device can communicate with the Tricon through the EICM, provided that aliases are assigned to the Tricon variables. Alias numbers must also be used when host computers access the Tricon through other communication modules, such as the NCM. See for more information.

EICM Specifications

Model Number	4119A, Isolated
Serial ports	4 ports RS-232, RS-422 or RS-485
Parallel ports	1, Centronics, isolated
Port isolation	500 VDC
Protocol	TriStation, Modbus
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	1200, 2400, 9600, or 19,200 Baud
Diagnostic Indicators	PASS, FAULT, ACTIVE
	TX (Transmit) — 1 per port
	RX (Receive) — 1 per port

PASS
FAULT
ACTIVE

1TX
1RX

Serial Port #1
for Modbus interface

2TX
2RX

Serial Port #2
for Modbus interface

3TX
3RX

Serial Port #3
for Modbus interface

4TX
4RX

Serial Port #4
for TriStation
or Modbus

PRT

Parallel Port #5
for Centronics
compatible printer

EICM
4119A
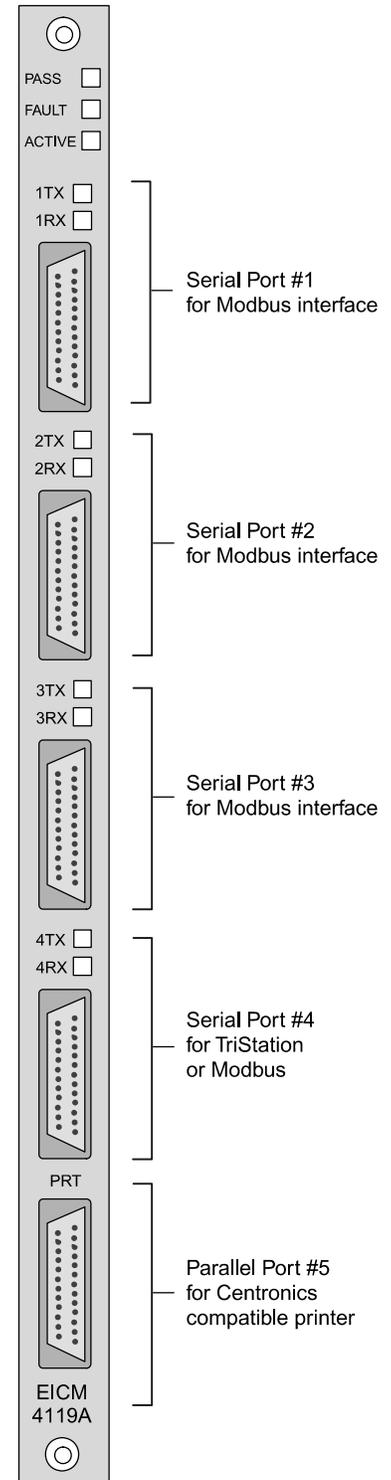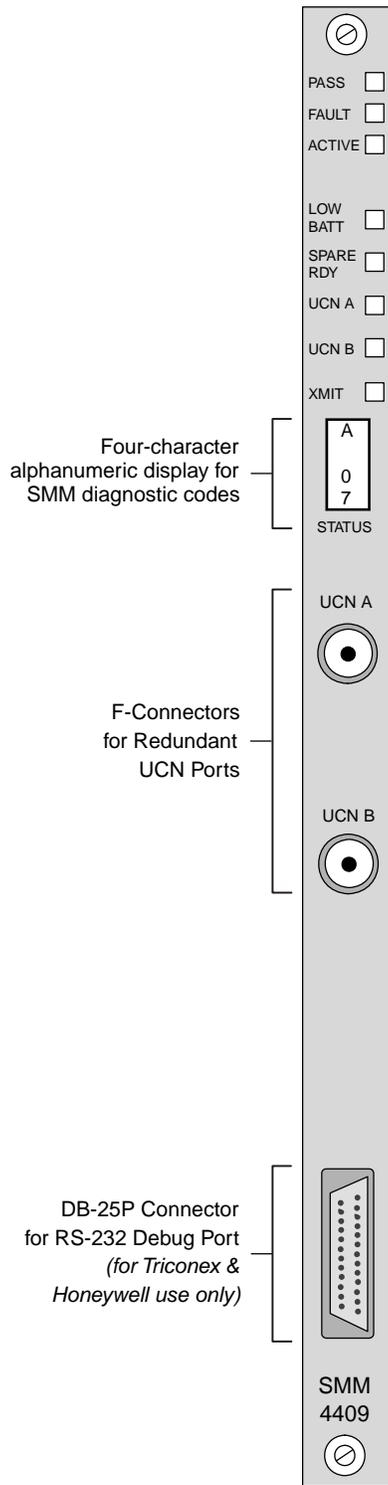
Safety Manager Module

The model 4409 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 Distributed Control System. Appearing to the Honeywell system as a safetynode on the UCN, the SMM communicates process information at full network data rates for use anywhere on the TDC 3000. The SMM transmits Tricon aliased data (including system variables) and diagnostic information to operator workstations in display formats that are familiar to Honeywell operators.

The SMM makes the following functions available to the TDC 3000:

- Handles critical I/O points and passes results to the DCS

- Processes Tricon alarms and propagates them to user-defined DCS destinations (consoles, printers, etc.)

- Reads/writes aliased data to satisfy DCS requests

- Reads Tricon diagnostics for display by the DCS

- Write protection to lock out changes to the Tricon safety system from all TDC 3000 sources

- *Time synchronization* from the DCS master clock

- *Peer-to-Peer communication* for plants with many Tricon safety systems, each containing an SMM— the DCS can use shared data to alert downstream Tricons of significant process changes

- *Sequence of Events*—transmits Tricon event data to Universal Stations for display or History Modules for recording, to help determine the cause of plant trips and increase process up-time

- Hot-spare capability for uninterrupted communication with Honeywell networks

Image labels (left of module illustration):

Four-character alphanumeric display for SMM diagnostic codes

F-Connectors for Redundant UCN Ports

DB-25P Connector for RS-232 Debug Port *(for Triconex & Honeywell use only)*

Module panel indicators: PASS, FAULT, ACTIVE, LOW BATT, SPARE RDY, UCN A, UCN B, XMIT, A 0 7 STATUS, UCN A, UCN B, SMM 4409

SMM Specifications

Model Number	4409
UCN ports	2 isolated (AC coupled)
UCN data rate	5 MBytes per second
Status indicators	PASS (Module Status)
	FAULT (Module Status)
	ACTIVE (Module Status)
	LOW BATT (Low Battery)
	SPARE RDY (Hot Spare Ready)
	UCN A (UCN Port A Active)
	UCN B (UCN Port B Active)
	XMIT (SMM Transmitting)
	STATUS (Module Node and Diagnostic Info.)
Power Module load	< 20 watts
Isolation	500 VDC

Network Communication Module

With a model 4329 Network Communication Module (NCM) installed, the Tricon can communicate with other Tricons and with external hosts over Ethernet (802.3) networks. The NCM supports a number of Triconex proprietary protocols and applications as well as user-written applications, including those that use TSAA protocol.

The NCMG module has the same functionality as the NCM as well as the ability to synchronize time based on a GPS system. For more information, see the *Tricon Communication Guide*.

The NCM provides two BNC connectors as ports: NET 1 supports Peer-to-Peer and Time Synchronization protocols for safety networks comprised of Tricons only. NET 2 supports open networking to external systems using Triconex applications such as TriStation, SOE, OPC Server, and DDE Server or user-written applications. See

for more information about Triconex protocols and applications.

Two NCMs can reside in one logical slot of the Tricon chassis, but they function independently, not as hot- spare modules. External hosts can read or write data only to Tricon variables to which Alias numbers have been assigned. (See for more information about Aliases.)

The NCM is compatible with the IEEE 802.3 electrical interface and operates at 10 megabits per second. The NCM connects with external host computers by means of coaxial cable (RG58) at typical distances up to 607 feet (185 meters). Distances up to 2.5 miles (4,000 meters) are possible using repeaters and standard (thick-net or fiber-optic) cabling.

The main processors typically refresh data on the NCM once per scan.

NCM Specifications

Model Number	4329, 4329G
Ethernet (802.3) ports	2, BNC connectors, RG58 50-ohm thin cable
External Transceiver Ports	2, 15-pin D-connectors
Serial port	1, RS-232 compatible
Port Isolation	500 VDC
Protocol	TSAA
	(TCP(UDP)/IP/802.3)
Functions supported	TRICON_DATA (Frame Type 1)
	TRICON_DATA_REQ (Frame Type 2)
	WRITE_TRICON_DATA (Frame Type 3)
	WRITE_TRICON_DATA_RSP (Frame Type 4)
	READ_TRICON_CLOCK (Frame Type 5)
	READ_TRICON_CLOCK_RSP (Frame Type 6)
	SET_TRICON_CLOCK (Frame Type 7)
	SET_TRICON_CLOCK_RSP (Frame Type 8)
	READ_TRICON_DATA (Frame Type 11)
	READ_TRICON_RSP (Frame Type 12)
Communication speed	10 megabits per second (for Ethernet ports)
Status indicators	PASS, FAULT, ACTIVE
	TX (Transmit) — 1 per port
	RX (Receive) — 1 per port

PASS
FAULT
ACTIVE

NET 1
TX
RX

BNC Connector for Thin IEEE 802.3 Cable

Port #1—for Peer-to-Peer & Time Synchronization Only

15-Pin "D" Connector for Self-powered External Transceiver (reserved)

NET 2
TX
RX

BNC Connector for Thin IEEE 802.3 Cable

Port #2—for TSAA, External Host Applications (including TRISTATION) & TCP-IP/UDP-IP

15-Pin "D" Connector for Self-powered External Transceiver (reserved)

COMM
TX
RX

RS-232 Serial Port Reserved for future use

NCM 4329

Interface to
I/A Series Nodebus

BNC Connector
Reserved

AUI Connector
to DNBI Nodebus Data

RS-423 Serial Port
to DNBI Nodebus Control

TriStation/TSAA Interface

Node Address Switches

NET2 BNC Connector
TriStation, SOE and
and TSAA applications

RS-232/422 Serial Port
Reserved

RS-232 Serial Port
Reserved

PASS
FAULT
ACTIVE

I/A SERIES
NODEBUS

ONLINE
SBRDY

TX RX

NET1

DNBI

TX RX

TS/TSAA

NODE
ADDRESS

TX RX
NET2

2 TX RX

1 TX RX

ACM
4609

Advanced Communication Module (ACM)

The model 4609 ACM acts as an interface between a Tricon controller and a Foxboro Intelligent Automation (I/A) Series system, appearing to the Foxboro system as a safety node on the 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 (including system variables and system aliases) 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 using the Object Management Database (OMDB)

- Processes Tricon alarms and propagates them to user-defined I/A Series destinations (consoles, printers, etc.)

- Propagates Tricon alarms as I/A Series system messages

- Reads/writes aliased data to satisfy I/A Series requests

- Time synchronization from the I/A Series environment

- Reads Tricon diagnostics for display by the I/A Series workstation

- Write protection to lock out changes to the Tricon safety system from all I/A Series sources

- Hot-spare capability for uninterrupted communication with the I/A Series Nodebus

The ACM also supports the following Triconex protocols and applications on external host PCs connected to a separate BNC port (labeled NET 2):

- Tristation protocol for the TriStation software

- TSAA protocol for Triconex applications

- TSAA/TCP(UDP)IP for user-written applications on external hosts

ACM Specifications

Model Number	4609
Nodebus Ports	
BNC connector	1 for RG58 50-ohm thin cable (reserved)
15-pin D connector	1 for AUI cable to DNBI
9-pin RS-423 connector	1 for Control Bus to DNBI
NET 2 port[1]	1 BNC connector for RG58 50-ohm
	Thin cable to Ethernet network
9-pin serial ports	RS-232/RS-485 protocol (reserved)
Port isolation	500 VDC (Ethernet and RS-232 ports)
Communication speeds	
BNC and 15-pin D connectors	10 megabits per second
9-pin Nodebus connector	2400 baud
Status indicators	
Module status	PASS, FAULT, ACTIVE
Nodebus/standby activity	ONLINE and SBRDY
Port activity	TX and RX—1 each per port
Power module load	20 watts

1. The address for this port is set by the TS/TSAA Node Addresses switches.

Hiway Interface Module

The model 4509 Hiway Interface Module (HIM) acts as an interface between a Tricon controller and a Honeywell TDC 3000 control system by means of the Hiway Gateway and Local Control Network (LCN). The HIM can also interface with Honeywell's older TDC 2000 control system by means of the Data Hiway.

The HIM enables higher-order devices on the LCN or Data Hiway, such as computers and operator workstations, to communicate with the Tricon.

The HIM allows redundant BNC connections directly to the Data Hiway and has the same functional capacity as four extended Data Hiway Port (DHP) addresses.

The HIM provides eight Hiway addresses, implements the same slot structure as the DHP, and typically refreshes all data in less than 0.5 seconds. The hot-spare capability allows online replacement of a faulty module.

HIM Specifications

Model Number	4509
Data Hiway channels	2 isolated (AC coupled)
Poll response switches	2 per channel
Baud rate	250 kilobits per second
Status indicators	PASS (Module Status)
	FAULT (Module Status)
	ACTIVE (Module Status)
	ON LN (HIM Online)
	H I/F (Hiway Interface)
	CAL UP (Call-up Received)
	CH A (Channel A Active)
	CH B (Channel B Active)
	XMIT (HIM Transmitting)
	STD BY IN (Standby Module Inserted)
	STD BY READY (Standby Module Ready)
Power Module load	< 10 watts
Isolation	500 VDC

STATUS LEDs

PASS — Self-test OK
FAULT — Module Fault
ACTIVE — Module Active
ON LN — HIM On-line
H I/F — Hiway Interface
CAL UP — Call-up Received
CH A — Channel A Active
CH B — Channel B Active
XMIT — HIM Transmitting
STD BY IN — Standy-by Module Inserted
STD BY READY — Stand-by Module Ready

A — Data Hiway Channel A

POLL RESPONSE SWITCHES

A/C — Channel A, Coarse Adjustments
A/F — Channel A, Fine Adjustments
B/C — Channel B, Coarse Adjustments
B/F — Channel B, Fine Adjustments

DB-9P Connector for RS-232 Debug Port (for Triconex use only)

B — Data Hiway Channel B

Highway Interface 4509

Product Specifications

Remote Extender Module (RXM)

RXMs and chassis allow I/O modules to be located several kilometers from the main chassis. RXM sets, consisting of three identical modules, serve as repeaters and extenders of the Tricon I/O bus and provide ground loop isolation. A primary RXM set supports three remote locations by connecting to three remote RXM sets housed in a remote chassis. See "System Configuration" on page 11 regarding configurations that use RXMs.

RXM sets are available for fiber-optic cables with a communication rate of 375 kilobits per second. These sets provide maximum immunity against electro-static and electro-magnetic interference, and support configurations with optical modems and fiber-optic point-to-point cabling. Remote sites can be located as far as 7.5 miles (12 kilometers) from the primary site.

The figure at right shows uni-directional cabling for three channels of a remote location. For each channel, one cable carries data transmitted from the primary RXM to the remote RXM, and the other cable carries data received by the primary RXM from the remote RXM. A pair of modules must be wired for each of the three channels, amounting to a total of six cables for each remote location.
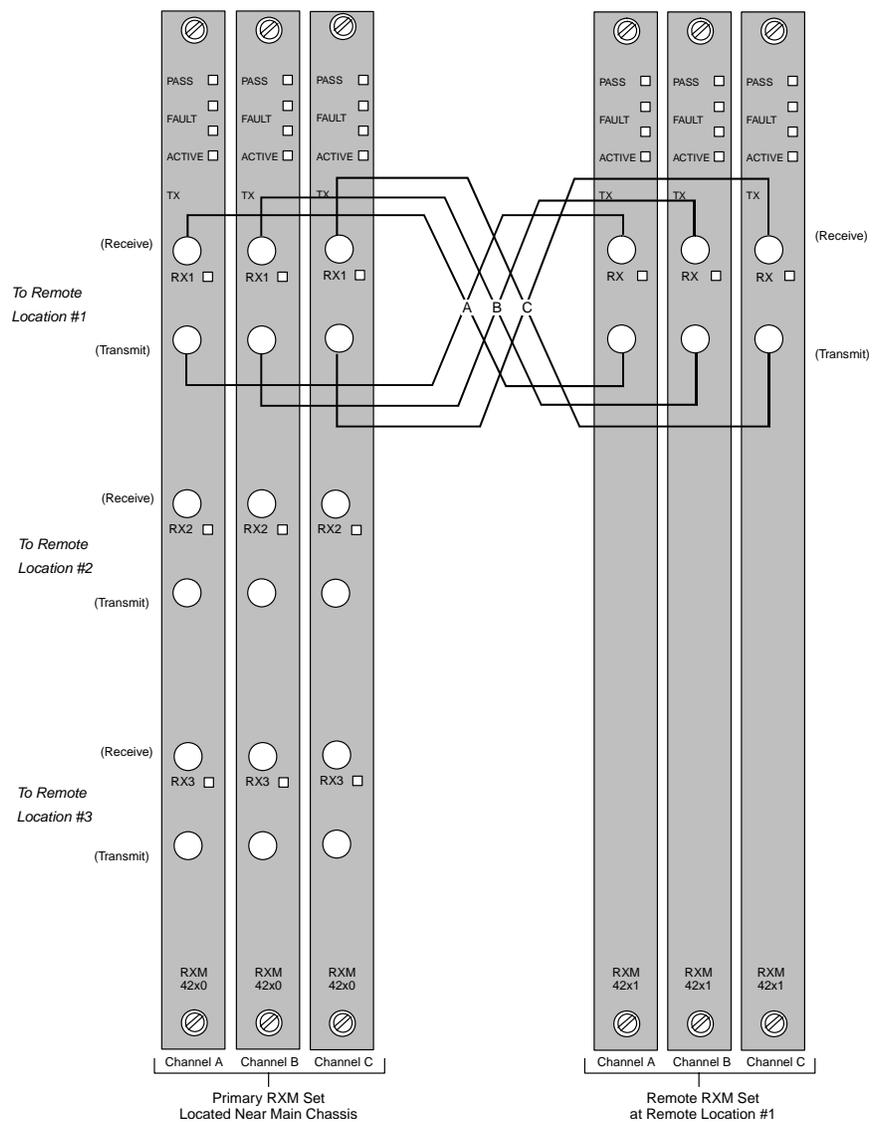
Sample Wiring for One Remote Location

NOTE: The selection and installation of fiber-optic cabling requires specialized knowledge, training and tools. Triconex recommends hiring a fiber-optic specialist to handle these tasks.

RXM Specifications

RXM Model	4200-3	4201-3	4210-3	4211-3
RXM Chassis Location	Primary	Remote	Primary	Remote
Cable Type	Multi-mode	Multi-mode	Single-mode	Single-mode
Cable Length Limit	1.2 miles (2 kilometers)	1.2 miles (2 kilometers)	7.5 miles (12 kilometers)	7.5 miles (12 kilometers)
Connectors	6/remote site	6	6/remote site	6
Remote Sites Supported	3	n/a	3	n/a
Modem Ports	Fiber Optic with ST connectors	Fiber Optic with ST connectors	Fiber Optic with ST connectors	Fiber Optic with ST connectors
Diagnostic Indicators	PASS, FAIL, ACTIVE, TX, RX1, RX2, RX3	PASS, FAIL, ACTIVE, TX, RX1, RX2, RX3	PASS, FAIL, ACTIVE, TX, RX1, RX2, RX3	PASS, FAIL, ACTIVE, TX, RX1, RX2, RX3

TMR Digital Input Modules

Each TMR digital input (DI) module has three isolated input channels which independently process all data input to the module. A microprocessor on each channel scans each input point, compiles data, and transmits it to the main processors upon demand. Then input data is voted at the main processors just prior to processing to ensure the highest integrity. All critical signal paths are 100 percent triplicated for guaranteed safety and maximum availability. Each channel conditions signals independently and provides optical isolation between the field and the Tricon.

All TMR digital input modules sustain complete, ongoing diagnostics for each channel. Failure of any diagnostic on any channel activates the module Fault indicator which in turn activates the chassis alarm signal. The module Fault indicator points to a channel fault, *not* a module failure. The module is guaranteed to operate properly in the presence of a single fault and may continue to operate properly with certain kinds of multiple faults.

Models 3502E, 3503E, and 3505E can self-test to detect stuck-ON conditions where the circuitry cannot tell whether a point has gone to the OFF state. Since most safety systems are set up with a

de-energize-to-trip capability, the ability to detect OFF points 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 communication processor while the test is running.

All TMR digital input modules support hot-spare capability, and require a separate external termination panel (ETP) with a cable interface to the Tricon backplane. Each module is mechanically keyed to prevent improper installation in a configured chassis.

Model Number	3501E/3501T	3502E	3503E	3505E
Type	TMR	TMR with Self-Test	TMR with Self-Test	TMR, Low Threshold
Voltage	115 VAC/VDC	48 VAC/VDC	24 VAC/VDC	24 VDC
Points	32, non-commoned, isolated	32, commoned in groups of 8	32, commoned in groups of 8	32, commoned in groups of 8
AC Range/DC Range	90-155 VAC/VDC	35-95 VAC/VDC	20-42.5 VAC/VDC	20-42.5 VDC
Frequency Range	DC or 47-63 Hz	DC or 47-63 Hz	DC or 47-63 Hz	n/a
Maximum Voltage	155 VAC/VDC	95 VAC/VDC	42.5 VAC/VDC	42.5 VDC
Switching Level				
OFF to ON	> 86 VAC/VDC	> 32 VAC/VDC	> 18 VAC/VDC	> 12 VDC
ON to OFF	< 28 VAC/VDC	< 11 VAC/VDC	< 6 VAC/VDC	< 4 VDC
Nominal Turn-On	6-9 mA	6-9 mA	6-9 mA	3 mA to 5 mA
Typical Hysteresis	32 VAC/VDC	7 VAC/VDC	4 VAC/VDC	2 VDC
Input Delay				
OFF to ON/ON to OFF	< 8 ms/< 15 ms	< 8 ms/< 15 ms	< 8 ms/< 15 ms	< 8 ms/< 15 ms
Point Isolation	1500 VDC/ 2500 VDC[1]	1500 VDC	1500 VDC	1500 VDC
Nominal Input Impedance	> 8.5 KΩ	> 2.9 KΩ	> 1.25 KΩ	> 1.25 KΩ
Nominal Field Power Load				
Per ON point	1.5 watts	1.0 watts	0.5 watts	0.5 watts
@ max. field voltage	2.9 watts	3.2 watts	1.5 watts	1.5 watts
Diagnostic Indicators				
Input Status	1 per point	1 per point	1 per point	1 per point
Module Status	PASS, FAULT, ACTIVE	PASS, FAULT, ACTIVE	PASS, FAULT, ACTIVE	PASS, FAULT, ACTIVE
Stuck Test	n/a	ON	ON	ON
Color Code	Red	Dark Red	Dark Red	Dark Red

1. For 3501T.

Product Specifications

64-Point Digital Input Modules

Each 64-point digital input (DI) module has three isolated channels which independently process all data input to the module. A microprocessor on each channel scans each input point, compiles data and transmits it to the main processors on demand. Then input data is voted at the main processors just prior to processing to ensure the highest integrity.

All digital input modules sustain complete, ongoing diagnostics for each channel. A failure on any channel activates the Fault indicator which in turn activates the chassis alarm. A TMR module is guaranteed to operate properly in the presence of a single fault and

may operate properly with certain kinds of multiple faults.

All digital input modules support hot-spare modules and require a separate external termination panel (ETP) with a cable interface to the Tricon backplane. Each module is mechanically keyed to prevent improper installation in a chassis.

The model 3504E *High Density Digital Input Module* continuously verifies the ability of the Tricon to detect transitions to the opposite state. On this TMR module, all critical signal paths are 100 percent triplicated for guaranteed safety and maximum availability. Each channel conditions signals independently between the field and the Tricon.

The *Single Digital Input Module* (model 3564) is optimized for safety-critical applications where low cost is more important than maximum availability. On single modules, only those portions of the signal path which are required to ensure safe operation are triplicated. Special self-test circuitry detects all stuck-ON and stuck-OFF fault conditions in less than half a second. If a single module detects an input fault, it reports that point as OFF, which may cause a glitch during switch-over to a hot-spare module.

Model Number	3564	3504E	
Type	Single	TMR	
Voltage	24 VDC	24 or 48 VDC[1]	
Points	64, commoned	64, commoned, DC coupled	
DC Range	15-30 VDC	20-72 VDC	
Maximum Voltage	36 VDC	72 VDC	
Switching Level		24 V	48 V
OFF to ON	> 15 VDC	>18 VDC	>32 VDC
ON to OFF	< 6 VDC	< 6 VDC	<11 VDC
Nominal Turn-On	2-3 mA	negligible	
Typical Hysteresis	4 VDC	4 VDC/7 VDC	
Input Delay			
OFF to ON/ON to OFF	< 2 ms/< 2 ms	< 10 ms/< 10 ms	
Minimum Point Isolation	1500 VDC	n/a	
Nominal Input Impedance	> 3.0 KΩ	> 30 KΩ	
Nominal Field Power Load			
Per ON point	0.2 watts	negligible	
@ maximum field voltage	0.5 watts	negligible	
Diagnostic Indicators			
Input Status	1 per point	1 per point	
Module Status	PASS, FAULT, ACTIVE	PASS, FAULT, ACTIVE	
Stuck Test	ON and OFF	ON and OFF	
Color Code	Dark Red	Dark Red	

1. The voltage is selected using the TriStation software.

Pulse Input Module

The pulse input (PI) module provides eight very sensitive, high-frequency inputs. It is optimized for use with non-amplified magnetic speed sensors common on rotating equipment such as turbines or compressors. The module senses voltage transitions from magnetic transducer input devices, accumulating them during a selected window of time (rate measurement). The resulting count is used to generate a frequency or RPM which is transmitted to the main processors. The pulse count is measured to 1 micro-second resolution.

The PI module includes three isolated input channels. Each input channel independently processes all data input to the module and passes the data to the main processors, which vote on the data to ensure the highest integrity.

Each module provides complete ongoing diagnostics on each channel. Failure of any diagnostic on any channel activates the Fault indicator, which in turn activates the chassis alarm signal. The Fault indicator merely indicates a channel fault, not a module failure. The module is guaranteed to operate properly in the presence of a single fault and may continue to operate properly with certain kinds of multiple faults.

The pulse input module supports hot-spare modules.

WARNING: The PI module does not provide a totalization capability—it is optimized for measuring the speed of rotation equipment. For pulse totalization model 3515, see .

Relay Output Module

The model 3636R/T Relay Output (RO) Module is a non-triplicated module for use on non-critical points which are not compatible with "high-side" solid-state output switches. An example is inter-facing with annunciator panels. The relay output module receives output signals from the main processors on each of three channels. The three sets of signals are then voted, and the voted data is used to drive the 32 individual relays.

Each output has a loopback circuit which verifies the operation of each relay switch independently of the presence of a load, while ongoing diagnostics test the operational status of the module. Failure of any diagnostic activates the Fault indicator, which in turn activates the chassis alarm.

The relay output module comes with normally open (NO) contacts. It supports hot-spare modules and requires a separate external termination panel (ETP) with a cable interface to the Tricon backplane.

Model Number	3511
Type	TMR
Input Signals	8, non-commoned
Resolution	16 bits
Accuracy	1000 Hz to 20,000 Hz, ± 0.01%
Input Characteristics (AC coupled, balanced differential)	
Update Rate	25 ms, typical
Impedance (load)	> 8 KW, 20 KW typical
Common Mode Range	-100 VDC to +100 VDC peak-to-peak
Normal Mode Range	1.5 V to 200 V peak-to-peak
Overrange Protection	±150 VDC, continuous
Hysteresis	150 millivolts, typical
Wave Shape	Sine, square, pulse, etc.
Duty Cycle	10% to 90%
Frequency	20 Hz to 20,000 Hz
Current Range	0-20 mA (250-ohm shunt)
Diagnostic Indicators (ON=true)	
Input Status	1 per point
Module Status	PASS, FAULT, ACTIVE
Color Code	Light Purple

Model Number	3636R/T
Type	Non-triplicated
Points	32, non-commoned
Voltage Range	155 VAC/VDC, maximum
Current Load	2A, maximum
Switching Power, Resistive	2000 V A, 150 watts maximum
Point Isolation	1500 VDC 2500 VDC[1]
Fuses	1 per output (2.5A fast-acting)
Diagnostic Indicators	
Output Status	1 per point
Module Status	PASS, FAULT, ACTIVE
Output Contact	Normally Open
Color Code	Silver Blue

1. For 3636T.

Product Specifications

Pulse Totalizer Module

The model 3515 Pulse Totalizer Input (PTI) Module provides 32 individual 31-bit counters that operate independently. The counters are used with active-flow sensors or per-unit sensors to measure a quantity (count) which is transmitted to the main processors. At the time specified by the TriStation control program, the main processors clear a single counter or all counters.

The PTI module has three isolated input channels. Each input channel independently processes all input data and passes it to the main processors, where it is voted before processing to ensure the highest integrity.

Each PTI module provides complete ongoing diagnostics on each channel, including channel-to-channel count comparison. Failure of any diagnostic on any channel activates the Fault indicator, which in turn activates the chassis alarm. The Fault indicator points to a channel fault, not a module failure. The PTI module is guaranteed to operate properly in the presence of a single fault, and may continue to operate with certain kinds of multiple faults.

The PTI module can operate with or without a hot-spare module. If you use a hot-spare module, it re-educates all counter values from the active module.

Model Number	3515
Type	TMR
Number of Input Signals	32, non-commoned
Input Frequency Range	0 Hz to 1 KHz
Minimum Input Pulse Width	300 microseconds
Accuracy	
Active Module	± 2 counts
Hot-spare module (maximum error counts during hot replacement)	1–10 >= 100 Hz 0-1 <= 100 Hz
Maximum Count	2147483647 (2^{31} - 1)
Counter Overflow (worst case @ 1 KHz)	596 Hours (24 days)
Count Overflow Indication	Count goes to negative integer
Count Resets	Individual reset per counter
Recommended Input Voltage Range	42.5 VDC absolute maximum
Count Up Switching Level	Rising edge (OFF to ON)
Switching Voltages	
OFF to ON	15 VDC typical, 18 VDC worst case
ON to OFF	8 VDC typical, 6 VDC worst case
Typical Hysteresis	4 VDC
Normal Turn-on Current	6mA to 9mA
Count Input Delay	< 15 ms
Point Isolation (opto-isolated)	1500 VDC minimum
Diagnostic Indicators	
ON or OFF State	1 per point
Module Status	PASS, FAULT, ACTIVE
Logic Power	< 10 watts
Nominal Field Power Load	0.5 watts per ON point 1.5 watts @ maximum field voltage
Color Code	Purple

TMR Digital Output Modules

A TMR digital output (DO) module receives output signals from the main processors on each of three channels. Each set of three signals is then voted by special quadruplicated output circuitry on the module. The circuitry produces one voted output signal and passes it to the field termination. The quadruplicated voter circuitry provides multiple redundancy for all critical signal paths, guaranteeing safety and maximum availability.

Each TMR digital output module has a voltage-loopback circuit which verifies the operation of each output switch independently of the presence of a load and determines whether latent faults exist. Failure of the detected field voltage to match the commanded state of the output point activates the LOAD/FUSE alarm indicator.

In addition, ongoing diagnostics are performed on each channel and circuit of a TMR digital output module. Failure of any diagnostic on any channel activates the Fault indicator, which in turn activates the chassis alarm signal. The Fault indicator merely indicates a channel fault, *not* a module failure. The module is guaranteed to operate properly in the presence of a single fault and may continue to operate properly with certain kinds of multiple faults.

All TMR digital output modules support hot-spare capability, and require a separate external termination panel (ETP) with a cable interface to the Tricon backplane. Each module is mechanically keyed to prevent improper installation in a configured chassis.

Digital outputs are designed to source the current to field devices, so field power must be wired to each output point on the field termination.

Model Number	3601E/3601T	3603B/3603E/3603T	3607E	3604E
Nominal Voltage	115 VAC	120 VDC	48 VDC	24 VDC
Type	TMR	TMR	TMR	TMR
Output Signals	16, non-commoned	16, commoned (3603E/T 16, non-commoned (3603B	16, non-commoned	16, non-commoned
Voltage Range	80-155 VAC	90-150 VDC	44-80 VDC	22-45 VDC
Voltage Drop[1]	< 3V, typical	< 1.5V, typical	< 3V, typical	< 4V, typical
Frequency Range	47-63 Hz	n/a	n/a	n/a
Current Ratings, Maximum	2A per point 12A surge/cycle	0.8A per point 4A surge/10 ms	1A per point 5A surge/10 ms	2A per point 10A surge/10 ms
Load Leakage	2 mA maximum @ 60 Hz	2 mA maximum	2 mA maximum	2 mA maximum
Chassis Leakage	4 mA maximum @ 60 Hz	n/a	n/a	n/a
Fuses (on Field Termination)	1 per output, 3A fast-acting	1 per output, 1.0A fast-acting	1 per output, 1.25A fast-acting	1 per output, 2.5A fast-acting
Point Isolation	1500 VDC/ 2500 VDC[2]	1500 VDC/ 2500 VDC[3]	1500 VDC	1500 VDC
Diagnostic Indicators				
ON or OFF state	1 per point	1 per point	1 per point	1 per point
Module Status	PASS, FAULT, ACTIVE	PASS, FAULT, ACTIVE	PASS, FAULT, ACTIVE	PASS, FAULT, ACTIVE
Field Alarm	LOAD/FUSE	LOAD/FUSE	LOAD/FUSE	LOAD/FUSE
Color Code	Green	Blue	Light Blue	Dark Blue

1. **WARNING**: The voltage drop may be significantly higher in some applications.
2. For 3601T.
3. For 3603T.

Product Specifications

16-Point Supervised and 32-Point Supervised/Non-Supervised Digital Output Modules

Designed for the most critical control programs, supervised digital output (SDO) modules meet the needs of systems whose outputs remain in a single state for extended periods of time (in some applications, for years). An SDO module receives output signals from the main processors on each of three channels. Each set of three signals is then voted upon by a fully fault-tolerant quadruplicated output switch whose elements are power transistors, so that one voted output signal is passed to the field termination.

Each SDO module has voltage and current loopback circuitry coupled with sophisticated online diagnostics that verify the operation of each output switch, the field circuit and the presence of a load. This design provides complete fault coverage without the need to influence the output signal.

The modules are called "supervised" because fault coverage is extended to include potential field problems. In other words, the field circuit is *supervised* by the SDO module so that the following field faults can be detected:

- Loss of power or blown fuse
- Open or missing load

- A field short resulting in the load being energized in error
- A shorted load in the de-energized state

Failure to detect field voltage on any output point energizes the power alarm indicator. Failure to detect the presence of a load energizes the load alarm indicator.

All SDO modules support hot-spare modules and require a separate external termination panel (ETP) with a cable interface to the Tricon backplane.

Model Number	3623/3623T[1]	3624	3625
Nominal Voltage	120 VDC	24 VDC	24 VDC
Type	TMR, Supervised	TMR, Supervised	TMR, Supervised/Non-Supervised
Output Signals	16, commoned	16, commoned	32, commoned
Voltage Range	90-150 VDC	16-30 VDC	16-32 VDC
Maximum Voltage	160 VDC	36 VDC	36 VDC
Voltage Drop	< 1.5 VDC, typical	< 1.5 VDC, typical	< 2.8 VDC @ 1.7A, typical
Power Module Load	< 10 watts	< 10 watts	< 13 watts
Current Ratings, Maximum	0.8A per point / 4A surge per 10 ms	0.7A per point / 4.8A surge per 10 ms	1.7A per point / 7A surge per 10 ms
Minimum Required Load	30 mA	30 mA	10 mA
Load Leakage	4 mA maximum	4 mA maximum	4 mA maximum
Fuses (on Field Termination)	1A fast-acting	n/a—self-protecting	n/a—self-protecting
Point Isolation	1500 VDC/ 2500 VDC[2]	1500 VDC	1500 VDC
Diagnostic Indicators			
ON or OFF State	1 per point	1 per point	1 per point
Module Status	PASS, FAULT, ACTIVE	PASS, FAULT, ACTIVE	PASS, FAULT, LOAD, ACTIVE
Field Alarm	POWER, LOAD (1 per point)	POWER, LOAD (1 per point)	LOAD (1 per point)
Color Code	Steel Blue	Turquoise Green	Dark Blue

1. CAUTION: Triconex highly recommends that you perform compatibility testing before selecting the model 3623T module for use in applications that have field wiring lengths over 328 feet (100 meters), cable that is not twisted pair, or atypical loads such as smart devices, strobe lights, or klaxons.
2. For 3623T.

8-Point Supervised Digital Output Modules

Designed for the most critical applications, supervised digital output (SDO) modules meet the needs of systems whose outputs remain in a single state for extended periods of time (in some applications, for years). An SDO module receives output signals from the main processors on each of three channels. Each set of three signals is then voted upon by a fully fault-tolerant quadruplicated output switch whose elements are mechanical power relays, so that one voted output signal is passed to the field termination.

Each SDO module has voltage and current loopback circuitry coupled with sophisticated online diagnostics that verify the operation of each output switch, the field circuit and the presence of a load. This design provides complete fault coverage without the need to influence the output signal.

The modules are called "supervised" because fault coverage is extended to include potential field problems. In other words, the field circuit is *supervised* by the SDO module so that the following field faults can be detected:

• Loss of power or blown fuse

• Open or missing load

• A field short resulting in the load being energized in error

• A shorted load in the de-energized state

Failure to detect field voltage on any output point energizes the power alarm indicator. Failure to detect the presence of a load energizes the load alarm indicator. When an optional secondary power supply is used, shorted loads in the OFF state can be detected. (This feature is not provided on model 3611E, an AC module.)

All SDO modules support hot-spare capability and require a separate external termination panel (ETP) with a cable interface to the Tricon backplane.

Model Number	3611E	3617E
Nominal Voltage	115 VAC	48 VDC
Type	TMR, Supervised	TMR, Supervised
Points	8, commoned	8, commoned
Voltage Range	90-155 VAC	36-72 VDC
Frequency Range	47-63 Hz	n/a
Maximum Switching Power	2000 VA (resistive)	150 W (resistive)
ON State Voltage Drop[1]	< 2V, typical	< 2V, typical
Current Ratings, Maximum	2A per point 10A/AC cycle	1A per point 5A/10 ms
Minimum Required Load	50 mA	100 mA
Voltage Range of Secondary Power Supply	n/a	5.00 VDC ±.25 VDC
Chassis Leakage	1mA max. @ 60 Hz	n/a
Load Leakage	4 mA max.	4 mA max.
Fuses (on Field Termination)	1 per output (2.5A fast-acting)	1 per output (1.25A fast-acting)
Point Isolation	1500 VDC, min.	1500 VDC, min.
Diagnostic Indicators		
Output Status Module Status	POINT, PWR, LOAD, PASS, FAULT, ACTIVE	POINT, PWR, LOAD, PASS, FAULT, ACTIVE
Color Code	Deep Green	Mint Green

1. **WARNING**: The voltage drop may be significantly higher in some applications.

Product Specifications

Dual Digital Output Module

The dual digital output (DDO) modules receive output signals from the main processors along a single parallel or series path, and applies a 2-out-of-3 voting process individually to each switch. The switches produce one output signal which is then passed to the field termination. While the quadru-plicated output circuitry on TMR modules provides multiple redundancy for all critical signal paths, dual circuitry provides just enough redun-dancy to ensure safe operation. The dual module is optimized for those safety-critical control programs where low cost is more important than maximum availability.

The dual digital output modules have a voltage-loopback circuit which verifies the operation of each output switch independently of the presence of a load and determines whether latent faults exist. Failure of the detected field voltage to match the commanded state of the output point activates the LOAD/FUSE alarm indicator.

In addition, ongoing diagnostics are performed on each channel and circuit of a dual digital output module. Failure of any diagnostic on any channel acti-vates the Fault indicator, which in turn activates the chassis alarm signal. A dual module operates properly in the presence of most single faults and may operate properly with some kinds of multiple faults, but stuck-OFF faults are an exception. If one of the output switches has a stuck-OFF fault, the output goes to the OFF state and a glitch may occur during switch-over to a hot-spare module.

The dual digital output modules support hot-spare capability which allows online replacement of a faulty module. Each module is mechanically keyed to prevent improper installation in a configured chassis.

The dual digital output modules require a separate external termination panel (ETP) with a cable interface to the Tricon backplane. Digital outputs are designed to source the current to field devices, so field power must be wired to each output point on the field termina-tion.

Model Number	3664/3674
Nominal Voltage	24 VDC
Type	Dual, serial (recommended for de-energize-to-trip control programs)
Output Signals	32, commoned
Voltage Range	16-30 VDC
Maximum Voltage	36 VDC
Voltage Drop	< 1.5 VDC, typical
Power Module Load	< 10 watts
Current Ratings, Maximum	2A per point
	10A surge per 10 ms
Load Leakage	2 mA maximum
Fuses (on Field Termination)	n/a—self-protecting
Point Isolation	1500 VDC minimum
Diagnostic Indicators	
ON or OFF State	1 per point
Module Status	PASS, FAULT, ACTIVE
Field Alarm	LOAD/FUSE
Load Alarm, output stuck-ON	3664 — Stuck-ON point, all others commanded state - ON or OFF
	3674 — Stuck-ON point, all others commanded OFF (de-energized)
Load Alarm, output stuck-OFF	3664 and 3674 — Stuck-OFF point, all others commanded state — ON or OFF
Color Code	Dark Blue

Analog Input Modules

An analog input (AI) module includes three independent input channels. Each input channel receives variable voltage signals from each point, converts them to digital values, and transmits the values to the three main processor modules on demand. In TMR mode, one value is then selected using a mid-value selection algorithm to ensure correct data for every scan.

Sensing of each input point is performed in a manner that prevents a single failure on one channel from affecting another channel. Each analog input module sustains complete, ongoing diagnostics for each channel. Failure of any diagnostic on any channel activates the Fault indicator for the module, which in turn activates the chassis alarm signal. The module's Fault indicator merely reports a channel fault, *not* a module failure—the module can operate properly with as many as two faulty channels.

Analog input modules support hot-spare capability which allows online replacement of a faulty module.

The analog input module requires a separate external termination panel (ETP) with a cable interface to the Tricon backplane. Each module is mechanically keyed for proper installation in a Tricon chassis.

Model Number	3700/3700A	3701	3703E
Voltage	0-5V, + 6% (only 3700A)	0-10V	0-5V or 0-10V[1], + 6%
Type	TMR	TMR	TMR
No. of Input Points	32, diff, DC coupled	32, diff, DC coupled	16, diff, isolated
Isolated Points	No	No	Yes
Input Update Rate	55 ms	55 ms	50 ms
Resolution	12 bits	12 bits	12 bits
Accuracy	< .15% of FSR, from 0° to 60°C	< .15% of FSR, from 0° to 60°C	< .15% of FSR, from 0° to 60°C
Input Resistance (load)	30 MΩ(DC), min.	30 MΩ(DC), min.	30 MΩ(DC), min.
Power-Off Resistance	30 KΩ(DC), typical	30 KΩ(DC), typical	30 MΩ(DC), min.
Common Mode Rejection	-80 dB (DC-100Hz), typical	-80 dB (DC-100Hz), typical	-90 dB @ 60Hz, min. -100 dB @ DC, min.
Common Mode Range	-12V to +12V peak	-12V to +12V peak	$\pm$200V peak
Leg-to-Leg Isolation	200 KΩ typical	200 KΩ typical	20 KΩ typical
Normal Mode Rejection			
@ 8Hz @ 60Hz @ 120Hz	-3 dB -17 dB -23 dB	-3 dB -17 dB -23 dB	-3 dB -17 dB -23 dB
Input Overrange Protection	150 VDC/115 VAC continuous	150 VDC/115 VAC continuous	150 VDC/115 VAC continuous
Current Range	0-20 mA, 250 Ω shunt	0-20 mA, 500 Ω shunt	0-20 mA, 250 Ω shunt for 5V 500 Ω shunt for 10V
Diagnostic Indicators			
Module Status	PASS, FAULT, ACTIVE	PASS, FAULT, ACTIVE	PASS, FAULT, ACTIVE
Color Code	Yellow	Light Yellow	Mustard Yellow

1. The voltage is selected using the TriStation software.

Product Specifications

Model Number	3704E	3720	3721
Voltage	0-5V or 0-10V[1], + 6%	0-5VDC, + 6%	0 to 5 VDC or -5 to +5 VDC[1], + 6%
Type	TMR	TMR	TMR
No. of Input Points	64, commoned	64, single-ended	32 differential, DC-coupled
Isolated Points	No	Yes	Yes
Input Update Rate	75 ms	10 ms	10 ms
Resolution	12 bits	12 bits or 14 bits programmable	12 bits or 14 bits programmable
Accuracy	< 0.25% of FSR from 0° to 60°C	< 0.15% of FSR from 0° to 60° C	< 0.15% of FSR from 0° to 60° C
Input Resistance (load)	30 MΩ (DC), min.	10 MΩ (DC), min.	10 MΩ (DC), min.
Power-Off Resistance	30 kΩ (DC), typical	140 kΩ (DC), typical	140 kΩ (DC), typical
Common Mode Rejection	n/a	n/a	-85 dB (DC - 100 Hz)
Common Mode Range	n/a	n/a	-12V to +12V peak
Leg-to-Leg Isolation	200 kΩ typical	420 kΩ typical	420 kΩ typical
Normal Mode Rejection	-1 dB @ 8Hz -12 dB @ 60Hz -18 dB @ 120Hz	-3 dB @ 8Hz -17 dB @ 60Hz -23 dB @ 120Hz	-3 dB @ 23 Hz -8 dB @ 60 Hz -14 dB @ 120 Hz
Input Overrange Protection	150 VDC/115 VAC continuous	150 VDC/115 VAC continuous	150 VDC/115 VAC continuous
Current Range	0-20 mA, 250 Ω shunt for 5V 500 Ω shunt for 10V	0-20 mA (plus 6% over-range) with 250 Ω shunt resistor	0-20 mA with 250 Ω shunt resistor
Diagnostic Indicators			
Module Status	PASS, FAULT, ACTIVE	PASS, FAULT, ACTIVE, FIELD	PASS, FAULT, ACTIVE, FIELD
Color Code	Copper	Yellow	Yellow

1. The voltage is selected using the TriStation software.

Analog Output Modules

An analog output (AO) module receives output signals from the main processor module on each of three channels. Each set of data is then voted and a healthy channel is selected to drive the eight outputs. The module monitors its own current outputs (as input voltages) and maintains an internal voltage reference to provide self-calibration and module health information.

Each channel on the module has a current loopback circuit which verifies the accuracy and presence of analog signals independently of load presence or channel selection. The module's design prevents a non-selected channel from driving an analog signal to the field. In addition, ongoing diagnostics are performed on each channel and circuit of the module. Failure of any diagnostic deactivates the faulty channel and activates the Fault indicator, which in turn activates the chassis alarm. The module Fault indicator merely indicates a channel fault, *not* a module failure. The module continues to operate properly with as many as two channels failed. Open loop detection is provided by a LOAD indicator which activates if the module is unable to drive current to one or more outputs.

The module provides for redundant loop power sources with individual power and fuse indicators called PWR1 and PWR2. External loop power supplies for analog outputs must be provided by the user. Each analog output module requires up to 1 amp @ 24-42.5 volts. A LOAD indicator activates if an open loop is detected on one or more output points. PWR1 and PWR2 are on if loop power is present. The 3806E High Current (AO) module is optimized for turbomachinery applications.

Analog output modules support hot-spare capability which allows online replacement of a faulty module.

The analog output module requires a separate external termination panel (ETP) with a cable interface to the Tricon backplane. Each module is mechanically keyed to prevent improper installation in a configured chassis.

Model Number	3805E	3806E		
Type	TMR	TMR		
Output current range	4-20 mA output (*+6% overrange*)	4-20 mA and 20-320 mA		
Number of output points	8	6 (4-20 mA); 2 (20-320 mA)		
Isolated points	No, commoned return, DC coupled	No, commoned return, DC coupled		
Resolution	12 bits	12 bits		
Output Accuracy	<0.25% (in range of 4-20 mA) of FSR (0-21.2 mA), from 32° to 140° F (0° to 60° C)	<0.25% (in range of 4-20 mA) of FSR (0-21.2 mA and 0-339.2 mA), from 32° to 140° F (0° to 60° C)		
External loop power (reverse voltage protected)	+42.5 VDC, maximum +24 VDC, nominal	+42.5 VDC, maximum +24 VDC, nominal		
Output loop power requirements		Max. load Vx external loop voltage		
Load (Ohms)	Loop power required		*4-20 mA*	*16-320 mA*
250	> 20 VDC (1 amp minimum)	20 VDC	≤ 275	≤15
500	> 25 VDC (1 amp minimum)	24 VDC	≤ 475	≤25
750	> 30 VDC (1 amp minimum)	28 VDC	≤ 650	≤40
1000	> 35 VDC (1 amp minimum)	32 VDC	≤ 825	≤50
Over-range protection	+42.5 VDC, continuous	< +42.5 VDC		
Switch time on leg failure	< 10 ms, typical	< 10 ms, typical		
Diagnostic Indicators				
Module status (one each per module)	PASS, FAULT, ACTIVE, LOAD, PWR1, PWR2	PASS, FAULT, ACTIVE, LOAD, PWR1, PWR2		
Color code	Pea Green	Light Green		

Product Specifications

Thermocouple Modules

A thermocouple input (TC) module includes three independent input channels. Each input channel receives variable voltage signals from each point, performs thermocouple linearization and cold-junction compensation, and converts the result to degrees Celsius or Fahrenheit. Each channel then transmits 16-bit signed integers representing 0.125 degrees per count to the three main processors on demand. In TMR mode, a value is then selected using a mid-value selection algorithm to ensure correct data for every scan.

Each thermocouple input module is programmable to support one thermocouple type, selected from J, K and T for standard thermocouple input modules and from J, K, T and E for isolated thermocouple input modules. The isolated module allows users to select upscale or downscale burnout detection with the TriStation software. For non-isolated modules, upscale or downscale burnout detection depends on the field termination selected.

Triplicated temperature transducers residing on the field termination panel support cold-junction compensation. Each channel of a thermocouple input module performs auto-calibration using internal precision voltage references. On the isolated module, a faulting cold-junction transducer is annunciated by a cold-junction indicator on the front panel.

Each module performs complete ongoing diagnostics on each channel.

Failure of any diagnostic on any channel activates the Fault indicator, which in turn activates the chassis alarm signal. The module Fault indicator merely reports a channel fault, not a module failure. The module continues to operate properly with as many as two faulty channels.

The thermocouple input module supports hot-spare capability which allows online replacement of a faulty module. The thermocouple input module requires a separate external termination panel (ETP) with a cable interface to the Tricon backplane.

Each module is mechanically keyed to prevent improper installation in a configured chassis.

Model Number	3706A	3708E
Type	TMR	TMR
Number of input signals	32 differential, DC coupled	16 differential, isolated
Isolated points	No	Yes
Input update rate	50 ms, maximum[1]	50 ms
Thermocouple types supported[2]	J, K, T	J, K, T, E
Accuracy/temp range	See Table A	See Table B
Input resistance (load)	22 MΩ (DC), typical	30 MΩ (DC), minimum
Noise rejection		
Common mode	-85 dB @ 0-60 Hz, minimum -95 dB @ DC, typical	-90 dB @ 0-60 Hz, minimum -100 dB @ DC, minimum
Normal mode	-17 dB @ 60 Hz	-3 dB @ 8 Hz, typical -17 dB @ 60 Hz, typical
Common mode range	±10 VDC max. (channel-to-channel or channel-to-ground)	±200 VDC, max (channel-to-channel or channel-to-ground)
Leg-to-leg isolation	200 KΩ, typical	20 KΩ, typical
Input point protection	110 VAC, continuous	110 VAC, continuous
Reference junction compensation range	32°-140°F (0°-60°C)	32°-140°F (0°-60°C)
Diagnostic indicators	PASS, FAULT, ACTIVE	PASS, FAULT, ACTIVE, CJ FAULT
Color code	Tan	Deep Yellow

1. Inputs frozen for 1 second upon insertion of spare module.
2. Must be selected with TriStation.

Table A. Accuracy of Thermocouple Types for Model 3706A

| TC Type | Temperature Range | Accuracy[1] (TC Termination Module @ 32-140° F [0-60° C]) | |
		T_a = 77° F (25° C) (Typical)	T_a = 32-140° F (0-60° C) (Maximum)
J	-250 to 32°F (-157 to 0°C)	± 5.0°F (2.8°C)	± 7.0°F (3.9°C)
	>32 to 2000°F (0 to 1093°C)	± 4.0°F (2.3°C)	± 5.0°F (2.8°C)
K	-250 to 32°F (-157 to 0°C)	± 6.0°F (3.4°C)	± 9.0°F (5.0°C)
	>32 to 2500°F (0 to 1371°C)	± 4.0°F (2.3°C)	± 6.0°F (3.4°C)
T	-250 to 32°F (-157 to 0°C)	± 5.0°F (2.8°C)	± 9.0°F (5.0°C)
	>32 to 752°F (0 to 400°C)	± 3.0°F (1.7°C)	± 5.0°F (2.8°C)

Table B. Accuracy of Thermocouple Types for Model 3708E

| TC Type | Temperature Range | Accuracy[1] (TC Termination Module @ 32-140° F [0-60° C]) | |
		T_a = 77° F (25° C) (Typical)	T_a = 32-140° F (0-60° C) (Maximum)
J	-238 to 32°F (-150 to 0°C)	± 3.0°F (1.7°C)	± 9.0°F (5.0°C)
	>32 to 1400°F (0 to 760°C)		± 5.5°F (3.1°C)
K	-238 to 32°F (-150 to 0°C)	± 4.0°F (2.3°C)	± 8.0°F (4.5°C)
	>32 to 2284°F (0 to 1370°C)		± 7.0°F (3.9°C)
T	-250 to 32°F (-161 to 0°C)	± 3.0°F (1.7°C)	± 8.5°F (4.8°C)
	>32 to 752°F (0 to 400°C)		± 4.5°F (2.5°C)
E	-328 to 32°F (-200 to 0°C)	± 3.0°F (1.7°C)	± 8.0°F (4.5°C)
	>32 to 1830°F (0 to 999°C)		± 5.0°F (2.8°C)

1. *Accuracy specifications account for errors related to reference-junction compensation, but do not account for errors caused by temperature gradients between the temperature transducers and the TC terminations. The user is responsible for maintaining a uniform temperature across the TC Termination Module.*

Notes

A termination panel and associated cable pass signals to or from the field,
permitting replacement of I/O Modules without disturbing field wiring.
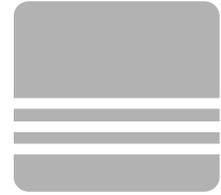
Field Termination Options

There are two general types of field termination products available from Triconex:

- External termination panels

- Cables

All termination panels and cables are built to withstand harsh industrial environments. The environmental specifications for components used on these products are the same as for a Tricon chassis. (See "General Environmental and EMC Specifications" on page 20 for details.)

External Termination Panels

An external termination panel (ETP) is an electrically-passive printed circuit board (PCB) to which field wiring is easily attached. A panel connector, terminal blocks and various components are mounted to the PCB and enclosed in a plastic housing. A termination panel and associated cable pass input signals from the field directly to an input module, or pass output signals from an output module directly to field wiring. This arrangement permits the removal or replacement of I/O modules
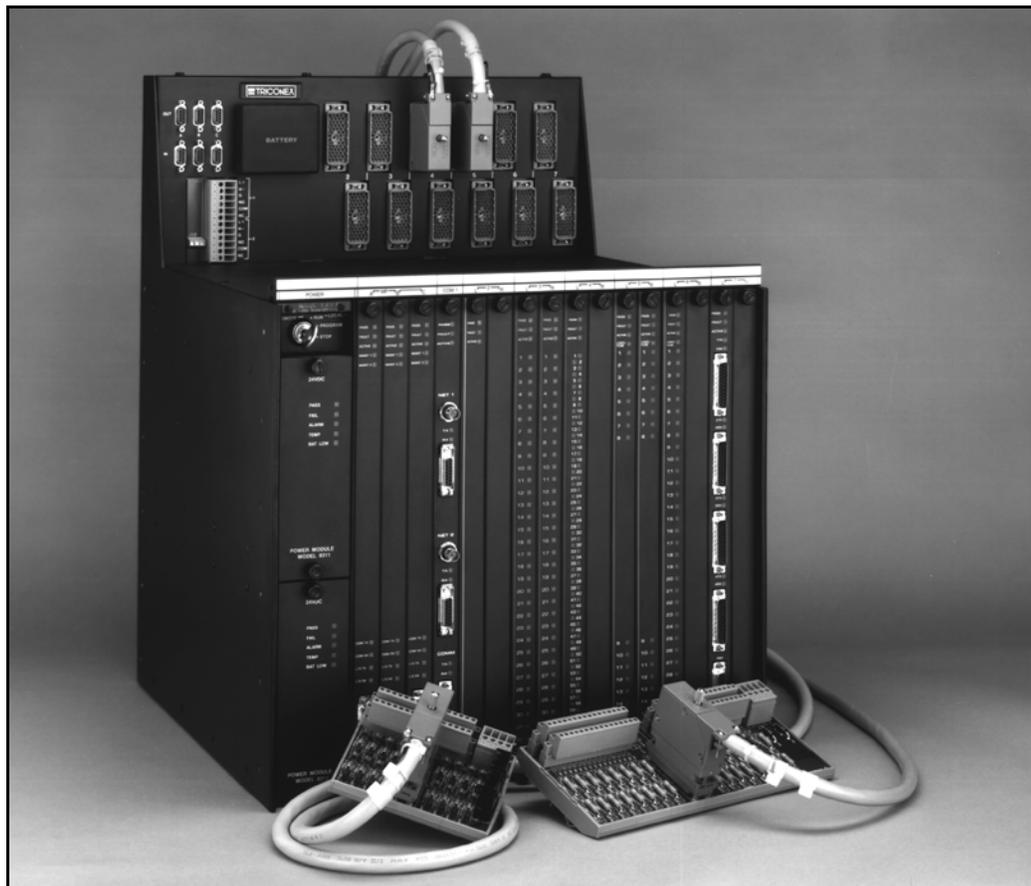
Tricon Chassis with External Termination Panels and Standard 10' Cables

Field Termination Options

removal or replacement of I/O modules without disturbing field wiring.

External termination panels allow you to marshal field signals in a separate enclosure up to 99 feet (30 meters) from a Tricon.

Standard termination panels are best for remote marshaling of field wiring where maximum flexibility, high density and simple maintenance is desired.

A standard termination panel consists of a PCB with all necessary components—such as two-piece terminal blocks, resistors, fuses and blown-fuse indicators—mounted on a DIN rail-compatible plastic housing. The housing snaps into mounting rails in accordance with DIN 50 022.

Compression terminals on the standard panel are designed for use with 24- to 12-gauge (0.3 mm^2 to 2.1 mm^2) wiring. Some panels have an optional current-limiting series resistor, others have a fuse with a blown-fuse indicator, to protect the field wiring and field device.

Standard termination panels are pre-configured for specific applications. For instance, the thermocouple input termination panel provides cold-junction temperature sensors and can be ordered with upscale, downscale or programmable burnout detection. A standard termination panel for analog voltage inputs provides commoned signal returns, while the current-mode version has a precision resistor at each input point to convert current to voltage.

Each standard termination panel is packaged with a matched interface cable that connects the panel to the backplane of a Tricon chassis. A female connector at one end of the cable is keyed to match the male connector on the Tricon backplane. A male connector on the other end of the cable attaches to the standard termination panel.

In addition to standard termination panels, there are other types of termination panels, including:

- Basic termination panels
- Hazardous location (nonincendive) termination panels
- Termination panels with interposing relays
- Bypass panels for digital inputs

- Termination panels with RTD/TC/AI input signal conditioning
- Termination panels for 3603B digital output modules
- Termination panels for 3806E analog output modules

Basic Termination Panels

Basic termination panels are a low-cost means of connecting field wiring to a Tricon. However, basic termination panels do not provide any components other than a 56-pin connector and terminal blocks. These two components are mounted on a DIN rail-compatible plastic housing that snaps into mounting rails in accordance with DIN 50 022. The user must provide any other components required by his application.

Other features of the basic termination panels are the same as for the standard panels.

Hazardous Location (Nonincendive) Termination Panels

Hazardous location (nonincendive) termination panels are suitable for use in Zone 2, and Class 1, Division 2 field circuits. These panels contain extra circuitry designed to limit power available to the field terminals and have been examined and certified by TÜV Rhineland as being nonincendive. This guarantees that if the field wires are accidentally opened, shorted, or grounded, and the Tricon is operating normally, the wiring and attached devices will not release sufficient energy to cause ignition in the specified flammable atmosphere.

Termination Panels with Interposing Relays

Interposing relays are recommended for applications that have load currents greater than 2 amps, or field voltages greater than 115 VAC which require
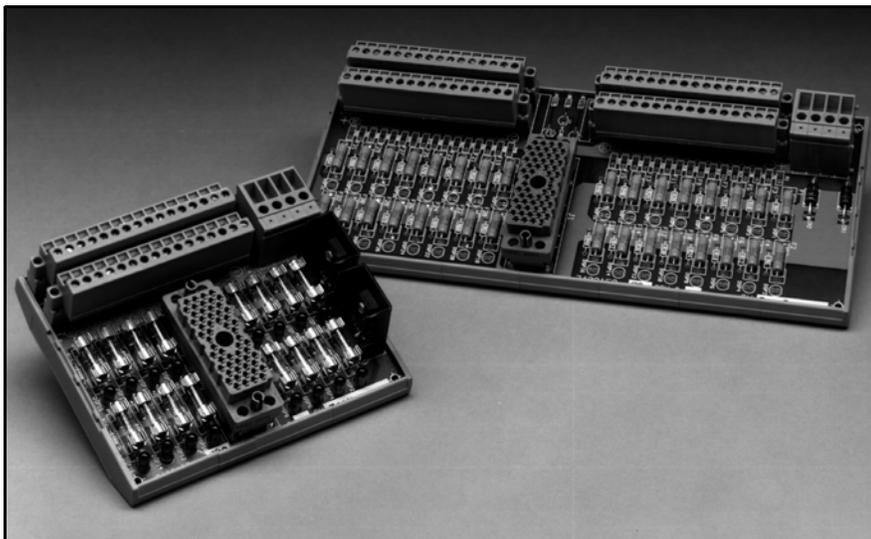
Standard Termination Panels in 16-Point and 32-Point Styles

field-circuit conversion or compatibility with motor-starter circuits.

Each interposing relay provides an auxiliary contact that can be connected to a digital input module by means of an optional loopback cable to verify relay activation by the digital output module. Interposing relay panels use compact general-purpose power relays for maximum reliability and can be used with most digital output modules.

Bypass Panels for Digital Inputs

Bypass termination panels can be used to connect digital inputs using a bank of 32 pre-wired switches. The bypass panel has a master keyswitch and terminals for redundant +24 VDC power sources. Each input point contains an ON status indicator and a position for a user-defined label. Each bypass termination panel comes with one or two 10-foot cables for connecting the termination panel to a Tricon backplane.

Termination Panels for Use with Signal Conditioners

Termination panels which use industry-standard analog signal conditioners provide a flexible, user-configurable interface to resistive thermal devices (RTDs), thermocouples, and 4-20 mA transmitters. Each termination panel supports 16 points and each analog module can support up to 2 panels.

These termination panels are compatible with any signal conditioners in the 1 to 5 volt output range. For example, the 7B series of signal conditioners from Analog Devices are known to work well.

These signal conditioners can be purchased from Triconex, or directly from Analog Devices at:

- http://www.analog.com/IOS
- 1-800-426-2564 in the USA
- 781-461-3100 from anywhere in the world

Fanned-Out Cables

Fanned-out cables are a low-cost alternative to using external termination panels. Fanned-out cables allow you to marshal field signals in a separate enclosure up to 99 feet (30 meters) from a Tricon. One end of a fanned-out cable has a female connector that connects to a Tricon chassis backplane. The other end of the cable contains 50 fanned-out leads, each individually labeled with its corresponding connector pin number.

Each fanned-out cable has the following characteristics:

- PVC outer covering
- 56-pin connector at one end
- 50 stranded, stripped, tinned and labeled 22-gauge leads at opposite end

Fanned-out cables should only be used with digital input and digital output modules. They are not certified for use with analog signals. Contact the Triconex Customer Support Center if you need a fanned-out cable for handling analog signals.

Although the normal length of all cables is 10 feet (3 meters), any length cable can be ordered up to 99 feet (30 meters) in 1-foot increments, using the last two digits of the cable model number to specify the length in feet. For example, the model number 9101-050 specifies a 50-foot cable instead of the normal 10-foot cable.

Termination Configuration Options

Terminations are available in various factory configurations:

- *Non-commoned* Terminations can accommodate individual power supplies for each point.
- *Commoned* Terminations can support one power supply which is

shared by multiple points. Points can be commoned in groups of 8 and groups of 16.

- Analog signals can be read as *3-wire transmitter inputs, voltage inputs* or *current inputs*.
- Thermocouple terminations provide cold-junction temperature sensors and are available for either *upscale* or *downscale burnout detection*. For the model 3706A, upscale or downscale burnout detection depends on which termination panel is installed. For model 3708E, upscale or downscale burnout detection is configured with TriStation.

The "Termination Options" table (on the next two pages) shows the available termination choices for each I/O module and gives the correct model number for each choice.

Over-Current Protection

Non-basic termination panels offer over-current protection in various ways:

- Fuses for individual points and/or field power sources
- Series resistors
- Self-protection for digital output and analog output modules

If basic termination panels are being used, the user must supply his own components for over-current protection.

Field Termination Options

Match your I/O module number in the first column with termination options on the right. An I/O module can be wired to a maximum of two termination panels, which may be of two different types—for example, commoned and non-commoned.

Module Part #	Module Description	Commoned Term Panels	Non-Common. Term Panels	Basic Term Panels	Nonincendive Term Panels	Fanned-out Cables	Bypass Panels	ERT Loop-Back Cables/Panels
3501E 3501T	DI, 115 VAC/VDC, 32 pts.	9561-810	9561-110	9551-110	n/a	9101-010	n/a	9141-010
3502E	DI, 48 VAC/VDC, 32 pts.	9562-810	n/a	9552-610	n/a	9101-010	n/a	9142-010
3503E	DI, 24 VAC/VDC, 32 pts.	9563-810	n/a	9553-610	9572-610	9101-010	BP9228-010	9143-010
3504E	DI, 24/48 VDC, non-isolated, 64 pts.	9566-810, 24V 9565-810, 48V	n/a n/a	9750-310, 24V 9750-410, 48V	9570-610, 24V n/a	n/a n/a	BP9229-010 n/a	n/a n/a
3505E	DI, 24 VDC, low threshold, 32 pts.	9563-810	n/a	9553-610	9572-610	9101-010	BP9228-010	9143-010
3510	PI, 20-20,000 Hz, 8 pts.	n/a	n/a	9753-110	n/a	n/a	n/a	n/a
3511	PI, 20-20,000 Hz, 8 pts.	n/a	n/a	9753-110	9793-110	n/a	n/a	n/a
3515	Pulse totalizer, 24 VDC, 32 pts.	n/a	n/a	9753-110	9572-610	n/a	n/a	n/a
3564	DI, 24 VDC, single, 64 pts.	9566-710	n/a	9553-610	9571-610	9101-010	n/a	n/a
3601E	DO, 115 VAC, 16 pts.	9661-610 9663-610	9661-110 9664-110	9651-110	n/a	9101-010	n/a	9670-110 9670-610
3601T	DO, 115 VAC, 16 pts.	9663-610	9664-110	n/a	n/a	n/a	n/a	n/a
3603B	DO, 120 VDC, 16 pts.	n/a	9251–210	n/a	n/a	n/a	n/a	n/a
3603E	DO, 120 VDC, 16 pts.	9661-910 9664-810	n/a	9651-110	n/a	9101-010	n/a	9673-810
3603T	DO, 120 VDC, 16 pts.	9664-810	n/a	n/a	n/a	n/a	n/a	9673-810
3604E	DO, 24 VDC, 16 pts.	9662-810	9662-110	9653-610	9671-610	9101-010	n/a	9671-810
3607E	DO, 48 VDC, 16 pts.	9667-810	9667-110	9652-610	n/a	9101-010	n/a	9672-810
3611E	DO, 115 VAC, 8 pts.	9661-510	n/a	n/a	n/a	n/a	n/a	n/a
3613E	DO, 120 VDC, 8 pts.	9661-810	n/a	n/a	n/a	n/a	n/a	n/a
3614E	DO, 24 VDC, 8 pts.	9662-910	n/a	n/a	n/a	n/a	n/a	n/a
3615E	DO, 24 VDC, low power, 8 pts.	9662-710	n/a	n/a	n/a	n/a	n/a	n/a
3617E	DO, 48 VDC, 8 pts.	9667-910	n/a	n/a	n/a	n/a	n/a	n/a
3623	DO, 120 VDC, 16 pts.	9661-910	n/a	9651-110	n/a	9101-010	n/a	n/a
3623T	DO, 120 VDC, 16 pts.	9664-810	n/a	n/a	n/a	n/a	n/a	n/a
3624	DO, 24 VDC, 16 pts.	9662-610	n/a	9653-610	9671-610	9101-010	n/a	n/a
3625	DO, 24 VDC, 32 pts.	9662-610	n/a	9653-610	9671-610	9101-010	n/a	n/a
3636R 3636T	Relay output (non-triplicated), 32 pts.	n/a	9668-110	9651-110	n/a	9101-010	n/a	n/a
3664	Dual DO, 24 VDC, self-protected, 32 pts.	9662-610	n/a	9653-610	9671-610	9101-010	n/a	9671-810
3674	Dual DO, 24 VDC, self-protected, 32 pts.	9662-610	n/a	9653-610	9671-610	9101-010	n/a	9671-810
3805E	AO, 4–20 mA, 8 pts.	n/a	n/a	9853-610	9861-610	n/a	n/a	n/a
3806E	AO, 6 4–20 mA outputs, 2 20–320 mA outputs	n/a	n/a	9863-710 (special panel)	n/a	n/a	n/a	n/a

Module Part #	Module Description	Upscale	Downscale	Basic Term Panels	Nonincendive Term Panels	Fanned-out Cables	Bypass Panels	ERT Loop-Back Cables/Panels
3706A	Thermocouple input, type J, K, T, differential, 32 pts.	9766-210	9766-510	n/a	9784-610, upscale 9785-610, downscale	n/a	n/a	n/a
3708E	Thermocouple input, type E, J, K, T, isolated, 16 pts.	9765-610	9765-610	n/a	9786-110	n/a	n/a	n/a

Module Part #	Module Description	3-Wire 4-20 mA	Voltage	2-Wire 4-20 mA	Nonincendive Term Panels	Basic	RTD/TC/AI
3700 3700A	AI, 0–5 VDC, differential, 32 pts.	n/a	9763-810	9761-210, 0–5 V 9771-210, 0–5 V	9791-610, current input 9787-110, voltage input	9753-110, 0–5 V	9764-310[1]
3701	AI, 0–10 VDC, differential, 32 pts.	n/a	9763-810	9761-410	n/a	9753-110, 0–10 V	n/a
3703E[2]	AI, 0–5/0–10 VDC, isolated, 16 pts.	n/a	9763-810	9762-210, 0–5 V 9762-410, 0–10 V 9771-210, 0-5 V	9791-610, current input 9787-110, voltage input	9753-110, 0–5/0–10 V	n/a
3704E[2]	AI, 0–5/0–10 VDC, non-isolated, 64 pts.	9765-210, 0–5V	n/a	9760-210, 0–5 V 9760-410, 0–10 V	9789-610, 4–20 mA	9750-210, 4–20 mA 9750-810, 0–5/0–10 V	n/a
3720	AI, 0–5 VDC, single-ended, 64 pts.	9765-210, 0–5 V	n/a	9760-210, 0–5 V 9760-410, 0–10 V	9789-610, 4–20 mA	9750-210, 4–20 mA 9750-810, 0–5/0–10 V	n/a
3721[2]	AI; 0 to 5 VDC or –5 to +5 VDC; differential; 32 pts.	n/a	9763-810	9761-210, 0–5 V 9761-410, 0–10 V 9771-210, 0–5 V	9791-610, current input 9787-110, voltage input	9753-110, 0–5 V	n/a

1. Signal conditioners must be ordered separately. A total of 16 is required for each termination panel.
2. Must be configured with TriStation.

Dimensions of External Termination Panels

Panel Model	Width (across DIN rail)	Length (along DIN rail)	Height (out from DIN rail)
9251-210	7 in (17.78 cm)	19 in (48.26 cm)	4.75 in (12.065 cm)
9551-110	3 in (7.62 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9552-610	3 in (7.62 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9553-610	3 in (7.62 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9561-110	4.5 in (11.43 cm)	7.75 in (19.685 cm)	4.25 in (10.795 cm)
9561-810	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9562-810	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9563-810	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9563-910	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9565-710	4.5 in (11.43 cm)	10 in (25.4 cm)	4.25 in (10.795 cm)

Field Termination Options

Panel Model	Width (across DIN rail)	Length (along DIN rail)	Height (out from DIN rail)
9565-810	4.5 in (11.43 cm)	10 in (25.4 cm)	4.25 in (10.795 cm)
9566-710	4.5 in (11.43 cm)	10 in (25.4 cm)	4.25 in (10.795 cm)
9566-810	4.5 in (11.43 cm)	10 in (25.4 cm)	4.25 in (10.795 cm)
9567-810	4.5 in (11.43 cm)	10 in (25.4 cm)	4.25 in (10.795 cm)
9570-610	4.42 in (11.23 cm)	9.88in (25.08 cm)	4.25 in (10.795 cm)
9571-610	4.42 in (11.23 cm)	9.88 in (25.08 cm)	4.25 in (10.795 cm)
9572-610	4.42 in (11.23 cm)	5.02 in (12.75 cm)	4.25 in (10.795 cm)
9651-110	3 in (7.62 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9652-610	3 in (7.62 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9653-610	3 in (7.62 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9661-110	4.5 in (11.43 cm)	7.75 in (19.685 cm)	4.25 in (10.795 cm)
9661-510	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9661-610	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9661-710	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9661-810	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9661-910	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9662-110	4.5 in (11.43 cm)	7.75 in (19.685 cm)	4.25 in (10.795 cm)
9662-610	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9662-710	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9662-810	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9662-910	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9663-610	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9664-110	4.5 in (11.43 cm)	7.75 in (19.685 cm)	4.25 in (10.795 cm)
9664-810	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9667-110	4.5 in (11.43 cm)	7.75 in (19.685 cm)	4.25 in (10.795 cm)
9667-610	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9667-710	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9667-810	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9667-910	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9668-110	4.5 in (11.43 cm)	7.75 in (19.685 cm)	4.25 in (10.795 cm)
9670-110	7 in (17.78 cm)	19 in (48.26 cm)	4.75 in (12.065 cm)
9670-610	7 in (17.78 cm)	19 in (48.26 cm)	4.75 in (12.065 cm)
9671-610	4.42 in (11.23 cm)	5.02 in (12.75 cm)	4.25 in (10.795 cm)
9671-810	7 in (17.78 cm)	19 in (48.26 cm)	4.75 in (12.065 cm)
9672-810	7 in (17.78 cm)	19 in (48.26 cm)	4.75 in (12.065 cm)
9673-810	7 in (17.78 cm)	19 in (48.26 cm)	4.75 in (12.065 cm)
9750-210	3 in (7.62 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9750-310	3 in (7.62 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9750-410	3 in (7.62 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)

Panel Model	Width (across DIN rail)	Length (along DIN rail)	Height (out from DIN rail)
9750-810	3 in (7.62 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9753-110	3 in (7.62 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9760-210	4.5 in (11.43 cm)	10 in (25.4 cm)	4.25 in (10.795 cm)
9760-410	4.5 in (11.43 cm)	10 in (25.4 cm)	4.25 in (10.795 cm)
9761-210	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9761-410	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9762-210	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9762-410	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9763-810	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9764-310	3.5 in (8.89 cm)	19 in (48.26 cm)	3 in (7.62 cm)
9765-210	4.5 in (11.43 cm)	10 in (25.4 cm)	4.25 in (10.795 cm)
9765-610	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9766-210	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9766-510	4.5 in (11.43 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9771-210	4.5 in (11.43 cm)	5.729 in (14.552 cm)	4.25 in (10.795 cm)
9784-610	4.42 in (11.23 cm)	5.02 in (12.75 cm)	4.25 in (10.795 cm)
9785-610	4.42 in (11.23 cm)	5.02 in (12.75 cm)	4.25 in (10.795 cm)
9786-110	4.42 in (11.23 cm)	5.02 in (12.75 cm)	4.25 in (10.795 cm)
9787-110	4.42 in (11.23 cm)	5.02 in (12.75 cm)	4.25 in (10.795 cm)
9789-610	4.42 in (11.23 cm)	9.88 in (25.08 cm)	4.25 in (10.795 cm)
9791-610	4.42 in (11.23 cm)	5.02 in (12.75 cm)	4.25 in (10.795 cm)
9793-110	4.42 in (11.23 cm)	5.02 in (12.75 cm)	4.25 in (10.795 cm)
9853-610	3 in (7.62 cm)	5 in (12.7 cm)	4.25 in (10.795 cm)
9861-610	4.42 in (11.23 cm)	5.02 in (12.75 cm)	4.25 in (10.795 cm)
9863-710	3 in (7.62 cm)	6.66 in (16.9164 cm)	4.25 in (10.795 cm)
BP9228-010	3.5 in (8.89 cm)	19 in (48.26 cm)	8 in (20.32 cm)
BP9229-010	3.5 in (8.89 cm)	19 in (48.26 cm)	8 in (20.32 cm)

Field Termination Options

Sample Drawings of External Termination Panels
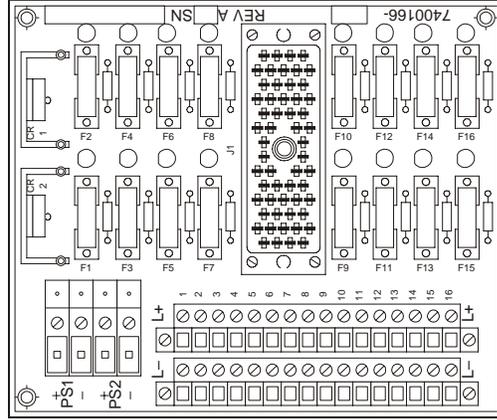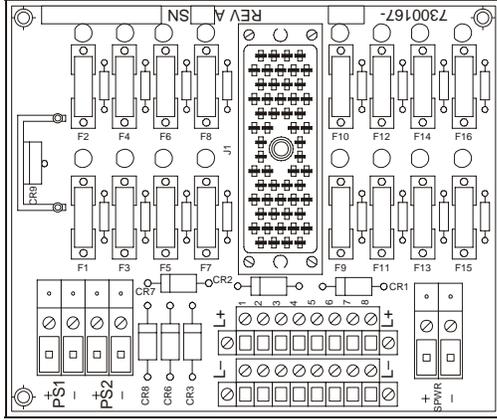
8-Point and 16-Point Digital Output Termination Panels with Fuses
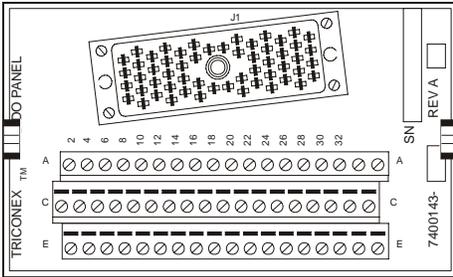
Basic Termination Panel for Various Types of I/O Modules
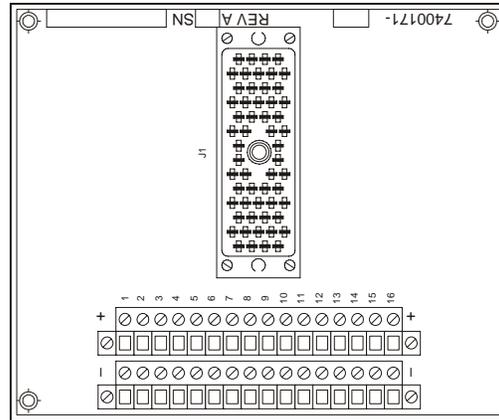
16-Point Thermocouple Input and Analog Input Termination Panels
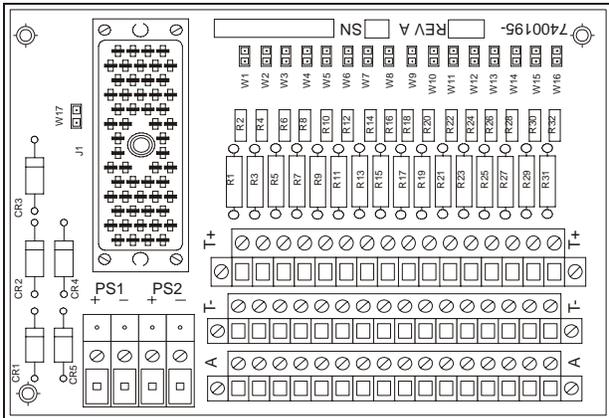
16-Point Analog Input and Digital Input Termination Panels
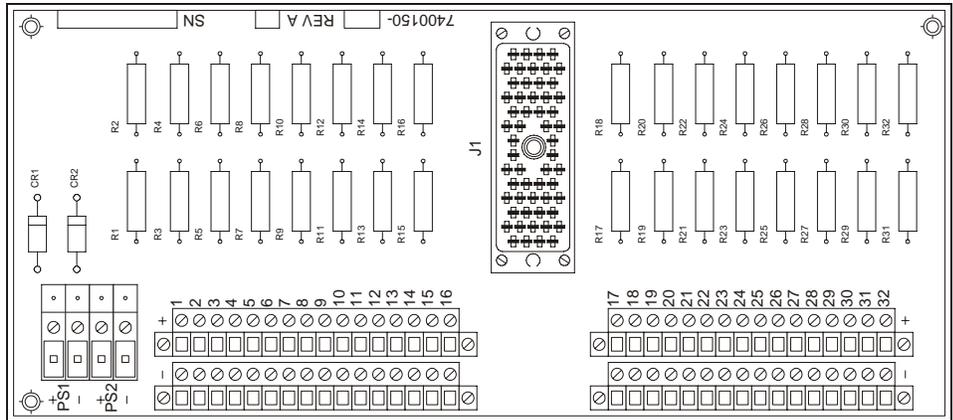
**32-Point Analog Input and Digital Input Termination Panels**
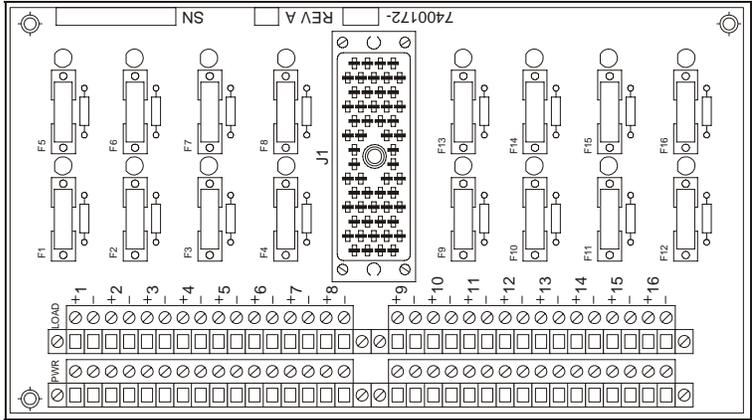
**Standard Non-Commoned Termination Panels
for Digital Input, Digital Output and Relay Modules**
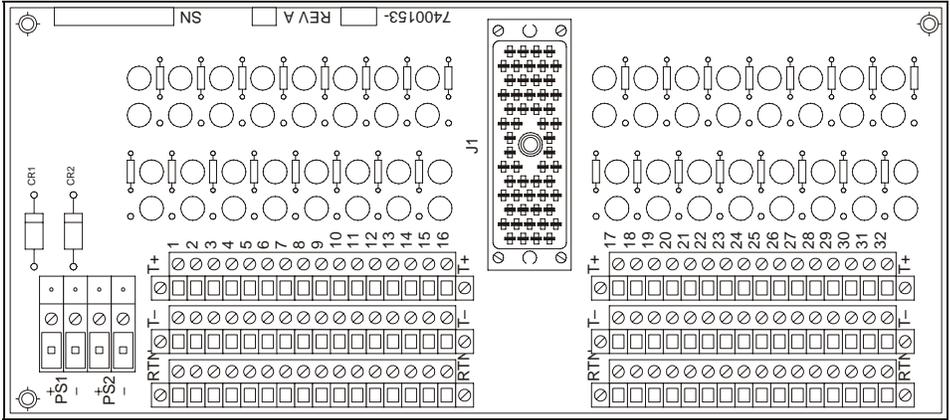
3-Wire Transmitter Analog Input Termination Panel

Field Termination Options
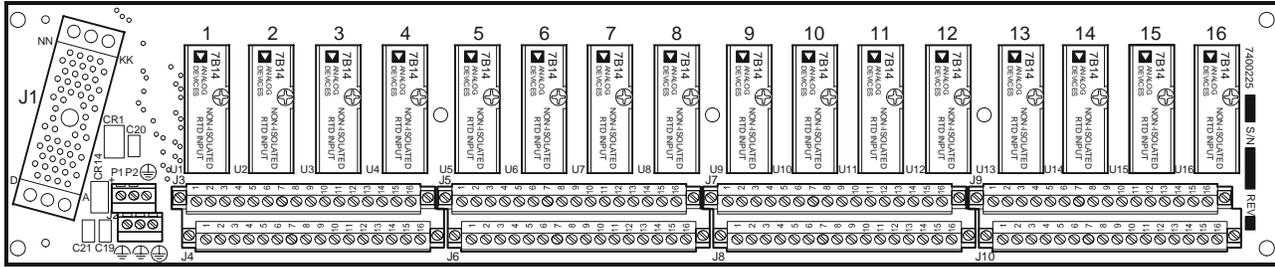
RTD/TC/AI External Termination Panel
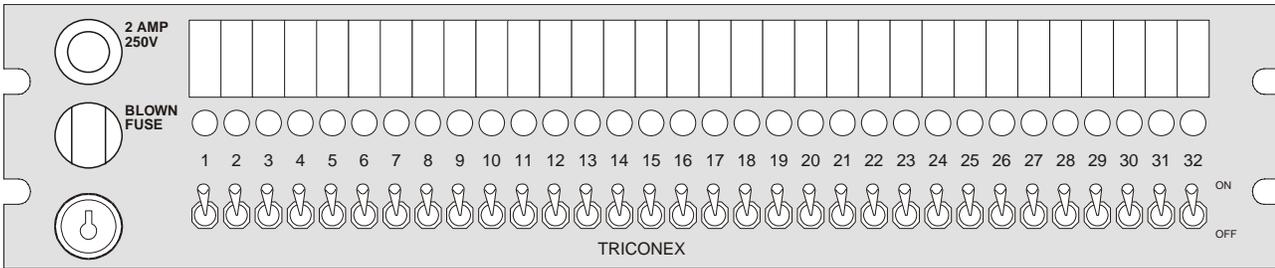
External Bypass Termination Panel
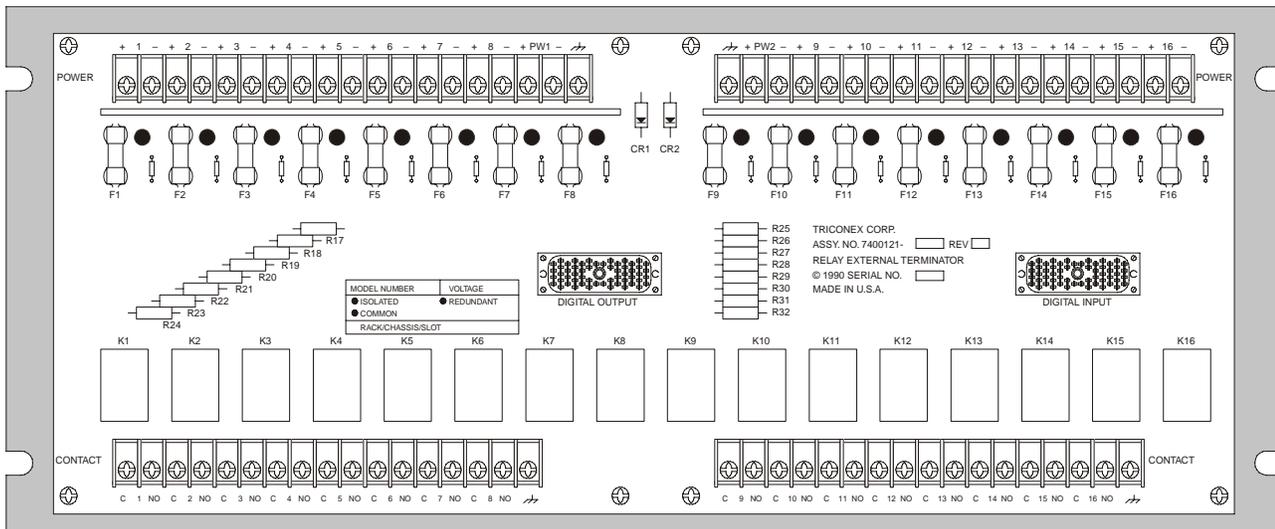
External Relay Termination with 16 Interposing Relay Contacts

Sample Drawings of Nonincendive External Termination Panels
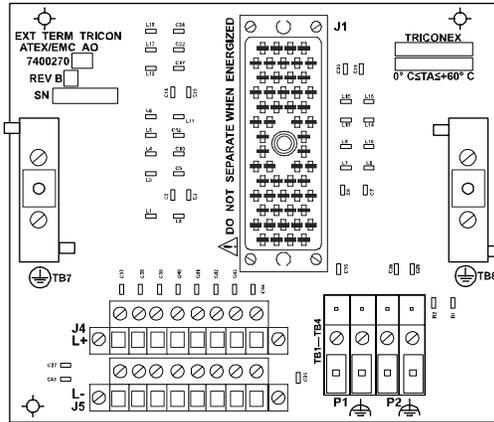
**8-Point Nonincendive Analog Output
Termination Panels**
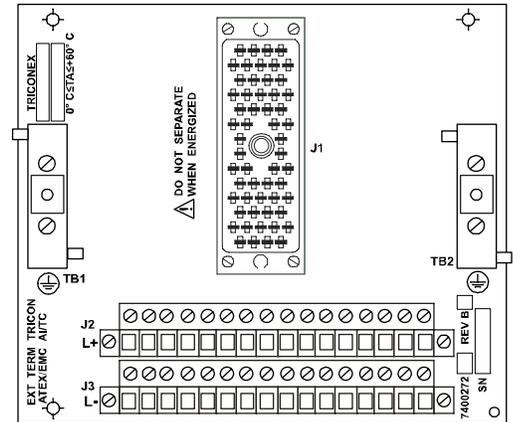
**16-Point Nonincendive Analog Input and
Pulse Input Termination Panels**
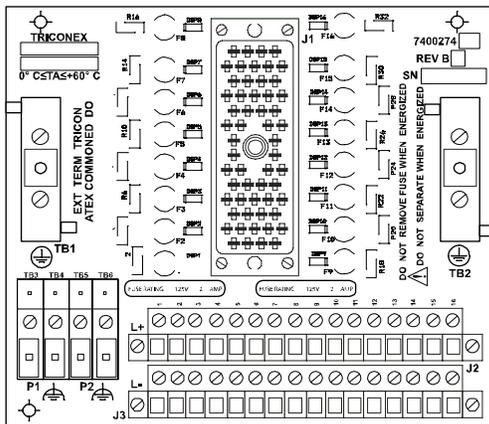
**16-Point Nonincendive Digital Output
Termination Panels**
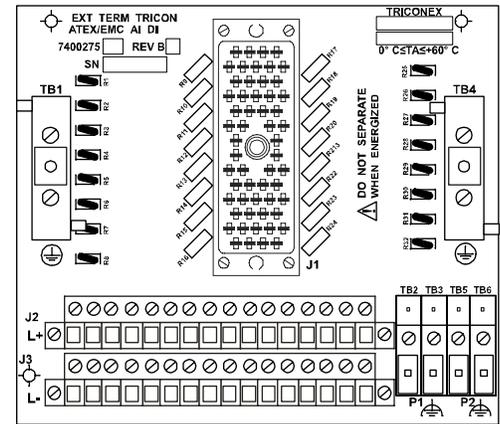
**16-Point Nonincendive Current Analog
Input and Digital Input Termination Panels**
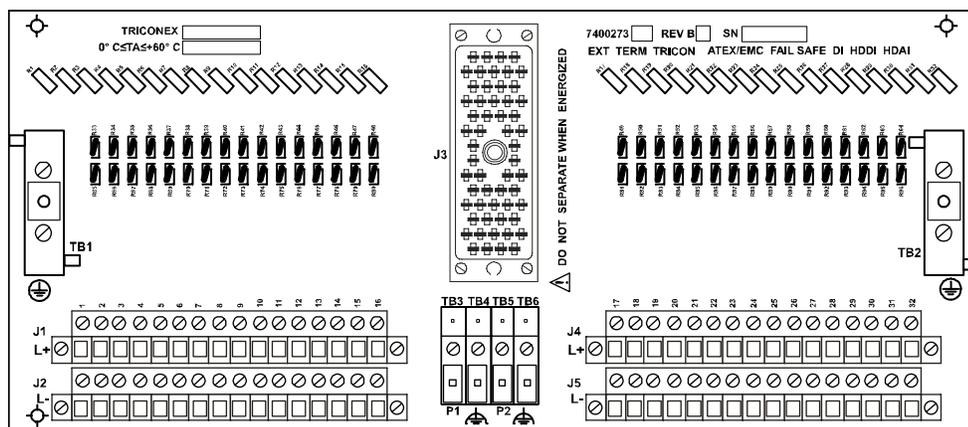
32-Point Nonincendive Analog Input and Digital Input Termination Panels

Notes

The Tricon controller can interface with Modbus masters and slaves, Distributed Control Systems (DCS), external host computers on Ethernet networks, other Triconex Controllers on a Peer-to-Peer network, and a TriStation PC.
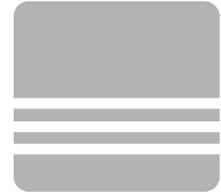
Communication Capabilities

In most process-control applications, there are two systems which monitor and manage the process. One is a Distributed Control System (DCS) and the other is a safety system such as the Tricon controller. These two systems are usually isolated, but share a common operator interface. Distributed Control Systems are designed to allow highly effective communication with the process operator, who must be informed of the state of the process at all times. This is desirable for safety systems as well, but was not feasible in the past because of the type of technology used to implement these systems.

Today, the state-of-the-art, microprocessor-based architecture of the Tricon controller supports several modes of communication. Depending on control program requirements, the Tricon can interface with:

- Any Modbus master, including DCS from ABB, Bailey, Fisher-Rosemount and Yokogawa
- Modbus slave devices
- A Foxboro Intelligent Automation (I/A) Series Nodebus
- A Honeywell Universal Control Network (UCN)
- A Honeywell Data Hiway and Local Control Network (LCN)

- External host computers on Ethernet (802.3) networks
- Other Triconex controllers in a Peer-to-Peer, TÜV-certified network
- A TriStation PC
- OPC Server for Triconex

Networking with Modbus

The *Tricon Communication Module (TCM)* supports the industry-standard Modbus protocol over a serial link or a TCP network. The *Enhanced Intelligent Communication Module (EICM)* supports the Modbus protocol over a serial link. Most suppliers of operator

TCM Communication with Modbus Master and TriStation
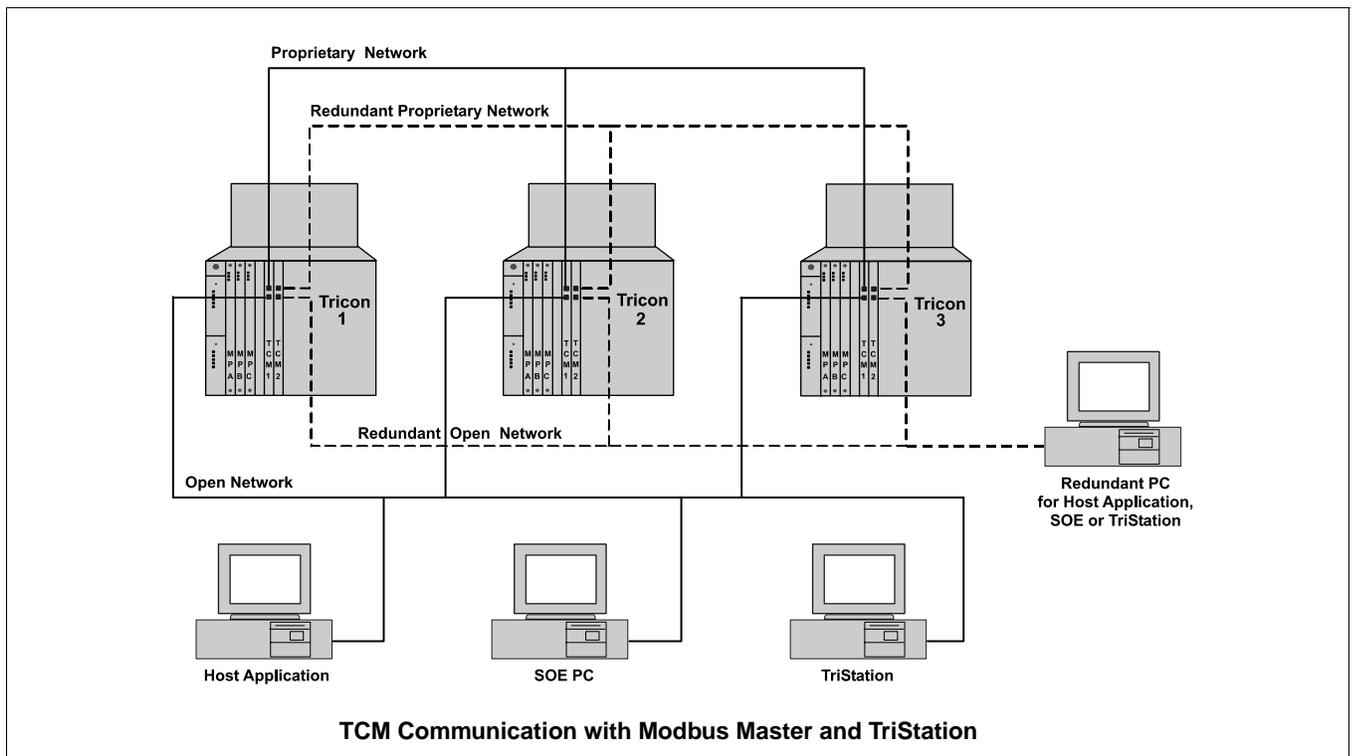
Communication Capabilities

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

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 software	✔	✔	✔	✔
OPC Server for Triconex*	✔	—	✔	—

Protocols and Applications for Networking

NOTES

TCM models 4351A and 4352A, and NCMs rely on an external Matrikon OPC Server. An Embedded OPC Server will be available in TCM models 4353 and 4354.

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. Triconex has developed one peer-to-peer protocol and three master/slave protocols (Time Synchro-

nization, TriStation, and TSAA) to support different types of applications. All of the following Triconex protocols support a maximum of 31 Tricons on a network. Please contact Triconex for application guidelines and potential performance limitations.

Peer-to-Peer

Peer-to-peer protocol allows Tricons 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 Developer's Guide.*

Time Synchronization

Time Synchronization is a master/slave protocol used to maintain a consistent time base for all Tricons 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 PC) communicates with the slave (Tricon) over an Ethernet network. Although the TriStation protocol supports a maximum of 31 Tricons, 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 (Tricons) 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 the these types of applications:

- Control (read/write) applications such as an operator interface that requires access to Tricon status and the ability to write data to the Tricon

- Monitor (read only) applications such as a Sequential Events Recorder, Event Logger or status display that retrieves data from the Tricon

For more information about TSAA, see the *Tricon Communication Guide*.

Triconex Applications

Triconex 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. Triconex 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

Triconex 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 alarms and propagates them to user-defined I/A Series destinations (consoles, printers, etc.)

- Propagates Tricon alarms as I/A Series system messages

- Reads/writes aliased data to satisfy I/A Series requests

- Enables time synchronization from the I/A Series environment

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 DDE client applications such as Excel to read and write Tricon aliased data.
OPC Server for Triconex*	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).

*TCM models 4351A and 4352A, and NCMs rely on an external Matrikon OPC Server. An Embedded OPC Server will be available in TCM models 4353 and 4354.

- Reads Tricon diagnostics for display by the I/A Series workstation

- Provides write protection to lock out changes to the Tricon safety system from all I/A Series sources

- Provides hot-spare capability for uninterrupted communication with the I/A Series Nodebus

The ACM also supports these Triconex protocols and applications on external host PCs connected to a separate BNC port (that is, NET 2):

- TriStation protocol for TriStation 1131

- TSAA protocol for Triconex applications

- TSAA/TCP(UDP)IP for user-written applications on external hosts

Honeywell's TDC 3000 DCS

Triconex offers the *Safety Manager Module (SMM)* and the *Hiway Interface Module (HIM)* for tightly-integrated interfacing with various networks of the TDC 3000 DCS.

The SMM is used solely for communication with the Universal Control Network (UCN), one of three principal networks of the TDC 3000. Appearing to the Honeywell system as a safety node, the SMM communicates process information at full network data rates for use anywhere on the TDC 3000. The SMM transmits all Tricon aliased data and diagnostic information to operator workstations in display formats that are familiar to Honeywell operators.

The SMM makes the following functions available to the TDC 3000:

- Handles critical I/O points and passes results to the DCS

- Processes Tricon alarms and propagates them to user-defined DCS destinations (consoles, printers, etc.)

- Reads/writes aliased data to satisfy DCS requests

- Reads Tricon diagnostics for display by the DCS

- Provides write protection to lock out changes to the Tricon safety system from all TDC 3000 sources

- Enables time synchronization from the DCS

- Allows Peer-to-Peer communication for plants with many Tricon safety systems

- Provides sequence of events to help determine the cause of plant trips and increase process uptime

- Provides hot-spare capability for uninterrupted communication with Honeywell networks

The HIM interfaces with the TDC 3000 by means of the Hiway Gateway and Local Control Network (LCN). The HIM can also interface with Honeywell's older TDC 2000 control system by means of the Data Hiway. Using the HIM, higher-order devices on the LCN or Data Hiway (such as computers and operator workstations) can communicate with the Tricon.

Both the SMM and the HIM offer the hot-spare capability for uninterrupted communication with Honeywell networks.

Easy-to-use developer's workbench allow you to develop, test and document process-control applications for the Tricon Controller.
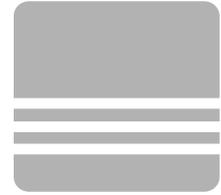
TriStation 1131 Developer's Workbench

TriStation 1131 Developer's Workbench is an integrated tool for developing, testing, and documenting safety and critical-process control applications for the Tricon controller. The programming methodology, user interface and self-documentation capabilities make the system superior to traditional and competing engineering tools.

This table identifies the compatibility of Tricon and TriStation versions.

TriStation 1131	Tricon
1.0.*x*	9.1.*x*—9.2.*x*
1.1.*x*	9.3.*x*
2.0	9.4.*x*—9.5.*x*
3.0.*x*	9.5.2—9.5.5
3.1.*x*—4.0	9.5.5—9.51
4.1.419–4.1.420	9.5.*x*–10.0.*x*
4.1.433 or later	9.5.x–10.1.x

TriStation is compliant with Part 3 of the IEC 61131 International Standard for Programmable Controllers, which defines programming languages.

TriStation v4.1 will run on Windows NT, Windows 2000, and Windows XP. TriStation v4.0 will run only on Windows NT and Windows 2000; however, it has only been validated to run on Windows 2000. Versions of TriStation lower than 4.0 will run only on Windows NT.

Functional Overview

TriStation provides three editors which support these IEC 61131-3 languages:

• Function Block Diagram

• Ladder Diagram
• Structured Text

An optional Triconex programming language, CEMPLE (Cause and Effect Matrix Programming Language Editor) supports the widely used Cause and Effect Matrix (CEM) methodology.

TriStation allows you to:

• Create programs, functions, and function blocks
• Define the controller configuration
• Declare tagnames
• Test applications in an emulator
• Download and monitor applications

New Features in TriStation v4.1

These are new features in TriStation v4.1:

• MS Windows 2000 and Windows XP compatible.

• Setup for new Analog Input, Digital Output, and Tricon Communication Modules.
• Backup project file is automatically saved after a Download All or Download Changes and can be used to restore the project file.
• Write to File feature for intermediate ST code.

Enhanced Diagnostic Monitor

The Enhanced Diagnostic Monitor is an application that monitors the control program and hardware status of multiple controllers.

Starting with TriStation v4.1.435, the Enhanced Diagnostic Monitor is a separate application from TriStation.

For more information on the Enhanced Diagnostic Monitor, see the online Help or printed guide included with the Enhanced Diagnostic Monitor.
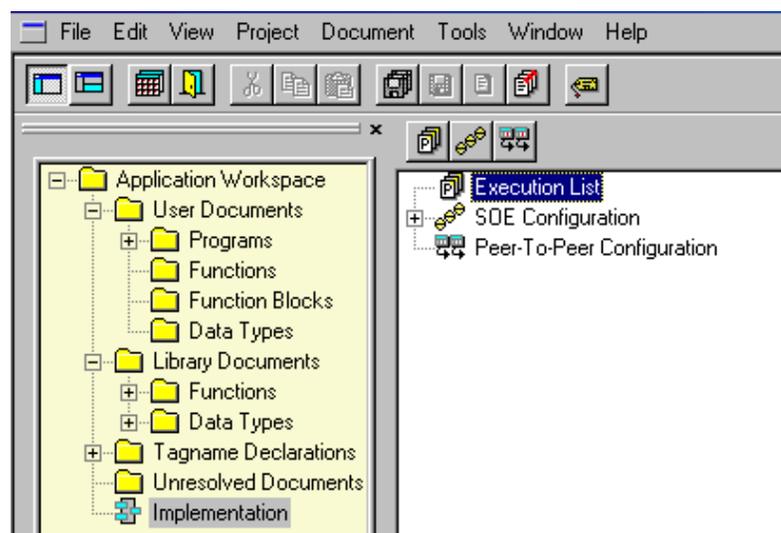
Example of TriStation v4.1 Interface

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TriStation 1131 Developer's Workbench

Elements of a TriStation Project

A TriStation project contains all of the elements required to implement a safety or control program in a Tricon controller. Some of these elements are automatically included in every project by TriStation, while others are user-created.

Programs

A program is the highest-level executable logic element in a TriStation project. It is an assembly of programming language elements (functions, function blocks, and data variables) that work together to allow a programmable control system to achieve control of a machine or a process. Each program is uniquely identified by a user-defined type name. A TriStation project can support hundreds of programs.

Functions

A function is a logic element which yields exactly one result. Unlike a function block, the data associated with a function is not retained from one evaluation of the function to the next. Functions do not have to be instanced.

Function Blocks

A function block is a logic element which yields one or more results. To use a function block in a program, an instance of the function block type must first be declared. Each instance is identified by a user-defined instance name. All of the data associated with a specific instance of a function block is retained from one evaluation of the function block to the next.

Data Types

A data type defines the size and characteristics of variables declared in a program, function or function block. Data types used by TriStation include discrete (BOOL), analog (DINT), and real (REAL).
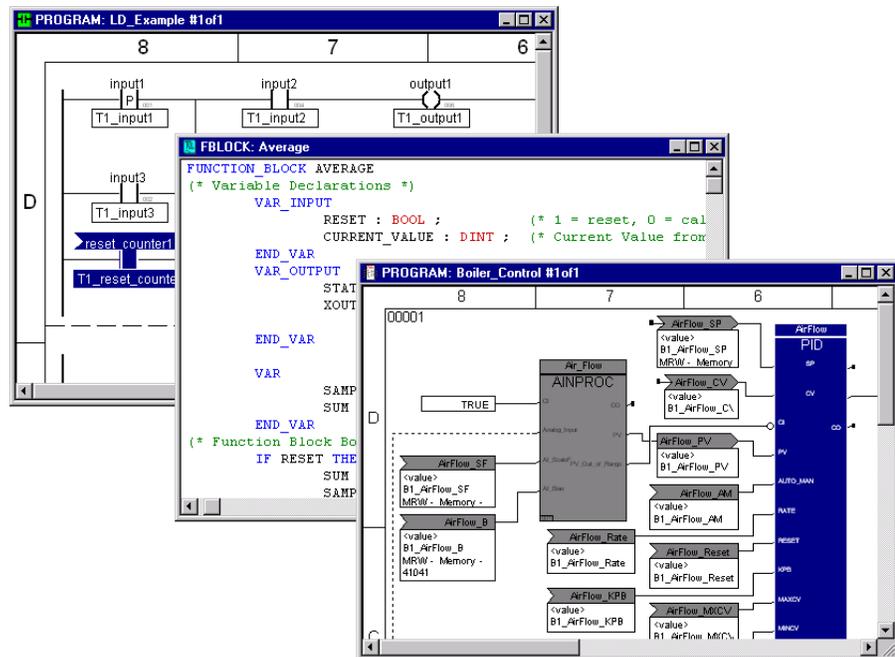
Sample Logic in FBD, ST and LD Languages

Libraries

TriStation includes libraries of pre-defined functions, function blocks, and data types that can be used in a project.

TriStation includes these libraries:

- IEC 61131-3 Standard Library – a set of functions and function blocks defined by the IEC 61131-3 Standard
- Triconex Library – a set of Triconex functions and function blocks that can be used with any Triconex programmable controller
- Tricon Library – a set of functions and function blocks that are specifically for use with the Tricon controller

In addition to the pre-defined libraries, you can also develop your own libraries of project elements. These libraries can include programs, functions, function blocks, and data types which can be imported to other TriStation projects.

Programming Languages

TriStation includes these programming languages: Function Block Diagram, Structured Text, and Ladder Diagram. An optional language, CEMPLE, can be purchased separately.

Function Block Diagram (FBD)

Function Block Diagram is a graphical language that corresponds to circuit diagrams. FBD elements appear as blocks that are wired together to form circuits. The wires transfer binary and other types of data between elements.

Structured Text (ST)

Structure Text is a high-level, textual programming language that is similar to PASCAL. Structured Text allows Boolean and arithmetic expressions, and programming structures such as conditional (IF…THEN…ELSE) statements. Functions and function blocks can be invoked in Structured Text.

In TriStation v4.0, these structures were added: arrays, structures, ForLoop and

Exit statements, CASE statement, enumerated data types, var-external, and var-temp variables.

Ladder Diagram (LD)

Ladder Diagram is a graphical language that uses a standard set of symbols for representing relay logic. The basic elements are coils and contacts which are connected by links. Links are different from the wires in FBD in that they transfer only binary data between the elements.

Cause and Effect Matrix Programming Language Editor (CEMPLE)

CEMPLE is a high-level graphical language that provides a two-dimensional matrix in which you can associate a problem in a process with one or more corrective actions. The problem is referred to as the cause and the action as the effect. The matrix associates a cause with an effect in the intersection of the cause row and the effect column.

CEMPLE is the first automated implementation of CEM, a methodology that is commonly used throughout the process-control industry and readily understood by a broad range of plant personnel. CEM diagrams are automatically translated into IEC 61131-3 compliant Function Block Diagrams, thereby eliminating the risks associated with manual translation from hand-drawn CEMs.

	Effect		UNIT_1_ALARM	UNIT_2_ALARM	UNIT_3_ALARM	UNIT_4_ALARM	UNIT_5_ALARM	
	Description		Low level alarm indicator for tank 1	Low level alarm indicator for tank 2	Low level alarm indicator for tank 3	Low level alarm indicator for tank 4	Low level alarm indicator for tank 5	

Input	Function	Cause	Description		E01	E02	E03	E04	E05	Comments
LEVEL_1_HI / LEVEL_1_LOW	LVLALRM		TRUE=Fluid in tank 1 has reached the min or max allowed level	C01	TON					Turn on level alarm after .5 secs
LEVEL_2_HI / LEVEL_2_LOW	LVLALRM		TRUE=Fluid in tank 2 has reached the min or max allowed level	C02		TON				Turn on level alarm after .5 secs
LEVEL_3_HI / LEVEL_3_LOW	LVLALRM		TRUE=Fluid in tank 3 has reached the min or max allowed level	C03			TON			Turn on level alarm after .5 secs
LEVEL_4_HI / LEVEL_4_LOW	LVLALRM		TRUE=Fluid in tank 4 has reached the min or max allowed level	C04				TON		Turn on level alarm after .5 secs
LEVEL_5_HI / LEVEL_5_LOW	LVLALRM		TRUE=Fluid in tank 5 has reached the min or max allowed level	C05					TON	Turn on level alarm after .5 secs

Loc	Terminal	VarName	VarType	DataType	Tagname	Description
C01	HI_LEV	LEVEL_1_HI	VAR_INPUT	BOOL		
C01	LOW_LEV	LEVEL_1_LOW	VAR_INPUT	BOOL		
C01	BYP	BYP_LEV_1	VAR_INPUT	BOOL		
C01	LVLALRM					

Cause Header Row 01

Sample CEM from a TriStation Project

Controller Configuration

In TriStation, the controller configuration identifies the modules in the system, communication settings, memory allocation for tagnames, and operating parameters. These configuration settings are included in the control program that is downloaded to the controller.

Emulator Panel

The Emulator Panel allows you to connect to an emulator, download the control program, and test and debug the control program. The panel lists the programs, variables, and tagnames in the control program. Testing can be done by dragging variables and tagnames from the list to the monitor panel and changing the values as desired. You can specify commands to run the control program without intervention, to run in single-step, or to halt the execution.

Controller Panel

The Controller Panel allows connection to the controller for real-time execution of the control program.

Diagnostic Panel

In TriStation versions prior to v4, the Diagnostic Panel allows you to monitor the status of MP, CM, and I/O modules in the controller and to diagnose faults. The panel also provides system performance information including the project name and version, memory size, scan time and current execution state.

In TriStation v4.1, the Diagnostic Monitor is a separate interface that
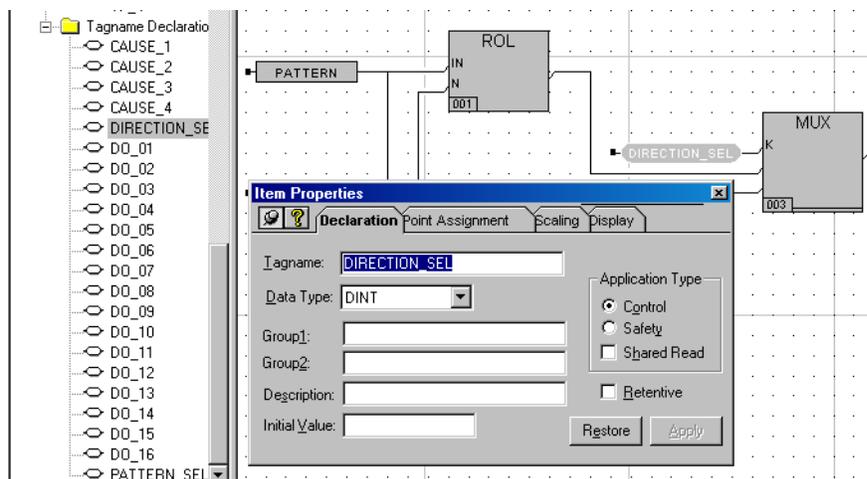
Declaring Tagnames in a Program
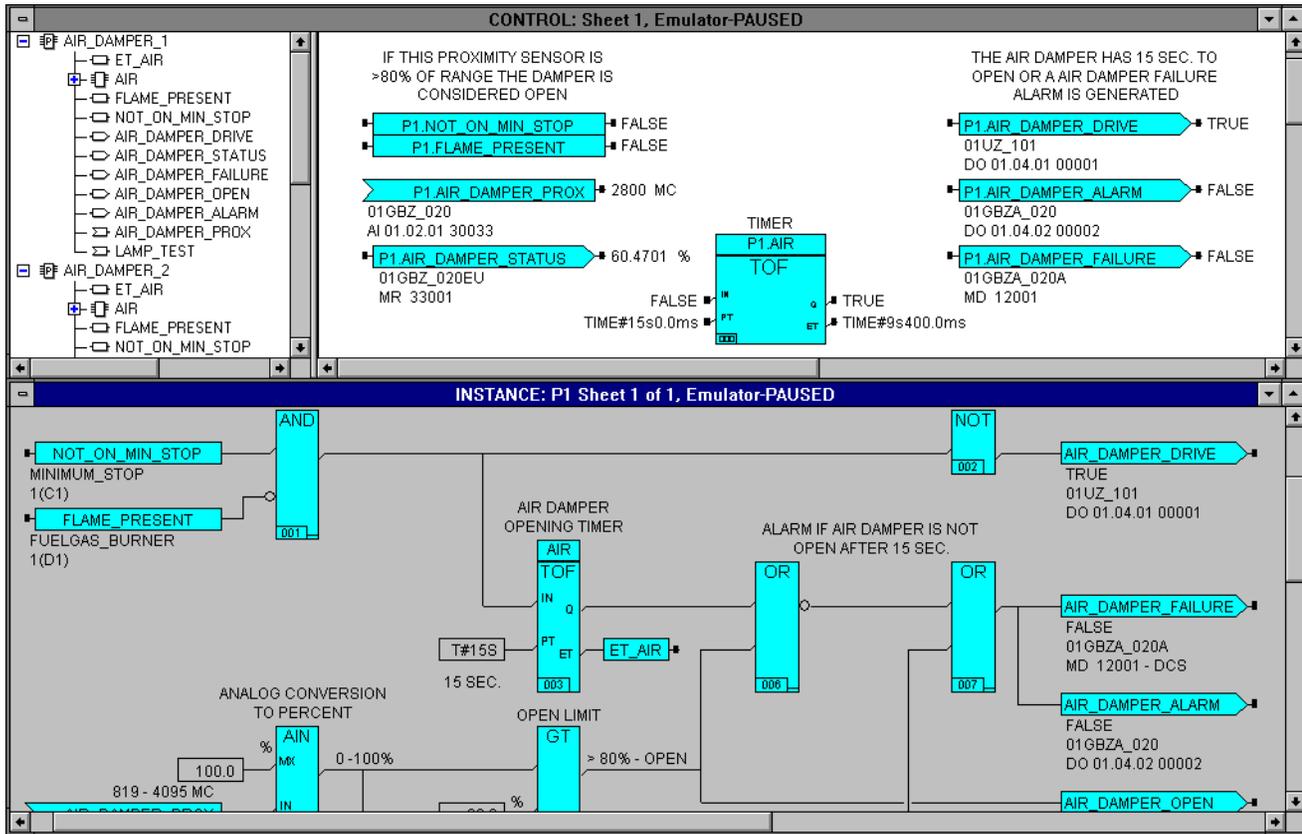
Emulator Panel with View of FBD Logic

enables monitoring of applications and hardware status on multiple controllers.

Starting with TriStation v4.1.435, the diagnostic functions from the Diagnostic Panel and the Diagnostic Monitor are included in the Enhanced Diagnostic Monitor, which is a separate application from TriStation.

TriStation Interface Options

TriStation allows you to specify options to be used in the interface. For example, you can specify the drawing colors used in the programming editors, and editor options such as double-spacing between function block terminals. You can also specify the directory location for files.

Reports and Documentation

TriStation includes multiple methods of sorting data and documenting project elements, both during and after project development. Printouts of user-developed function blocks and programs can be obtained on a variety of user-selected engineering drawing templates.

Standard reports are available to document the project configuration data. You can also create customized reports with Crystal Reports™.

Password Security

TriStation provides a security system that defines users and their privileges with regard to editing, library changes, state changes and other operations.

Project History

An audit trail function is provided to document the history of a project and its program version changes. This detailed log keeps track of user actions and comments by automatically time-stamping critical events within a session and manually logging user comments on demand.

Annotations

Annotations can be added to constants, tagnames, and variables An annotation can be used to display descriptive text, including information specified in system and user-modifiable macros. You can also display the value of a variable during program execution.

Comments

Comments can be added to programs, functions, and function blocks to add information about the operations.

Help Documentation

TriStation features an online Help system which provides detailed information about TriStation.

CEMPLE is the Triconex automated implementation of the traditional CEM methodology that has been used by process control engineers for decades.
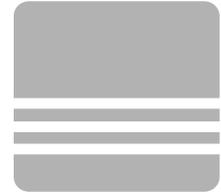
CEM Programming Language Editor

Cause and Effect Matrix (CEM) is a methodology that is commonly used in the process control industry to define alarms, emergency shutdown strategies, and mitigation actions. For decades, process control engineers have used manual methods such as graph paper and spreadsheet programs to identify problem conditions and corrective actions.

Automated CEM Called CEMPLE

The traditional CEM method is time-consuming and subject to errors caused by misinterpretation of the matrix or inaccurate coding. Triconex has automated the CEM process with the Cause and Effect Matrix Programming Language Editor, referred to as CEMPLE.

CEMPLE enables a cause and effect matrix to be used as the basis for a TriStation program.

CEMPLE Features

CEMPLE includes the following features:

- Ability to specify up to 99 causes, 99 effects, and 1,000 intersections

- Ability to invoke functions and function blocks to evaluate cause, intersection, and effect states

- Automatic conversion of matrix to Function Block Diagram language

- Customized view monitoring of active causes, intersections, and effects

- Multiple levels of undo and redo editing

CEM Editor

The CEM Editor includes the following components as shown in the figure below:

- Matrix

- FBD Network

- Variable Detail Table

Matrix

As the major component of the CEM Editor, the Matrix identifies the parts of associated with causes, effects, and intersections. The Matrix can also include functions or function blocks related to causes, effects, and intersections.

FBD Network

The FBD Network displays the Function Block Diagram (FBD) related to the cause, intersection, or effect that is selected in the matrix. It can also be used to specify properties and to invert values for variables.

The FBD network uses internal boolean variables to save and move results to

CEM Editor Components

Instance View of a Matrix

variable values based on the state of an effect, and using time delays.

User-created functions and function blocks, must be created and enabled for use before they can beincluded in a matrix.

Testing and Monitoring

Like all TriStation programs, a matrix can be tested and debugged off-line using the Emulator Control Panel. After the project is downloaded, the Control Panel can be used to monitor the values of variables during real-time execution.

In an instance view of a matrix, active causes, intersections, and effects can be viewed in a choice of colors.

As with other types of execut-able elements, values and variables can be set for use during emulation and real-time execution.

CEMPLE Tools

A matrix can be developed and edited using a variety of graphical interface methods. Commands can be selected from a main menu, toolbar, and pop-up menu.

Variables can be added or renamed by making changes in the Variable Detail Table. Where appropriate, drop-down lists provide variable names or function and function block names to be selected.

For more information, see the *TriStation 1131 Developer's Guide*.

associated cells so that causes and effects can be evaluated. For each cause, effect, and intersection, an internal variable is automatically created to store and move results between cells.

Variable Detail Table

The Variable Detail Table displays the inputs and outputs of the FBD Network that are generated when a cause, effect, or intersection is selected.

The variable type and data type can also be specified from the Variable Detail Table.

Developing a Matrix

A matrix created in CEMPLE can be as basic or complex as the situation requires. In a basic matrix, causes are identified as true or false inputs related to one or more effects through the inter-

sections between them. The state of a cause (true or false) determines the state of the related effect. If more than one cause is related to an effect, the state of the effect is based on how the matrix is evaluated.

The effect state can be determined in either of two ways: by a logical AND operation or by a logical OR operation on the intersection. A logical AND is typically used for de-energize to trip systems; a logical OR is typically used for energize to trip systems.

Using Functions and Function Blocks

For more complex processes, CEMPLE enables functions and function blocks to be added to causes, effects, and inter-sections. This feature can be used for many purposes, such as; evaluation of process input to determine the cause state, calculating one or more process

During each scan of the TriStation project, the Main Processors examine selected discrete variables for state changes known as events.
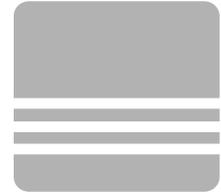
Sequence of Events (SOE) Capability

Triconex controllers and software include sequence of events capability which provides the potential to track events which lead to an unsafe process or system shutdown. During each scan of the control program, the Main Processors examine specified discrete variables for state changes known as events. Triconex software can be used to retrieve the event data from the controller.

SOE for TriStation 1131 is compatible with Tricon v9.5 and later systems.

The following host systems can be used to retrieve event data:

- SOE software from Triconex which runs on a PC

- Safety Manager Module (SMM) for Honeywell DCS systems

- Advanced Communication Module (ACM) for Foxboro DCS systems

- An OPC client control program which has implemented the Alarm and Events Handler as specified in the OPC standard version 1.0

With SOE software you can:

- Collect and analyze event data

- Export event database files

- Print reports with event data

The SOE data file, which is output from TriStation, is only for use with the Triconex the SOE software. This file is read by the software and adds descriptive information which is associated with the tagname in the Configuration file in TriStation.

Preparing Your System for Event Collection

To enable the controller to detect events, event variables and SOE blocks are identified in the TriStation project. In addition, the project must include an SOE function block that startsthe event collection.

After an SOE-enabled project is downloaded to the controller, TriStation creates an SOE definition file that contains the SOE block definitions.

When the SOE software collects an event from the controller, it obtains the tagname, alias, state name, and other information about the event variable from the SOE definition file.

These tasks are done in TriStation:

- Defining SOE blocks with buffer size and block types

- Assigning event variables to the SOE blocks

- Adding SOE function blocks to the program logic

Types of Event Variables

The types of discrete variables that can be designated as event variables are:

- BOOL input

- BOOL aliased memory variables

Configuring SOE Blocks

An SOE block is a data structure that resides in the memory of a controller's Main Processors. When SOEblocks are configured, the event variables to be detected by the controller are specified for each block.

The maximum individual block size is 20,000 events, with 60,000 events for

Tricon Network with SOE PC
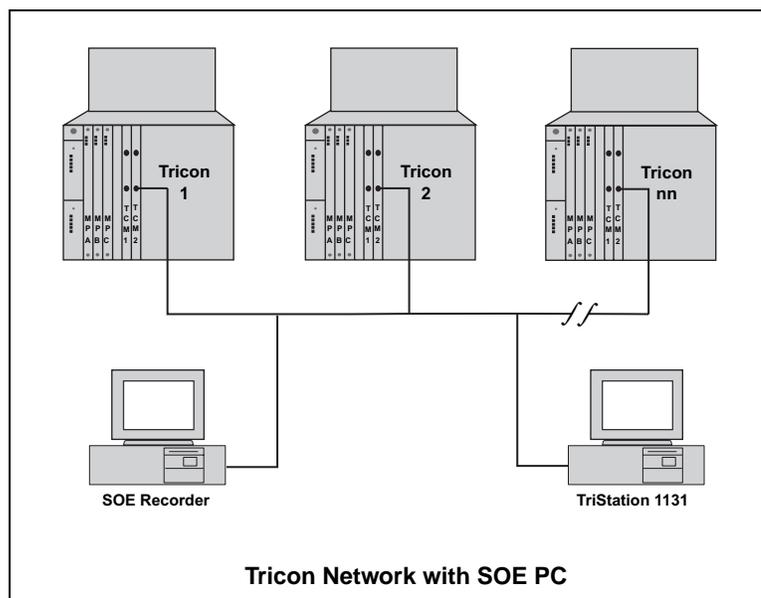
all blocks. The block size is the amount of memory that the Main Processors reserve for recording of events.

When a block is collecting events, the Main Processors write an event entry which includes the values of event variables that changed during the current scan and a time stamp.

SOE Function Blocks

SOE function blocks control and verify event collection for SOE blocks. The following function blocks are available:

- SOESTRT starts event collection
- SOESTOP stops event collection
- SOESTAT checks status of SOE blocks
- SOECLR clears status of SOE blocks

The SOESTRT function block must be added to the TriStation program to identify the SOE blocks from which events are to be collected. The other SOE function blocks are optional.

SOE Software

SOE software can simultaneously collect event data from as many as 31 networked controllers. It queries all the controllers on the network to determine which downloaded TriStation projects include SOE blocks. If a project includes one or more SOE blocks, the software opens the appropriate SOE definition file and begins collecting events from the associated controller.

While the TriStation project is running, the SOE software can be used to analyze events online as it collects them from the controllers. Snapshots of events that cover specific periods of time before or after trips have occurred can also be saved.

To analyze the event data, the SOE software includes tools for these tasks:

- Finding events and copying them to other Windows applications

Date	Time	Alias	TagName	Vari...	Node	Block
08/24/2000	21:14:41.246	02001	EVENT_VAR1	ON	06 - TRINODE06	01 - soe_block_1
08/24/2000	21:14:41.246	02002	EVENT_VAR2	OFF	06 - TRINODE06	01 - soe_block_1
08/24/2000	21:14:41.246	02003	EVENT_VAR3	ON	06 - TRINODE06	01 - soe_block_1
08/24/2000	21:14:41.246	02004	EVENT_VAR4	OFF	06 - TRINODE06	01 - soe_block_1
08/24/2000	21:14:41.246	02005	EVENT_VAR5	ON	06 - TRINODE06	01 - soe_block_1
08/24/2000	21:14:41.246	02006	EVENT_VAR6	OFF	06 - TRINODE06	01 - soe_block_1
08/24/2000	21:14:41.246	02007	EVENT_VAR7	ON	06 - TRINODE06	01 - soe_block_1
08/24/2000	21:14:41.246	02008	EVENT_VAR8	OFF	06 - TRINODE06	01 - soe_block_1
08/24/2000	21:14:41.246	02009	EVENT_VAR9	OFF	06 - TRINODE06	01 - soe_block_1
08/24/2000	21:14:41.246	02010	EVENT_VAR10	ON	06 - TRINODE06	01 - soe_block_1
08/24/2000	21:14:41.246	02011	EVENT_VAR11	OFF	06 - TRINODE06	01 - soe_block_1
08/24/2000	21:14:41.246	02012	EVENT_VAR12	ON	06 - TRINODE06	01 - soe_block_1
08/24/2000	21:14:41.246	02013	EVENT_VAR13	OFF	06 - TRINODE06	01 - soe_block_1
08/24/2000	21:14:41.246	02014	EVENT_VAR14	ON	06 - TRINODE06	01 - soe_block_1
08/24/2000	21:14:41.246	02015	EVENT_VAR15	OFF	06 - TRINODE06	01 - soe_block_1
08/24/2000	21:14:41.246	02016	EVENT_VAR16	ON	06 - TRINODE06	01 - soe_block_1
08/24/2000	21:14:41.246	02017	EVENT_VAR17	OFF	06 - TRINODE06	01 - soe_block_1
08/24/2000	21:14:41.246	02018	EVENT_VAR18	ON	06 - TRINODE06	01 - soe_block_1
08/24/2000	21:14:41.246	02019	EVENT_VAR19	OFF	06 - TRINODE06	01 - soe_block_1

SOE Events File

- Filtering and sorting saved event data
- Specifying the display of point properties for event data
- Viewing the properties of individual events

The SOE software also allows event data to be exported to database or ASCII text files, either manually or automatically. A report engine and standard report are included.

Trip Processing

A trip is a shutdown of the controlled process, or a portion of the controlled process. A TriStation project used for safety shutdown typically includes one trip variable, whose state change initiates the shutdown activities. If a project requires several variables related to trip conditions, these variables must be evaluated in combination to determine the final state of the trip variable. When a trip event occurs, the SOE software can automatically create a trip snapshot. This snapshot is a file of events that occurred x minutes before a trip and y minutes after a trip, based on TriStation settings.

Time Synchronization and Time Stamps

In a typical Peer-to-Peer network, the controllers synchronize their time with the master node (the controller with the lowest node number) within ±25 milliseconds. A controller recognizes events on a scan basis and time-stamps each event at the beginning of the scan.

Because the scans of the various controllers on the network are not synchronized, the same event can be logged by two controllers with different time stamps. The worst-case difference is the longer scan time plus 25 milliseconds.

Each day, the SOE software compares its clock with the clock of each controller from which event data is being collected. If a controller's clock is out of sync by more than five minutes, a message is displayed in the SOE message bar.

Part Number Cross-Reference

This table identifies the ETA part number and cable part number for each termination panel model.

Model #	ETA	Cable
9551-110	3000400-160	4000093-110
9552-610	3000400-260	4000093-210
9553-610	3000400-360	4000093-310
9561-110	3000560-110	4000093-110
9561-810	3000510-180	4000093-110
9562-810	3000510-280	4000093-210
9563-810	3000510-380	4000093-310
9565-710	3000530-280	4000093-210
9565-810	3000540-280	4000093-210
9566-710	3000530-380	4000093-310
9566-810	3000540-380	4000093-310
9567-810	3000530-180	4000093-110
9570-610	3000768-370	4000165-310
9571-610	3000768-390	4000165-310
9572-610	3000771-380	4000165-310
9651-110	3000410-160	4000094-110
9652-610	3000410-260	4000094-210
9653-610	3000410-360	4000094-310
9661-110	3000570-110	4000094-110
9661-510	3000550-160	4000094-110
9661-610	3000520-160	4000094-110
9661-710	3000520-190	4000094-110
9661-810	3000550-180	4000094-110
9661-910	3000520-180	4000094-110
9662-110	3000570-310	4000094-310
9662-610	3000520-390	4000094-310
9662-710	3000550-390	4000094-310
9662-810	3000520-380	4000094-310
9662-910	3000550-380	4000094-310

Model #	ETA	Cable
9663-610	3000725-160 400009	4-110
9664-110	3000726-110	4000094-110
9664-810	3000520-170	4000094-110
9667-110	3000570-710	4000094-210
9667-610	3000520-290	4000094-210
9667-710	3000520-260	4000094-210
9667-810	3000520-280	4000094-210
9667-910	3000550-280	4000094-210
9668-110	3000590-110	4000094-110
9670-110	3000290-110	4000111-110
9670-610	3000290-160	4000111-110
9671-610	3000769-390	4000166-310
9671-810	3000290-380	4000111-310
9672-810	3000290-280	4000111-210
9673-810	3000290-181	4000111-110
9750-210	3000420-120	4000093-510
9750-310	3000420-310	4000093-310
9750-410	3000420-410	4000093-210
9750-810	3000420-180	4000093-510
9753-110	3000400-510	4000103-510
9760-210	3000470-510	4000093-510
9760-410	3000470-530	4000093-510
9761-210	3000510-510	4000103-510
9761-410	3000510-530	4000103-510
9762-210	3000510-560	4000103-510
9762-410	3000510-580	4000103-510
9763-810	3000580-110	4000103-510
9764-310	3000712-200	4000103-510
9765-210	3000475-520	4000093-510

Part Number Cross-Reference

Model #	ETA	Cable
9765-610	3000580-230	4000103-510
9766-210	3000580-210	4000103-510
9766-510	3000580-220	4000103-510
9771-210	3000656-210	4000103-510
9784-610	3000767-220	4000164-510
9785-610	3000767-210	4000164-510
9786-110	3000767-230	4000164-510
9787-110	3000767-110	4000164-510
9789-610	3000768-510	4000165-510
9791-610	3000771-510	4000164-510
9793-110	3000767-115	4000164-510
9853-610	3000400-530	4000098-510
9861-610	3000770-560	4000163-510
9863-710	1600049-010 1600049-100	4000098-510

Glossary

Ω

The symbol which represents ohm.

µ

The symbol which represents micro.

A

Abbreviation for amp.

alias

A five-digit number which identifies the data type and hardware address of a point in the Triconex controller. Alias is a convention of Modbus which is a communication protocol available with Triconex communication modules.

control program

In TriStation 1131, an control program is the compiled code (built from program elements and configuration information) that is downloaded to and runs in a Triconex controller.

ASIC

Stands for control program Specific Integrated Circuit.

ATEX

Stands for "Atomsphères Explosibles" and refers to the European Union Directive 94/9/EC, which is one of a number of new approach directives developed by the European Union and covers all equipment and protective systems intended for use in potentially explosive atmospheres.

availability

The probability that the control system is operational at some instant of time.

bin

An address range of aliased variables in Triconex controllers, based on Class and Type combinations.

board

See *module.*

card

See *module.*

cause

In CEM methodology, a cause is a problem to be solved by the matrix.

CEM

Stands for Cause and Effect Matrix which is a two-dimensional matrix for the development of safety control programs. In this type of matrix, causes are represented by rows and effects are represented by columns.

CE Mark

A type of certification by the European Union which ensures the electro-magnetic compatibility of Triconex controllers with other pieces of electrical and electronic equipment.

CEMPLE

A language editor in the TriStation 1131 Developer's Workbench that allows you to develop CEMs for safety shutdown applications.

communication modules

Modules that enable the Triconex controllers to communicate with host computers. Triconex offers communication modules with Ethernet and serial protocol.

configuration

In TriStation 1131, the modules and settings used in a Triconex controller, including Main Processors, communication and I/O modules, field termination panels, and memory and module settings.

control system

The system which governs the operation of plant, machinery or other equipment by producing appropriate instructions in response to input signals.

controller

A Triconex controller includes Main Processors, communication and I/O modules, and field termination devices.

DCS

Stands for distributed control system, which is a system that controls a process and provides status information to an operator.

Glossary

DDE
Stands for Dynamic Data Exchange (DDE) which is an interprocess communication mechanism provided by Microsoft Windows. Applications running under Windows can use DDE to send and receive data and instructions to and from each other.

debug
The act of locating and correcting faults: 1) one of the normal operations in software development such as editing, compiling, debugging, loading, and verifying; or 2) the identification and isolation of a faulty physical component, including its replacement or repair to return the PLC to operational status.

effect
In CEM methodology, an effect is an action that must be taken to solve a cause (problem).

event
A state change of a discrete aliased variable which has been designated for event logging. An event occurs when a variable changes from the normal state to another state.

event logger
A utility that logs, displays and prints critical events in real time, based on state changes of discrete variables in the user-written control program. Proper use of an event logger warns users about dangerous conditions and print-outs of events can help identify the sequence of events that led to a trip.

event variable
A discrete memory variable or discrete input point that has been assigned to an SOE block.

fault tolerance
The ability to identify and compensate for failed control system elements and allow repair while continuing an assigned task without process interruption. Fault tolerance is achieved by incorporating redundancy and fault masking.

FBD
Stands for Function Block Diagram which is a graphical programming language that corresponds to circuit diagrams. Used for connective programming, FBD programs are structured by groups of interconnected elements (networks), allowing the integration of function and function blocks.

hazardous location
Any location that contains, or has the potential to contain, an explosive or flammable atmosphere.

host
See external host.

hot-spare
A unique feature of Triconex controllers which allows spare I/O modules to be installed with automatic switch to the spare in case the primary module fails.

IEEE
Stands for the Institute of Electrical and Electronics Engineers (IEEE) which is a professional society for engineers.

IEC 61131-3
The part of the IEC 61131 standard for programmable controllers that specifies the syntax and semantics of a unified suite of programming languages for programmable controllers.

input poll time
The time required by the Triconex controller to collect input data from the controlled process. Input polling is asynchronous and overlaps execution of the user-written control program.

instance view
In TriStation 1131, the Emulator Control Panel and Triconex Control Panel displays the values of annotated variables while a TriStation 1131 project is running. In an instance view, you can change the values of variables during emulation or real-time execution.

intermittent fault
A fault or error that is only occasionally present due to unstable hardware or varying software states.

intersection
In CEMPLE, a cell in a matrix where a cause row intersects an effect column.

intersection function
In CEMPLE, a function or function block that can be selected from a list in the Intersection cell of a cause row and an effect row.

ISO

Stands for the International Organization for Standard-ization (ISO) which is a worldwide federation of national standards bodies (ISO member bodies) that promulgates standards affecting international commerce and commu-nications.

LD

Stands for Ladder Diagram, which is a graphical programming language that uses a set of symbols to represent relay logic. Modules are defined by their connection to a left and right power rail.

logical slot

In a Triconex chassis, a logical slot is a repository for a primary module, a hot-spare module, and their associated field termination component.

m

Abbreviation for milli.

Markov model

A generalized modeling technique which can be used to represent a system with an arbitrary number of modules, failure events, and repair events. A Markov model can be mathematically solved to produce a resultant probability.

matrix

1. A CEM program
2. A traditional methodology for ESD applications which associates a problem (cause) in a process with one or more actions (effects) that must be taken to correct the problem.

module

An active field-replaceable unit consisting of an elec-tronic circuit assembly housed in a metal spine. Also called *board* or *card*.

MTBF

Stands for Mean Time Between Failure which is the expected average time between failures of a system, including the time taken to repair the system. Usually expressed in hours.

MTTF

Stands for Mean Time To Failure which is the expected average time to a system failure in a population of iden-tical systems. Usually expressed in hours.

MTTR

Stands for Mean Time To Repair which is the expected time to repair a failed system or subsystem. Usually expressed in hours.

node

Any of the machines on a network. In this document, node usually means a Triconex controller.

node number

The physical address of a node.

nonincendive

Not capable of igniting a flammable gas or vapor under normal operating conditions.

open network

A network to which an external host can be connected.

output poll time

The time required by the Triconex controller to imple-ment the outputs generated by the user-written control program in response to inputs from the controlled process.

Peer-to-Peer

A protocol that allow multiple Triconex controllers on a proprietary network to exchange limited amounts of process and safety information.

program

1. The set of instructions, commands, and/or directions that define the Triconex controller's output signals in terms of input signals. 2. The act of creating such a set of instructions using the relay ladder language of the TriS-tation programming system.

protocol

A set of rules describing the format used for data exchange between two entities.

reliability

The probability that no failure of the system will have occurred in a given period of time.

scan time

The period of the Triconex controller's cycle of required control functions. Scan time is composed of three elements:
- Input poll time (asynchronous with execution of the user-written control program)

Glossary

- The time required to execute the user-written control program

- Output poll time

ST
Stands for Structured Text, which is a high-level programming language used for complex arithmetic calculations and procedures that are not easily expressed in graphical languages.

system
Consists of a set of components which interact under the control of a design.

TCP/IP
Stands for Transmission Control Protocol/Internet Protocol (TCP/IP) which are protocols for the Transport and Network layers of the OSI network model. TCP/IP provides reliable, sequenced data delivery.

Time Synchronization
A Triconex protocol used to establish and maintain a synchronized, network-wide time basis. Time can be synchronized with the master node in a network of Tricon or Tricon controllers, with a distributed control system (DCS), or with an OPC client/server control program.

transient fault
A fault or error resulting from a temporary environmental condition.

TMR
Stands for Triple-Modular Redundant architecture, which allows Triconex controllers to achieve fault tolerance. The complete system is triplicated; each of the three identical systems is called a leg. Each leg independently

executes the user-written control program in parallel with the other legs.

trip
A safety-related shutdown of the controlled process or a portion of the controlled process.

TriStation 1131
An control program for developing and downloading user-written control programs and for performing maintenance and diagnostics. Runs on Windows 2000 or NT operating systems.

TriStation protocol
A master/slave protocol used by a TriStation for communication with the Triconex controllers.

TÜV Rheinland
TÜV stands for Technischer Überwachungs-Verein which translates to Technical Supervisory Association. In Germany, TÜV Rheinland is an authorized technical inspection agency for a wide variety of products, processes, installations, plants and equipment.

UDP/IP
Stands for User Datagram Protocol/Internet Protocol (UDP/IP) which are protocols for the Transport and Network layers of the OSI network model. UDP/IP provides best-effort datagram delivery.

voting
A mechanism whereby each leg of a TMR system compares and corrects the data in each leg using a two-out-of-three majority voting scheme.