Triconex®

by Schneider Electric

Tricon™ v9–v11 Systems

Planning and Installation Guide

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1

Introduction

Controller Features

The Tricon controller is a state-of-the-art programmable logic and process controller that provides a high level of system fault tolerance. To ensure the highest possible system integrity at all times, the Tricon controller includes these features:

- Provides Triple Modular Redundant (TMR) architecture whereby each of three identical system channels independently executes the control program, and specialized hardware/software mechanisms “vote” all inputs and outputs.
- Withstands harsh industrial environments.
- Enables field installation and repair to be done at the module level while the controller remains online. Replacing an I/O module does not disturb field wiring.
- Supports up to 118 I/O modules (analog and digital) and optional communication modules that interface with Modbus masters and slaves, Foxboro® and Honeywell™ Distributed Control Systems (DCS), other Triconex controllers in Peer-to-Peer networks, and external host applications on Ethernet networks.
- Provides integral support for remote I/O modules located as far away as 7.5 miles (12 kilometers) from the Main Chassis, using SRXM modules.
- Executes control programs developed and debugged with TriStation™ 1131 Developer’s Workbench Software or TriStation MSW software.
- Provides intelligence in the input and output modules to reduce the workload of the Main Processors. Each I/O module has three microprocessors. Input module microprocessors filter and debounce the inputs and diagnose hardware faults on the module. Output module microprocessors supply information for the voting of output data, check loopback data from the output terminal for final validation of the output state, and diagnose field-wiring problems.
- Provides integral online diagnostics with adaptive-repair capabilities.
- Allows normal maintenance while the Tricon controller is operating, without disturbing the controlled process.
- Supports transition to a hot-spare I/O module for critical applications where prompt service may not be possible.

Fault Tolerance

Fault tolerance, the most important capability of the Tricon controller, is the ability to detect transient and steady-state error conditions and to take appropriate corrective action online. With fault tolerance, there is an increase in safety and an increase in the availability of the controller and the process being controlled.

The Tricon controller provides fault tolerance through Triple Modular Redundant (TMR) architecture. The controller consists of three identical system channels, except for the Power Modules which are dual-redundant. Each channel independently executes the control program (also referred to as the TriStation application) in parallel with the other two channels. Hardware voting mechanisms qualify and verify all digital inputs and outputs from the field; analog inputs are subject to a mid-value selection process.

Because each channel is isolated from the others, no single-point failure in any channel can pass to another. If a hardware failure occurs in one channel, the faulty channel is overridden by the other channels. Repairs consist of removing and replacing the failed module in the faulty channel while the Tricon controller is online and without process interruption. The controller then reconfigures itself to full TMR operation.

Extensive diagnostics on each channel, module, and functional circuit immediately detect and report operational faults by means of indicators or alarms. The diagnostics also store information about faults in system variables. If faults are detected, the operator can use the diagnostic information to modify control actions or direct maintenance procedures.

Because the triplicated system operates as one control system, the Tricon controller can be programmed with one control program that terminates sensors and actuators at a single wiring terminal.

System Configuration

Physically, a basic Tricon controller consists of Main Processors and I/O modules, communication modules, the chassis enclosing the modules, field wiring connections, and a TriStation PC. This section briefly describes these components and provides general specifications.

Tricon modules are field-replaceable units consisting of an electronic assembly housed in a metal spine. Each module has a protective cover that ensures no components or circuits are exposed even when a module is removed from the chassis. Offset backplane connectors make it impossible to plug a module in upside down, and *keys* on each module prevent the insertion of modules into incorrect slots. The Tricon controller supports digital and analog input and output points, as well as pulse and thermocouple inputs and multiple communication protocols.

Tricon Controller Chassis

A Tricon controller can include a maximum of 15 chassis, housing any appropriate combination of input, output, communication, interface, and hot-spare modules. There are three types of chassis: Main, Expansion, and RXM.

- The Main Chassis houses the Main Processor modules and I/O modules. The Model 8110 Main Chassis houses up to six slot sets of I/O modules and the Model 8120E Enhanced Performance Main Chassis houses up to five sets of I/O modules. The I/O modules in a chassis are connected via I/O expansion bus ports that are triplicated RS-485 bi-directional communication ports.
- An Expansion Chassis (chassis 2 to 15) houses up to eight slot sets of I/O modules and HART™ Interface Modules. The Expansion Chassis connects to the Main Chassis by means of a triplicated RS-485 bi-directional communication port. Generally, the last Expansion Chassis must be located no more than 100 feet (30 meters) from the Main Chassis or an RXM Chassis.
- An RXM Chassis houses a Primary or Remote RXM Module set and six slot sets of I/O modules. An RXM Chassis enables a system to extend to remote locations up to 7.5 miles (12 kilometers) from the Main Chassis, using SRXM modules.

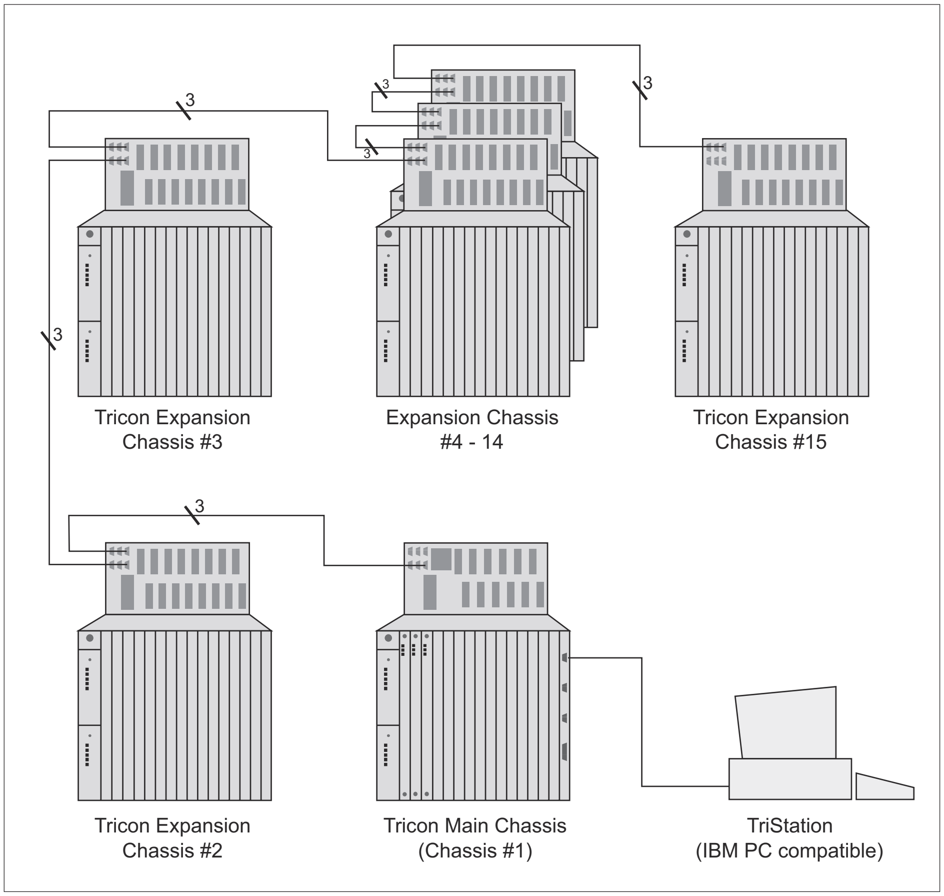


Figure 1 Tricon Sample Configuration

Tricon Controller Field Wiring

External termination assemblies are available for connection to field devices. For additional information on termination products, see the *Field Terminations Guide for Tricon v9–v11 Systems.*

TriStation Software

TriStation 1131 or TriStation MSW software is required to develop and download the control program that runs on the Tricon controller. TriStation MSW includes Relay Ladder Logic for program development. TriStation 1131 provides three programming languages which comply with the IEC 61131-3 standard: Function Block Diagram, Ladder Diagram, and Structured Text. An optional language, CEMPLE (Cause and Effect Matrix), can be purchased separately.

For more information, see the *TriStation 1131 Developer's Guide* for the version being used.

Theory of Operation

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

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

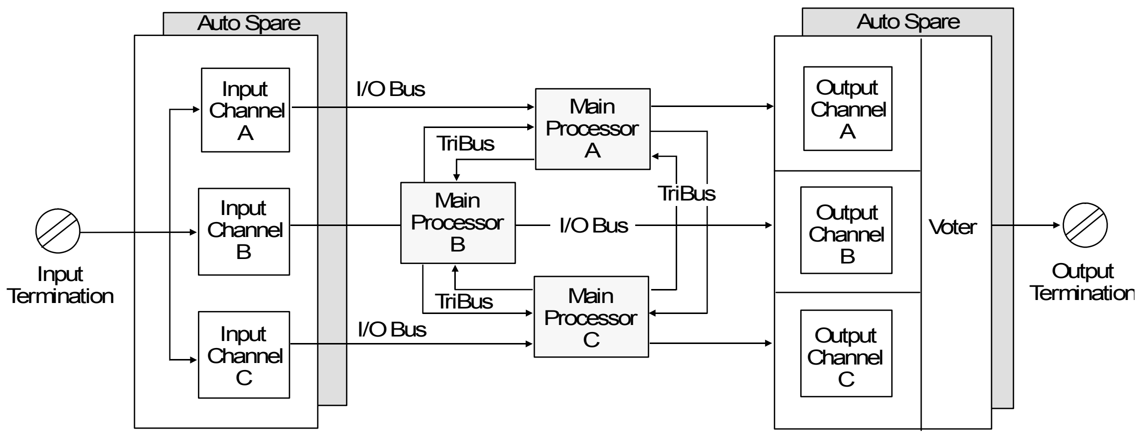


Figure 2 Triplicated Architecture of the Tricon Controller

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

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

Main Processor Modules

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

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

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

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

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

The control program generates a table of output values which are based on the table of input values according to customer-defined rules built into the control program. The I/O Processor on 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 output messages, each corresponding to an individual output module in the system. Each output message is transmitted to the appropriate channel of the corresponding output module over the I/O bus. For example, Main Processor A transmits the appropriate table to Channel A of each output module over I/O Bus A. The transmittal of output data has priority over the routine scanning of all I/O modules. The I/O Processor manages the data exchanged between the Main Processors and the communication modules using the communication bus which supports a broadcast mechanism.

Main Processors receive power from dual Power Modules and power rails in the Main Chassis. A failure on one Power Module or power rail does not affect the system performance.

Model 3009 Main Processors

Model 3009 has 256 MB DRAM (without battery backup) and 2 MB NVRAM (SRAM with battery backup).

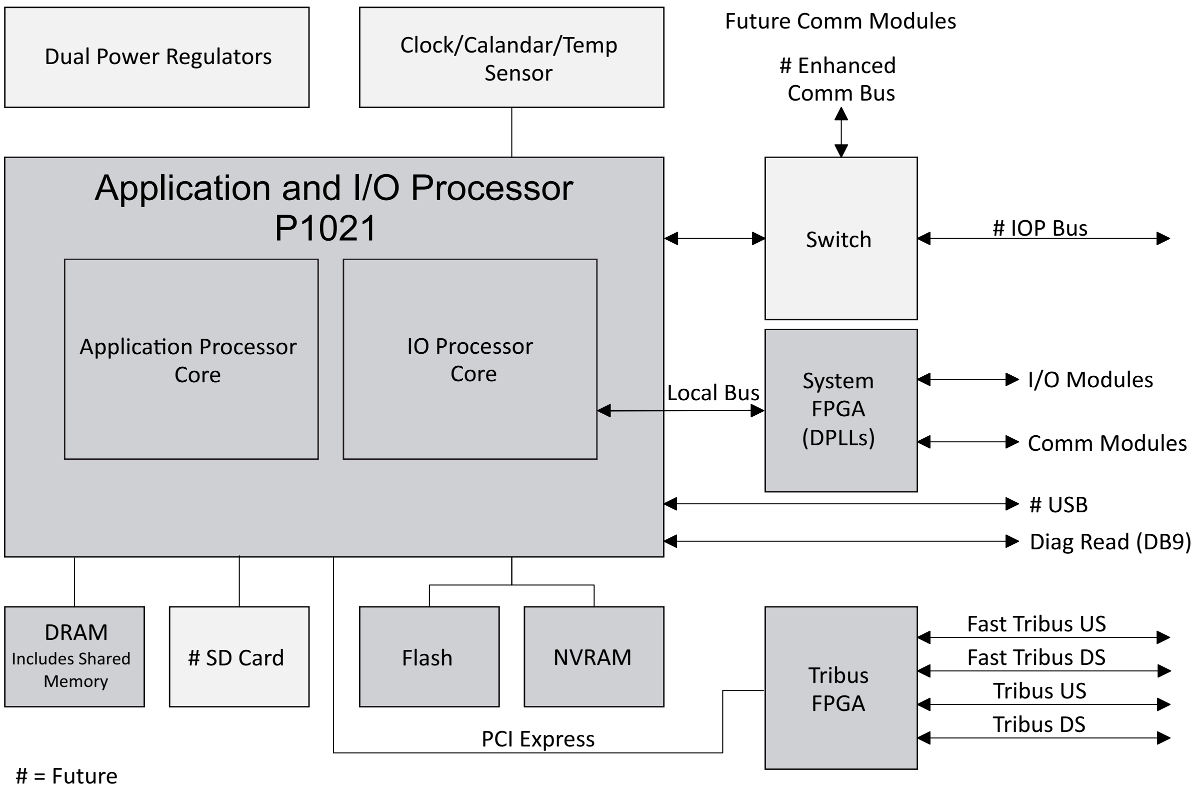


Figure 3 Architecture of a Model 3009 Main Processor

Model 3008 Main Processors

Model 3008 has 16 megabytes DRAM (without battery backup) and 32 kilobytes SRAM (with battery backup).

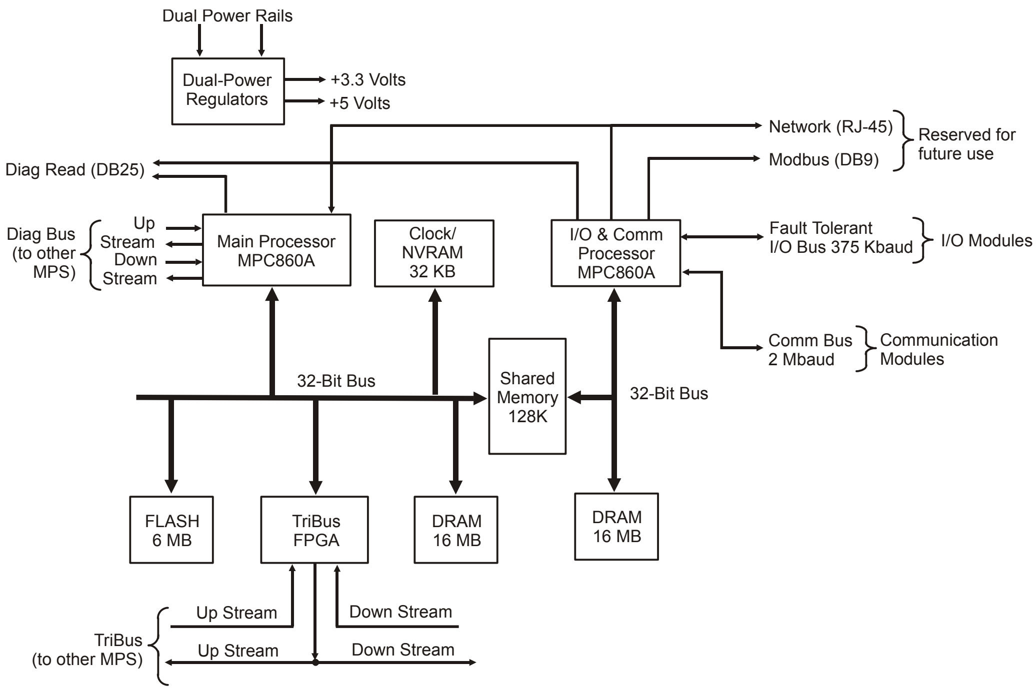


Figure 4 Architecture of a Model 3008 Main Processor

Model 3006 and 3007 Main Processors

Models 3006 and 3007 can be used with Tricon v9.0 to v9.5.x systems. They have the same architecture and specifications, except for SRAM, which is 2 megabytes for the 3006 and 1 megabyte for the 3007.

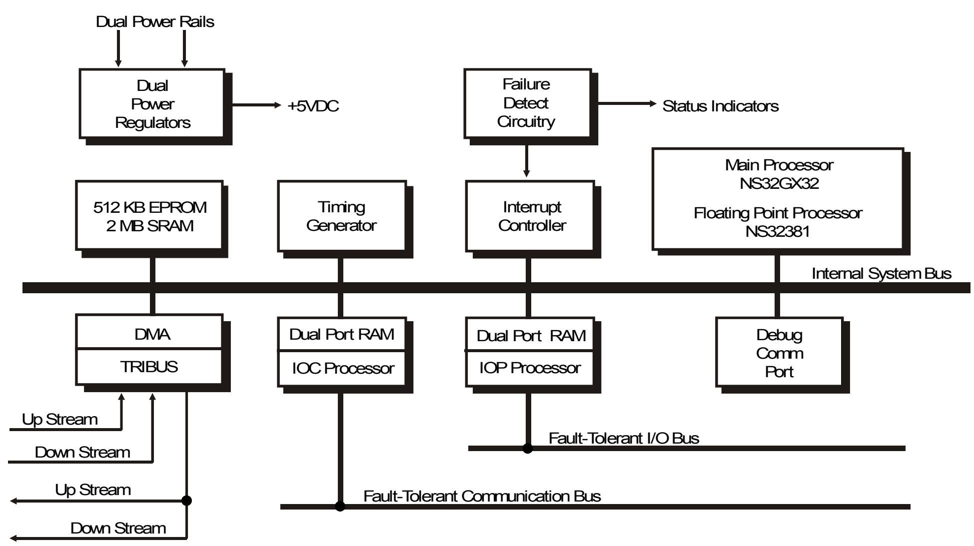


Figure 5 Architecture of a Model 3006 or 3007 Main Processor

Bus Systems and Power Distribution

This figure depicts the three triplicated bus systems which are etched on the Model 8110 Main chassis backplane: the TriBus, the I/O bus, and the communication bus.

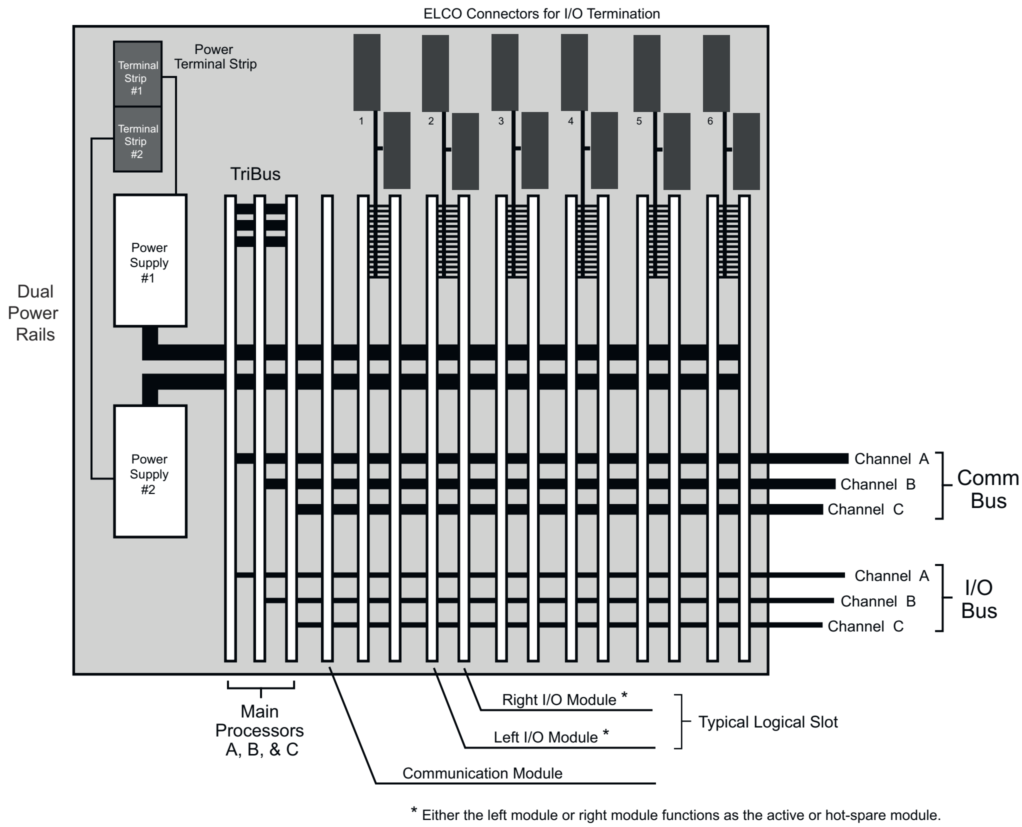


Figure 6 Bus Systems and Power Distribution in the Model 8110 Main Chassis

This figure depicts the three triplicated bus systems which are etched on the Model 8120E Enhanced Performance Main chassis backplane: the TriBus, the I/O bus, and the communication bus.

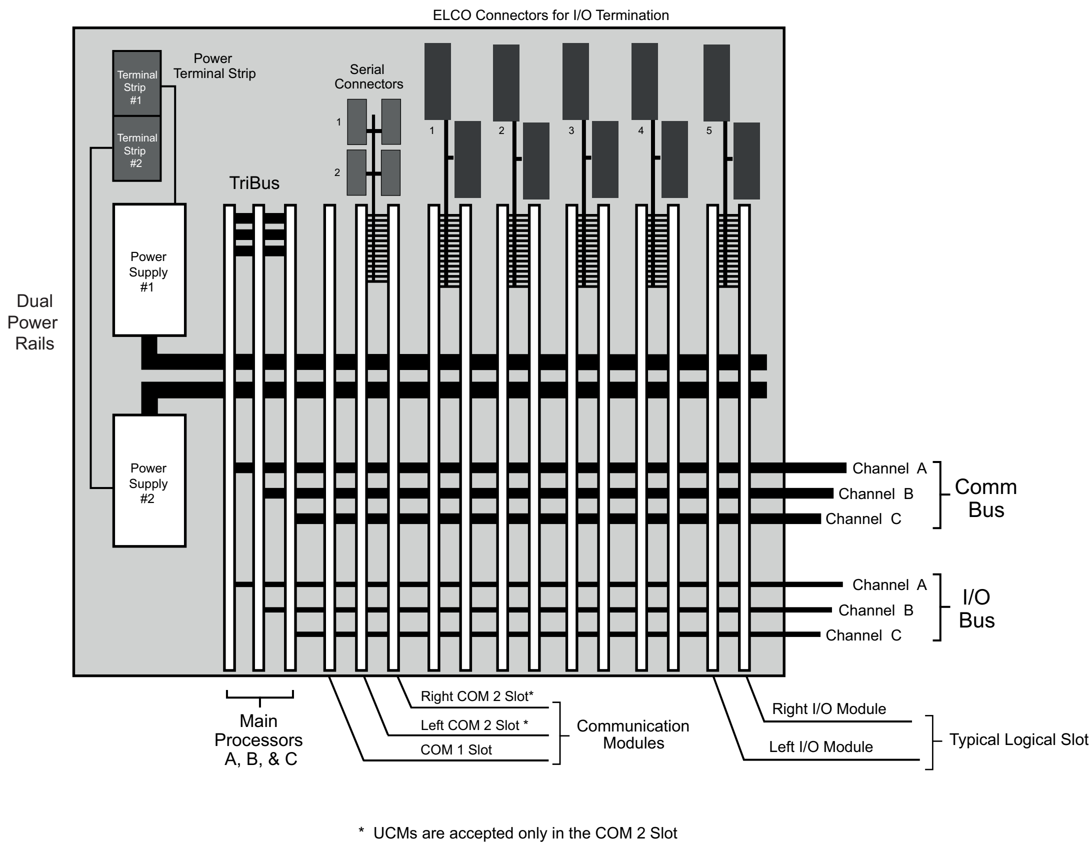


Figure 7 Bus Systems and Power Distribution in the Model 8120E Enhanced Performance Main Chassis

TriBus Operation

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

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

An important feature of Tricon controller architecture is the use of a single transmitter to send data to both the upstream and downstream Main Processors, which ensures the same data is received by the upstream processor and downstream processor.

I/O Bus Operation

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

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

Communication Bus Operation

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

Power Distribution

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

Power Modules

Each Tricon controller 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.

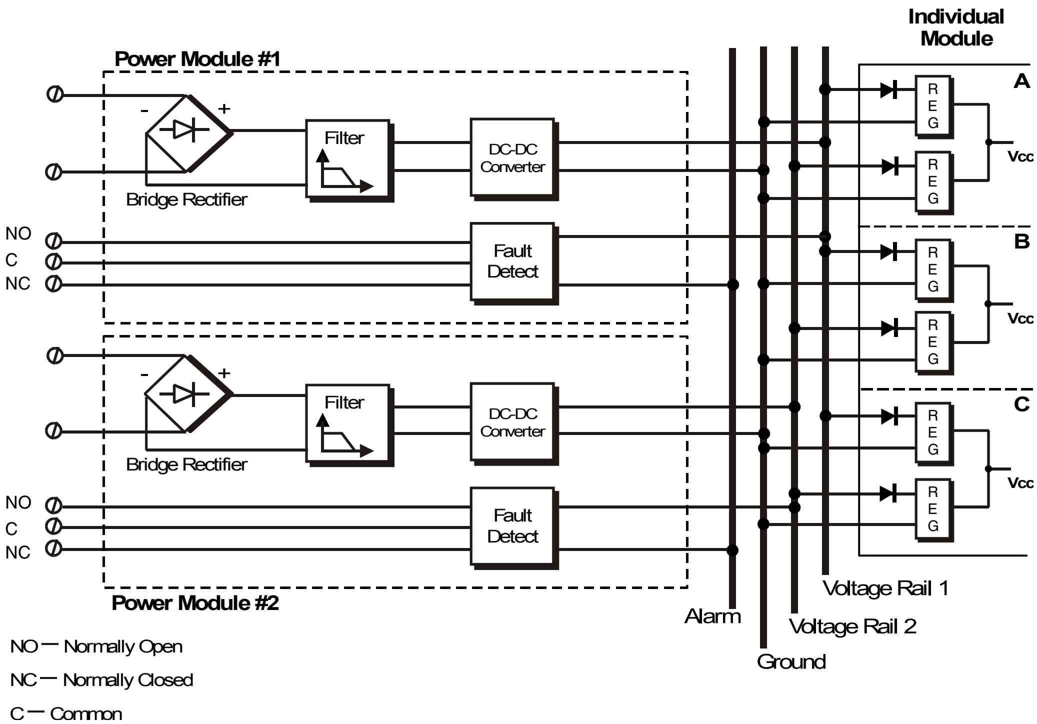


Figure 8 Architecture of Power Module Subsystem

System Diagnostics and Status Indicators

The Tricon controller incorporates integral online diagnostics. Probable failure modes are anticipated and made detectable by specialized circuitry. Fault-monitoring circuitry in each module helps fulfill this requirement. The circuitry includes but is not limited to I/O loopback, deadman timers, loss-of-power sensors, and so on. This aspect of the system design enables the Tricon controller to reconfigure itself and perform limited self-repair according to the health of each module and channel.

Each Tricon controller module can activate the system integrity alarm. The alarm consists of a normally closed or normally opened (NC or NO) relay contact on each Power Module. Any failure condition, including loss or brownout of system power, activates the alarm to summon plant maintenance personnel.

The front panel of each module provides LED (light-emitting-diode) indicators that show the status of the module or the external systems to which it is connected. Pass, Fault, and Active are common indicators. Other indicators are specific to each module.

Maintenance consists of replacing plug-in modules. A lighted Fault indicator shows that the module has detected a fault and must be replaced. The control circuitry for the indicators is isolated from each of the three channels and is redundant.

All internal diagnostic and alarm status data is available for remote logging and report generation. This reporting is done through a local or remote TriStation PC, or through a host computer. For more information, see the *TriStation 1131 Developer's Guide* for the version of TriStation being used.

Analog Input Modules

For Analog Input Modules, 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 using the I/O bus. The input table in each Main Processor is transferred to its neighbors across the TriBus. The middle value is selected by each Main Processor and the input table in each Main Processor is corrected accordingly. In TMR mode, the mid-value data is used by the control program; in duplex mode, the average is used.

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

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

For specifications, see Analog Input Modules on page 83.

Analog Output Modules

An 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 loopback inputs on each point which are read by all three microprocessors. If a fault occurs in the driving channel, that channel is declared faulty, and a new channel is selected to drive the field device. The designation of driving channel is rotated among the channels so that all three channels are periodically tested.

Each Analog Output Module is guaranteed to remain in calibration for the life of the controller; periodic manual calibration is not required.

For specifications, see Analog Output Modules on page 98.

Digital Input 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, which means a fault on one channel cannot pass to another. In addition, each channel contains an 8-bit microprocessor called the I/O communication processor which handles communication with its corresponding Main Processor.

Each of the three input channels asynchronously measures the input signals from each point on the input module, determines the respective states of the input signals, and places the values into input tables A, B, and C respectively. Each input table is regularly interrogated over the I/O bus by the I/O communication processor located on the corresponding Main Processor. For example, Main Processor A interrogates Input Table A over I/O Bus A.

There are two basic types of Digital Input Modules: TMR and Single.

For specifications, see Digital Input Modules on page 108.

TMR Digital Input Modules

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

Models 3502E, 3503E, and 3505E include a self-test feature which verifies the ability of the Tricon controller to detect transitions from a normally energized circuit to the Off state. Because most safety systems use a de-energize-to-trip setting, the ability to detect the Off state is an important feature. To test for stuck-On inputs, a switch within the input circuitry is closed to allow a zero input (Off) to be read by the optical isolation circuitry. The last data reading is frozen in the I/O Processor while the test is running.

Single Digital Input Modules

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

Digital Output Modules

Every Digital Output Module houses the circuitry for three identical, isolated channels. Each channel includes an I/O microprocessor which receives its output table from the I/O Processor on its corresponding Main Processor. All of the Digital Output Modules, except the dual DC modules, use a patented quadruplicated output circuitry, referred to as *Quad Voter*, which votes on the individual output signals just before they are applied to the load. This voter circuitry is based on parallel-series paths which pass power if the drivers for Channels A and B, or Channels B and C, or Channels A and C command them to close—in other words, 2-out-of-3 drivers voted On. Dual Digital Output Modules provide a single series path, with the 2-out-of-3 voting process applied individually to each switch. The quadruplicated output circuitry provides multiple redundancy for all critical signal paths, guaranteeing safety and maximum availability.

For specifications, see Digital Output Modules on page 124.

OVD (Output Voter Diagnostics)

Every Digital Output Module executes a specific type of Output Voter Diagnostics (OVD) for every point. This safety feature allows unrestricted operation under a variety of multiple-fault scenarios. In general, during OVD execution the commanded state of each point is momentarily reversed on one of the output drivers, one after another. Loopback on the module allows each microprocessor to read the output value for the point to determine whether a latent fault exists within the output circuit. (For devices that cannot tolerate a signal transition of any length, OVD on both AC and DC voltage Digital Output Modules can be disabled.)

AC Digital Output Modules

On AC voltage Digital Output Modules, a fault switch identified by the OVD process causes the output signal to transition to the opposite state for a maximum of half an AC cycle. This transition may not be transparent to all field devices. After a fault is detected, the module discontinues further iterations of OVD. Each point on an AC voltage Digital Output Module requires periodic cycling to both the On and Off states to ensure 100 percent fault coverage.

DC Digital Output Modules

DC voltage Digital Output Modules are specifically designed to control devices which hold points in one state for long periods of time. The OVD strategy for a DC voltage Digital Output Module ensures full fault coverage even if the commanded state of the points never changes. On this type of module, the output signal transition normally occurs during OVD execution, but is guaranteed to be less than 2.0 milliseconds (500 microseconds is typical) and is transparent to most field devices.

Dual DC Digital Output Modules

Dual Digital Output (DDO) Modules provide just enough redundancy to ensure safe operation. Dual modules are optimized for those safety-critical applications where low cost is more important than maximum availability.

Supervised Digital Output Modules

Supervised Digital Output Modules provide both voltage and current loopback, allowing complete fault coverage for both energized-to-trip and de-energized-to-trip conditions. In addition, a Supervised Digital Output Module verifies the presence of the field load by doing continuous circuit-continuity checks. Any loss of field load is annunciated by the module.

Pulse Input Modules

Each Pulse Input Module includes three channels which measure the input frequency independently. Special algorithms, optimized for accurately measuring the speed of rotating machinery, are used to compensate for irregularly spaced teeth on timing gear or for periodic acceleration/de-acceleration. The results are placed into a table of values. Each input table is passed to its associated MP using the corresponding I/O bus. The input table in each MP is transferred to its neighbors across the TriBus. The middle value is selected by each MP and the input table in each MP is corrected accordingly. In TMR mode, the mid-value is used by the application; in duplex mode, the average is used. Special self-test circuitry is provided to diagnose the health state of all input points, even when an active signal is not present. Each Pulse Input Module is guaranteed to remain in calibration for the life of the controller; periodic manual calibration is not required.

For specifications, see Pulse Input Modules on page 162 and Pulse Totalizer Input Module on page 167.

Thermocouple Input Modules

Each Thermocouple Input Module has 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. To ensure correct data for every scan, a value is selected using a mid-value selection algorithm.

Triplicated temperature transducers residing on the field termination module support cold-junction compensation. Each channel of a thermocouple module performs auto-calibration and reference-junction compensation every five seconds using internal-precision voltage references. On the Isolated Thermocouple Module, a cold-junction indicator announces the failure of a cold-junction transducer. On the Non-Isolated Thermocouple Module, a Fault indicator announces a transducer fault.

Sensing of each thermocouple input is performed in a manner which prevents a single failure on one channel from affecting another channel. Each module performs complete ongoing diagnostics on each channel.

For specifications, see Thermocouple Input Modules on page 171.

Field Terminations

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

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

A fanned-out cable is a lower-cost alternative to an ETP when using digital input or digital output modules. One end of a fanned-out cable connects to the Tricon chassis backplane and the other end provides 50 fanned-out leads, each individually labeled with a pin number that matches the connector signals. For more information, see the *Field Terminations Guide for Tricon v9–v11 Systems*.

Communication Modules

A Tricon controller can communicate with other Triconex controllers and external devices. Communication modules enable serial and network communication using a variety of communication protocols. 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 about communication setup and protocols, see the *Communication Guide for Tricon v9–v11 Systems*.

Advanced Communication Module (ACM)

The ACM (Advanced Communication Module) acts as an interface between a Tricon controller and a Foxboro Intelligent Automation (I/A) Series DCS, 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 DCS, transmitting all Tricon controller aliased data (including system variables and system aliases) and diagnostic information to operator workstations in display formats that are familiar to Foxboro operators.

Note ACMs are compatible with Tricon v10.x and earlier systems.

For specifications, see Advanced Communication Module (ACM) on page 187.

Enhanced Intelligent Communication Module (EICM)

The Enhanced Intelligent Communication Module (EICM) enables a Tricon controller to communicate with Modbus devices (masters or slaves), with a TriStation PC, and with a printer. The four serial ports are uniquely addressed and can be used for Modbus or TriStation communication at speeds up to 19.2 kilobits per second. A single Tricon High-Density controller supports up to two EICM modules which reside in one logical slot. This arrangement provides a total of six Modbus ports, two TriStation ports, and two printer ports.

Note EICMs are compatible with Tricon v10.x and earlier systems.

For specifications, see Enhanced Intelligent Communication Module (EICM) on page 190.

Hiway Interface Module (HIM)

The Hiway Interface Module (HIM) acts as an interface between a Tricon controller and a Honeywell TDC-3000 control system via the Hiway Gateway and Local Control Network (LCN). The HIM can also interface with a Honeywell TDC-2000 control system via 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 controller. The HIM allows redundant BNC connections directly to the Data Hiway and has the same functional capacity as up to four extended Data Hiway Port (DHP) addresses.

Note HIMs are compatible with Tricon v10.x and earlier systems.

For specifications, see Hiway Interface Module (HIM) on page 192.

Network Communication Module (NCM)

The Network Communication Module (NCM) enables the Tricon controller to communicate with other Triconex controllers and with external devices on Ethernet networks using a high-speed 10 megabits per second data link. The NCMG allows the Tricon controller to synchronize controller time based on GPS information.

Note NCMs are compatible with Tricon v10.x and earlier systems.

For specifications, see Network Communication Module (NCM) on page 194.

Safety Manager Module (SMM)

The Safety Manager Module (SMM) acts as an interface between a Tricon controller and a Honeywell Universal Control Network (UCN), which is one of three principal networks of the TDC-3000 Distributed Control System. Appearing to the Honeywell system as a safety node on the UCN, the SMM communicates process information at full network data rates for use anywhere on the TDC-3000. The SMM transmits all Tricon controller aliased data (including system variables and system aliases) and diagnostic information to operator workstations in display formats that are familiar to Honeywell operators.

For specifications, see Safety Manager Module (SMM) on page 196.

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 controllers, and other external devices on Ethernet networks.

Each TCM has four serial ports, two Ethernet network ports, and one debug port (for Invensys use). TCM Models 4353 and 4354 have an embedded OPC server, which allows up to ten OPC clients to subscribe to data collected by the OPC server. The embedded OPC server supports the Data Access standard and the Alarms and Events standard.

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.

TCMs are compatible only with Tricon v10.0 and later systems. TCM Models 4351B, 4352B, 4353, and 4354 are compatible only with Tricon v10.3 and later systems. For complete compatibility information, see the Tricon Product Release Notices available on the Global Customer Support (GCS) center website.

For specifications, see Tricon Communication Module (TCM) on page 198.

Unified Communication Module (UCM)

The Unified Communication Module (UCM) acts as an interface between a Tricon controller and the Foxboro Evo™ Process Automation System. Appearing as a control station on the mesh network, the UCM transmits Tricon controller aliased data as a peer on the mesh network. The Field Device System Integrator (FDSI) in the UCM also displays on the control station.

Each UCM contains two serial ports, four fiber-optic Ethernet network ports, one Infrared port, one Time Synchronization port, and one debug port (for Invensys use).

The serial ports are uniquely addressed and are mounted on the backplane of the Model 8120E Enhanced Performance Main Chassis.

Each serial port can be used for Modbus or TriStation communication at speeds up to 115 Kbps per port. Serial port 1 supports the Modbus interface and serial port 2 supports either the Modbus or the TriStation interface.

UCMs are compatible only with TriStation 1131 4.11.x and later versions, and Tricon v11.x systems that use the Model 8120E Enhanced Performance Main Chassis and the Model 3009 Main Processor. A single Tricon controller supports up to two UCMs, which must reside in logical COM 2 slot of the Model 8120E Enhanced Performance Main Chassis. You cannot install the UCM in the COM 1 slot.

For specifications, see Unified Communication Module (UCM) on page 203.

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 controller for use around the world in safety critical applications. Test reports from the various certification agencies are available upon request.

Topics include:

- Canadian Standards Association (CSA) on page 20
- Factory Mutual (FM) on page 21
- Bureau Veritas (BV) on page 21
- TÜV Rheinland on page 22
- Nuclear Regulatory Commission (NRC) on page 24
- European Union CE Mark on page 25

Canadian Standards Association (CSA)

CSA has certified that the Tricon controller is in full compliance with the following internationally recognized electrical safety standards and is qualified for general use in North American and other jurisdictions requiring compliance with these standards.

Standard Number	Title
CAN/CSA-C22.2 No. 61010-1-04	Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, Part 1: General Requirements
UL Std. No. 61010-1 (2nd Edition)	Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 1: General Requirements
CSA Std. C22.2 No. 14-10	Industrial Control Equipment
ANSI/UL 508 (17th Edition)	Industrial Control Equipment

Factory Mutual (FM)

FM has certified that the Tricon controller is in full compliance with the following internationally 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.

In North America, the field signals used with ATEX-compliant external termination panels are certified for Class I, Division 2, Groups C and D.

Standard Number	Title
3600	3600 Electrical Equipment for Use in Hazardous (Classified) Locations-General Requirements
3611	Electrical Equipment for use in Class I-Division 2; Class II-Division 2; and Class III-Divisions 1 and 2, Hazardous Locations
3810	Electrical and Electronic Test, Measuring and Process Control Equipment
CSA C22.2 No. 213, Reaffirmed 2004	Non-Incendive Electrical Equipment for Use in Class I, Division 2 Hazardous Locations - Industrial Products
CSA C22.2 No 1010.1, Issued 2004	Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 1: General Requirements

Notes

- For hazardous location applications, redundant power sources should be used for system power. Also, any signal going to or through a hazardous atmosphere must use hazardous location protection, such as an IS Barrier. For information on application-specific installation instructions for hazardous locations, refer to Chapter 3, Installation and Maintenance.
- FM has not certified the following Tricon products: Model 8110ATEX Main Chassis, Model 8111ATEX Expansion Chassis, Model 8112ATEX RXM Chassis, Model 3009 Main Processor, Model 4610 Unified Communication Module, and Model 8120E Enhanced Performance Main Chassis.

For more information about FM certifications for Tricon Products, contact the Global Customer Support (GCS) center.

Bureau Veritas (BV)

BV has certified specific Tricon products as being in full compliance with the following internationally recognized standard and qualified for use in marine environments.

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

Note BV has not certified the Model 3009 Main Processor.

For more information, see Tricon Equipment Certified for Use in Marine Environments on page 41. Also, refer to Chapter 3, Installation and Maintenance for application-specific installation instructions. For more information about Bureau Veritas certifications for Tricon products, contact the Global Customer Support (GCS) center.

TÜV Rheinland

TÜV has certified that the Tricon controller is in full compliance with the internationally recognized standards listed below, and thus is qualified for use in the following applications and jurisdictions.

- Emergency safety shutdown or other critical control applications requiring SIL 1-3 certification per the functional safety requirements of IEC 61508
- 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
- Burner management applications requiring certification per the requirements of EN 50156-1
- Burner management applications requiring certification per the requirements of NFPA 85 or NFPA 86
- All applications for use in European Union or other jurisdictions requiring compliance with the EMC Directive No. 2004/108/EC and Low Voltage Equipment Directive No. 2006/95/EE
- All applications for use in the European Union or other jurisdictions requiring compliance with the ATEX Directive No. 94/9/EC for Zone 2, Group IIB hazardous locations

Standard Number	Title
IEC 61508, Parts 1-7:2010	Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems
IEC 61511, Parts 1-3:2004	Functional safety - Safety instrumented systems for the process industry sector
IEC 61326-3-1:2008	Electrical equipment for measurement, control and laboratory use - EMC requirements – Part 3-1: Immunity requirements for safety-related systems and for equipment intended to perform safety-related functions (functional safety) - General industrial applications
IEC 61131-2:2007	Programmable controllers. Equipment requirements and tests. Overvoltage Category II and Zone B (EMC Immunity) are assumed
EN 50130-4:1995 + A1:1998 + A2:2003	Alarm systems – Part 4: Electromagnetic compatibility - Product family standard: Immunity requirements for components of fire, intruder and social alarm systems

Standard Number	Title
EN 50156-1:2004	Electrical equipment for furnaces and ancillary equipment – Part 1: Requirements for application design and installation
EN 50178:1998	Electronic equipment for use in power installations
EN 61000-6-2:2005	Electromagnetic compatibility (EMC) – Part 6-2: Generic standards - Immunity for industrial environments
EN 61000-6-4:2007	Electromagnetic compatibility (EMC) – Part 6-4: Generic standards - Emission standard for industrial environments
EN 54-2:1997 + AC:1999 + A1:2006	Fire detection and fire alarm systems – Part 2: Control and indicating equipment
EN 298: 2012	Automatic gas burner control systems for gas burners and gas burning appliances with or without fans
NFPA 72	National Fire Alarm and Signaling Code, 2013 Edition
NFPA 85	Boiler and Combustion Systems Hazards Code, 2011 Edition
NFPA 86	Standard for Ovens and Furnaces, 2011 Edition
EN 61000-4-2:2008	Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test
EN 61000-4-3:2006 + A1:2008 + IS1:2009	Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test
EN 61000-4-4:2012	Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test
EN 61000-4-5:2006	Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques - Surge immunity test
EN 61000-4-12:2006	Electromagnetic compatibility (EMC) – Part 4-12: Testing and measurement techniques - Ring wave immunity test
EN 61000-4-16:1998 + A1:2004	Electromagnetic compatibility (EMC) – Part 4-16: Testing and measurement techniques - Test for immunity to conducted, common mode disturbances in the frequency range 0 Hz to 150 kHz
ISA 84.00.01	Functional Safety: Safety Instrumented Systems for the Process Industry Sector (ANSI/ISA-84.00.01-2004)

Notes

- The list of standards above applies only to systems being shipped with this version of the *Planning and Installation Guide for Tricon v9–v11 Systems* (April 2013, Document No. 9720077-018). For standards applicable to older systems, refer to the version of the *Planning and Installation Guide for Tricon v9–v11 Systems* that came with the system, or the applicable TÜV Certification Report. If you need assistance, please contact the Global Customer Support (GCS) center.

- To meet Performance Criteria A for the “Fast Transient Burst” test defined in EN 54-2:1997+A1:2006, the Model 3564 Digital Input Module must have an EMI filter, similar to the Schaffner FN 2010-20, installed on the 24 V field power line. Note that this is the definition of Performance Criteria A: “During testing, normal performance within the specification limits.”
- The following table identifies modules that met Performance Criteria B, rather than the required Performance Criteria A, for some of the tests defined in IEC 61326-1:2012, IEC 61131-2:2007, and EN 54-2:1997+A1:2006. Note that this is the definition of Performance Criteria B: “During testing, temporary degradation, or loss of function or performance which is self-recovering.”

Module	Conducted Immunity - Performance Criteria B	Radiated Susceptibility - Performance Criteria B	Surge - Performance Criteria B
3706A	✓	✓	✓
3708E		✓	✓
3805E	✓		✓
3805H	✓		✓

Refer to Chapter 3, Installation and Maintenance for application-specific installation instructions.

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) ML120900890, *Final Safety Evaluation By The Office Of Nuclear Reactor Regulation, Triconex Topical Report 7286-545-1, Revision 4*. This report is available from the NRC via the Agency Document Access and Management System (ADAMS) website. 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*.

Notes

- For compliance with the CE 102 conducted emissions requirements, the Model 8311N2 24 VDC Power Module requires installation of an external line filter (Corcom Model 60DCB6F) on the input power leads. For the Model 8310N2 120 V Power Module and the Model 8312N2 230 VAC Power Module, please contact the Global Customer Support (GCS) center.
- The Model 3009 Main Processor and the Model 4610 Unified Communication Module are not certified for use in nuclear 1E applications.
- For details on models and revisions qualified for 1E applications, please contact the Global Customer Support (GCS) center.

European Union CE Mark

Based upon independent TÜV evaluations and test results, Invensys has certified that:

- The Tricon v10.x and Tricon v11.x controllers are suitable to use in the European Union and all other jurisdictions requiring compliance with the European Union EMC Directive No. 2004/108/EC and Low Voltage Equipment Directive No. 2006/95/EC.
- The Tricon v9.x 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 the EC Declarations of Conformity for details.

Refer to Chapter 3, Installation and Maintenance for application-specific installation instructions.

Declaration of Conformity

The following declarations of conformity with the European Union directives for electromagnetic compatibility and low-voltage equipment are provided as a convenience. These declarations are the latest available at publication time and may have been superseded. For updates, contact the Global Customer Support (GCS) center.

Invensys Systems, Inc.
26561 Rancho Parkway South
Lake Forest, CA 92630 USA

EC Declaration of Conformity

EU Directives Covered by this Declaration

- 2004/108/EC Electromagnetic Compatibility Directive
- 2006/95/EC Low Voltage Equipment Directive

Products Covered by this Declaration

Tricon (Triple Modular Redundant Controller) Version 11.x—2770H, 2870H, 3008, 3009, 3501T, 3502E, 3503E, 3504E, 3505E, 3510, 3511, 3515, 3564, 3601T, 3603T, 3604E, 3607E, 3614E, 3615E, 3617E, 3623T, 3624, 3625, 3625A, 3636T, 3664, 3674, 3700, 3700A, 3701, 3703E, 3704E, 3706A, 3708E, 3720, 3721, 3805E, 3805H, 3806E, 3807, 4200, 4201, 4210, 4211, 4351, 4351A, 4351B, 4352, 4352A, 4352B, 4353, 4354, 4409, 4610, 8310, 8311, 8312, chassis, termination products

Basis on which Conformity is being Declared

The product identified above complies with the requirements of the above EU Directives by meeting these standards.

1.	**EN 61000-6-4:2007**	**EMC – Emissions**
	EN 55011:2007 Gr. 1 Kl. A	Conducted and radiated
	IEC 61131-2:2007	Radiated interference (class A)
	IEC 61000-6-4:2007	Radiated interference (class A)
	IEC 61131-2:2007	Conducted interference (class A)
2.	**EN 61131-2:2007**	**EMC – Immunity**
	IEC 61131-2:2007 - 9.5	Electrostatic discharge
	IEC 61326-3-2:2008	Electrostatic discharge
	EN 50130-4:2003	Electrostatic discharge
	EN 61000-4-2:2008	Electrostatic discharge
	EN 61000-4-3:2006 + A1:2008 + IS1:2009	Radiated HF fields
	IEC 61131-2:2007 - 9.8	Fast transient bursts
	IEC 61326-3-1:2008	Fast transient bursts
	IEC 61326-3-2:2008	Fast transient bursts
	EN 50130-4:2003	Fast transient bursts
	EN 61000-4-4:2012	Fast transient bursts
	IEC 61131-2:2007 - 9.9	High-energy surges
	IEC 61326-3-2:2008	High-energy surges
	EN 50130-4:2003	High-energy surges
	EN 61000-4-5:2006	High-energy surges
	IEC 61131-2:2007	Damped oscillatory wave (Ringwave)
	EN 61000-4-12:2006	Damped oscillatory wave (Ringwave)
	IEC 61326-3-1:2008 - Table 1 b-e	Conducted common mode voltage
	EN 61000-4-16:1998 + A1:2004	Conducted common mode voltage
3.	**EN 61131-2:2007**	**Product Safety**
	EN 61010-1:2007	Overvoltage Category II

Note Not all listed products have been tested against the latest version or all of the standards listed. In all cases, the listed products have been tested against the standards in force at the date of the product introduction.

The technical documentation required to demonstrate that the product meets the requirements of the above directives has been compiled by the signatory below and is available for inspection by the relevant enforcement authorities.

The CE mark was first applied in: 1996

Special Measures and Limitations which Must be Observed

The product must be installed and operated as described in the Planning and Installation Guide for Tricon v9-v11 Systems.

Signed:

Frank W. Kloer, P.E., Qualification Engineer
Invensys Systems, Inc.
20 May 2014

Invensys Operations Management, a business group of Invensys plc
26561 Rancho Parkway South
Lake Forest, CA 92630 USA

EC Declaration of Conformity

EU Directives Covered by this Declaration

- 2004/108/EC Electromagnetic Compatibility Directive
- 2006/95/EC Low Voltage Equipment Directive

Products Covered by this Declaration

Tricon (Triple Modular Redundant Controller) Version 10.x—2770H, 2870H, 3008, 3501T, 3502E, 3503E, 3504E, 3505E, 3510, 3511, 3515, 3564, 3601T, 3603T, 3604E, 3607E, 3614E, 3615E, 3617E, 3623T, 3624, 3625, 3625A, 3636T, 3664, 3674, 3700, 3700A, 3701, 3703E, 3704E, 3706A, 3708E, 3720, 3721, 3805E, 3805H, 3806E, 3807, 4119, 4119A, 4200, 4201, 4210, 4211, 4329, 4351, 4351A, 4351B, 4352, 4352A, 4352B, 4353, 4354, 4409, 4609, 8310, 8311, 8312, chassis, termination products

Basis on which Conformity is being Declared

The product identified above complies with the requirements of the above EU Directives by meeting these standards.

1.	**EN 61000-6-4:2007**	**EMC – Emissions**
	EN 55011:2007 Gr. 1 Kl. A	Conducted and radiated
	IEC 61131-2:2007	Radiated interference (class A)
	IEC 61000-6-4:2007	Radiated interference (class A)
	IEC 61131-2:2007	Conducted interference (class A)
2.	**EN 61131-2:2007**	**EMC – Immunity**
	IEC 61131-2:2007 - 9.5	Electrostatic discharge
	IEC 61326-3-2:2008	Electrostatic discharge
	EN 50130-4:2003	Electrostatic discharge
	EN 61000-4-2:2008	Electrostatic discharge
	EN 61000-4-3:2006 + A1:2008 + IS1:2009	Radiated HF fields
	IEC 61131-2:2007 - 9.8	Fast transient bursts
	IEC 61326-3-1:2008	Fast transient bursts
	IEC 61326-3-2:2008	Fast transient bursts
	EN 50130-4:2003	Fast transient bursts
	EN 61000-4-4:2004	Fast transient bursts
	IEC 61131-2:2007 - 9.9	High-energy surges
	IEC 61326-3-2:2008	High-energy surges
	EN 50130-4:2003	High-energy surges
	EN 61000-4-5:2006	High-energy surges
	IEC 61131-2:2007	Damped oscillatory wave (Ringwave)
	EN 61000-4-12:2006	Damped oscillatory wave (Ringwave)
	IEC 61326-3-1:2008 - Table 1 b-e	Conducted common mode voltage
	EN 61000-4-16:1998 + A1:2004	Conducted common mode voltage
3.	**EN 61131-2:2007**	**Product Safety**
	EN 61010-1:2007	Overvoltage Category II

Note Not all listed products have been tested against the latest version or all of the standards listed. In all cases, the listed products have been tested against the standards in force at the date of the product introduction.

The technical documentation required to demonstrate that the product meets the requirements of the above directives has been compiled by the signatory below and is available for inspection by the relevant enforcement authorities.

The CE mark was first applied in: 1996

Special Measures and Limitations which Must be Observed

The product must be installed and operated as described in the Planning and Installation Guide for Tricon v9-v10 Systems.

Signed:

Frank W. Kloer, P.E., Qualification Engineer
Invensys Operations Management
6 February 2013

Triconex Business Unit of Invensys Systems, Inc.
26561 Rancho Parkway South
Lake Forest, CA 92630 USA

EU-Declaration of Conformity

The EU Directives covered by this Declaration

- 89/336/EEC Electromagnetic Compatibility Directive, amended by 92/31/EEC & 93/68/EEC
- 72/23/EEC Low Voltage Equipment Directive, amended by 93/68/EEC

The Products Covered by this Declaration

Tricon (Triple Modular Redundant Controller) Version 9.x—3006, 3008, 3501T, 3502E, 3503E, 3504E, 3505E, 3510, 3511, 3515, 3564, 3601T, 3603T, 3604E, 3607E, 3614E, 3615E, 3617E, 3623T, 3624, 3636T, 3664, 3674, 3700, 3700A, 3701, 3703E, 3704E, 3706A, 3708E, 3805E, 3806E, 4119, 4119A, 4200, 4201, 4210, 4211, 4329, 4409, 4609, 8310, 8311, 8312, chassis, termination products

The Basis on which Conformity is being Declared

The product identified above complies with the requirements of the above EU Directives by meeting these standards.

1.	**EN 50081-2:1993**	**EMC - Emissions**
	EN 55011:1998 Gr. 1 Kl. A	Conducted and radiated
2.	**EN 61131-2:1994/A11:1996**	**EMC - Immunity**
	EN 61000-4-2:1995/A1:1998	ESD
	EN 61000-4-3:1996	Radiated HF fields
	EN 61000-4-4:1995	Burst
	EN 61000-4-5:1995	Surge
	EN 61000-4-12:1995	Ringwave
3.	**EN 61131-2:1994/A11:1996**	**Product Safety**
	EN 61010-1:1993	Overvoltage Category II

Note: Not all listed products have been tested against the latest version or all of the standards listed. In all cases, the listed products have been tested against the standards in force at the date of the product introduction.

The technical documentation required to demonstrate that the product meets the requirements of the above directives has been compiled by the signatory below and is available for inspection by the relevant enforcement authorities. The CE mark was first applied in: 1996.

Special Measures and Limitations which must be Observed

The product must be installed and operated as described in the Planning and Installation Guide for Tricon v9 Systems.

Signed:

Paul Mesmer, Director, Quality Assurance
Invensys Triconex
16 October 2008

Environmental Certification

The Tricon system has been tested for use in harsh environmental conditions up to Class G3 (Harsh) environments as defined in ISA Standard S71.04-1985: Environmental Conditions for Process Measurement and Control systems: Airborne Contaminants, based on mixed flowing gas exposure testing according to EIA Standard 364-65, Class IIIA, against the environmental conditions described in the following table.

Feature	Specification
Temperature	30° C ± 1° C
Relative Humidity	70% ± 2%
$C1_2$	20 ± 5 ppb
NO_2	200 ± 50 ppb
H_2S	100 ± 20 ppb
SO_2	200 ± 50 ppb
Exposure Time[a]	20 days

a. The exposure time of 20 days is the “accepted equivalency of 10 years” in an industrial environment.

Notes

- The synergistic effects of various combinations of corrosive gases make the determination of severity levels complex.
- The affects of elevated temperature and high or variable relative humidity may cause the acceleration of corrosion by gaseous contaminants and will impact the corrosion rates.
- The differing levels of exposure to harsh environmental conditions can reduce the equipment Mean Time Between Failure (MTBF).
- The Tricon system is not designed for prolonged exposure to particulate corrosive elements such as Sulphur. Under such conditions, provide suitable protection, such as purged air cabinets with appropriate filtration systems, to ensure that the Tricon hardware is not exposed to particulate based corrosive elements.
- The use of conformal coating does not stop the corrosive effects of harsh environmental conditions.
- For equipment installations in harsh environmental conditions, Invensys suggests that customers obtain the guidance of an environmental chemical or biological specialist.

The following table lists Tricon equipment that has been tested for mixed flowing gas exposure.

Table 1 Tricon Equipment Tested for Mixed Flowing Gas Exposure

Model Number	Description
Modules and Chassis	
8110	Main Chassis
8111	Expansion Chassis
8310	High-Density Power Module, 120 V
8311	High-Density Power Module, 24 VDC
8312	High-Density Power Module, 230 VAC
3008	Enhanced Main Processor III, 16 Mb
4200	Primary Fiber Optic RXM, Single Module
4210	Primary Fiber Optic SRXM, Single Module
4354	Tricon Communication Module (TCM), Multimode Fiber Optic, Embedded OPC
2870H	AO HART Interface, TMR
3501E	DI, 115 VAC/VDC, Isolated, Non-commoned, TMR, 32 pts.
3503E	DI, 24 VAC/VDC, Commoned in Groups of 8, Self-Test, TMR, 32 pts.
3504E	DI, 24 VDC or 48 VDC, TMR, 64 pts.
3511	Pulse Input, Differential, AC Coupled, TMR, 8 pts.
3515	Pulse Totalizer Input, TMR, 32 pts.
3564	DI, 24 VDC, Commoned, Single, 64 pts.
3601E	DO, 115 VAC, Non-commoned, TMR, 16 pts.
3603B	DO, 120 VDC, Non-commoned, TMR, 16 pts.
3603T	DO, 120 VDC, Opto-isolated, Commoned, TMR, 16 pts.
3604E	DO, 24 VDC, Opto-isolated, Non-commoned, TMR, 16 pts.
3617E	DO, 48 VDC, Supervised, Commoned, TMR, 8 pts.
3624	DO, 24 VDC, Opto-isolated, Commoned, Supervised, TMR, 16 pts.
3625	DO, 24 VDC, Supervised/Non-supervised, Commoned, TMR, 32 pts.
3636T	Relay Output, Non-commoned, Simplex, 32 pts.
3700A	AI, 0–5 VDC, Non-commoned, TMR, 32 pts.
3704E	AI, 0–5 VDC or 0–10 VDC, Commoned, TMR, 64 pts.
3708E	Thermocouple Input; Type E, J, K, T; Isolated, TMR, 16 pts.
3806E	AO, 6 outputs at 4–20 mA, 2 outputs at 20–320 mA, TMR
3807	AO, Bipolar -60 to 60 mA, TMR, 4 pts.

Table 1 Tricon Equipment Tested for Mixed Flowing Gas Exposure *(continued)*

Model Number	Description
3721	AI, 0–5 VDC or –5 to +5 VDC, Differential, DC Coupled, TMR, 32 pts.
External Termination Panels	
9251-210	DO ETP, 120 VDC, Non-commoned, 3603B Module, 16 pts.
9553-610	DI ETP, Basic, 24 V, 32 pts.
9561-110	DI ETP, 115 V, Non-commoned, Fuse Protection, 16 pts.
9563-810	DI ETP, 24 V, Commoned, Fuse Protection, 16 pts.
9566-810	DI ETP, 24 VDC, Commoned, Resistor Protection, 32 pts.
9570-610	DI ETP, Hazardous Location (ATEX), 24 VDC, High-density, Resistor Protection, 32 pts.
9572-610	DI ETP, Hazardous Location (ATEX), 24 VDC, Commoned, Resistor Protection, 16 pts.
9653-610	DO ETP, Basic, 24 V, 16 pts.
9661-510	DO ETP, 115 VAC, Commoned, Fuse Protection, 8 pts.
9662-810	DO ETP, 24 VDC, Commoned, Fuse Protection, 16 pts.
9662-110	DO ETP, 24 VDC, Non-commoned, Fuse Protection, 16 pts.
9663-610	DO ETP, 115 VAC, Commoned, Fuse Protection, 16 pts.
9664-110	DO ETP, 115 VAC, Non-commoned, Fuse Protection, 16 pts.
9668-110	DO ETP, Relay Output, Non-commoned, Fuse Protection, 16 pts.
9671-610	DO ETP, Hazardous Location (ATEX), 24 VDC, Commoned, 16 pts.
9671-810	DO ETP, 24 VDC, Interposing Relay, Commoned, 16 pts.
9750-810	AO ETP, Basic, 0-5 VDC/0-10 VDC Voltage Input, 32 pts.
9750-310	DI ETP, Basic, 24 V, 32 pts.
9753-110	Pulse Input and Pulse Totalizer Input ETP, 8 PI pts./16 PTI pts.
9760-210	AI ETP, Current Input, 0-5 VDC, Resistor Protection, 32 pts.
9761-210	AI ETP, Current Input, 0-5 VDC, Resistor Protection, 16 pts.
9762-210	AI ETP, Current Input, 0-5 VDC, Resistor Protection, 16 pts.
9763-810	AI ETP, 0–5 VDC/0–10 VDC Voltage Input, 16 pts.
9764-310	AI ETP, RTD/TC/AI Input, 0-5 VDC, 16 pts.
9765-210	AI ETP, 3-Wire Current Input, 0-5 VDC, Fuse Protection, 32 pts.
9765-610	AI ETP, Thermocouple Input, Upscale/Downscale, 16 pts.
9771-210	AI ETP, Current Input, 0-5 VDC, User-Configurable, Resistor Protection, 16 pts.
9786-110	AI ETP, Hazardous Location (ATEX), Thermocouple Input, Upscale/Downscale, 16 pts.
9791-610	AI ETP, Hazardous Location (ATEX), 4-20 mA, 0–5 VDC, Resistor Protection, 16 pts.
9793-110	Pulse Input ETP, Hazardous Location (ATEX), 8 pts.

Table 1 Tricon Equipment Tested for Mixed Flowing Gas Exposure *(continued)*

Model Number	Description
9861-610	AO ETP, Hazardous Location (ATEX), 3805E/H module, 8 pts.
9871-810	AO ETP, Hazardous Location (ATEX), 3807 Module, 4 pts.

Harsh Environment Statement of Compliance - Class G3

The following statement of compliance with the International Society of Automation (ISA) S71.04 *Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants* standard for operational environments is provided as a convenience. This statement of compliance is the latest available at publication time and may have been superseded. For updates, contact the Global Customer Support (GCS) center.

Triconex

by Schneider Electric

Triconex Tricon System G3 Corrosion Rating - Compliance Statement

Triconex Tricon system offerings are suitable for use in Class G3 (Harsh) environments as defined in ISA Standard S71.04, based on exposure testing according to EIA Standard 364-65, Class IIIA *

Standards applied:

Standard ISA S71.04-1985 - *Environmental Conditions for Process Measurement and Control Systems: Airborne Contaminants* covers airborne contaminants that affect electrical/electronic equipment and establishes airborne contaminant classes. Severity levels are established, and measured as total angstroms of corrosion reactivity on copper coupons. The total number of angstroms measured on the reactivity coupons correlates with the reliability of the electronic equipment in that space.

Standard EIA 364-65 – *TP65A Mixed Flowing Gas*, defines a laboratory test in which the temperature (ºC), relative humidity (%RH), concentration of gaseous pollutants (ppb level), and other critical variables (such as volume exchange rate and airflow rate) are carefully defined, monitored, and controlled. For industrial applications, EIA-364-65 is widely accepted as a qualification test method to accelerate atmospheric corrosion and its effect on electronic applications.

Mixed Gas Test:

The operational environments for electronic equipments in atmosphere are divided into four classes, from least corrosive (Class G1) to most corrosive (Class GX). Class G1 means well-controlled office environment with continuous adjustment. Class G2 means light industrial environment, such as business offices without effective or continuous environment control. Class G3 means moderate industrial environment, such as process areas with poor environment control. Class GX has no upper boundary and would apply to a heavy industrial environment, such as locations adjacent to primary sources of atmospheric pollutant gases.

Triconex test methods employ EIA Class IIIA as a reasonable approximation of ISA Class G3 using a combination of temperature, humidity, and four corrosive gases (NO_2, H_2S, Cl_2, SO_2) to accelerate corrosion.

The mixed flowing gas environment is widely accepted by the process industry as an accelerated testing method. The testing methods employ appropriate checks and balances to ensure proper test conditions and concentration. Exposure testing is performed routinely on all new control and I/O product designs to simulate no less than 10 years of service in a G3 environment. Functionality of the products following exposure is verified in all cases to meet published specifications.

* Modules excluded from certification are Models 3807, 3611E, and 3617E.

Signature:

Name: Frank Kloer
Title: Qualification Engineer
Date: June 12, 2014

2

System Components

Overview

This chapter describes the hardware components available for Tricon systems. A Tricon system consists of a Main Chassis and as many as 14 Expansion or RXM (remote) Chassis, with a maximum of 118 I/O modules. Numerous communication modules are available to interface with OPC clients, Modbus devices, Internet devices, Foxboro and Honeywell DCS, and other Tricon, Trident™, and Tri-GP controllers.

General Environmental and EMC Specifications

The Tricon controller fully meets the requirements of IEC 61131, Part 2: Programmable Controllers, Equipment requirements and tests, for environmental withstand and immunity, and electromagnetic compatibility. This table outlines the general environmental and EMC specifications for the Tricon controller. For details, refer to IEC 61131.

Table 2 General Environmental and EMC Specifications for the Tricon Controller

Feature	Specification
Operating Temperature	32° to 140° F (0° to 60° C), ambient, as measured at the bottom of the chassis, per IEC 61131-2:2007
Storage Temperature	-40° to 167° F (-40° to 75° C), per IEC 61131-2:2007
Relative Humidity	5% to 95%, non-condensing, per IEC 61131-2:2007
Corrosive Environment	Class G3 Level as defined in ISA Standard S71.04, based on exposure testing according to EIA Standard 364-65, Class IIIA[a]
Sinusoidal Vibrations per Axis	1 G @ 8.4 to 150 Hz, 3.5mm @ 5 to 8.4 Hz, per IEC 61131-2
Shock	15 G for 6-11 ms in each axis, per IEC 61131-2:2007
Electrostatic Discharge	IEC 61000-4-2, 8 kV air, 4 kV contact
Conducted Susceptibility	IEC 61000-4-4, Fast Transient/Burst, 2 kV power, 1 kV 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 according to the guidelines in this manual
Radiated Emissions	CISPR 11, Class A, 30-1000 MHz @ 10m, 4-47 db when installed according to the guidelines in this manual

a. For more details on the suitability of the Tricon system in corrosive environments, see the Harsh Environment Statement of Compliance - Class G3 on page 34.

Bureau Veritas (BV) has certified specific Tricon products for use in marine environments. For more information, see Tricon Equipment Certified for Use in Marine Environments on page 41.

The NRC has certified that:

- Tricon v9.x controller is suitable for use in nuclear 1E applications per the requirements of EPRI TR - 102323, *Guidelines for Electromagnetic Interference Testing In Power Plants*, and IEEE 344, *Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations*.
- Tricon v10.x controller is suitable for use in nuclear 1E applications per the requirements of Regulatory Guide 1.180, Revision 1, *Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems*.

For details on models and revisions qualified for 1E applications, see Tricon v9.x Equipment Certified for Use in Nuclear 1E Applications on page 43, Tricon v10.x Equipment Certified for Use in Nuclear 1E Applications on page 49 or contact Global Customer Support Center.

Typical Weight of Components

This table identifies the typical weight of Tricon components.

Table 3 Weight of Tricon Components

Component	Approximate Weight
Main or Expansion Chassis (with no modules installed)	54.0 lbs (24.5 kg)
Main Processor	4.7 lbs (2.1 kg)
Power Module	7.2 lbs (3.3 kg)
I/O Module	4.75 lbs (2.1 kg to 2.7 kg)
Communication Module	5.0 lbs (2.3 kg)
16-point Termination Panel	0.8 lbs (.36 kg)
32-point Termination Panel	1.4 lbs (.64 kg)
Typical Loaded Chassis	160 lbs (72.6 kg)—average

Cable Flame Test Ratings

All standard Triconex interface cables and I/O bus cables shipped after April 1, 2009 meet flame test ratings as described in this table.

Cable	Rating
Interface cables (connect external termination panels to I/O modules)	FT4 Vertical Flame Test-Cables in Cable Trays per C.S.A. C22.2 No. 0.3-92 Para 4.11.4[a]
I/O bus cables (connect chassis)	FT6 Horizontal Flame & Smoke Test-per C.S.A. C22.2 No. 0.3-92 Appendix B[b]

a. Cables will be marked with FT4 or CMG rating, but they all actually meet the more stringent FT4 rating.

b. Cables will be marked with FT6 or CMR rating, but they all actually meet the more stringent FT6 rating.

Ground Systems

The Tricon controller includes three separate ground systems:

- Protective earth ⏚ —an AC safety or chassis ground
- Signal or instrument ground ⏚ —a functional earth
- Shield ground ⏚ —a functional earth

The digital and analog portions of each module use separate and isolated signal return paths which are connected together to form the Tricon controller signal ground. The chassis ground (sheet metal) of the Tricon controller acts as an electrostatic shield for the digital and analog circuitry. (All communication cable shields are terminated to the chassis ground.)

For installation procedures, see Controller Grounding on page 264.

Conformal Coating

Most of the Tricon hardware models in the *Planning and Installation Guide for Tricon v9–v11 Systems* and the *Field Terminations Guide for Tricon v9–v11 Systems* can be ordered with conformal coating by adding the letter "C" to the end of the standard model number. Note that the Model 3009 MP, the Model 4610 UCM, and the Model 8120E Enhanced Performance Main Chassis always have conformal coating.

The following equipment *cannot* be ordered with conformal coating:

- Equipment certified for use in nuclear 1E applications
- All types of cables; including interface cables, I/O bus cables, and fanned-out cables
- Blank slot covers

Neoprene dust covers are provided with external termination panels and chassis that are conformal coated. You can install the dust covers on unused external termination panel connectors and unused backplane connectors, at your discretion.

Some of the Tricon hardware with conformal coating has been certified for use in marine environments. For more information, see Tricon Equipment Certified for Use in Marine Environments on page 41.

Tricon Equipment Certified for Use in Marine Environments

Bureau Veritas (BV) has certified specific Tricon products, which are conformal coated, for use in marine environments.

The following table lists the model numbers of Tricon equipment certified for use in marine environments and identifies the standard model to see for information about the equipment. All of the information (specifications, simplified schematics, installation guidelines, and so on) for standard equipment also applies to marine equipment. Additionally, refer to Marine Environment Applications on page 227 for application-specific installation instructions.

Note The Model 3009 Main Processor and the Model 4610 Unified Communication Module are not certified for use in marine environments.

Table 4 Tricon Equipment Certified for Use in Marine Environments

Model Number	Description	See this Model
Modules and Chassis		
8110C	Main Chassis	8110
8111C	Expansion Chassis	8111
8112C	Remote Expansion Chassis	8112
8310C	High-Density Power Module, 120 V	8310
8311C	High-Density Power Module, 24 VDC	8311
8312C	High-Density Power Module, 230 VAC	8312
3008C	Enhanced Main Processor III, 16 Mb	3008
4200C	Remote Extender Module	4200
4200-3C	Remote Extender Module (Set)	4200-3
4201C	Remote Extender Module	4201
4201-3C	Remote Extender Module (Set)	4201-3
4351BC	Tricon Communication Module (TCM), copper	4351B
4352BC	Tricon Communication Module (TCM), fiber-optic	4352B
4353C	Tricon Communication Module (TCM), Embedded OPC Server, copper	4353
4354C	Tricon Communication Module (TCM), Embedded OPC Server, fiber-optic	4354

Table 4 Tricon Equipment Certified for Use in Marine Environments *(continued)*

Model Number	Description	See this Model
3703EC	AI, 0–5 VDC or 0–10 VDC, differential, isolated, TMR, 16 pts.	3703E
3721C	AI, 0–5 VDC or –5 to +5 VDC, differential, DC-coupled, TMR, 32 pts.	3721
3700AC	AI, 0–5 VDC, non-commoned, differential, DC-coupled, TMR, 32 pts.	3700A
3720C	AI, 0–5 VDC, single-ended, 64 pts.	3720
3805HC	AO, 4–20 mA, current loop, DC-coupled, TMR, 8 pts.	3805H
3505EC	DI, 24 VDC, low threshold, 32 pts.	3505E
3503EC	DI, 24 VAC/VDC, commoned in groups of 8, self-test, TMR, 32 pts.	3503E
3564C	DI, 0–5 VDC, single-ended, high-density, TMR, 64 pts.	3564
3664C	DO, 24 VDC, commoned, opto-isolated, self-protected, dual, 32 pts.	3664
3625C	DO, 24 VDC, supervised/non-supervised, commoned, TMR, 32 pts.	3625
3625AC	DO, 24 VDC, supervised/non-supervised, commoned, TMR, 32 pts.	3625A
3511C	Pulse Input, differential, AC-coupled, TMR, 8 pts.	3511
3636TC	Relay Output, normally open, non-triplicated, 32 pts.	3636T
External Termination Panels and FT4 Interface Cables[a]		
9563-810FC	Term panel with cable 4000187-310; for use with 3503EC and 3505EC	9563-810F
9566-710FC	Term panel with cable 4000187-310; for use with 3564C	9566-710F
9662-610FC	Term panel with cable 4000188-310; for use with 3625C, 3625AC, and 3664C	9662-610F
9668-110FC	Term panel with cable 4000188-110[b]; for use with 3636TC	9668-110F
9753-110FC	Term panel with cable 4000189-510; for use with 3511C	9753-110F
9765-210FC	Term panel with cable 4000206-510; for use with 3720C	9765-210F
9771-210FC	Term panel with cable 4000189-510; for use with 3700AC, 3703EC, and 3721C	9771-210F
9853-610FC	Term panel with cable 4000190-510; for use with 3805HC	9853-610F

a. For information about external termination panels and interface cables, see the *Field Terminations Guide for Tricon v9–v11 Systems*.

b. A low smoke zero halogen (LSZH) cable is also certified for use with the external termination assembly (ETA) that is included with model 9668-110FC. If you need the LSZH cable, order ETA 3000590-110C and LSZH cable 4000141-110, separately.

Tricon v9.x Equipment Certified for Use in Nuclear 1E Applications

Invensys has qualified specific Tricon version 9 products for use in 1E (safety-related) applications in nuclear power plants in accordance with EPRI Report TR-107330, "Generic Requirements Specification for Qualifying Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants." EMC testing was performed in accordance with EPRI Report TR-102323-R1, "Guidelines for Electromagnetic Interference Testing in Power Plants." The US Nuclear Regulatory Commission (NRC) issued a Safety Evaluation Report (ADAMS Accession Number ML011790327) for Triconex Topical Report 7286-545-1-A, Revision 1 (ADAMS Accession Number ML020730573).

All of the information (specifications, simplified schematics, installation guidelines, and so on) for standard equipment also applies to nuclear equipment. The following table lists the model numbers of Tricon v9.x equipment certified for use in Nuclear 1E applications and identifies the standard model to see for information about the equipment.

Table 5 Tricon v9.x Equipment Certified for Use in Nuclear 1E Applications

Model Number	Description	See This Standard Model
Modules and Chassis		
8110N	Main Chassis, High-Density Configuration	8110
8111N	Expansion Chassis, High-Density Configuration	8111
8112N	Remote Expansion Chassis	8112
8310N	High-Density Power Module, 120 VAC	8310
8311N	High-Density Power Module, 24 VDC	8311
8312N	High-Density Power Module, 230 VAC	8312
3006N	Enhanced Main Processor II, 2 Mb	3006
4210N	Remote Extender Module	4210
4210-3N	Remote Extender Module (Set)	4210-3
4211N	Remote Extender Module	4211
4211-3N	Remote Extender Module (Set)	4211-3
4119AN	Enhanced Intelligent Communication Module (EICM), serial (RS-232/RS-485) ports	4119A
4329N	Network Communication Module	4329
4609N	Advanced Communication Module	4609
3700AN	0–5 VDC, Differential, DC Coupled, Triple Modular Redundant (TMR)	3700A
3701N	0–10 VDC, Differential, DC Coupled, TMR	3701
3703EN	0–5 VDC or 0–10 VDC, Differential, Isolated, TMR	3703E
3704EN	0–5 VDC or 0–10 VDC, High-Density, Differential, DC Coupled, TMR	3704E

Table 5 Tricon v9.x Equipment Certified for Use in Nuclear 1E Applications *(continued)*

Model Number	Description	See This Standard Model
3805EN	4–20 mA, Current Loop, DC Coupled, TMR	3805E
3501TN	115 VAC/VDC, Opto-isolated, Non-commoned, TMR	3501T
3502EN	48 VAC/VDC, Commoned in Groups of 8, Self-Test, TMR	3502E
3503EN	24 VAC/VDC, Commoned in Groups of 8, Self-Test, TMR	3503E
3504EN	24 VDC or 48 VDC, High-Density, DC Coupled, TMR	3504E
3505EN	24 VDC, Low Threshold with Self-Test, Commoned, TMR	3505E
3601TN	115 VAC, Opto-Isolated, Non-commoned, TMR	3601T
3603TN	120 VDC, Opto-Isolated, Commoned, TMR	3603T
3604EN	24 VDC, Opto-Isolated, Non-commoned, TMR	3604E
3607EN	48 VDC, Opto-Isolated, Non-commoned, TMR	3607E
3623TN	120 VDC, Opto-Isolated, Commoned, Supervised, TMR	3623T
3624N	24 VDC, Opto-Isolated, Commoned, Supervised, TMR	3624
3510N	Pulse Input Module, TMR	3510
3706AN	Thermocouple, Differential, DC Coupled, TMR	3706A
3708EN	Thermocouple, Differential, Isolated, TMR	3708E
3636TN	Relay Output, Non-triplicated, Normally Open	3636T
8105N	Blank Module Panel	8105
External Termination Panels with XLPE I/F Cables [a]		
2551-1N	Term Panel (DI 3501TN) with XLPE Cable	2551-1
2552-6N	Term Panel (DI 3502EN) with XLPE Cable	2552-6
2553-6N	Term Panel (DI 3503EN, DI 3505 EN) with XLPE Cable	2553-6
2554-6N	Term Panel (DI 3504EN) with XLPE Cable	2554-6
2651-1N	Term Panel (DO 3601TN) with XLPE Cable	2651-1
2652-1N	Term Panel (DO 3604EN) with XLPE Cable	2652-1
2657-1N	Term Panel (DO 3607EN) with XLPE Cable	2657-1
2658-1N	Term Panel (RO 3636TN) with XLPE Cable	2658-1
2750-8N	Term Panel (AI 3700AN, AI 3701N) with XLPE Cable	2750-8
2752-2N	Term Panel (AI 3703EN) with XLPE Cable	2752-2
2755-6N	Term Panel (TC 3708EN) with XLPE Cable	2755-6
2760-2N	Term Panel (AI 3704EN) with XLPE Cable	2760-2
2790-310TN	Term Panel (AI 3700AN/RTD) with XLPE Cable	Contact Invensys
2852-1N	Term Panel (AO 3805EN) with XLPE Cable	2852-1

Table 5 Tricon v9.x Equipment Certified for Use in Nuclear 1E Applications *(continued)*

Model Number	Description	See This Standard Model
9561-810N	Term Panel (DI 3501TN, Commoned) with XLPE Cable	9561-810F
9562-810N	Term Panel (DI 3502EN, Commoned) with XLPE Cable	9562-810F
9563-810N	Term Panel (DI 3503EN, 3505EN) with XLPE Cable	9563-810F
9661-910N	Term Panel (DO 3603TN, DO 3623TN) with XLPE Cable	9661-910F
9662-110N	Term Panel (DO 3604EN) with XLPE Cable	9662-110F
9662-610N	Term Panel (DO 3624N) with XLPE Cable	9662-610F
9662-810N	Term Panel (DO 3604EN, Commoned) with XLPE Cable	9662-810F
9664-810N	Term Panel (DO 3603TN, DO 3623TN, upgraded replacement for 9661-910N) with XLPE Cable	9664-810F
9667-110N	Term Panel (DO 3607EN, Non-commoned) with XLPE Cable	9667-110F
9667-810N	Term Panel (DO 3607EN, Commoned) with XLPE Cable	9667-810F
9668-110N	Term Panel (RO 3636TN) with XLPE Cable	9668-110F
9753-110N	Term Panel (PI 3510N) with XLPE Cable	9753-110F
9761-210N	Term Panel (AI 3700AN, 4–20 mA, 0–5V) with XLPE Cable	9761-210F
9761-410N	Term Panel (AI 3701N, 4–20 mA, 0–10V) with XLPE Cable	9761-410F
9762-210N	Term Panel (AI 3703EN) with XLPE Cable	9762-210F
9762-410N	Term Panel (AI 3703EN, 4–20 mA, 0–10V) with XLPE Cable	9762-410F
9763-810N	Term Panel (3700AN, 3701N, 3703EN) with XLPE Cable	9763-810F
9764-310N	Term Panel (AI 3700AN/RTD, upgraded replacement for 2790-310TN) with XLPE Cable	9764-310F
9792-610N	Term Panel (AI 3700AN, 3703 EN) with XLPE Cable	9792-610F
9853-610N	Term Panel (AO 3805EN) with XLPE Cable	9853-610F
External Termination Panels with XLPEJ I/F Cables[a]		
2551-1NJ	Term Panel (DI 3501TN) with XLPEJ Cable	2551-1
2552-6NJ	Term Panel (DI 3502EN) with XLPEJ Cable	2551-6
2553-6NJ	Term Panel (DI 3503EN, DI 3505EN) with XLPEJ Cable	2553-6
2554-6NJ	Term Panel (DI 3504EN) with XLPEJ Cable	2554-6
2651-1NJ	Term Panel (DO 3601TN) with XLPEJ Cable	2651-1
2652-1NJ	Term Panel (DO 3604EN) with XLPEJ Cable	2652-1
2657-1NJ	Term Panel (DO 3607EN) with XLPEJ Cable	2657-1
2658-1NJ	Term Panel (RO 3636TN) with XLPEJ Cable	2658-1
2750-8NJ	Term Panel (AI 3700AN, AI 3701N) with XLPEJ Cable	2750-8

Table 5 Tricon v9.x Equipment Certified for Use in Nuclear 1E Applications *(continued)*

Model Number	Description	See This Standard Model
2752-2NJ	Term Panel (3703EN) with XLPEJ Cable	2752-2
2755-6NJ	Term Panel (TC 3708EN) with XLPEJ Cable	2755-6
2760-2NJ	Term Panel (AI 3704EN)with XLPEJ Cable	2760-2
2790-310TNJ	Term Panel (AI 3700AN/RTD) with XLPEJ Cable	Contact Invensys
2852-1NJ	Term Panel (AO 3805EN) with XLPEJ Cable	2852-1
9561-810NJ	Term Panel (DI 3501TN, Commoned)	9561-810F
9562-810NJ	Term Panel (DI 3502 EN, Commoned) with XLPEJ Cable	9562-810F
9563-810NJ	Term Panel (DI 3503EN, 3505EN) with XLPEJ Cable	9563-810F
9661-910NJ	Term Panel (DO 3603TN, DO 3623TN) with XLPEJ Cable	9661-910F
9662-110NJ	Term Panel (DO 3604EN) with XLPEJ Cable	9662-110F
9662-610NJ	Term Panel (3624N) with XLPEJ Cable	9662-610F
9662-810NJ	Term Panel (DO 3604EN, Commoned) with XLPEJ Cable	9662-810F
9664-810NJ	Term Panel (DO 3603TN, DO 3623TN, upgraded replacement for 9661-910N) with XLPEJ Cable	9664-810F
9667-110NJ	Term Panel (DO 3607EN, Non-commoned) with XLPEJ Cable	9667-110F
9667-810NJ	Term Panel (DO 3607EN, Commoned) with XLPEJ Cable	9667-810F
9668-110NJ	Term Panel (RO 3636TN) with XLPEJ Cable	9668-110F
9753-110NJ	Term Panel (PI 3510N) with XLPEJ Cable	9753-110F
9761-210NJ	Term Panel (AI 3700AN, 4–20 mA, 0-5V) with XLPEJ Cable	9761-210F
9761-410NJ	Term Panel (AI 3701N, 4–20 mA, 0-10V) with XLPEJ Cable	9761-410F
9762-210NJ	Term Panel (AI 3703EN) with XLPEJ Cable	9762-210F
9762-410NJ	Term Panel (AI 3703EN, 4–20 mA, 0-10V) with XLPEJ Cable	9762-410F
9763-810NJ	Term Panel (AI 3700AN, 3701N, 3703EN) with XPLEJ Cable	9763-810F
9764-310NJ	Term Panel (AI 3700AN/RTD, upgraded replacement for 2790-310TN) with XLPEJ Cable	9764-310F
9792-610NJ	Term Panel (AI 3700AN, 3703EN) with XLPEJ Cable	9792-610F
9853-610NJ	Term Panel (AO 3805EN) with XLPEJ Cable	9853-610F
External Termination Panels with PVC I/F Cables[a]		
2551-1N-P	Term Panel (DI 3501TN) with PVC Cable	2551-1
2552-6N-P	Term Panel (DI 3502EN) with PVC Cable	2552-6
2553-6N-P	Term Panel (DI 3503, DI 3505EN) with PVC Cable	2553-6
2554-6N-P	Term Panel (DI 3504EN) with PVC Cable	2554-6

Table 5 Tricon v9.x Equipment Certified for Use in Nuclear 1E Applications *(continued)*

Model Number	Description	See This Standard Model
2651-1N-P	Term Panel (DO 3601TN) with PVC Cable	2651-1
2652-1N-P	Term Panel (DO 3604EN) with PVC Cable	2652-1
2657-1N-P	Term Panel (DO 3607EN) with PVC Cable	2657-1
2658-1N-P	Term Panel (RO 3636TN) with PVC Cable	2658-1
2750-8N-P	Term Panel (AI 3700AN, AI 3701N) with PVC Cable	2750-8
2752-2N-P	Term Panel (AI 3703EN) with PVC Cable	2752-2
2755-6N-P	Term Panel (TC 3708EN) with PVC Cable	2755-6
2760-2N-P	Term Panel (AI 3704EN) with PVC Cable	2760-2
2790-310TN-P	Term Panel (AI 3700AN/RTD) with PVC Cable	Contact Invensys
2852-1N-P	Term Panel (AO 3805EN) with PVC Cable	2852-1
9561-810N-P	Term Panel (DI 3501TN, Commoned) with PVC Cable	9561-810F
9562-810N-P	Term Panel (DI 3502EN, Commoned) with PVC Cable	9562-810F
9563-810N-P	Term Panel (DI 3503EN, DI 3505EN) with PVC Cable	9563-810F
9661-910N-P	Term Panel (DO 3603TN, DO 3623TN) with PVC Cable	9661-910F
9662-110N-P	Term Panel (DO 3604EN) with PVC Cable	9662-110F
9662-610N-P	Term Panel (DO 3624N) with PVC Cable	9662-610F
9662-810N-P	Term Panel (DO 3604EN, Commoned) with PVC Cable	9662-810F
9664-810N-P	Term Panel (DO 3603TN, DO 3623TN, upgraded replacement for 9661-910N) with PVC Cable	9664-810F
9667-110N-P	Term Panel (DO 3607EN, Non-commoned) with PVC Cable	9667-110F
9667-810N-P	Term Panel (DO 3607EN, Commoned) with PVC Cable	9667-810F
9668-110N-P	Term Panel (RO 3636TN) with PVC Cable	9668-110F
9753-110N-P	Term Panel (PI 3510N) with PVC Cable	9753-110F
9761-210N-P	Term Panel (AI 3700AN, 4–20 mA, 0-5V) with PVC Cable	9761-210F
9761-410N-P	Term Panel (AI 3701N, 4–20 mA, 0–10V) with PVC Cable	9761-410F
9762-210N-P	Term Panel (AI 3703EN) with PVC Cable	9762-210F
9762-410N-P	Term Panel (AI 3703EN, 4–20 mA, 0–5V) with PVC Cable	9762-410F
9763-810N-P	Term Panel (AI 3700AN, 3701N, 3703EN) with PVC Cable	9763-810F
9764-310N-P	Term Panel (AI 3700AN/RTD, upgraded replacement for 2790-310TN) with PVC Cable	9764-310F
9792-610N-P	Term Panel (AI 3700AN, 3703EN) with PVC Cable	9792-610F
9853-610N-P	Term Panel (AO 3805EN) with PVC Cable	9853-610F

Table 5 Tricon v9.x Equipment Certified for Use in Nuclear 1E Applications *(continued)*

Model Number	Description	See This Standard Model
Tricon I/O Cable Sets[b]		
9000N	I/O Bus Cable Set with XLPE Cable	9000
9001N	I/O and Comm Bus Cable Set with XLPE Cable	9001
9000NJ	I/O Bus Cable Set with XLPEJ Cable	9000
9001NJ	I/O and Comm Bus Cable Set with XLPEJ Cable	9001
9000N-P	I/O Bus Cable Set with PVC Cable	9000
9001N-P	I/O and Comm Bus Cable Set with PVC Cable	9001
Signal Conditioners[c]		
1600024-010N	Signal Conditioner (-100/+100) Pt	1600024-010
1600024-020N	Signal Conditioner (0/+100) Pt	1600024-020
1600024-030N	Signal Conditioner (0/+200) Pt	1600024-030
1600024-040N	Signal Conditioner (0/+600) Pt	1600024-040
External Termination Ass em by (ETA) Mounting Plates (Blank Panels)		
9420017-070N	ETA Blank Panel 7 inches	Contact Invensys
Chassis Mounting Bracket Kits		
8405N	Auxiliary chassis mounting bracket assembly kit (auxiliary/rear bracket)	8405

a. For information regarding External Termination Panels, see the *Field Terminations Guide for Tricon v9–v11 Systems.*

b. The maximum length for cable models 9001N, 9001NJ, and 9001N-P is 6 feet.

c. For information regarding Signal Conditioners, see the *Field Terminations Guide for Tricon v9–v11 Systems.*

Tricon v10.x Equipment Certified for Use in Nuclear 1E Applications

Invensys has qualified specific Tricon version 10 products for use in 1E (safety-related) applications in accordance with EPRI Report TR-107330, "Generic Requirements Specification for Qualifying Commercially Available PLC for Safety-Related Applications in Nuclear Power Plants." EMC testing was performed in accordance with US Nuclear Regulatory Commission (NRC) Regulatory Guide 1.180, Revision 1, "Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems." The NRC issued a Safety Evaluation Report (ADAMS Accession Number ML120900890) for Triconex Topical Report 7286-545-1-A, Revision 4.

All of the information (specifications, simplified schematics, installation guidelines, and so on) for standard equipment also applies to nuclear equipment. The following table lists the model numbers of Tricon 10.x equipment certified for use in Nuclear 1E applications and identifies the standard model to see for information about the equipment.

Table 6 Tricon v10.x Equipment Certified for Use in Nuclear 1E Applications

Model Number	Description	See this Standard Model
Modules and Chassis		
8110N2	Main Chassis	8110
8111N	Expansion Chassis	8111
8112N	Remote Expansion Chassis	8112
8310N2	High-Density Power Module, 120 V	8310
8311N2	High-Density Power Module, 24 VDC	8311
8312N2	High-Density Power Module, 230 VAC	8312
3008N	Enhanced Main Processor III, 16 Mb	3008
4200N	Remote Extender Module	4200
4200-3N	Remote Extender Module (Set)	4200-3
4201N	Remote Extender Module	4201
4201-3N	Remote Extender Module (Set)	4201-3
4352AN	Tricon Communication Module (TCM)	4352A
4352BN	Tricon Communication Module (TCM)	4352B
3701N2	0–10 VDC, Differential DC Coupled, TMR	3701
3703EN	0–5 VDC or 0–10 VDC, Differential, Isolated, TMR	3703E
3721N	0–5 VDC or –5 to +5 VDC, Differential, DC Coupled, TMR	3721
3805HN	4–20 mA, Current Loop, DC Coupled, TMR	3805H
3501TN2	115 VAC, Opto-isolated, Non-commoned, TMR	3501T
3502EN2	48 VAC/VDC, Commoned in Groups of 8, Self-Test, TMR	3502E
3503EN2	24 VAC/VDC, Commoned in Groups of 8, Self-Test, TMR	3503E

Table 6 Tricon v10.x Equipment Certified for Use in Nuclear 1E Applications

Model Number	Description	See this Standard Model
3601TN	115 VAC, Opto-isolated, Non-commoned TMR	3601T
3603TN	120 VDC, Opto-isolated, Commoned, TMR	3603T
3607EN	48 VDC, Opto-isolate, Non-commoned, TMR	3607
3623TN	120 VDC, Opto-isolated, Commoned, Supervised, TMR	3623T
3625N	24 VDC, Supervised/Non-supervised, Commoned, TMR	3625
3511N	Pulse Input, Differential, AC Coupled, TMR	3511
3708EN	Thermocouple, Differential, Isolated, TMR	3708
3636TN	Relay Output, Normally Open, Non-triplicated	3636T
8105N	Blank Module Panel	8105
8107N	Seismic Balance Module	Contact Invensys
External Termination Panels with XLPE I/F Cables[a]		
9561-110N	Term Panel (3501TN2) with XLPE Cable	9561-110F
9561-810N	Term Panel (3501TN2) with XLPE Cable	9561-810F
9562-810N	Term Panel (3502EN2) with XLPE Cable	9562-810F
9563-810N	Term Panel (3503EN2) with XLPE Cable	9563-810F
9662-610N	Term Panel (3625N) with XLPE Cable	9662-610F
9662-810N	Term Panel (3625N) with XLPE Cable	9662-810F
9663-610N	Term Panel (3601TN) with XLPE Cable	9663-610F
9664-810N	Term Panel (3603TN, 3623TN) with XLPE Cable	9664-810F
9667-810N	Term Panel (3607EN) with XLPE Cable	9667-810F
9668-110N	Term Panel (3636TN) with XLPE Cable	9668-110F
9764-310N	Term Panel (3721N) with XLPE Cable	9764-310F
9782-110N	Term Panel (3708EN) with XLPE Cable	9782-110F
9783-110N	Term Panels (3721N, 3703EN, 3701N2) with XLPE Cable	9783-110F
9790-610N	Term Panels (3721N, 3703EN) with XLPE Cable	9790-610F
9792-610N	Term Panels (16–56 V Analog Input, 4–20 mA Nuclear EMC) with XLPE Cable	9792-610F
9794-110N	Term Panel (3511N) with XLPE Cable	9794-110F
9795-610N	Term Panel (3701N2) with XLPE Cable	9795-610F
9860-610N	Term Panel (3805HN) with XLPE Cable	9860-610F
External Termination Panels with XLPEJ I/F Cables[a]		
9561-110NJ	Term Panel (3501TN2) with XLPEJ Cable	9561-110F

Table 6 Tricon v10.x Equipment Certified for Use in Nuclear 1E Applications

Model Number	Description	See this Standard Model
9561-810NJ	Term Panel (3501TN2) with XLPEJ Cable	9561-810F
9562-810NJ	Term Panel (3502EN2) with XLPEJ Cable	9562-810F
9563-810NJ	Term Panel (3503EN2) with XLPEJ Cable	9563-810F
9662-610NJ	Term Panel (3625N) with XLPEJ Cable	9662-610F
9662-810NJ	Term Panel (3625N) with XLPEJ Cable	9662-810F
9663-610NJ	Term Panel (3601TN) with XLPEJ Cable	9663-610F
9664-810NJ	Term Panel (3603TN, 3623TN) with XLPEJ Cable	9664-810F
9667-810NJ	Term Panel (3607EN) with XLPEJ Cable	9667-810F
9668-110NJ	Term Panel (3636TN) with XLPEJ Cable	9668-110F
9764-310NJ	Term Panel (3721N) with XLPEJ Cable	9764-310F
9782-110NJ	Term Panel (3708EN) with XLPEJ Cable	9782-110F
9783-110NJ	Term Panel (3721N, 3703EN, 3701N2) with XLPEJ Cable	9783-110F
9790-610NJ	Term Panel (3721N, 3703EN) with XLPEJ Cable	9790-610F
9792-610NJ	Term Panel (16–56 V Analog Input, 4–20 mA Nuclear EMC) with XLPEJ Cable	9792-610F
9794-110NJ	Term Panel (3511N) with XLPEJ Cable	9794-110F
9795-610NJ	Term Panel (3701N2) with XLPEJ Cable	9795-610F
9860-610NJ	Term Panel (3805HN) with XLPEJ Cable	9860-610F
External Termination Panels with PVC I/F Cables [a]		
9561-110N-P	Term Panel (3501TN2) with PVC Cable	9561-110F
9561-810N-P	Term Panel (3501TN2) with PVC Cable	9561-810F
9562-810N-P	Term Panel (3502EN2) with PVC Cable	9562-810F
9563-810N-P	Term Panel (3503EN2) with PVC Cable	9563-810F
9662-610N-P	Term Panel (3625N) with PVC Cable	9662-610F
9662-810N-P	Term Panel (3625N) with PVC Cable	9662-810F
9663-610N-P	Term Panel (3601TN) with PVC Cable	9663-610F
9664-810N-P	Term Panel (3603TN, 3623TN) with PVC Cable	9664-810F
9667-810N-P	Term Panel (3607EN) with PVC Cable	9667-810F
9668-110N-P	Term Panel (3636TN) with PVC Cable	9668-110F
9764-310N-P	Term Panel (3721N) with PVC Cable	9764-310F
9782-110N-P	Term Panel (3708EN) with PVC Cable	9782-110F
9783-110N-P	Term Panel (3721N, 3703N, 3701N) with PVC Cable	9783-110F

Table 6 Tricon v10.x Equipment Certified for Use in Nuclear 1E Applications

Model Number	Description	See this Standard Model
9790-610N-P	Term Panel (3721N, 3703N)	9790-610F
9792-610N-P	Term Panel (16–56 V analog input, 4–20 mA Nuclear EMC) with PVC Cable	9792-610F
9794-110N-P	Term Panel (3511N) with PVC Cable	9794-110F
9795-610N-P	Term Panel (3701N2) with PVC Cable	9795-610F
9860-610N-P	Term Panel (3805HN) with PVC Cable	9860-610F
Tricon I/O Cable Sets[b]		
9000N	I/O Bus Cable Set with XLPE Cable	9000
9001N	I/O and Comm Bus Cable Set with XLPE Cable	9001
9000NJ	I/O Bus Cable Set with XLPEJ Cable	9000
9001NJ	I/O and Comm Bus Cable Set with XLPEJ Cable	9001
9000N-P	I/O Bus Cable Set with PVC Cable	9000
9001N-P	I/O and Comm Bus Cable Set with PVC Cable	9001
Signal Conditioners[c]		
1600024-010N	Signal Conditioner (-100/+100) Pt	1600024-010
1600024-020N	Signal Conditioner (0/+100) Pt	1600024-020
1600024-030N	Signal Conditioner (0/+200) Pt	1600024-030
1600024-040N	Signal Conditioner (0/+600) Pt	1600024-040
1600081-001N	Signal Conditioner (0 to 120° C) Cu	1600081-001
1600082-001N	Signal Conditioner (0 to 100 mV) Pt	1600082-001
1600083-200N	Signal Conditioner (0 to 200° C) Pt	Contact Invensys
1600083-600N	Signal Conditioner (0 to 600° C) Pt	Contact Invensys
External Termination Assembly (ETA) Mounting Plates (Blank Panels)		
9420017-010N	ETA Blank Panel 1.75 inches	Contact Invensys
9420017-030N	ETA Blank Panel 3.5 inches	Contact Invensys
9420017-050N	ETA Blank Panel 5.25 inches	Contact Invensys
9420017-070N	ETA Blank Panel 7 inches	Contact Invensys
Chassis Mounting Bracket Kits		
8405N	Auxiliary chassis mounting bracket assembly kit (auxiliary/rear bracket)	8405

a. For information about Termination Panels see the *Field Terminations Guide for Tricon v9–v11 Systems*.

b. The maximum length for cable models 9001N, 9001NJ, and 9001N-P is 6 feet.

c. For information about Signal Conditioners, see the *Field Terminations Guide for Tricon v9–v11 Systems*.

Main Chassis

This section describes the Main Chassis available for use with Tricon v9–v11 systems. For installation information, see Chassis and Module Installation on page 230.

Table 7 Main Chassis

Model[a]	Description	Compatible System Versions
8110	Main Chassis	9.0–11.x
8120E	Enhanced Performance Main Chassis	11.x

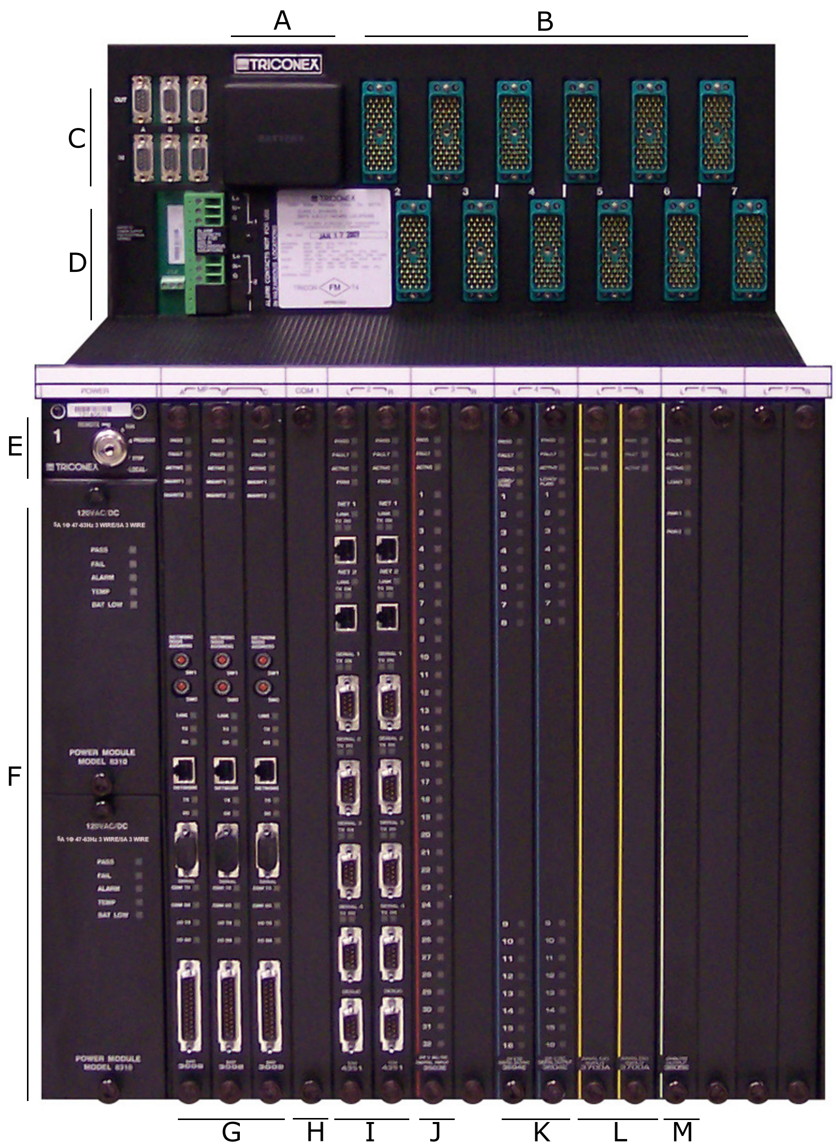
a. The Model 8100-1 Low-Density Main Chassis is also available for use with Tricon v9-v11 systems.

Model 8110 Main Chassis

A Tricon Model 8110 Main Chassis accepts two Power Modules, three Main Processors, two batteries, one communication (COM) slot with no hot-spare slot, and six logical slots for I/O and communication modules. Each logical slot provides two physical spaces for modules.

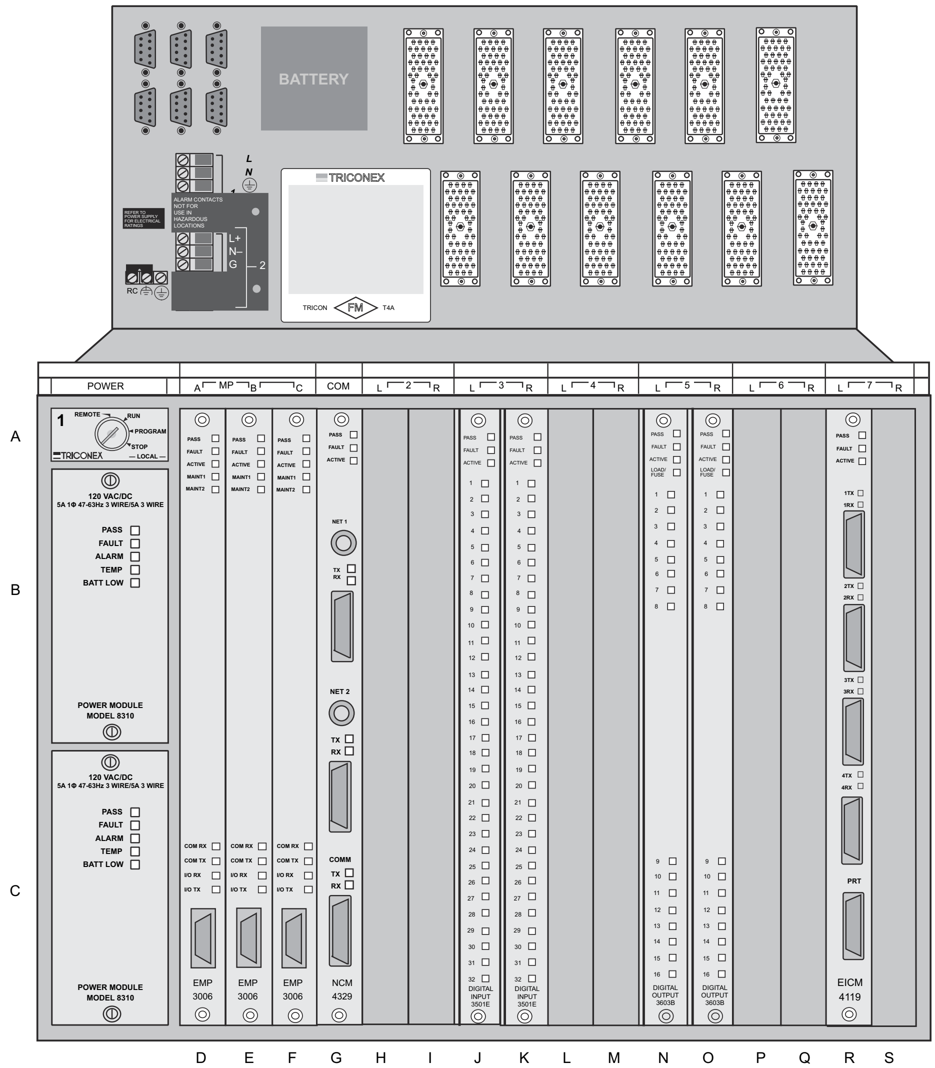
The TriBus in the Model 8110 Main Chassis operates at a speed of 25 Mbps when the Model 3008 MP or the Model 3009 MP is installed in the system. The TriBus operates at a speed of 4 Mbps when the Model 3006 MP or the Model 3007 MP is installed in the system.

Note For 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, use the Model 8110ATEX Main Chassis.



A. Memory backup battery
B. Connectors for terminations
C. I/O expansion ports
D. Power terminals
E. Keyswitch
F. Redundant power modules
G. Three main processors
H. COM 1 slot (empty)
I. Two TCMs
J. DI module without spare
K. DO module with hot-spare
L. AI module with hot-spare
M. AO module without spare

Figure 9 Typical Tricon v10.x System with a Model 8110 Main Chassis



A	Keyswitch with Chassis Number
B, C	Redundant Power Modules
D, E, F	Three Main Processors
G	Network Communication Module (NCM) in COM Slot
H, I	Blank
J, K	Digital Input Module with Hot Spare
L, M	Blank
N, O	Digital Output Module with Hot Spare
P, Q	Blank
R	Enhanced Intelligent Communication Module (EICM)
S	Blank

Figure 10 Typical Tricon v9.x System with a Model 8110 Main Chassis

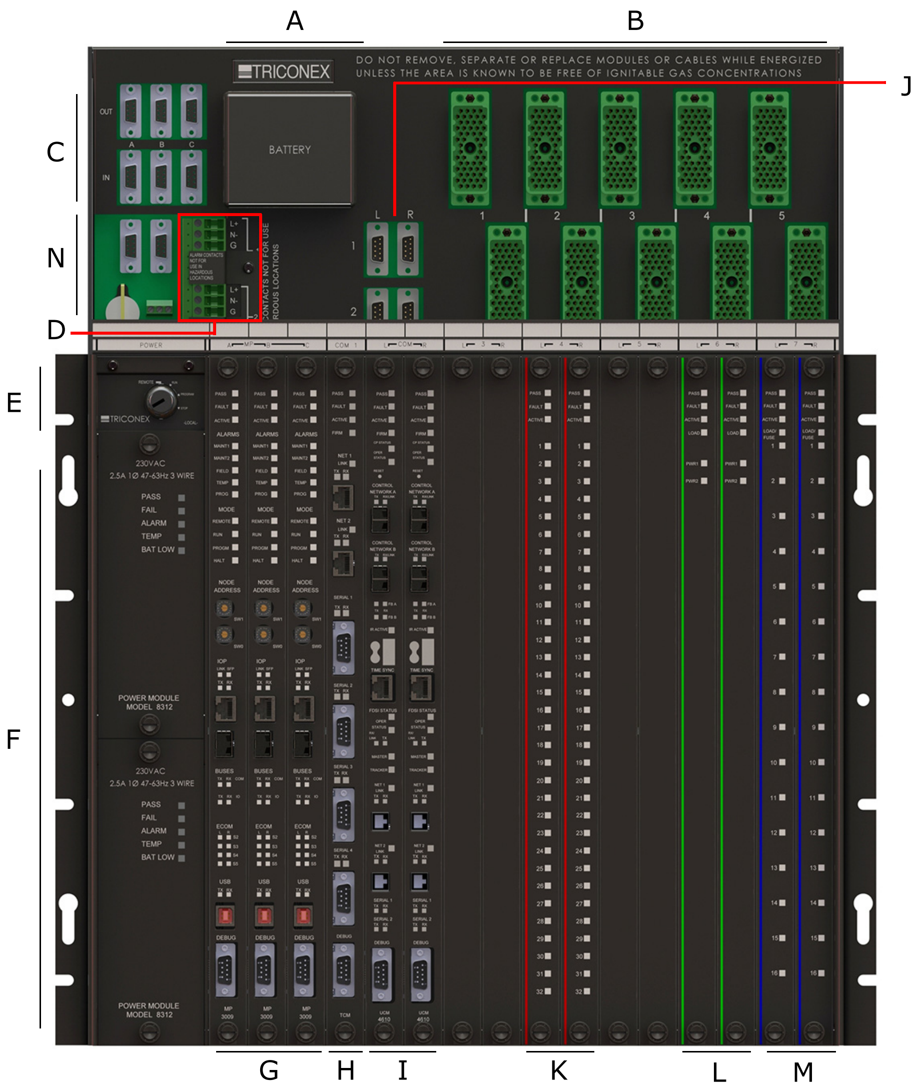
Model 8120E Enhanced Performance Main Chassis

A Tricon Model 8120E Enhanced Performance Main Chassis accepts two Power Modules, three Main Processors, and two batteries. It contains one communication slot (COM 1) with one module position, one communication slot (COM 2) with two module positions, and five logical slots for I/O and communication modules. Each logical slot, other than COM 1, provides two physical positions for modules. UCMs can be installed only in the COM 2 slot of this chassis.

The TriBus on the Tricon Model 8120E Enhanced Performance Main Chassis operates at a speed of 1000 Mbps when used with Model 3009 MPs. You should use the Model 8120E Enhanced Performance Main Chassis if you need fast response times and/or you are using UCMs.

CAUTION

The Model 8120E Enhanced Performance Main Chassis is designed for use with Model 3009 MPs. If you install other MP models, do so carefully because there is a risk of damage to the backplane of the chassis if you insert the modules too forcefully.



A. Memory backup battery
B. Connectors for terminations
C. I/O expansion ports
D. Power terminals
E. Keyswitch
F. Redundant power modules
G. Three main processors
H. COM 1 slot with TCM
I. COM 2 slot with UCMs
J. UCM serial ports
K. DI module with hot-spare
L. AO module with hot-spare
M. DO module with hot-spare
N. Reserved for future use

Figure 11 Typical Tricon v11.x System with a Model 8120E Enhanced Performance Main Chassis

Main Chassis Batteries

The Tricon controller dual-redundant batteries provide memory backup in case of a complete power failure of the controller. (The backplanes of Expansion and RXM Chassis do not include batteries.) In the absence of field power, a sole battery can sustain the control program in the Main Processor RAM.

If a total power failure occurs, these lithium batteries can maintain data and programs for a cumulative time period of six months. Each battery has a shelf-life of 8–10 years. Invensys recommends that the batteries be replaced either every 8–10 years or after they accumulate six months of use, whichever comes first.

WARNING There is a danger of explosion if a battery is replaced incorrectly. Replace only with the same or equivalent type recommended by the manufacturer. Dispose of used batteries according to the manufacturer's instructions.

If the BAT LOW (battery low) indicator on the Power Modules is on, it indicates the battery should be replaced. For instructions, see Replacing the Main Chassis Batteries on page 286.

Tricon Controller Keyswitch

The keyswitch is a four-position switch located above the Power Modules that determines the type of operations that can be taken on the Tricon controller. The position of the keyswitch is readable by the Tricon controller, Modbus masters, external devices, and the control program by using the TR_SCAN_STATUS function block. The position of the keyswitch enables or disable functions for the entire Tricon system, including Expansion and RXM Chassis.

This table describes the meaning of the keyswitch positions.

Keyswitch Position	Function
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, a control program may call gated access functions to enable external host writes during a designated window of time. For more information, see the GATDIS and GATENB function blocks in the *TriStation 1131 Libraries Reference*.
PROGRAM	For control program loading and verification. Allows control of the Tricon controller from TriStation, including Download All and Download Changes. Also allows writes to program variables by Modbus masters and external hosts.

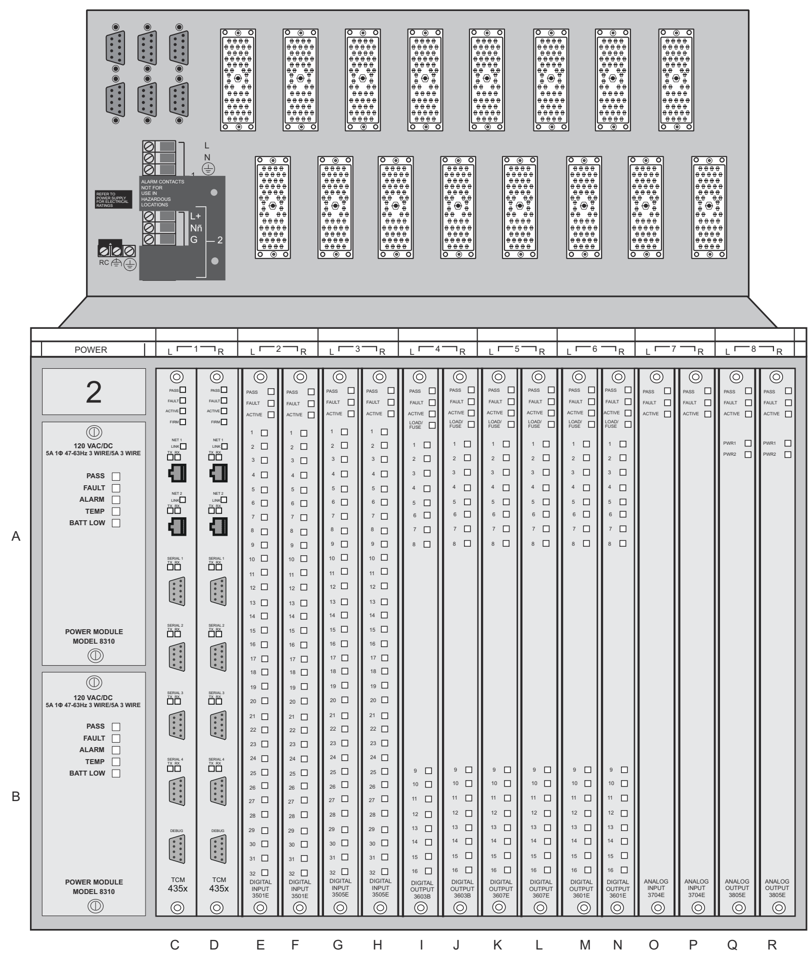
Keyswitch Position	Function
STOP	Stops reading inputs, forces non-retentive digital and analog outputs to 0, and halts the control program. Retentive outputs return to the value they had before the keyswitch was turned to Stop. The Stop setting is recommended for installation and service of process-related equipment, *but is not required for service of the Tricon controller.* You can use TriStation to prevent the application from halting when the keyswitch is turned to Stop. Note that this is the only position that can be overridden by TriStation. For more information, see "Restricting Access to a Tricon Controller" in the *TriStation 1131 Developer's Guide*.
REMOTE	Allows writes to control program variables by TriStation, Modbus masters, and external devices. (Download All and Download Changes by TriStation are not allowed.)

Expansion Chassis

This section contains information about the Model 8111 Expansion Chassis and the Model 8121 Low-Density Expansion Chassis.

Model 8111 Expansion Chassis

The Model 8111 Expansion Chassis allows additional I/O and communication modules to be included in a system. The Model 8111 Expansion Chassis includes two Power Modules and eight logical slots for I/O and communication modules. (Communication modules can only be included in Expansion Chassis 2.) Expansion Chassis can be used when the total I/O Bus cable length for the system from the Main Chassis to the last Expansion Chassis is no greater than 100 feet (30 meters).



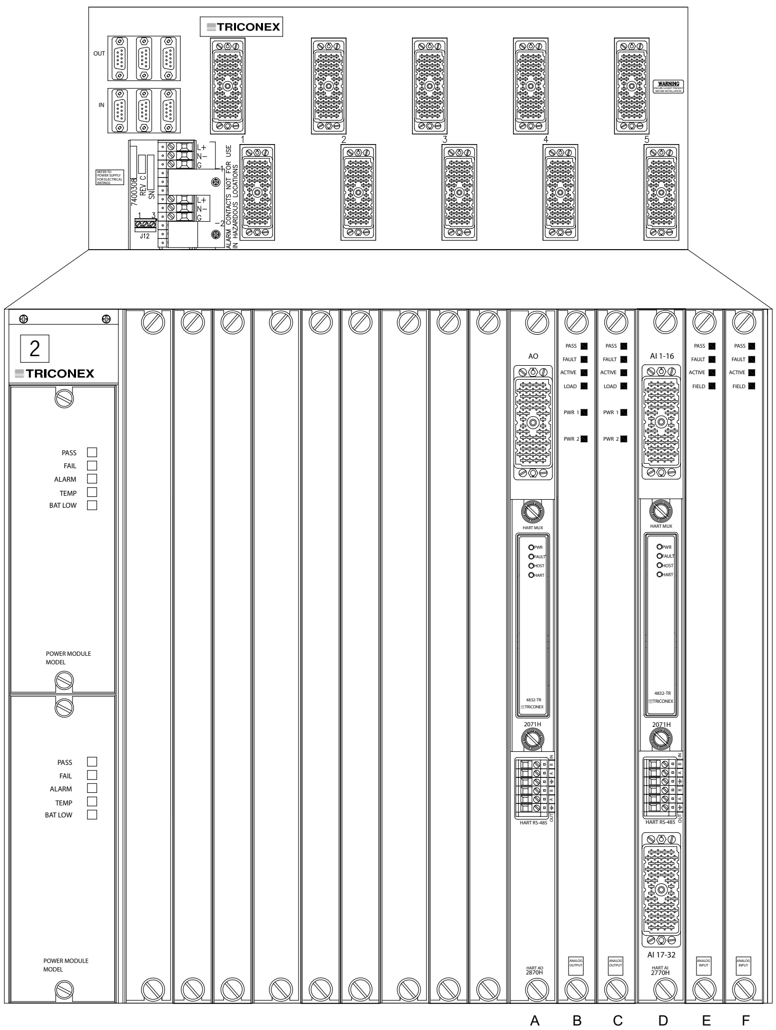
A, B	Redundant Power Modules
C, D	Tricon Communication Modules in Adjacent Slots
E, F	Digital Input Module with Hot-Spare
G, H	Digital Input Module with Hot-Spare
I, J	Digital Output Module with Hot-Spare
K, L	Digital Output Module with Hot-Spare
M, N	Digital Output Module with Hot-Spare
O, P	Analog Input Module with Hot-Spare
Q, R	Analog Output Module with Hot-Spare

Figure 12 Typical Model 8111 Expansion Chassis

Note For 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, use the Model 8111ATEX Expansion Chassis.

Model 8121 Enhanced Low-Density Expansion Chassis

The Model 8121 Enhanced Low-Density Expansion Chassis allows additional I/O modules to be included in a system and allows the use of HART communication through HART Interface Modules (2770H and 2870H). The Enhanced Low-Density Expansion Chassis includes two Power Modules and five logical slots for I/O modules. Expansion Chassis can be used when the total I/O Bus cable length for the system from the Main Chassis to the last Expansion Chassis is no greater than 100 feet (30 meters).



A	HART Analog Output Interface Module
B, C	Analog Output Module with Hot Spare
D	HART Analog Input Interface Module
E, F	Analog Input Module with Hot Spare

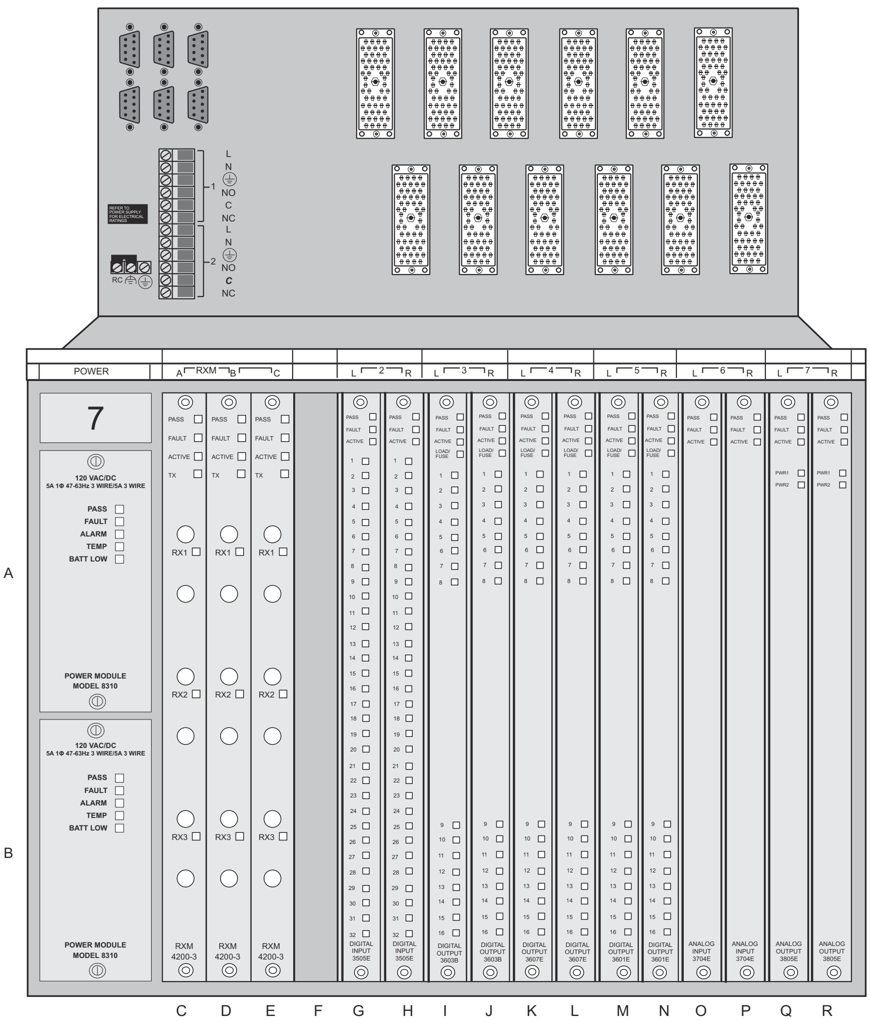
Figure 13 Typical Model 8121 Enhanced Low-Density Expansion Chassis

RXM Chassis

A Tricon RXM Chassis (Model 8112) enables additional I/O modules to be included in a system at a distance that exceeds 100 feet (30 meters) from the Main Chassis. RXM Chassis include two Power Modules, one Primary or Remote RXM Set, and six logical slots for I/O modules.

One main cluster of chassis can contain up to three Primary RXM chassis, which can support up to nine remote clusters of chassis. The total number of chassis cannot exceed 15, regardless of location. A cluster of chassis can be as few as one, or as many as 14.

For installation information, see Installing an RXM Chassis on page 262.



A, B Redundant Power Modules
C, D, E Set of 3 Modules for Primary RXM Chassis
F Comm Slot (blank)
G, H Digital Input Module with Hot-Spare
I, J Digital Output Module with Hot-Spare
K, L Digital Output Module with Hot-Spare
M, N Digital Output Module with Hot-Spare
O, P Analog Input Module with Hot-Spare
Q, R Analog Output Module with Hot-Spare

NOTE: The modules shown above are examples only. For available modules, see Chapter 3.

Figure 14 Typical RXM Chassis

Note For 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, use the Model 8112ATEX RXM Chassis.

I/O Bus Ports and Connections

Each Tricon chassis includes two sets of triplicated RS-485 I/O bus ports which enable the I/O bus to be expanded from the Main Chassis to other Tricon chassis in the system. The I/O ports are grouped as three pairs forming a triplicated extension of the Tricon controller I/O bus. The communication speed is 375 kilobits per second, which is the same rate as for the internal Tricon controller I/O bus. This means the three control channels are physically and logically extended to the Expansion Chassis without sacrificing performance.

This figure shows the location of the I/O Bus Ports, which includes a port for each input and output channel.

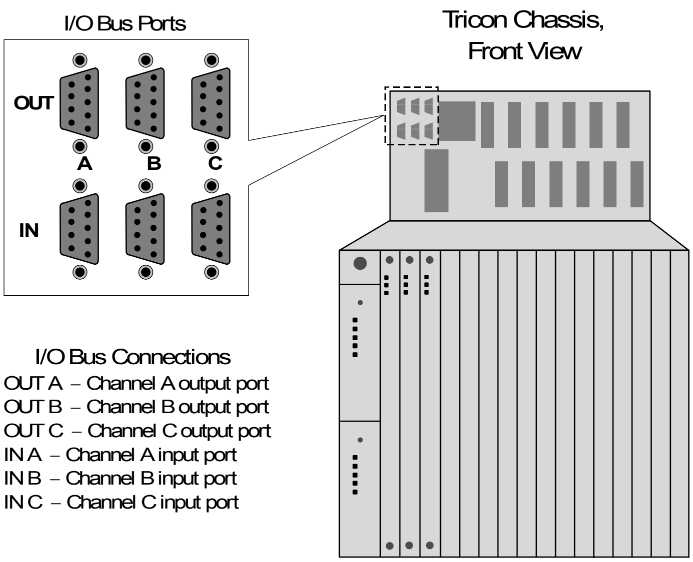


Figure 15 I/O Expansion Bus Ports

Power Modules

Each Tricon Chassis is equipped with two Power Modules—either one is fully capable of running the controller at full load and rated temperature. Any combination of Power Module models can be used in Tricon systems.

For more information, see Planning Power for a Tricon System on page 213

Model	Power Module
8310	120 VAC/DC Power Module
8311	24 VDC Power Module
8312	230 VAC Power Module

The Power Modules, located on the lower left side of the chassis, convert line power to DC power appropriate for all Tricon controller modules. Two terminal strips on the backplane are used to select controller grounding options, and for incoming power and alarm connections.

Each Power Module provides an in-line, slow-blow fuse for each external power source, mounted inside the module. The module can be replaced without disconnecting any wiring by removing the module from the chassis. The fuse on the Model 8311 24 VDC Power Module is not removable. If this fuse fails, you must return the module to Invensys for fuse replacement.

Each Tricon controller Power Module is a field-replaceable unit that uses high-efficiency DC-DC converters. All models of Power Modules are protected against reverse connection of the DC inputs.

Figure 16 shows the terminal strip and front panel for the Power Modules. The figure does not show the covers on the terminals for alarm applications, which are required for hazardous locations.

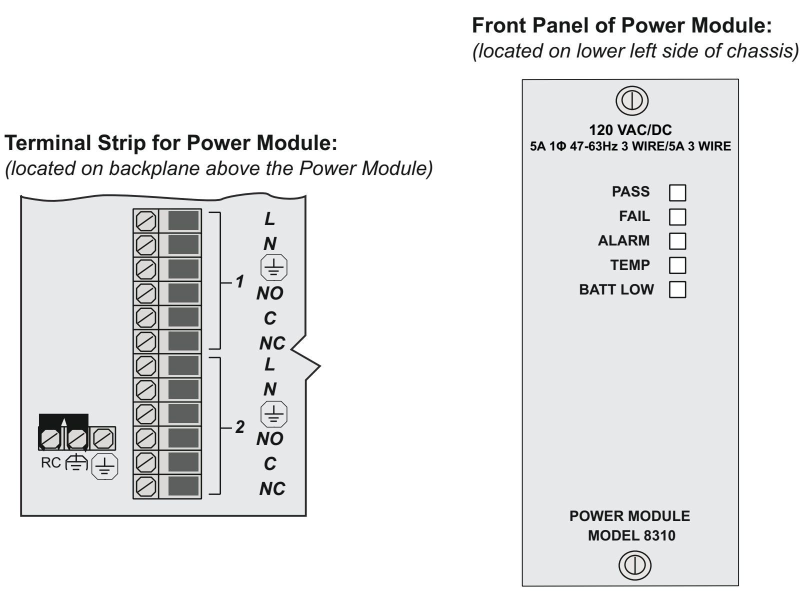


Figure 16 Power Module Terminals and Front Panel

Ground Terminals on Power Modules

This table describes the ground terminals included with the Power Module. Typically, the Tricon controller is delivered with a jumper installed between RC and signal ground. You can remove the jumper to use either a direct connection to signal ground or to chassis ground. For more information, see Controller Grounding on page 264.

- RC—RC network connected to chassis ground.
- ⏚ —Direct connection to Tricon controller internal signal ground (functional earth).
- ⏚ —Direct connection to chassis ground (protective earth).

Alarm and Power Terminals on Power Modules

This table describes the alarm and power terminals included with the Power Modules, which includes two sets of six terminals for each Power Module.

Terminals 1 and 2	Description
L	Line (hot) or DC+
N	Neutral or DC-
⏚	Chassis ground, protective earth
NO	NO (normally open) chassis alarm contact—opens when an alarm condition occurs
C	Common alarm contact
NC	NC (normally closed) chassis alarm contact—closes when an alarm condition occurs

Main Chassis Alarm Behavior

The alarm contacts on Main Chassis Power Modules are asserted when any of these situations occur:

- The controller configuration does not match the control program configuration.
- A Digital Output (DO) module experiences a Load/Fuse error.
- A module is missing somewhere in the controller. (No status indicators warn you of this problem.)
- A Main Processor or I/O module in the Main Chassis fails.
- An I/O module in an Expansion Chassis fails.
- A Main Processor detects a system fault. In this case, both alarm contacts may be asserted without a corresponding module failure.
- The inter-chassis I/O bus cables are incorrectly installed—for example, the cable for Channel A is accidentally connected to Channel B.

An alarm contact on at least one of the Main Chassis Power Modules is asserted when any of these situations occurs:

- A Power Module fails.
- Primary power to a Power Module is lost.
- A Power Module has a Low Battery or Over Temperature warning.

Expansion Chassis Alarm Behavior

The alarm contacts on both Power Modules of an Expansion Chassis are asserted when an I/O module fails. An alarm contact on at least one of the Power Modules of an Expansion Chassis is asserted when any of these situations occurs:

- A Power Module fails.
- Primary power to a Power Module is lost.
- A Power Module has an Over Temperature warning.

Alarm Contacts Specifications

This table lists the alarm contacts specifications for all models of Power Modules.

WARNING Do not use alarm contacts in hazardous locations.

Table 8 Alarm Contacts for Power Modules

Feature	Specification
Isolation	1,000 VAC or 1,500 VDC, Input to Output
Voltage range	140 VAC/VDC maximum
Switching power, resistive[a]	125 VAC, 60 W maximum
Current load	2 amp maximum
Maximum cycle rate of contacts	< 20 cycles per minute
Expected life at maximum rated load	> 10,000 cycles

a. When switching reactive loads, de-rate the switching power of the contacts to 25% of maximum—that is, 31.25 volts for AC applications, 15 watts for DC. When switching incandescent lamps, the inrush current can be 10-15 times the rated nominal load current of the lamp. Contact the lamp manufacturer for detailed specifications regarding inrush amplitude and duration. The inrush current must be used when calculating the required contact switching power.

120 Volt Power Module Specifications

This table lists the specifications for Model 8310, which is a 120 VAC/VDC Power Module.

Table 9 8310 Power Module Specifications

Feature	Description
Isolation	1,000 VAC or 1,500 VDC, Input to Output
Recommended input voltage range	120 VAC/VDC (-15% to +10%)
Extended input voltage range	85–140 VAC, 95–180 VDC
Low line on/off hysteresis	1.5 VAC/VDC typical
Input power required	240 W (2.75 amps) minimum per power source
Input frequency	47–63 Hz
Power factor	0.70 typical
Crest factor	2.5 typical
Input current	
Steady-state	0.75 amps, typical; 2.75 amps, maximum
In-rush (1/2 AC cycle)	18 amps maximum @ 120 VAC/DC
Input fuse rating and type	5 amps, time-delay
Output voltage	6.5 VDC, ±1%
Output current	27 amps maximum at 140° F (60° C) ambient, which is the air temperature measured at the bottom of the chassis
Output power	175 watts at 140° F (60° C) ambient
Output hold time @ 0 volts input	20 ms minimum 80 ms typical
Output over-voltage protection	115% typical, recycle power to restart
Output over-current limit	135%, typical, auto restart
Over-temperature warning sensor	Temperature monitor trips when the internal power module temperature is greater than 181° F (83° C). Typically, this occurs at an ambient temperature of 140° F (60° C) or higher.

24 Volt Power Module Specifications

This table lists the specifications for Model 8311, which is a 24 VDC Power Module.

Table 10 8311 Power Module Specifications

Feature	Description
Isolation	1,000 VAC or 1,500 VDC, Input to Output
Recommended input voltage range	24 VDC, –15% to +20% (protected against reverse connection)
Extended input voltage range[a]	19.2 to 36 VDC
Low line on/off hysteresis	0.1 VDC minimum
Input power required	240 W minimum per power source
Input over-voltage clamp	40 VDC
Input current	
Steady-state	5 amps typical, 10 amps maximum
In-rush	29 amps maximum @ 24 VDC (10 ms)
Input fuse rating and type	15 amps, time-delay
Output voltage	6.5 VDC, ±1%
Output current	27 amps maximum at 140° F (60° C) ambient, which is the air temperature measured at the bottom of the chassis
Output power	175 watts at 140° F (60° C) ambient
Output over-voltage protection	115%, typical, recycle power to restart
Output over-current limit	110%, typical, auto restart
Output hold time @ 0 volts input	2.0 milliseconds minimum; 5.6 milliseconds typical
Over-temperature warning sensor	Temperature monitor trips when the internal power module temperature is greater than 181° F (83° C). Typically, this occurs at an ambient temperature of 140° F (60° C) or higher.

a. During normal operation, you should keep the input power within the recommended input voltage range. Operation in the extended voltage range is advisable only for short periods of time.

Be careful to minimize input transients which are caused by the off/on switching of the redundant power source. Do not allow the power source to drop below the minimum input voltage (19.2 VDC) when its load increases to 100% of the Tricon controller power module requirements, or rise above the maximum voltage (36 VDC) when the load decreases to 40 to 60% of the Tricon controller power module requirements.

For example, assuming minimal voltage losses to the input wiring and a power source of 24V ±5%, the transient response to the power source should not exceed these limits.

Typical Input Current Change	Maximum Input Voltage Deviation
+6A/ms	–3.6 volts
-6A/ms	10.8 volts

230 Volt Power Module Specifications

This table lists the specifications for Model 8312, which is a 230 VAC Power Module.

Table 11 8312 Power Module Specifications

Feature	Description
Isolation	1,000 VAC or 1,500 VDC, Input to Output
Nominal input voltage	230 VAC (–15% to +10%)
Low line on/off hysteresis	7.5 VAC typical
Input power required	240 W minimum per power source
Input frequency	47 to 63 Hz
Power factor	0.70 typical
Crest factor	2.5 typical
Input current	
Steady-state	0.4 amps, typical; 1.2 amps, maximum
In-rush (1/2 AC cycle)	18 amps maximum @ 230 VAC
Input fuse rating and type	2.5 amps, time-delay
Output voltage	6.5 VDC, ±1% under all operating conditions
Output current	27 amps maximum at 140° F (60° C) ambient, which refers to the air temperature measured at the bottom of the chassis
Output power	175 watts at 140° F (60° C) ambient
Output hold time @ 0 volts input	20 ms minimum; 80 ms typical
Output over-voltage protection	125%, typical, recycle power to restart
Output over-current limit	140%, typical, auto restart
Over-temperature warning sensor	Temperature monitor trips when the internal power module temperature is greater than 181° F (83° C). Typically occurs at an ambient temperature of 140° F (60° C) or higher.

WARNING Do not use the Model 8312 Power Module in Tricon systems that are located in hazardous locations and must meet ATEX requirements. If you have 230 V line voltage and your system must meet ATEX requirements, use the Model 8311 24 VDC Power Module along with any ATEX-certified 24 VDC power supply, such as one from Phoenix Contact—part number QUINT-PS-100-240AC/24DC/10/EX.

Main Processor Modules

A Tricon chassis houses three Main Processor (MP) Modules, each serving one channel (also referred to as a *leg*) of the controller. Each processor independently communicates with its I/O subsystem and executes the control program. The three MP Modules compare data and the control program at regular intervals. Each Main Processor operates autonomously with no shared clocks, power regulators, or circuitry. Processor specifications are listed in the specifications table for each MP.

A high-speed proprietary bus system called TriBus provides these functions: interprocessor communications, hardware majority voting of all digital input data, and comparison of control program variables. TriBus uses a fully isolated, serial communication channel, which operates at 4 Mbps with the Model 3006 and Model 3007 MPs, at 25 Mbps with the Model 3008 MPs or the Model 3009 MPs when they are installed in the Model 8110 Main Chassis, and at 1000 Mbps when the Model 3009 MPs are installed in the Model 8120E Enhanced Performance Main Chassis. A direct memory access controller manages the synchronization, transfer, voting, and data correction independent of the control program or executive software.

DRAM (dynamic random-access memory) is used for control program, sequence-of-events data, I/O data, diagnostics, and communication buffers. SRAM (static random-access memory) is used for the defined program retentives and configuration of disabled points. Memory is regularly validated by the TriBus hardware-voting circuitry.

To guarantee that the controller provides a deterministic response time, the scan time should always be set to a value greater than the I/O poll time (the maximum time needed by the controller to obtain data from the input modules). You can view the I/O poll time on the System Overview screen in the Enhanced Diagnostic Monitor (sold separately). For more information, see the *Enhanced Diagnostic Monitor User's Guide*. Also, TriStation 1131 4.11.x and later provide an estimate of the poll time.

Sequence of Events Capability

Main Processors work with the communication modules to provide the Tricon controller with sequence of events (SOE) capability. During each scan, the Main Processors inspect designated discrete (Boolean) variables for changes of state known as *events*. When an event occurs, the Main Processors save the current state of the variable and include a time stamp in an area of memory called a buffer, which is a part of an SOE block. You can configure the SOE blocks using TriStation and retrieve the event data with software such as the Triconex SOE Recorder.

Compatibility of Main Processor Modules

This table identifies the compatibility of Main Processor modules with Tricon system versions.

Table 12 Compatibility of Main Processor Modules

Main Processor Model	Compatible System Versions
3006 and 3007	9.5.x, 9.51.x, and 9.52.x
3008	9.6—10.x
3009	11.x

Main Processor Models

This section includes front panel diagrams, architecture diagrams, and specifications for the Main Processor Models (Models 3006 and 3007, Model 3008, and Model 3009) available for use with Tricon v9–v11 systems.

Topics include:

- Model 3006 and Model 3007 Main Processor Modules on page 72
- Model 3008 Main Processor Modules on page 75
- Model 3009 Main Processor Modules on page 78

Model 3006 and Model 3007 Main Processor Modules

This figure depicts the front panels of Model 3006 and Model 3007 Main Processors.

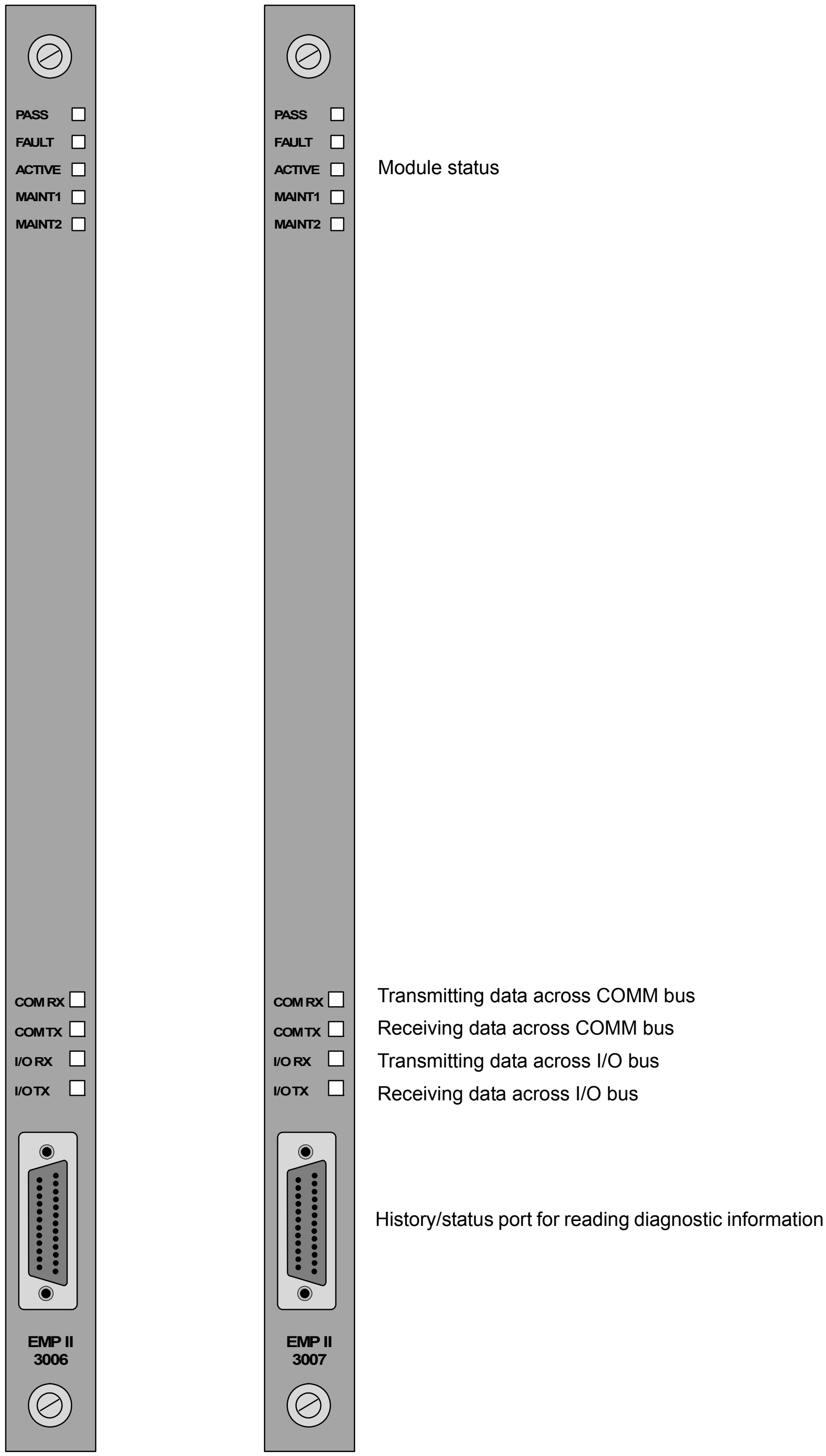


Figure 17 3006 and 3007 Main Processor Front Panels

3006 and 3007 Main Processor Architecture

This figure depicts the architecture of Model 3006 and Model 3007 Main Processors, which can be used with Tricon v9.0—v9.5 systems. They have the same architecture and specifications as the Model 3008 MPs, except for SRAM, which is 2 megabytes for the 3006 and 1 megabyte for the 3007.

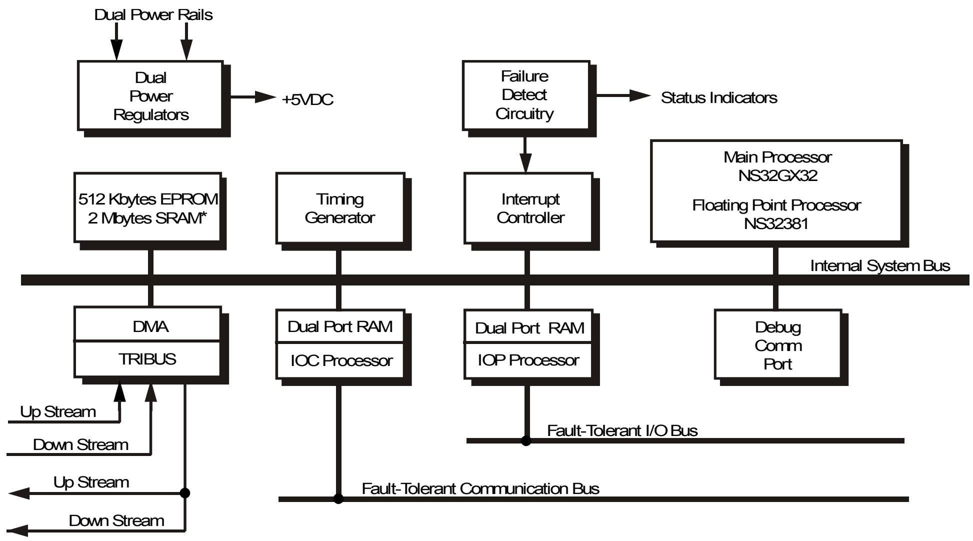


Figure 18 3006 and 3007 Main Processor Architecture

3006 and 3007 Specifications

This table lists the specifications for the Model 3006 and Model 3007 Main Processors, which can be used with Tricon v9.0—v9.5 systems.

Table 13 3006 and 3007 Main Processor Specifications

Feature	Specification
Central processor	National NS32GX32, 32 bits, 25 MHz
Math co-processor	National NS32381, 32 bits, 25 MHz
EPROM memory	512KB
SRAM	Model 3006: 2 MB Model 3007: 1 MB
Clock calendar	Time and date Battery backup Typical drift: ±2 seconds per day Maximum drift: ±8.6 seconds per day
TriBus	4 Mbps, 16-bit DMA
Serial port	For Diagread diagnostic analysis Optically isolated RS-232 interface on one 25-pin connector 500 VDC isolation

Table 13 3006 and 3007 Main Processor Specifications

Feature	Specification
Communication processor	Intel® 80C152 32 KB EPROM, 64K shared memory interface 16 MHz
Communication Interface	
Protocol	RS-485
Baud rate	2 Mbps
I/O processor	Intel 80C31 12 MHz 32 KB EPROM 64K Shared Memory Interface
I/O interface	
Protocol	RS-485
Baud Rate	375 kilobits per second
Logic power	15 W

Model 3008 Main Processor Modules

This figure depicts the front panel of the Model 3008 Main Processor.

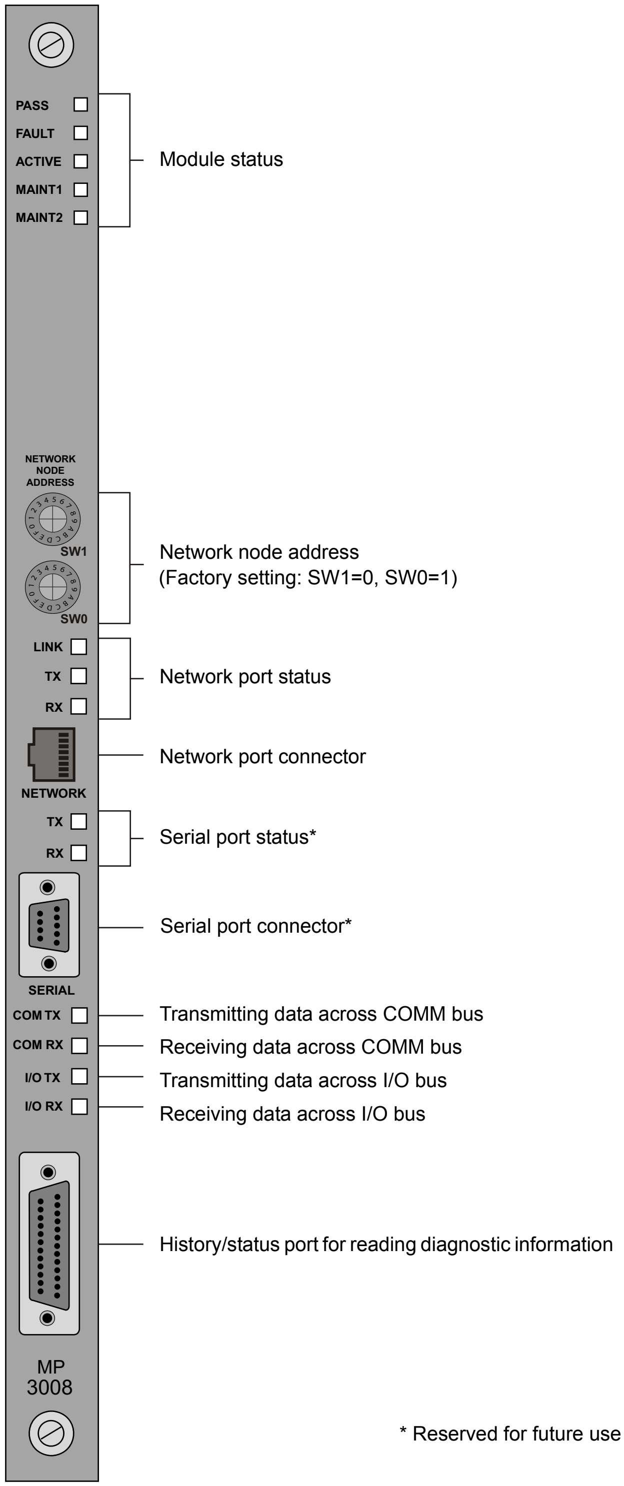


Figure 19 3008 Main Processor Front Panel

3008 Main Processor Architecture

This figure depicts the architecture of the Model 3008 Main Processor, which can be used with Tricon v9.6—v10.x systems.

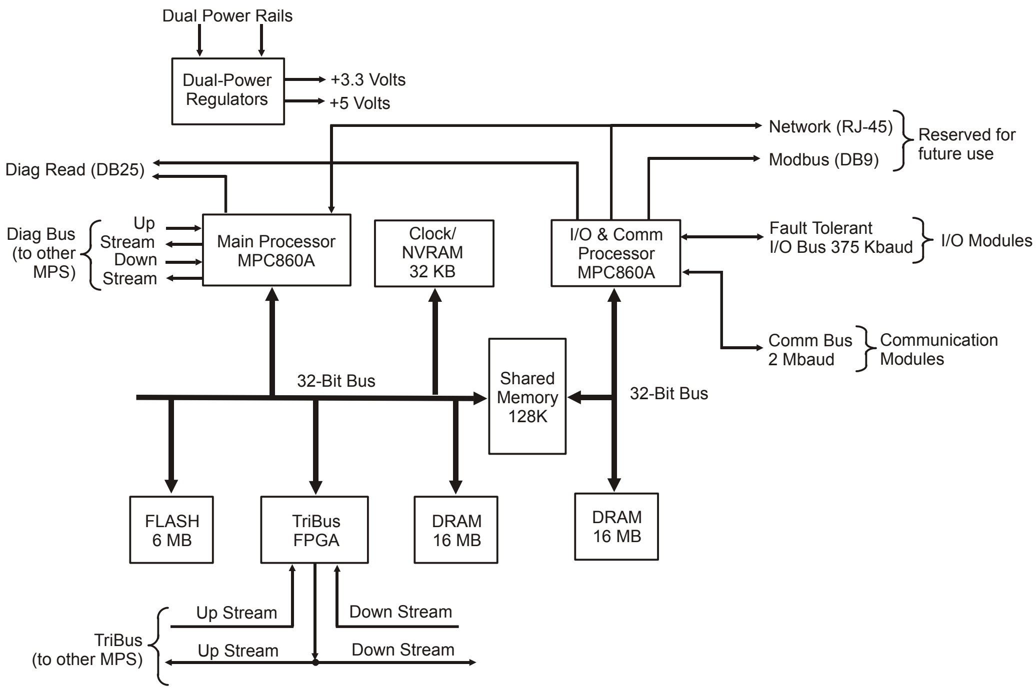


Figure 20 3008 Architecture

3008 Specifications

This table lists the specifications for the Model 3008 Main Processor, which can be used with Tricon v9.6—v10.x systems.

Table 14 3008 Main Processor Specifications

Feature	Description
Main processor	Motorola® MPC860, 32-bit, 50 MHz
Memory	16 MB DRAM (without battery backup) 32 KB SRAM (with battery backup) 6 MB Flash PROM
TriClock	Time and date Battery backup Typical drift: ±2 seconds/day Maximum drift: ±2.16 seconds/day
TriBus	25 Mbps 32-bit CRC-protected 32-bit DMA, fully isolated
Serial port	For diagread diagnostic analysis Optically isolated RS-232 interface on one 25-pin connector 500 VDC isolation

Table 14 3008 Main Processor Specifications *(continued)*

Feature	Description
Communication processor	Motorola MPC860, 50 MHz, 32-bit
Communication interface	
Protocol	RS-485
Baud rate	2 Mbps
I/O interface	
Protocol	RS-485
Baud Rate	375 kilobits per second
Logic power	10 W

Model 3009 Main Processor Modules

This figure depicts the front panel of the Model 3009 Main Processor.

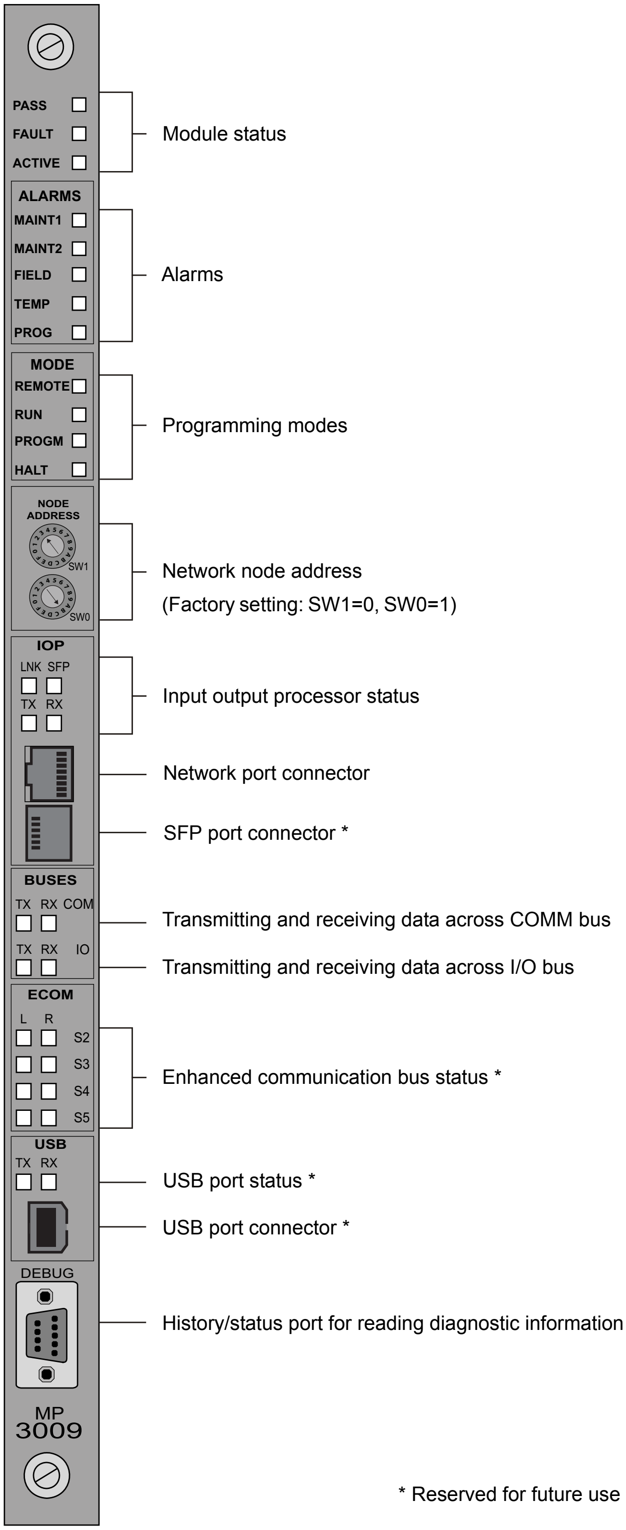


Figure 21 3009 Main Processor Front Panel

3009 Main Processor Architecture

This figure depicts the architecture of the Model 3009 Main Processor, which can be used with Tricon v11.x systems.

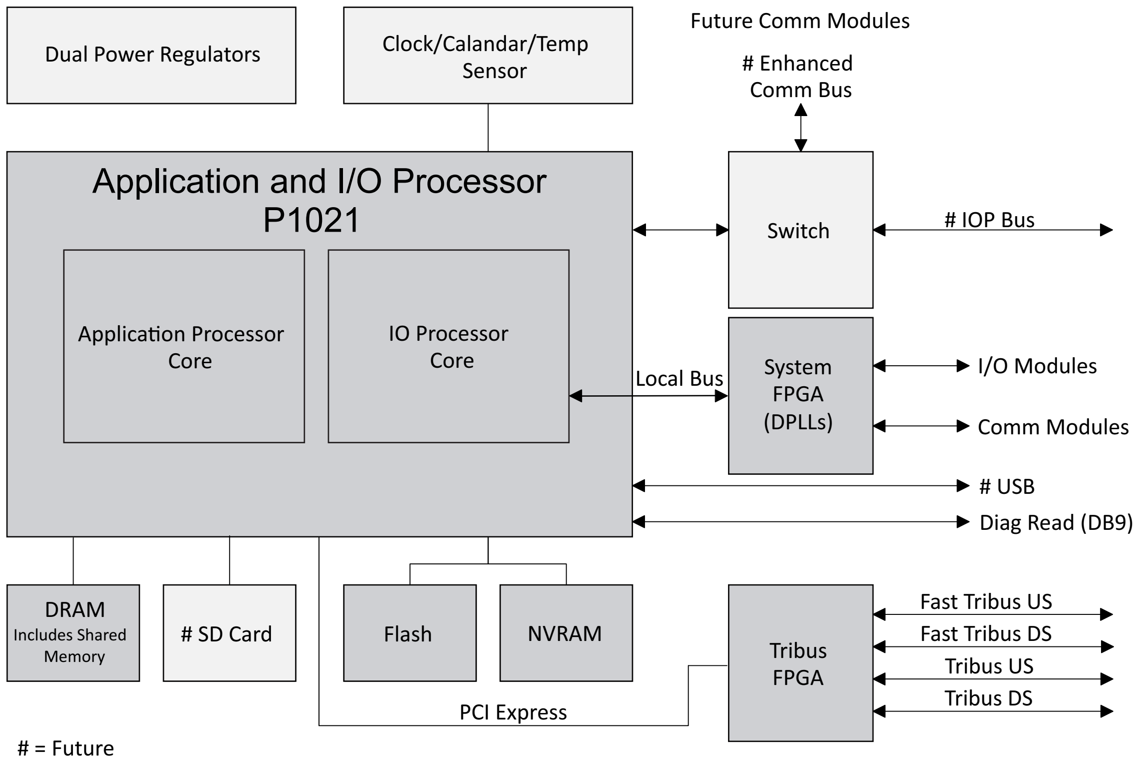


Figure 22 3009 Architecture

3009 Specifications

This table lists the specifications for the Model 3009 Main Processor, which can be used with Tricon v11.x systems.

Table 15 3009 Main Processor Specifications

Feature	Description
Main processor	QorlQ P1021, dual core processor, 32KB L1 cache, 2MB L2 cache, 800 MHz
Memory	256 MB DRAM (without battery backup) 2 MB SRAM (with battery backup) 128 MB Flash PROM
Clock Calendar	Time and date Battery backup Typical drift: ±2 seconds/day Maximum drift: ±2.16 seconds/day

Table 15 3009 Main Processor Specifications *(continued)*

Feature	Description
TriBus	32-bit CRC-protected 32-bit DMA, fully isolated
Speed	Model 8110 Main Chassis: 25 Mbps Model 8100-1 Low-Density Main Chassis: 25 Mbps Model 8120E Enhanced Performance Main Chassis: 1000 Mbps
Serial port	For diagread diagnostic analysis Optically isolated RS-232 interface on one 9-pin connector 500 VDC isolation
Communication interface	
Protocol	RS-485
Baud rate	2 Mbps
I/O interface	
Protocol	RS-485
Baud Rate	375 Kbps
Logic power	14 Watts

Diagnostics for Main Processors

Extensive diagnostics validate the health of each Main Processor as well as each 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 or operated in a fault-tolerant manner until hot replacement is completed.

Main Processor diagnostics include these features:

- Verify fixed-program memory
- Verify the static portion of RAM
- Test all basic processor instructions and operating modes
- Test all basic floating-point processor instructions
- Verify the shared memory interface with I/O processors
- Verify each I/O processor, communication processor, local memory, shared memory access, and loopback of RS-485 transceivers
- Verify the TriClock interface
- Verify the Tribus interface

At the bottom of each MP, there is an RS-232 serial port that can be used for diagnostic analysis by Invensys representatives. These ports—also know as Diagread ports—are fully isolated (500 VDC, maximum) to protect against ground faults.

On Model 3006, 3007, and 3008 MPs, the port has a 25-pin DB-25 socket that operates at 9600 bits per second. On Model 3009 MPs, the port has a 9-pin DB-09 socket that operates at 115200 bits per second.

RXM and SRXM Modules

This section describes RXM and SRXM Modules, which are used in RXM Chassis to extend the I/O communication from the Main Chassis. Multi-mode cable is used for locations as far as 1.2 miles (2 kilometers) from the Main Chassis; single-mode cable is used for locations as far as 7.5 miles (12 kilometers). RXM and SRXM Modules communicate at 375 kilobits per second. The modules provide exceptional immunity against electro-static and electro-magnetic interference and use optical modems and fiber-optic point-to-point cabling.

For installation information, see RXM Chassis Installation on page 259.

Table 16 RXM and SRXM Module Sets

Model	Description
4200-3	Primary RXM Module Set uses multi-mode fiber optic cable. Supports three remote RXM Chassis or Expansion Chassis.
4201-3	Remote RXM Module Set uses multi-mode fiber optic cable.
4210-3	Primary SRXM Module Set uses single-mode fiber optic cable. Supports three remote RXM Chassis or Expansion Chassis.
4211-3	Remote SRXM Module Set uses single-mode fiber optic cable.

RXM Modules

RXM Modules (Model 4200-3 and 4201-3) are optimized for use with 62.5/125 micrometer multi-mode fiber. The cable should be specified for operation at a wave length of 850 nanometers (nm), with a worst-case optical attenuation of 4 decibels per kilometer. The RXM optical transmitter/receiver pair has a total optical power budget of 15 decibels, typical (8 decibels, worst case), which allows a maximum cable length of 1.2 miles (2 kilometers).

RXM Modules are compatible with industry-standard ST fiber-optic connectors. The specified worst-case optical power budget of 8 decibels includes losses due to the fiber-optic connectors at the RXM transmitter and receiver. Additional losses incurred by fiber-optic cable splices or junction-box couplings should be considered when calculating the maximum installed cable length.

SRXM Modules

SRXM Modules (Model 4210-3 and 4211-3) are optimized for use with 9/125 micrometer single-mode fiber. The cable should be specified for operation at a wave length of 1300 nanometers (nm), with a worst-case optical attenuation of 0.5 decibels per kilometer. The RXM optical transmitter/receiver pair has a total optical power budget of 10 decibels, typical (7 decibels, worst case), which allows a maximum cable length of 7.5 miles (12 kilometers).

SRXM Modules are compatible with industry-standard ST fiber-optic connectors. The specified worst-case optical power budget of decibels includes losses due to the fiber-optic connectors at the SRXM transmitter and receiver, and 2 decibels margin/aging loss. Additional losses incurred by fiber-optic cable splices or junction-box couplings should be considered when calculating the maximum installed cable length.

Analog Input Modules

This section describes the Analog Input Modules available for use with Tricon v9–v11 systems. For installation information, see Replacing I/O Modules on page 293.

Table 17 Analog Input Modules

Model	Voltage Range	Type	Module Description
3700 3700A	0–5 VDC	TMR	Analog Input
3701	0–10 VDC	TMR	Analog Input
3703E	0–5 or 0–10 VDC	TMR	Isolated Analog Input
3704E	0–5 or 0–10 VDC	TMR	High-Density
3720[a]	0–5 VDC	TMR	High-Density Single-Ended
3721[a]	0 to 5 or –5 to +5 VDC	TMR	Differential

a. The 3720 and 3721 modules can be installed only in Tricon v10.2 and later systems.

All Analog Input Modules have 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 Processors on demand. To ensure correct data for every scan, one value is selected using a mid-value selection algorithm. Sensing of each input point is performed in a manner that prevents a single failure on one channel from affecting another channel.

The Model 3700A, 3703E, 3704E, 3720, and 3721 Analog Input Modules provide a six percent over-range measurement capability. The 3703E provides open-input detection, which can be configured as upscale or downscale in TriStation 1131. If an open input (< 0 VDC) goes out of range downscale, the Main Processors receive the integer value –32,767. If an open input (> 5 VDC or 10 VDC) goes out of range upscale, the Main Processors receive the integer value +32,767.

Models 3720 and 3721 can be configured in TriStation 1131 for either Standard (12 bit) resolution or High (14 bit) resolution. In High resolution, the 3721 can be configured in TriStation 1131 for Unipolar (0 to 5 VDC) or Bipolar (-5 to +5 VDC) inputs.

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 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 some multiple faults.

Analog Input Modules include the hot-spare feature, which allows online replacement of a faulty module. Like all I/O modules, Analog Input Modules require a separate field termination assembly with a cable interface to the Tricon controller backplane. Each module is mechanically keyed to prevent improper installation in a configured chassis.

Mis-Compare Readings

All Analog Input Modules are susceptible to mis-compare readings which can increase the probability of a fault. Generally, the greater the difference between readings and the longer the period of mis-compares, the more probable that a fault will be declared. The amount of difference and period varies among Analog Input Modules.

- For Models 3700, 3700A, and 3701, if the readings differ by a minimum of 2 percent of full scale and continue for a minimum period of 40 input samples, the probability of a fault increases.
- For Models 3703E and 3704E, if the readings differ by a minimum of 0.5 percent of full scale and continue for a minimum period of 256 input samples, the probability of a fault increases.
- For Model 3720, if the readings differ by a minimum of 0.5 percent of full scale and continue for a minimum period of 25 input samples, the probability of a fault increases.
- For Model 3721, if the readings differ by a minimum of 2 percent of full scale and continue for a minimum period of 25 input samples, the probability of a fault increases.

32-Point Differential Analog Input Modules

This figure is a simplified schematic for Models 3700, 3700A, and 3701, which are 32-point TMR Analog Input Modules.

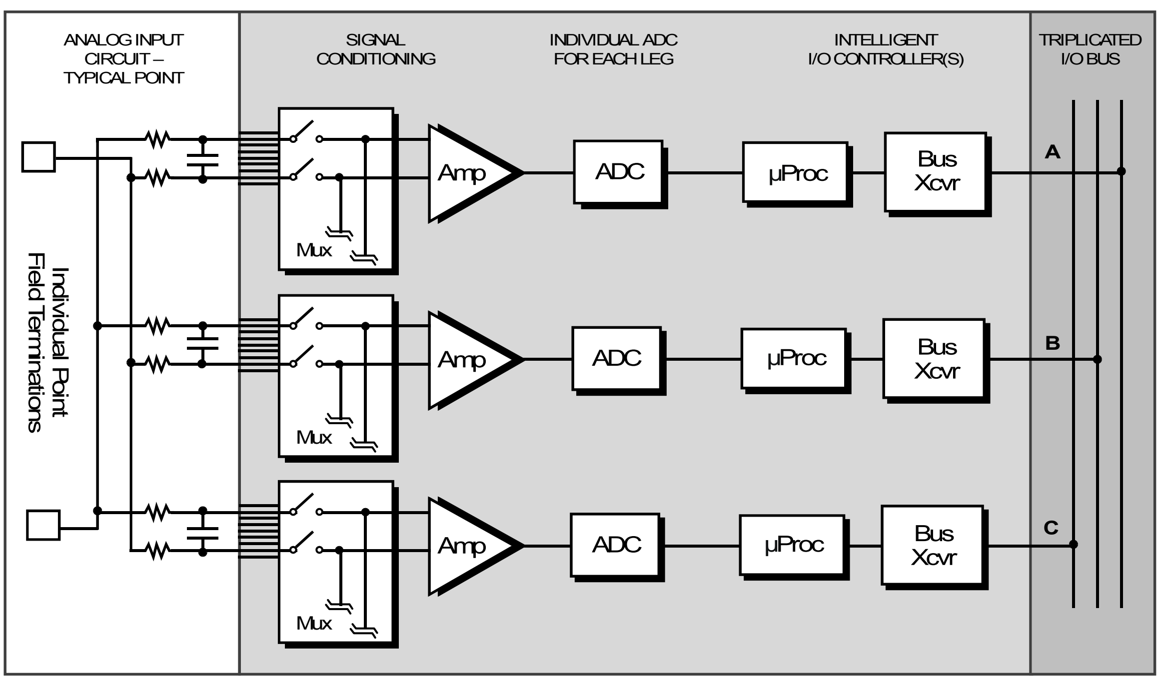


Figure 23 3700, 3700A, and 3701 Simplified Schematic

This figure is a simplified schematic for Model 3721, which is a 32-point TMR Analog Input Module with field-to-system isolation.

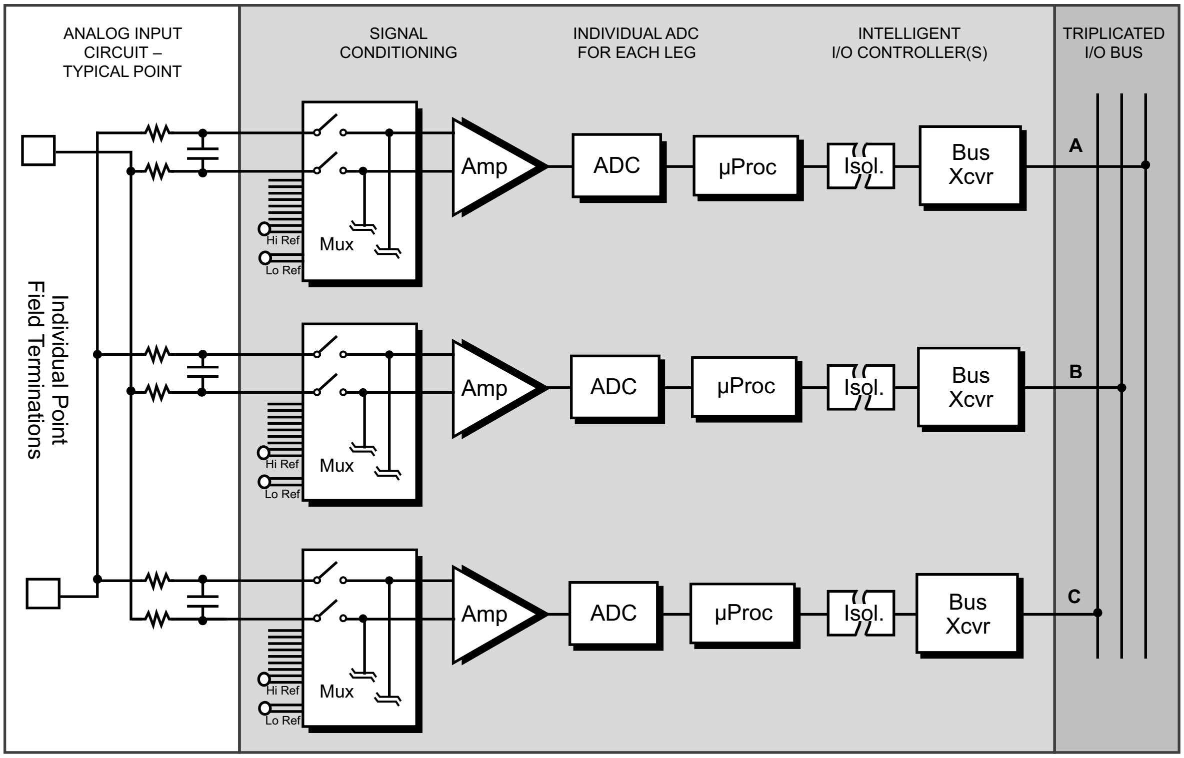


Figure 24 3721 Simplified Schematic

This figure shows the front panels of Models 3700, 3700A, 3701, and 3721.

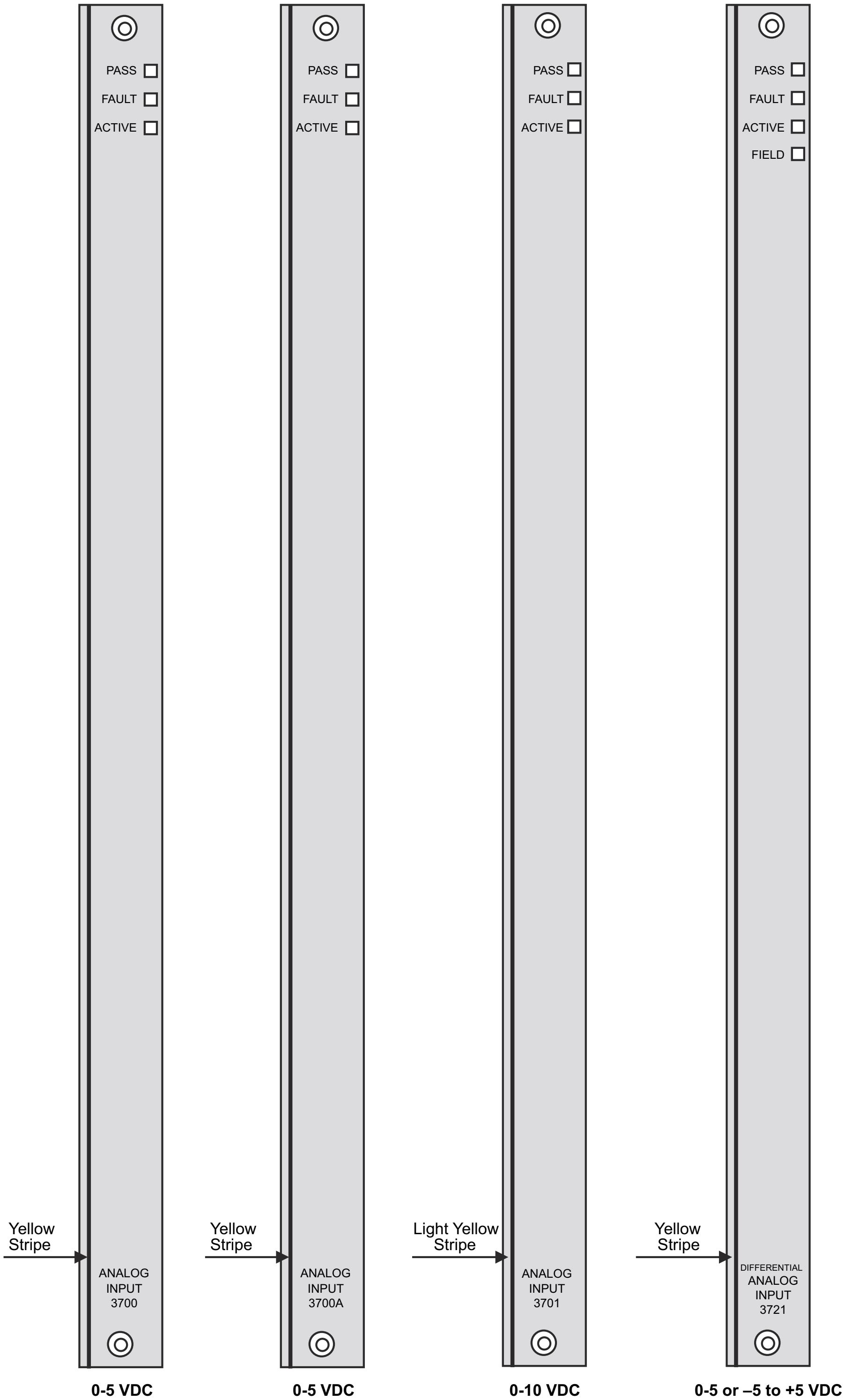


Figure 25 3700, 3700A, 3701, and 3721 Front Panels

3700A Specifications

This section includes specifications for Model 3700A, which is a TMR Analog Input Module with a voltage range of 0 to 5 VDC.

WARNING If the common-mode voltage range of a channel is exceeded, Invensys does not guarantee proper operation of the module and accuracy of other channels.

Table 18 3700/3700A Analog Input Specifications

Feature	Specification
Color code	Yellow
Number of input signals	32 differential, DC-coupled
Input update rate	55 ms
Resolution	12 bits
Accuracy	< 0.15% of FSR, from 32° to 140° F (0° to 60° C)
Input resistance (load)	30 MΩ (DC), minimum
Input resistance @ power off	30 kΩ (DC), typical
Common mode rejection (typical)	-80 dB (DC - 100 Hz)
Common mode range (*See above Warning*)	-12V to +12V peak
Channel-to-channel isolation	200 kΩ, typical
Normal mode rejection	-3 dB @ 8 Hz -17 dB @ 60 Hz -23 dB @ 120 Hz
Input voltage range	0 to 5V
Input over-range measurement (only for 3700A)	+6%, 0 to 5.3 VDC
Logic power	< 10 watts
Input over-range protection	150 VDC continuous, 115 VAC continuous
Input current range	0 to 20 mA with 250 Ω shunt resistor
Module status indicators	Pass, Fault, Active
Input diagnostic fault coverage[a]	
Minimum input change	2% of full scale
Input change sample period	1 scan or 200 ms, whichever is greater
Minimum period of mis-compares	40 samples

a. Rapidly or continuously changing inputs may cause mis-compare readings because the measured values of the three channels may differ by more than 0.5 percent of full scale, which can cause a fault to be declared in error. If the input readings differ by a minimum of 2 percent of full scale and continue for a minimum period of 40 input samples, the probability of a fault increases.

3701 Specifications

This section includes specifications for Model 3701, which is a TMR Analog Input Module with a voltage range of 0 to 10 VDC.

WARNING If the common-mode voltage range of a channel is exceeded, Invensys does not guarantee proper operation of the module and accuracy of other channels.

Table 19 3701 Analog Input Specifications

Feature	Specification
Color code	Light yellow
Number of input signals	32 differential, DC-coupled
Input update rate	55 ms
Resolution	12 bits
Accuracy	< 0.15% of FSR from 32° to 140° F (0° – 60° C)
Input resistance (load)	30 MΩ (DC), minimum
Input resistance @ power off	30 kΩ (DC), typical
Common mode rejection (typical)	-80 dB (DC - 100 Hz)
Common mode voltage range (*See above Warning*)	-12V to +12V peak
Channel-to-channel isolation	200 kΩ, typical
Normal mode rejection	-3 dB @ 8 Hz -17 dB @ 60 Hz -23 dB @ 120 Hz
Input voltage range	0 to 10 V
Logic power	< 10 watts
Input over-range protection	150 VDC continuous, 115 VA continuous
Input current range	0 to 20 mA with 500 Ω shunt resistor
Module status indicators	Pass, Fault, Active
Input diagnostic fault coverage[a]	
Minimum input change	2% of full scale
Input change sample period	1 scan or 200 ms, whichever is greater
Minimum period of mis-compares	40 samples

a. Rapidly or continuously changing inputs may cause mis-compare readings because the measured values of the three channels may differ by more than 0.5 percent of full scale, which can cause a fault to be declared in error. If the input readings differ by a minimum of 2 percent of full scale and continue for a minimum period of 40 input samples, the probability of a fault increases.

3721 Specifications

This section includes specifications for Model 3721, which is a TMR Analog Input Module with a voltage range of 0 to 5 VDC or -5 to +5 VDC. The 3721 module can be installed only in Tricon v10.2 and later systems.

Table 20 3721 Analog Input Specifications

Feature	Specification
Color code	Yellow
Number of input signals	32 differential, DC-coupled
Input update rate	10 ms
Resolution	12 bits or 14 bits programmable
Accuracy	< 0.15% of FSR from 32° to 140° F (0° to 60° C)
Input resistance (load)	10 MΩ (DC), minimum
Input resistance at power off	140 kΩ (DC), typical
Common mode rejection (typical)	-85 dB (DC - 100 Hz)
Common mode voltage range	-12V to +12V peak
Channel-to-channel isolation	420 kΩ, typical
Normal mode rejection	-3 dB @ 23 Hz -8 dB @ 60 Hz -14 dB @ 120 Hz
Input voltage range	0 to 5 or –5 to 5 VDC
Input over-range measurement	+6%, -5.3 to +5.3 VDC
Logic power	< 12 watts
Input over-range protection	150 VDC continuous, 115 VAC continuous
Input current range	0 to 20 mA with 250 Ω shunt resistor
Field to system isolation	800 VDC minimum
Module status indicators	Pass, Fault, Active, Field
Input diagnostic fault coverage[a]	
Minimum input change	2% of full scale
Input change sample period	20 ms
Minimum period of mis-compares	25 samples

a. Rapidly or continuously changing inputs may cause the time to detect a fault to increase. If an input sample changes by more than 0.25 percent from the previous sample, the readings will not be compared.

Note The Model 3721 can be installed in low-density systems that have been upgraded to v10.2.x or later. For more information, see “Appendix I, Low-Density Chassis I/O Module Compatibility” in the *Field Terminations Guide for Tricon v9–v11 Systems*.

16-Point Isolated Analog Input Module

This figure is a simplified schematic for Model 3703E, which is a 16-point TMR Analog Input Module that can be configured as 0 to 5 VDC or 0 to 10 VDC.

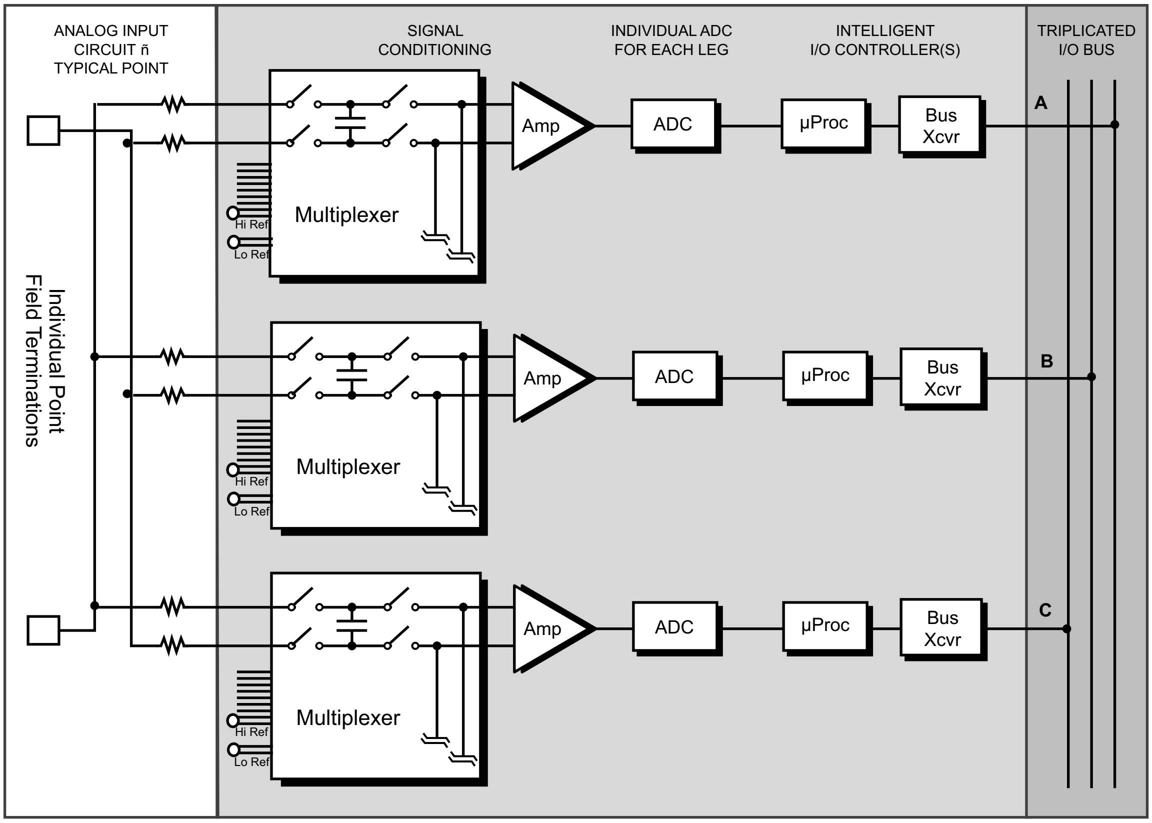


Figure 26 3703E Simplified Schematic

This figure shows the front panel of Model 3703E.

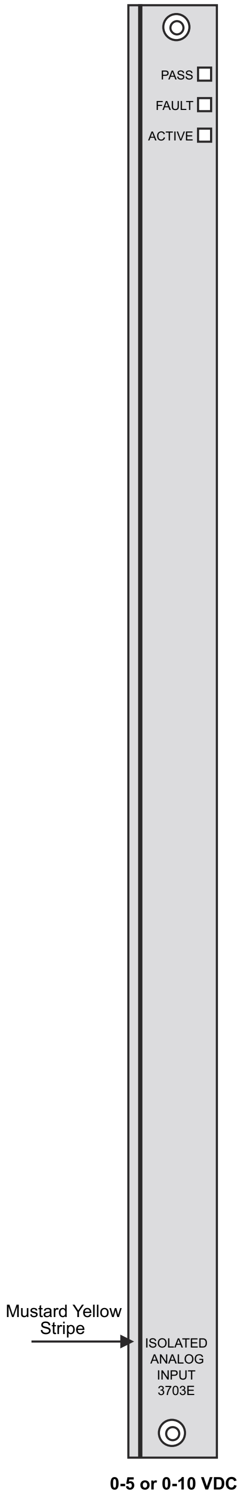


Figure 27 3703E Front Panel

3703E Specifications

This section includes specifications for Model 3703E, which is an isolated TMR Analog Input Module.

Table 21 3703E Analog Input Specifications

Feature	Specification
Color code	Mustard yellow
Number of input signals	16 differential, isolated
Input update rate	< 50 ms
Resolution	12 bits
Accuracy	< 0.15% of FSR, from 32° to 140° F (0° to 60° C)
Input resistance (load)	30 MΩ (DC) minimum
Input resistance @ power-off	30 MΩ (DC) minimum
Common mode rejection (typical)	-90 dB @ 60 Hz, minimum, -100 dB @ DC minimum
Common mode voltage range (see Warning)	± 200 VDC maximum (channel-to-channel or channel-to-ground)
Channel-to-channel isolation	20 kΩ typical
Normal mode rejection	-3 dB @ 8 Hz -17 dB @ 60 Hz -23 dB @ 120 Hz
Input range voltage	0–5 VDC or 0–10 VDC, TriStation-configurable
Input over-range measurement	+6%, 0–5.3 VDC or 0–10.6 VDC
Logic power	< 15 watts
Input over-range protection	115 VAC continuous, 150 VDC continuous
Open detect	Upscale or downscale, TriStation-configurable
Input range current	0 – 20 mA with 250 Ω shunt resistor
Module status indicators	Pass, Fault, Active
Input diagnostic fault coverage[a]	
Minimum input change	0.5% of full scale
Input change sample period	1 scan or 50 ms, whichever is greater
Minimum period of mis-compares	256 samples

a. Rapidly or continuously changing inputs may cause mis-compare readings because the measured values of the three channels may differ by more than 0.5 percent of full scale, which can cause a fault to be declared in error. If the input readings differ by a minimum of 0.5 percent of full scale and continue for a minimum period of 256 input samples, the probability of a fault increases.

WARNING If the common-mode voltage range of a channel is exceeded, Invensys does not guarantee proper operation of the module and accuracy of other channels.

64-Point Single-Ended Analog Input Modules

This figure is a simplified schematic for Model 3704E, which is a 64-point TMR Analog Input Module.

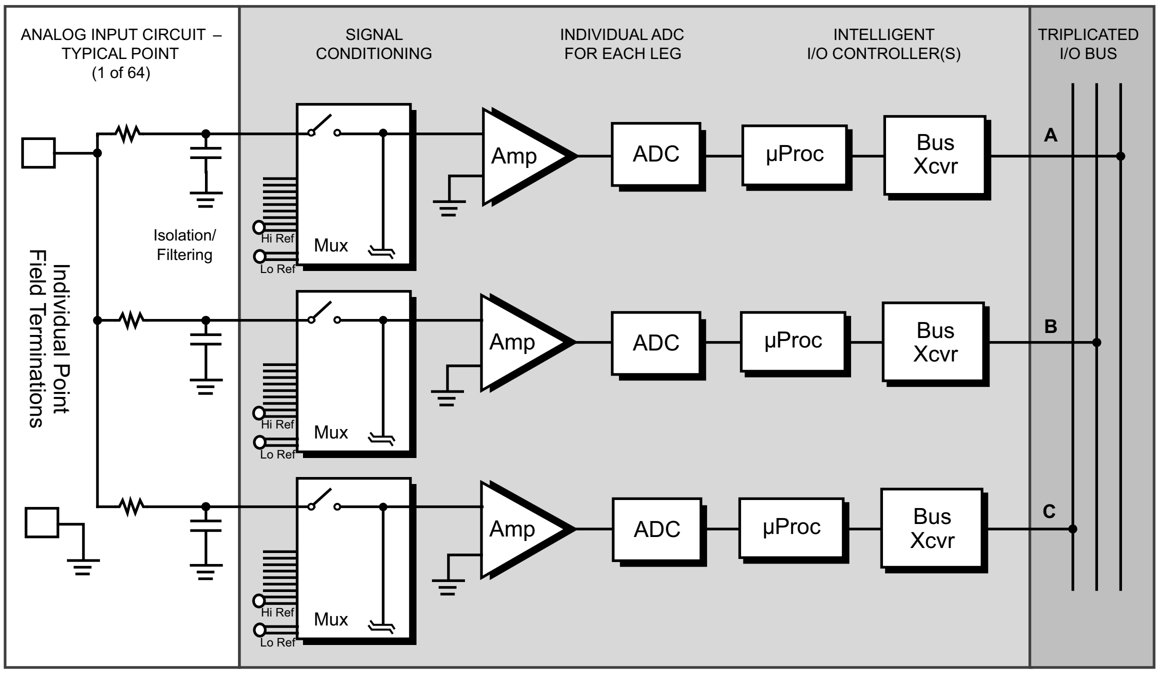


Figure 28 3704E Simplified Schematic

This figure is a simplified schematic for Model 3720, which is a 64-point TMR Analog Input Module with field-to-system isolation.

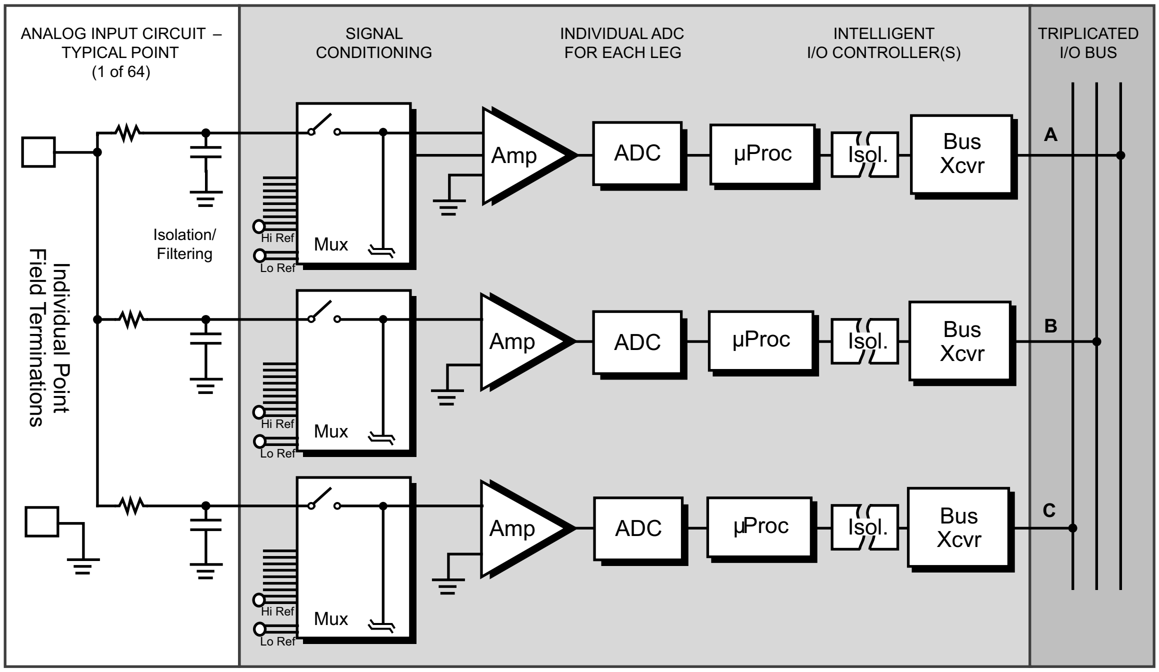


Figure 29 3720 Simplified Schematic

This figure shows the front panels of Models 3704E and 3720.

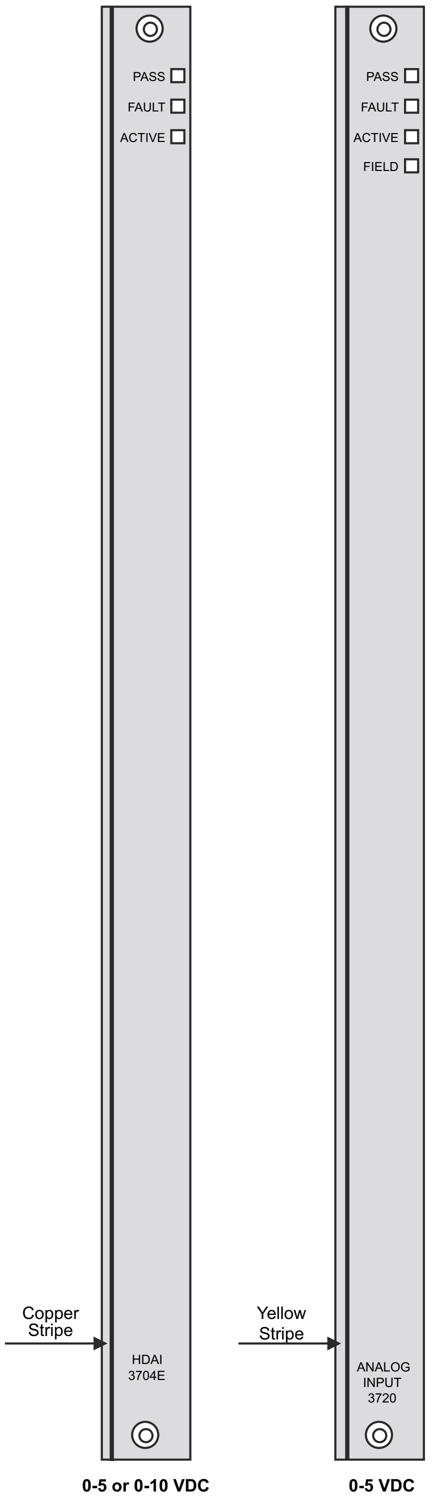


Figure 30 3704E and 3720 Front Panels

3704E Specifications

This section includes specifications for Model 3704E, which is a TMR Analog Input Module with a voltage range of 0 to 5 VDC or 0 to 10 VDC.

Table 22 3704E Analog Input Specifications

Feature	Specification
Color code	Copper
Number of input signals	64, commoned, DC-coupled
Input update rate	75 ms
Resolution	12 bits
Accuracy	< 0.25% of FSR, from 32° to 140° F (0° to 60° C)
Input resistance (load)	30 MΩ (DC) minimum
Input resistance @ power off	30 kΩ (DC) typical
Channel-to-channel isolation	200 kΩ typical
Normal mode rejection	-1 dB @ 8 Hz -12 dB @ 60 Hz -18 dB @ 120 Hz
Input range voltage	0 to 5 VDC or 0 to 10 VDC, (TriStation-configurable)
Input over-range measurement	+6%, 0 to 5.3 VDC or 0 to 10.6 VDC
Logic power	< 10 watts
Input over-range protection	150 VDC continuous; 115 VAC continuous
Input range current	0 to 20 mA with 250 or 500 Ω shunt resistor
Module status indicators	Pass, Fault, Active
Input diagnostic fault coverage[a]	
Minimum input change	0.5% of full scale
Input change sample period	1 scan or 50 ms, whichever is greater
Minimum period of mis-compares	256 samples

a. Rapidly or continuously changing inputs may cause mis-compare readings because the measured values of the three channels may differ by more than 0.5 percent of full scale, which can cause a fault to be declared in error. If the input readings differ by a minimum of 0.5 percent of full scale and continue for a minimum period of 256 input samples, the probability of a fault increases.

3720 Specifications

This section includes specifications for Model 3720, which is a TMR Analog Input Module with a voltage range of 0 to 5 VDC. The 3720 module can be installed only in Tricon v10.2 and later systems.

Table 23 3720 Analog Input Specifications

Feature	Specification
Color code	Yellow
Number of input signals	64, single-ended
Input update rate	10 ms
Resolution	12 bits or 14 bits programmable
Accuracy	< 0.15% of FSR from 32° to 140° F (0° to 60° C)
Input resistance (load)	10 MΩ (DC), minimum
Input resistance at power off	140 kΩ (DC), typical
Channel-to-channel isolation	420 kΩ, typical
Normal mode rejection	-3 dB @ 8 Hz -17 dB @ 60 Hz -23 dB @ 120 Hz
Input voltage range	0 to 5 VDC
Input over-range measurement	+6%, 0 to 5.3 V
Logic power	< 12 watts
Input over-range protection	150 VDC continuous, 115 VAC continuous
Input current range	0 to 20 mA (plus 6% over-range) with 250 Ω shunt resistor
Field to system isolation	800 VDC minimum
Module status indicators	Pass, Fault, Active, Field
Input diagnostic fault coverage[a]	
Minimum input change	0.5% of full scale
Input change sample period	10 ms
Minimum period of mis-compares	25 samples

a. Rapidly or continuously changing inputs may cause the time to detect a fault to increase. If an input sample changes by more than 0.25 percent from the previous sample, the readings will not be compared.

Note The Model 3720 can be installed in low-density systems that have been upgraded to v10.2.x or later. For more information, see “Appendix I, Low-Density Chassis I/O Module Compatibility” in the *Field Terminations Guide for Tricon v9–v11 Systems*.

Analog Output Modules

This section describes the Analog Output Modules available for use with Tricon v9–v11 systems. For installation instructions, see Replacing I/O Modules on page 293.

Table 24 Analog Output Modules

Model	Module Description	Output Current	Type
3805E/H	Analog Output	8 outputs @ 4–20 mA	TMR
3806E	Analog Output	2 outputs @ 20–320 mA 6 outputs @ 4–20 mA	TMR
3807	Bipolar Analog Output	4 outputs @ –60 to +60 mA	TMR

Analog Output Modules receive output signals from the Main Processors on each of three channels. Each set of data is voted, and a healthy channel is selected to drive the outputs. The module monitors its own current outputs (as input voltages) and maintains an internal voltage reference that provides self-calibration and module health information.

Each channel on an Analog Output Module has two independent current loopback circuits per point that are readable by the other channels. The information from these circuits is used as part of the hardware voting process. The first circuit verifies the accuracy and presence of the analog signal for each point, independent of the load presence or channel selection. The second circuit verifies the actual current flow for each point from the selected channel. If a current flow is detected from any point on a non-selected channel, that channel is immediately shutdown. The Load alarm status indicator is annunciated if the module cannot drive current from any point—for example, open load.

Analog Output Modules provide for the connection of redundant field loop power sources with individual indicators on the module called Pwr1 and Pwr2. Field loop power supplies for analog outputs must be provided externally. Connection of the field loop power supplies is made on the termination panel. A Status indicator activates if an open loop is detected on one or more output points. The Pwr1 and Pwr2 indicators are On if loop power is present.

Each module sustains complete and ongoing diagnostics for each channel. Failure of any diagnostic test on any channel activates the module Fault status indicator and the chassis alarm signal. The Fault status 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 multiple faults.

Analog Output Modules include the hot-spare feature, which allows online replacement of a faulty module. Like all I/O modules, Analog Output Modules require a separate field termination assembly with a cable interface to the Tricon controller backplane. Each module is mechanically keyed to prevent improper installation in a configured chassis.

Analog Output Schematic

This figure is a simplified schematic for Models 3805E, 3805H, and 3806E TMR Analog Output Modules.

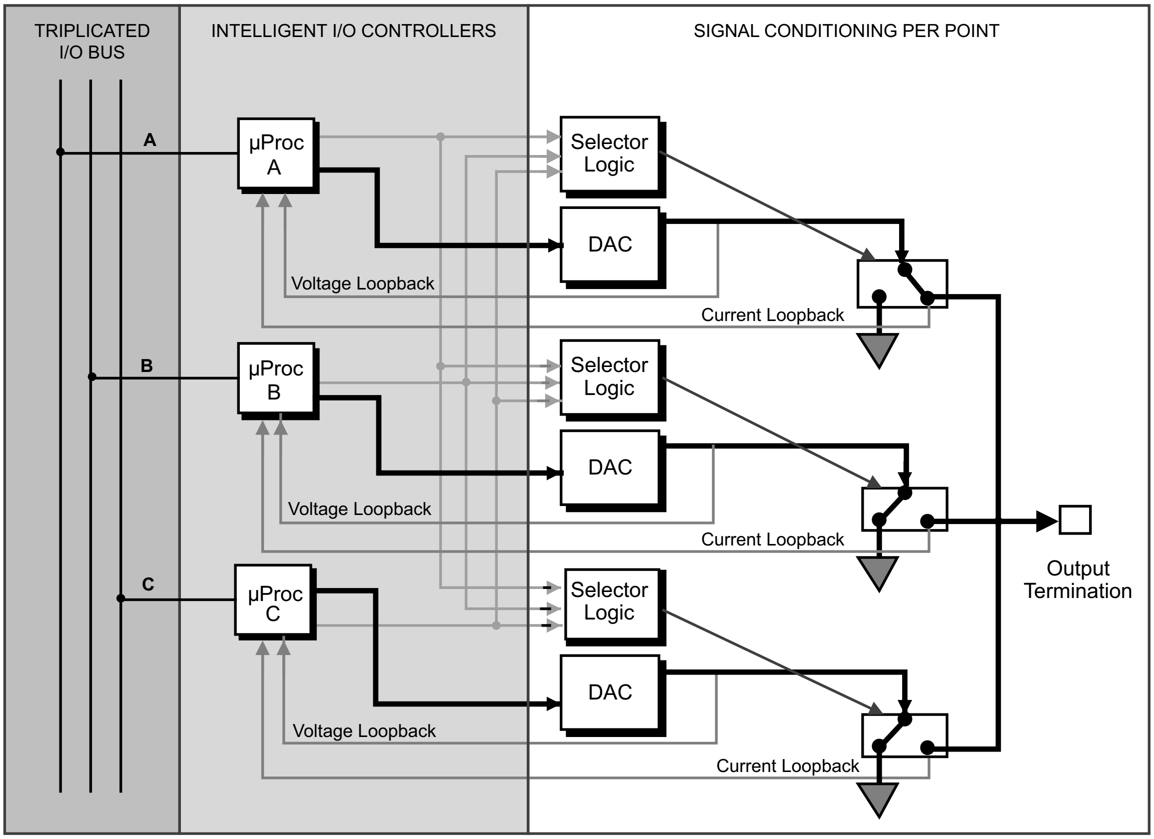


Figure 31 3805E, 3805H, and 3806E Simplified Schematic

This figure is a simplified schematic for the Model 3807 TMR Bipolar Analog Output Module.

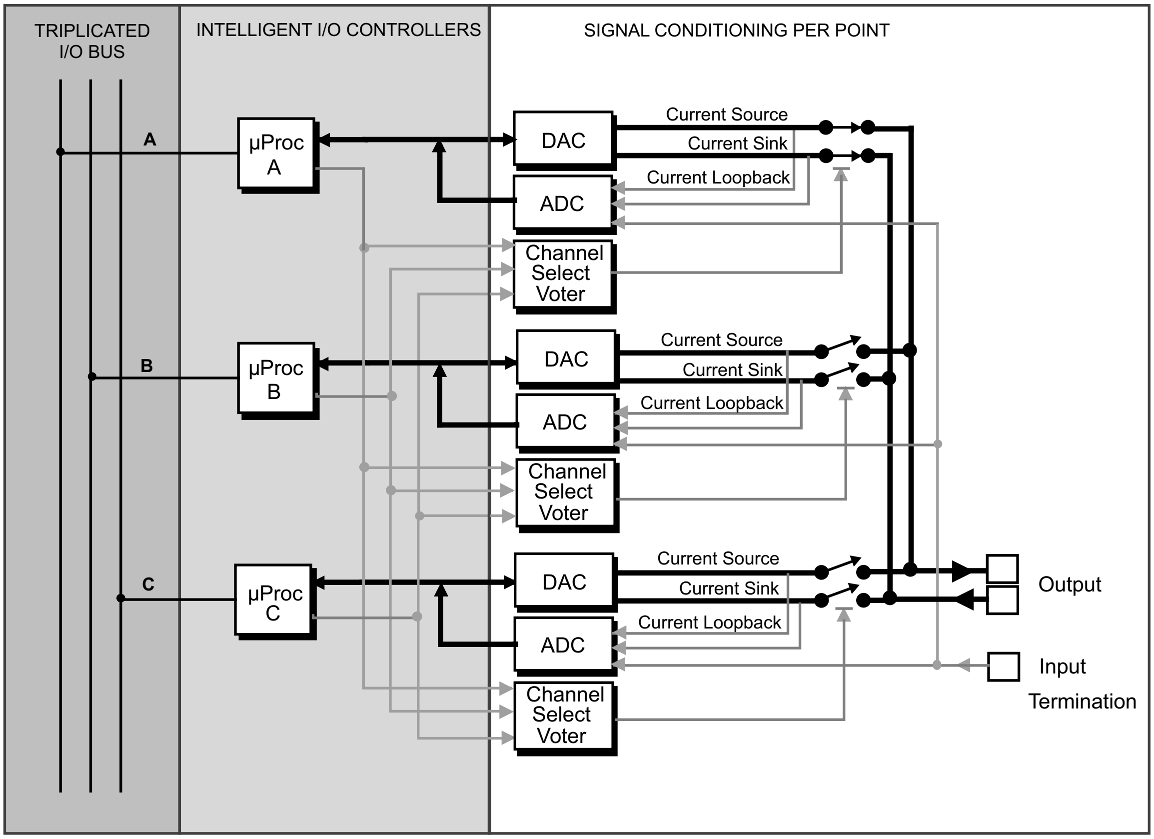


Figure 32 3807 Simplified Schematic

Analog Output Front Panels

This figure shows the front panels of Models 3805E, 3805H, 3806E, and 3807.

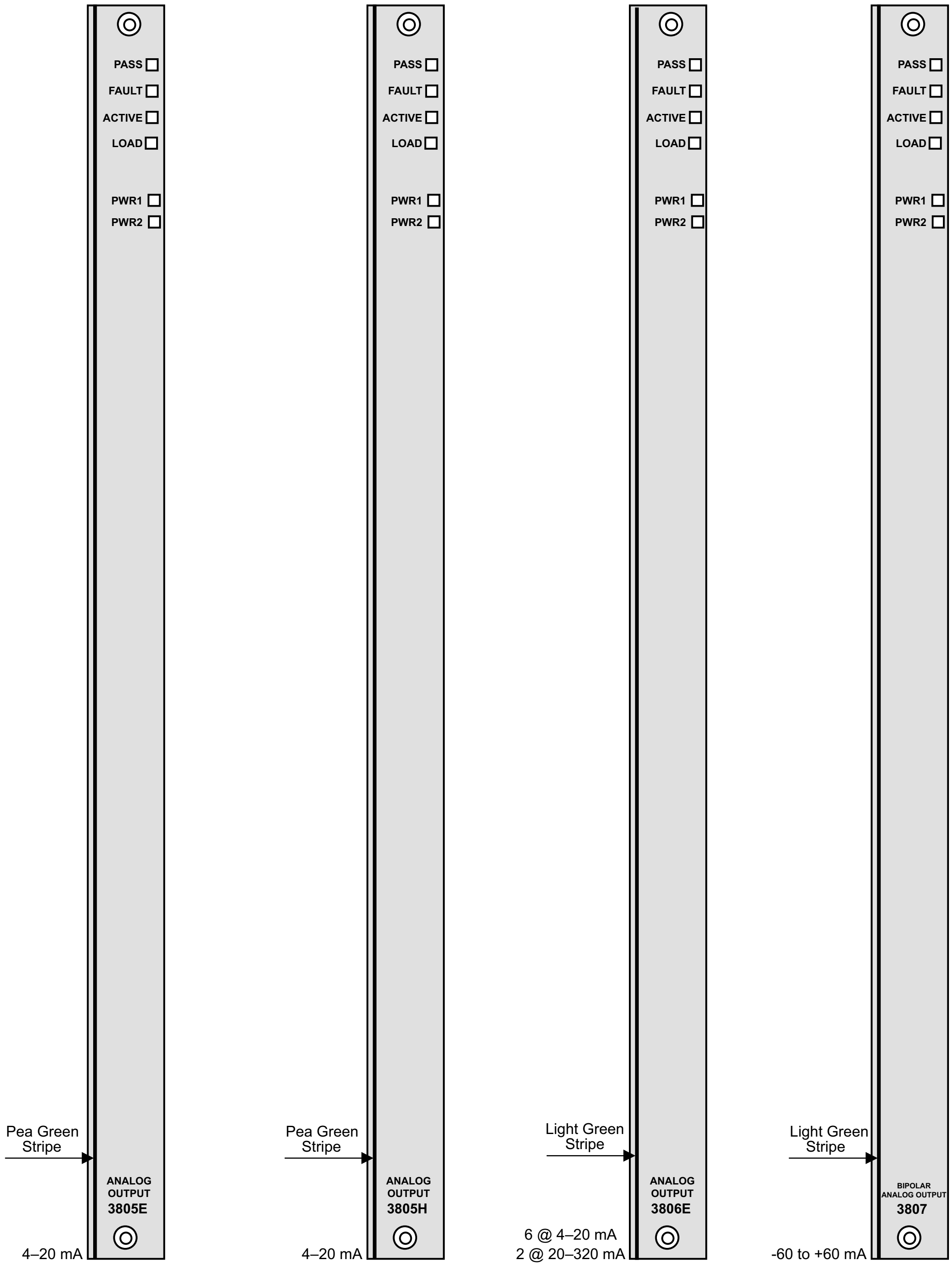


Figure 33 3805E, 3805H, 3806E, and 3807 Front Panels

3805E and 3805H Specifications

This table lists the specifications for the Model 3805E and 3805H TMR Analog Output Modules.

Table 25 3805E and 3805H Analog Output Specifications

Feature	Specification
Color code	Pea green
Number of output points	8, output, commoned return, DC-coupled
Resolution	12 bits
Output current range	4–20 mA (+6% over-range)
Output over-range capability	2–21.2 mA
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)
External loop power (reverse voltage protected)	+42.5 VDC maximum +24 VDC nominal
Output loop power requirement: load	Required
Output loop power requirement: 250 Ω load	> 20V (1 A minimum)
Output loop power requirement: 500 Ω load	> 25V (1 A minimum)
Output loop power requirement: 750 Ω load	> 30V (1 A minimum)
Output loop power requirement: 1000 Ωload	> 35V (1 A minimum)
Output over-range protection	+42.5 VDC continuous, 0 VDC continuous
Switch time on channel failure	10 ms (typical), 20 ms (maximum)
Status indicator: Module status	Pass, Fault, Active, Load
Status indicator: Loop power status[a]	Pwr1, Pwr2
Output diagnostic fault coverage: Minimum input change Output change sample period Minimum period of mis-compares	 Not applicable Not applicable Not applicable
Logic power	< 15 watts

a. The loop-power detectors which drive the Pwr1 and Pwr2 indicators identify the presence of loop power (greater than 20 VDC), and do not verify adequate loop power for the attached load.

Notes

- The Model 3805H module has been modified to support increased inductive loads. It is fully compatible for use in all applications of the Model 3805E module.
- For information about compliance with IEC 61508, Parts 1-7:2010, see TÜV Rheinland on page 22.

3806E Specifications

This table lists the specifications for the Model 3806E TMR Analog Output Module.

Table 26 3806E Analog Output Specifications

Feature	Specification
Color code	Light green
Number of output points	6 outputs @ 4–20 mA 2 outputs @ 20–320 mA, commoned return, DC-coupled
Resolution	12 bits
Recommended operating voltage range	24–32 VDC, 3 amp minimum
Extended operating voltage range	20–36 VDC, 3 amp minimum
Over-voltage protection	< 42.5 VDC continuous
Points 2-4 and 6–8, 4–20 mA output:	
Output current range	4–20 mA
Output over-range capability	2–21.2 mA (+6% over-range)
Output accuracy	< 0.25% (in normal range of 4–20 mA) of FSR (2–21.2 mA), from 32° to 140° F (0° to 60° C)
Maximum load vs. external loop voltage (See Figure 28 on page 68 for more information on these specifications)	≤ 275 Ω @ 20 VDC ≤ 475 Ω @ 24 VDC ≤ 650 Ω @ 28 VDC ≤ 825 Ω @ 32 VDC
Points 1 and 5, 20–320 mA output:	
Output current range	20–320 mA
Output over-range capability	20–339.2 mA (+6% over-range)
Output accuracy	< 0.25% (in normal range of 20–320 mA) of FSR (20–339.2 mA), from 0° to 60° C
Maximum load vs. external loop voltage	≤ 15 Ω @ 20 VDC ≤ 25 Ω @ 24 VDC ≤ 40 Ω @ 28 VDC ≤ 50 Ω @ 32 VDC
External loop power (reverse voltage protected)	+42.5 VDC maximum; +24 VDC nominal

Table 26 3806E Analog Output Specifications *(continued)*

Feature	Specification
Temperature de-rating vs. total output current vs. loop voltage:	
836 mA (all points @ maximum over-range output), 32 VDC loop voltage	≤ 104° F (≤ 40° C), ambient (measured at bottom of chassis)
836 mA (all points @ maximum over-range output), 28 VDC loop voltage	≤ 126.5° F (≤ 52.5° C), ambient (measured at bottom of chassis)
836 mA (all points @ maximum over-range output), 24 VDC loop voltage	≤ 140° F (≤ 60° C), ambient (measured at bottom of chassis)
774 mA (sum of all points), 28 VDC loop voltage	≤ 140° F (≤ 60° C), ambient (measured at bottom of chassis)
760 mA (all points @ maximum output), 28.5 VDC loop voltage	≤ 140° F (≤ 60° C), ambient (measured at bottom of chassis)
677 mA (sum of all points), 32 VDC loop voltage	≤ 140° F (≤ 60° C) C, ambient (measured at bottom of chassis)
602 mA (sum of all points), 36 VDC loop voltage	≤ 140° F (≤ 60° C), ambient (measured at bottom of chassis)
Status indicator: Module status	Pass, Fault, Active, Load
Status indicator: Loop power status[a]	Pwr1, Pwr2
Output diagnostic fault coverage:	
Minimum input change	Not applicable
Output change sample period	Not applicable
Minimum period of mis-compares	Not applicable
Switch time upon channel fault	10 ms (typical), 20 ms maximum
Logic power	< 15 watts

a. The loop-power detectors which drive the Pwr1 and Pwr2 indicators identify the presence of loop power (greater than 20 VDC), and do not verify adequate loop power for the attached load.

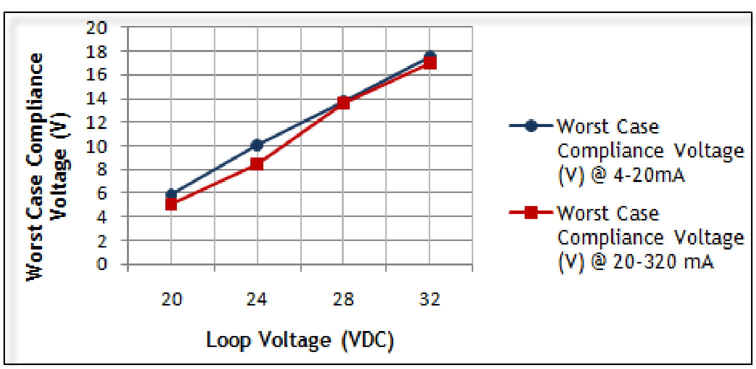


Figure 34 Graph of Worst Case Compliance Voltage for 4-20mA and 20-320 mA Current Points

Graphical values are rated at 25° C and should be de-rated for temperature. Compliance voltage is defined as the voltage developed across the load at the commanded current; field wiring is not considered. Current output cannot exceed compliance voltage divided by load resistance.

Note The Model 3806E AO Module is not certified by TÜV.

3807 Specifications and Description

This table lists the specifications for the Model 3807 TMR Bipolar Analog Output Module (BPAO).

Table 27 3807 Bipolar Analog Output Specifications

Feature	Specification
Color code	Light green
Output points	4, bipolar outputs
Resolution	13 bits
Output current range	-60 to +60 mA
Output over-range capability	none
Output accuracy	< 0.25% (in range of -60 to 60 mA) of Full Scale Range (FSR), from 32° to 140° F (0° to 60° C). FSR = 120 mA.
Coil diagnostic input signals[a]	4 differential, DC-coupled
Coil diagnostic input resolution	12 bits
Coil diagnostic input normal-range measurement	± 10 V
External loop power range	24 VDC –15%/+20%, +5% ripple
Absolute external loop power range	19.2–30.0 VDC
Over-voltage protection	36 VDC continuous
External loop power current[b]	3.5 amp minimum
Reverse voltage protected	–36 VDC continuous
Redundant loop power support	Yes
Compliance voltage[c]	–9 V minimum +9 V maximum
Resistive load operating range	150 ohm @ ± 60 mA 1 kohm @ ± 9 mA 9 kohm @ ± 1 mA
Inductive load operating range—using standard termination with 300 Ω 680 nF snubber	0.0 H minimum 1.0 H maximum
Inductive load operating range—using external 300 Ω 4.7 uF snubber[d]	0.0 H minimum 2.6 H maximum
Capacitive load operating range	0 uF minimum 133 uF maximum, non-polar, with parallel resistor

Table 27 3807 Bipolar Analog Output Specifications *(continued)*

Feature	Specification
Maximum glitch time, hourly switch to hot-spare module	Less than 20 msec
Maximum glitch time, current dropouts caused by the periodic rotation between channels driving the load. Channels rotate every 10 seconds.	Less than 1 msec
Status indicator: module status	Pass, Fault, Active, Load
Status indicator: Loop power	Pwr1, Pwr2
Output diagnostic fault coverage:	
Minimum input change	Not applicable
Output change sample period	Not applicable
Minimum period of mis-compares	Not applicable
Logic power	< 20 watts

a. Four input points are used in the application program for coil diagnostic purposes.
b. The loop-power detectors which drive the Pwr1 and Pwr2 indicators identify the presence of loop power (greater than 19.2 VDC), but do not verify adequate loop power current for the attached load.
c. Compliance voltage is voltage developed across the load at the commanded current.
d. Contact the Global Customer Support (GCS) center or your regional support center for alternate snubber configurations.

The Model 3807 BPAO Module can be installed in low-density systems that have been upgraded to v10.2.x or later. For more information, see Appendix I, "Low-Density Chassis I/O Module Compatibility" in the *Field Terminations Guide for Tricon v9–v11 Systems*.

The Model 3807 BPAO Module is designed to provide positive and negative drive current for position, velocity, and force in motion control applications. **It should not be used in safety applications**.

The BPAO module includes analog input points, otherwise known as coil diagnostic inputs, intended for loopback measurement of the voltage developed across servo-valve coil/redundant coils as measured at the termination panel. These inputs are available to the application program.

Consider the following factors when developing an application program that uses loopback voltage measurement:

- The coil diagnostic inputs are directly tied to corresponding bipolar outputs on the termination panel.
- The BPAO coil diagnostic inputs read the voltage at the termination panel, regardless of the length of the termination cable.
- When calculating voltages read by the BPAO coil diagnostic inputs, consider the resistance of the termination cable wires *plus* the resistance of the wires from the termination panel to the load *plus* the resistance of the load itself.
- Microphonic voltage generated by the coil from mechanical forces on the coil mechanics (torque motor).

- Back EMF voltage generated by the coil in response to current changes.
- Commanded current variations from the control program.
- Environmental background electromagnetic noise.
- The delay of three to four scans that occurs between writing an output (commanded current) and reading the loopback voltage input.

You should include a one-scan filter in the control program function to eliminate:

- Twenty-millisecond current dropouts caused by hourly board switch between the active and stand-by module (if installed).
- One-millisecond current dropouts caused by the rotation between channels driving the load. Channels rotate every 10 seconds.

The dropouts are asynchronous to the coil diagnostic input samples and may or may not be detected.

The Load alarm status indicator is activated if the module cannot drive current from any point. This condition can exist if the load is disconnected or if the loop power is missing (zero mA flowing out/in). However, if the output current is commanded to be at zero mA then the module internal diagnostics will not recognize an open loop or missing loop power. In this condition, the measured loopback voltage may be used to detect an open circuit or missing loop power.

This table shows the relationship between the commanded current, the measured loop back input, and the Load alarm status indication.

Table 28 3807 Bipolar Analog Output Field Fault Cases and Indications

Fault Case	Condition	Load Indicator Load Variable	Alarm	Loopback Input
Open load	Set current > 1ma	On	On	4,095
Open load	-1ma < Set current < 1ma	Off	Off	Changing (all values)
Open load	Set current < -1ma	On	On	–4,095
Shorted load	Set current > 1ma	Off	Off	-10 to +10 counts
Shorted load	Set current < -1ma	Off	Off	-10 to +10 counts

Each BPAO channel provides loop-power current limiting to protect the external power supplies.

For more information, see these sections:

- Model 3807 Bipolar Analog Output Module Installation on page 250
- Performance Proof Testing Model 3807 Bipolar Analog Output Modules on page 288

Digital Input Modules

This section describes the Digital Input Modules available for use with Tricon v9–v11 systems, which include TMR and Single (non-triplicated) modules. For installation instructions, see Replacing I/O Modules on page 293.

Table 29 Digital Input Modules

Model	Voltage/Type	Points	Description
3501E/T	115 VAC/VDC	32	TMR, isolated, non-commoned
3502E	48 VAC/VDC	32	TMR, commoned in groups of 8, with a circuit stuck-On self-test feature.
3503E	24 VAC/VDC	32	TMR, commoned in groups of 8, with a circuit stuck-On self-test feature.
3504E	24/48 VDC	64	TMR, commoned, high-density, DC-coupled, with a circuit stuck-On or stuck-Off self-test feature. Configured in TriStation as 24 or 48 VDC.
3505E	24 VDC	32	TMR, commoned, low threshold, with a circuit stuck-On self-test feature.
3564	24 VDC	64	Single, commoned

Each Digital Input Module has three independent channels which process all data input to the module. On each channel, a microprocessor scans each input point, compiles data, and transmits it to the Main Processors upon demand. Then input data is voted at the Main Processors before processing to ensure the highest integrity.

All Digital Input Modules sustain complete, ongoing diagnostics for each channel. Failure of any diagnostic on any channel activates the Fault indicator, which in turn activates the chassis alarm signal. The 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.

Digital Input Modules include the hot-spare feature, which allows online replacement of a faulty module. Like all I/O modules, Digital Input Modules require a cable interface to a remotely located external termination panel. Each module is mechanically keyed to prevent improper installation in a configured chassis.

Self-Test Feature

The self-test feature continuously verifies the ability of the Tricon controller to detect the transition of a circuit. This feature is available in two versions:

1) Models 3502E, 3503E, and 3505E include a circuit stuck-On self-test feature that verifies the ability to detect transitions from a normally energized circuit to the Off state.

2) Models 3504E and 3564 include a circuit stuck-On or stuck-Off self-test feature that verifies the ability of a Tricon controller to detect transitions to the opposite state—either from On to Off, or from Off to On.

Single Digital Input Module

Model 3564 is a Single Digital Input Module, which 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 that are required to ensure safe operation are triplicated. Self-test circuitry detects all stuck-On and stuck-Off fault conditions within the non-triplicated signal conditioners in less than 500 milliseconds. This is a mandatory feature of a fail-safe system, which must detect all faults in a timely manner and upon detection of a fault, force the measured input value to the safe state. Because the Tricon controller 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. Although this module is fail-safe, it does not offer the same level of availability and reliability as a TMR module.

115 VAC/VDC Digital Input Modules

This figure is a simplified schematic for Models 3501E and 3501T, which are 16-point TMR Digital Input Modules without a self-test feature.

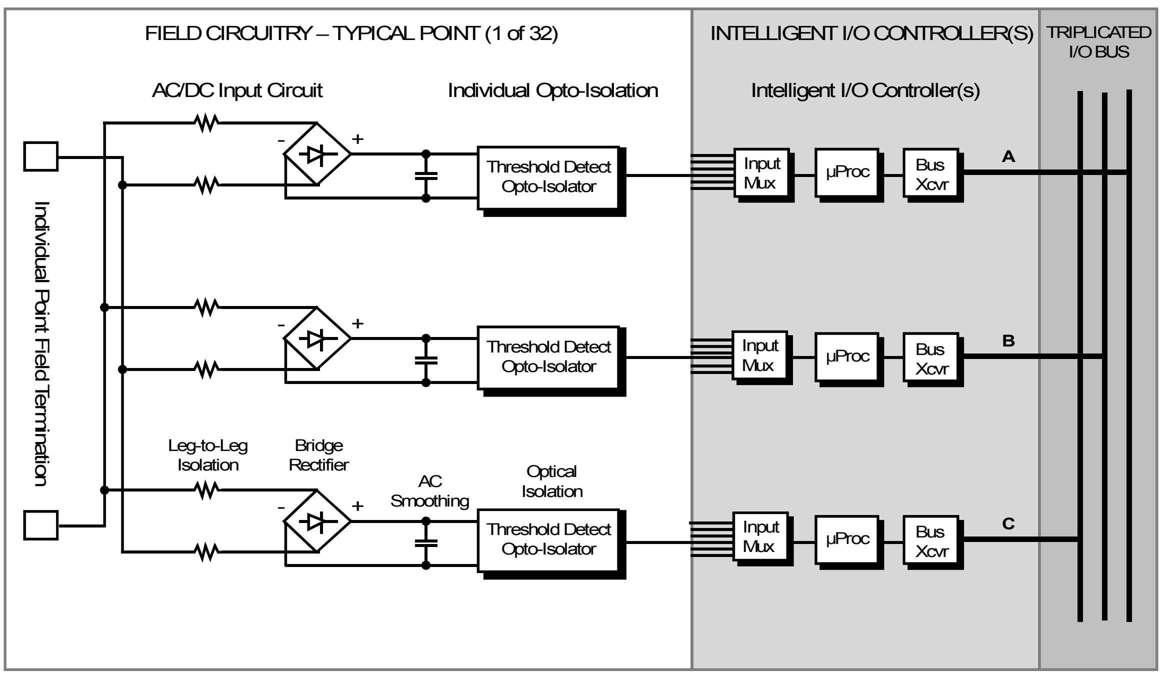


Figure 35 3501E and 3501T Simplified Schematic

This figure shows the front panels of Models 3501E and 3501T.

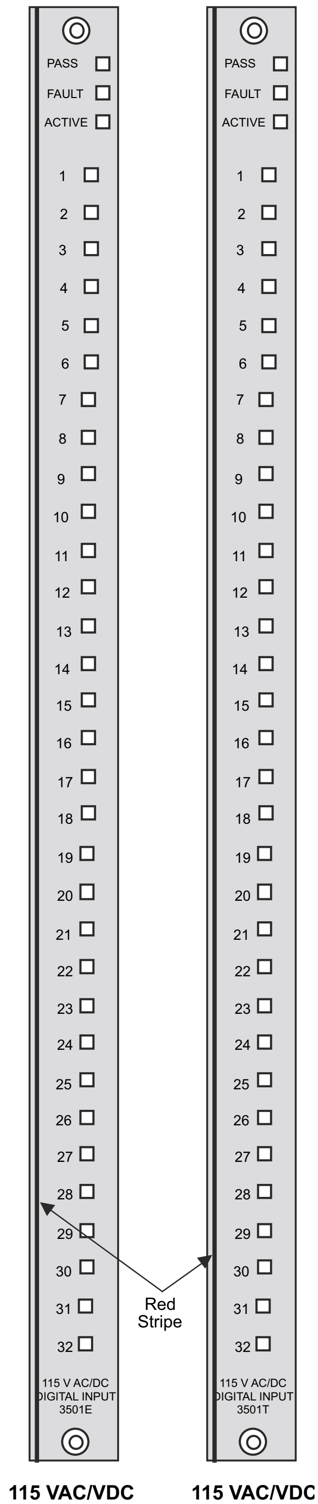


Figure 36 3501E and 3501T Front Panels

3501E and 3501T Specifications

This table lists the specifications for Models 3501E and 3501T, which are 16-point TMR Digital Input Modules with a nominal input voltage of 115 VAC/VDC. Model 3501T has a higher point isolation minimum than Model 3501E.

Table 30 3501E and 3501T Digital Input Specifications

Feature	Specification
Color code	Red
Number of input points	32, non-commoned, isolated
Input frequency range	DC or 47-63 Hz
Recommended input range	90–155 VAC/VDC
Maximum voltage	155 VAC/VDC
Switching level: Off to On	69 VAC/VDC typical, 86 VAC/VDC worst-case
Switching level: On to Off	36 VAC/VDC typical, 28 VAC/VDC worst-case
Typical hysteresis	32 VAC/VDC
Nominal turn-on	6 mA to 9 mA
Input impedance	> 8.5 kΩ nominal
Input delay: Off to On	< 8 ms
Input delay: On to Off	< 15 ms
Point isolation, opto-isolated: 3501E	1,000 VAC minimum, 1,500 VDC minimum
Point isolation, opto-isolated: 3501T	1,780 VAC minimum, 2,500 VDC minimum
Status indicator: On or Off state	1 per point
Status indicator: Module status	Pass, Fault, Active
Logic power	< 10 watts
Nominal field power load	1.5 watts per On point, 2.9 watts @ maximum field voltage
Leakage current to chassis @ 60 Hz	1 mA maximum per On point
Input diagnostic fault coverage:	
Maximum input toggle rate[a]	Every 100 ms
Minimum input toggle rate	Every 24 months (manually toggled by the user)[b]
Diagnostic glitch duration	Not applicable

a. The maximum input toggle rate enables proper operation of I/O diagnostics and detection of all normally detectable faults.

b. For more information, see Toggling Field I/O Points on page 288.

24 to 48 VAC/VDC Digital Input Modules

This figure is a simplified schematic for Models 3502E, 3503E, and 3505E, which are 24 to 48 VAC/VDC, 32-point TMR Digital Input Modules with a self-test feature. The self-test feature continuously verifies the ability of a Tricon controller to detect the transition of a normally energized circuit to the Off state.

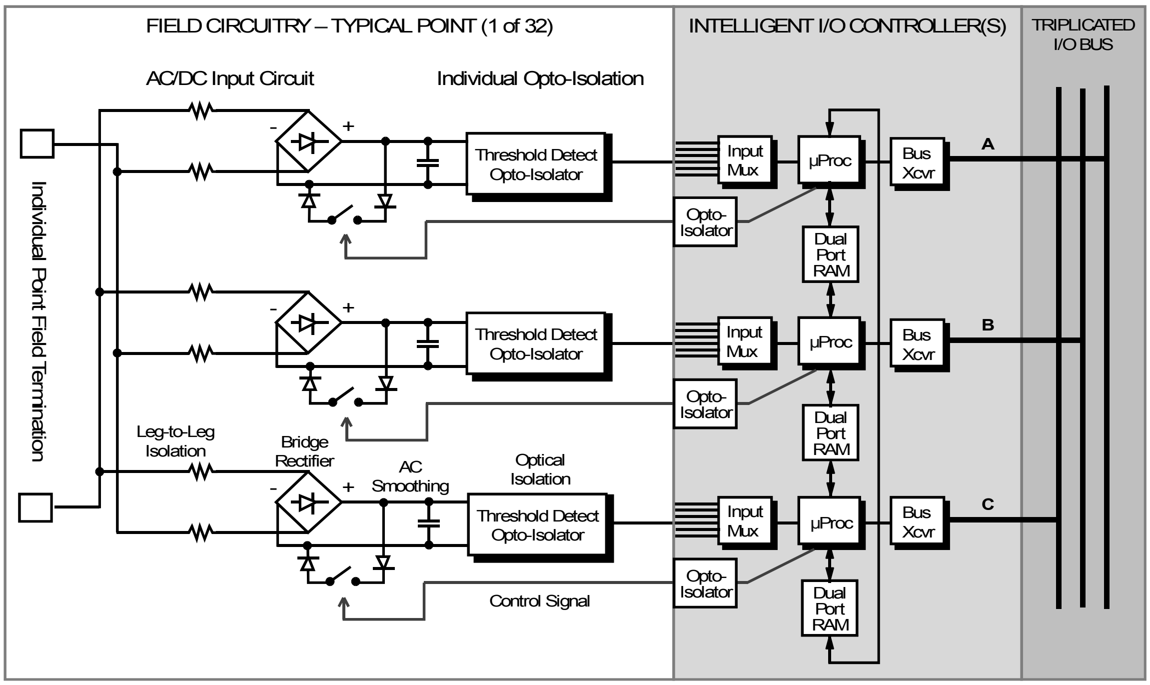


Figure 37 3502E, 3503E, and 3505E Simplified Schematic

This figure shows the front panels of Models 3502E, 3503E, and 3505E.

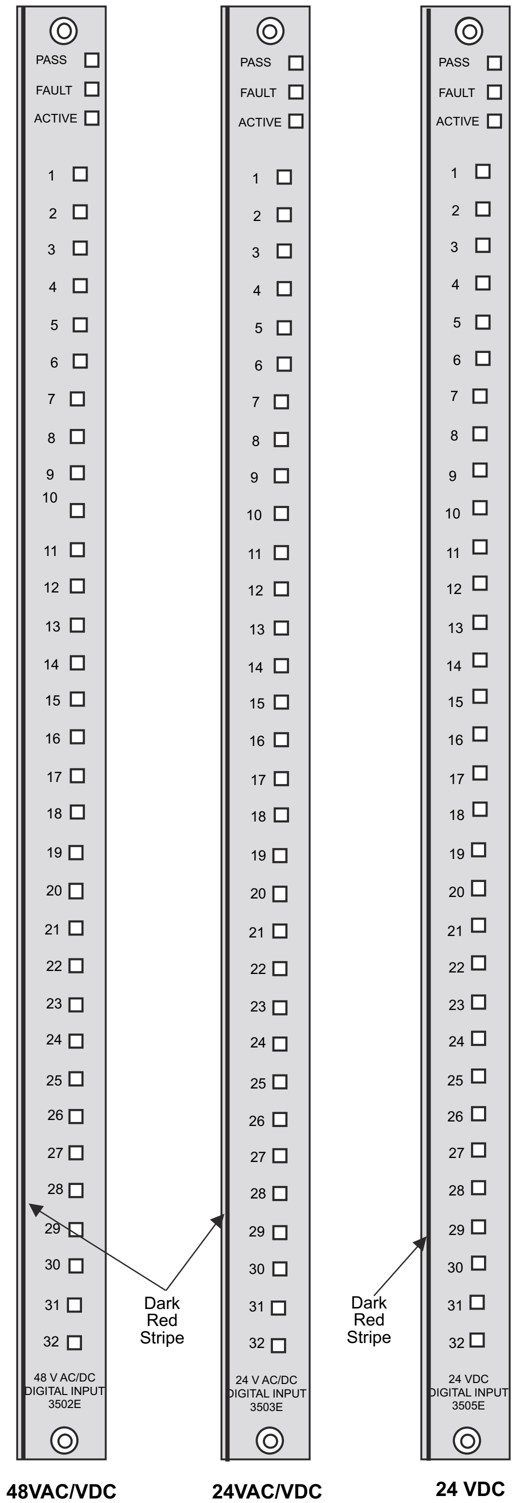


Figure 38 3502E, 3503E, and 3505E Front Panels

3502E Specifications

This table lists the specifications for Model 3502E, which is a TMR Digital Input Module with a nominal input voltage of 48 VAC/VDC and a self-test feature.

Table 31 3502E Digital Input Specifications

Feature	Specification
Color code	Dark red
Number of input points	32, commoned in groups of 8
Input frequency range	DC or 47-63 Hz
Recommended input range	35–95 VAC/VDC
Maximum voltage	95 VAC/VDC
Switching level: Off to On	27 VAC/VDC typical, 32 VAC/VDC worst-case
Switching level: On to Off	14 VAC/VDC typical, 11 VAC/VDC worst-case
Typical hysteresis	7 VAC/VDC
Nominal turn-on	6 mA to 9 mA
Input impedance	> 2.9 kΩ nominal
Input delay: Off to On	< 8 ms
Input delay: On to Off	< 15 ms
Point isolation, opto-isolated	1,000 VAC minimum, 1,500 VDC minimum
Status indicator: On or Off state	1 per point
Status indicator: Module status	Pass, Fault, Active
Logic power	< 10 watts
Nominal field power load	1.0 watts per On point, 3.2 watts @ maximum field voltage
Leakage current to chassis @ 60 Hz	0.5 mA maximum per On point
Input diagnostic fault coverage:	
Maximum input toggle rate[a]	Every 100 ms
Minimum input toggle rate, On state	Not required
Minimum input toggle rate, Off state	Every 24 months (manually toggled by the user)[b]
Diagnostic glitch duration[c]	20 ms typical
Output voltage	$< 1/2V_{IN}$
Output impedance	< 4.22 kΩ

a. The maximum input toggle rate enables proper operation of I/O diagnostics and detection of all normally detectable faults.

b. For more information, see Toggling Field I/O Points on page 288.

c. V_{IN} is the voltage applied to an energized point. Output voltage is noticeable on an adjacent de-energized point for the duration of the diagnostic glitch. Be advised that the glitch output may falsely energize the paralleled input of another piece of equipment.

3503E Specifications

This table lists the specifications for Model 3503E, which is a TMR Digital Input Module with a nominal input voltage of 24 VAC/VDC and a self-test feature.

CAUTION The Model 3503E is not recommended for use with shunt-diode intrinsic safety barriers. For these applications, Invensys recommends the Model 3505E.

Table 32 3503E Digital Input Specifications

Feature	Specification
Color code	Dark red
Number of input points	32, commoned in groups of 8
Input frequency range	DC or 47-63 Hz
Recommended input range	20–42.5 VDC
Maximum voltage	42.5 VAC/VDC
Switching level: Off to On	15 VAC/VDC typical, 18 VAC/VDC worst-case
Switching level: On to Off	8 VAC/VDC typical, 6 VAC/VDC worst-case
Typical hysteresis	4 VAC/VDC
Nominal turn-on	6 mA to 9 mA
Input impedance	> 1.25 kΩ nominal
Input delay: Off to On	< 8 ms
Input delay: On to Off	< 15 ms
Point isolation, opto-isolated	1,000 VAC minimum, 1,500 VDC minimum
Status indicator: On or Off State	1 per point
Status indicator: Module status	Pass, Fault, Active
Logic power	< 10 watts
Nominal field power load	0.5 watts per On point[a] 1.5 watts @ maximum field voltage
Leakage current to chassis @ 60 Hz	0.25 mA maximum per On point
Input diagnostic fault coverage: Maximum input toggle rate[b] Minimum input toggle rate, On state Minimum input toggle rate, Off state	 Every 100 ms Not required Every 24 months (manually toggled by the user)[c]
Diagnostic glitch duration[d] Output voltage Output impedance	20 ms typical $< 1/2\ V_{IN}$ < 1.87 kΩ

a. When used with a typical shunt-diode intrinsic safety barrier, the nominal field power per On point is approximately 350 milliwatts @ 24 VDC.

b. The maximum input toggle rate enables proper operation of I/O diagnostics and detection of all normally detectable faults.

c. For more information, see Toggling Field I/O Points on page 288.

d. V_{IN} is the voltage applied to an energized point. Output voltage is noticeable on an adjacent de-energized point for the duration of the diagnostic glitch. Be advised that the glitch output may falsely energize the paralleled input of another piece of equipment.

3505E Specifications

This table lists the specifications for Model 3505E, which is a low-threshold TMR Digital Input Module.

Table 33 3505E Digital Input Specifications

Feature	Specification
Color code	Dark red
Number of input points	32, commoned in groups of 8
Recommended input range	20–42.5 VDC
Maximum voltage	42.5 VDC
Switching level: Off to On	10 VDC typical, 12 VDC worst-case
Switching level: On to Off	5 VDC typical, 4 VDC worst-case
Typical hysteresis	2 VDC
Nominal turn-on	3 mA to 5 mA
Input impedance	> 1.25 kΩ nominal
Input delay: Off to On	< 8 ms
Input delay: On to Off	< 15 ms
Point isolation, opto-isolated	1,000 VAC minimum, 1,500 VDC minimum
Status indicator: On or Off State	1 per point
Status indicator: Module status	Pass, Fault, Active
Logic power	< 10 watts
Nominal field power load	0.5 watts per On point[a] 1.5 watts @ maximum field voltage
Leakage current to chassis @ 60 Hz	0.25 mA maximum per On point
Input diagnostic fault coverage:	
Maximum input toggle rate[b]	Every 100 ms
Minimum input toggle rate, On state	Not required
Minimum input toggle rate, Off state	Every 24 months (manually toggled by the user)[c]

Table 33 3505E Digital Input Specifications *(continued)*

Feature	Specification
Diagnostic glitch duration[d]	20 ms typical
Output voltage	< 1/2 V_{IN}
Output impedance	< 1.87 kΩ

a. When used with a typical shunt-diode intrinsic safety barrier, the nominal field power per On point is approximately 350 milliwatts @ 24 VDC.

b. The maximum input toggle rate enables proper operation of I/O diagnostics and detection of all normally detectable faults.

c. For more information, see Toggling Field I/O Points on page 288.

d. V_{IN} is the voltage applied to an energized point. Output voltage is noticeable on an adjacent de-energized point for the duration of the diagnostic glitch. Be advised that the glitch output may falsely energize the paralleled input of another piece of equipment.

24 to 48 VDC Digital Input Modules

This figure is a simplified schematic for Model 3504E, which is a high-density TMR Digital Input Module.

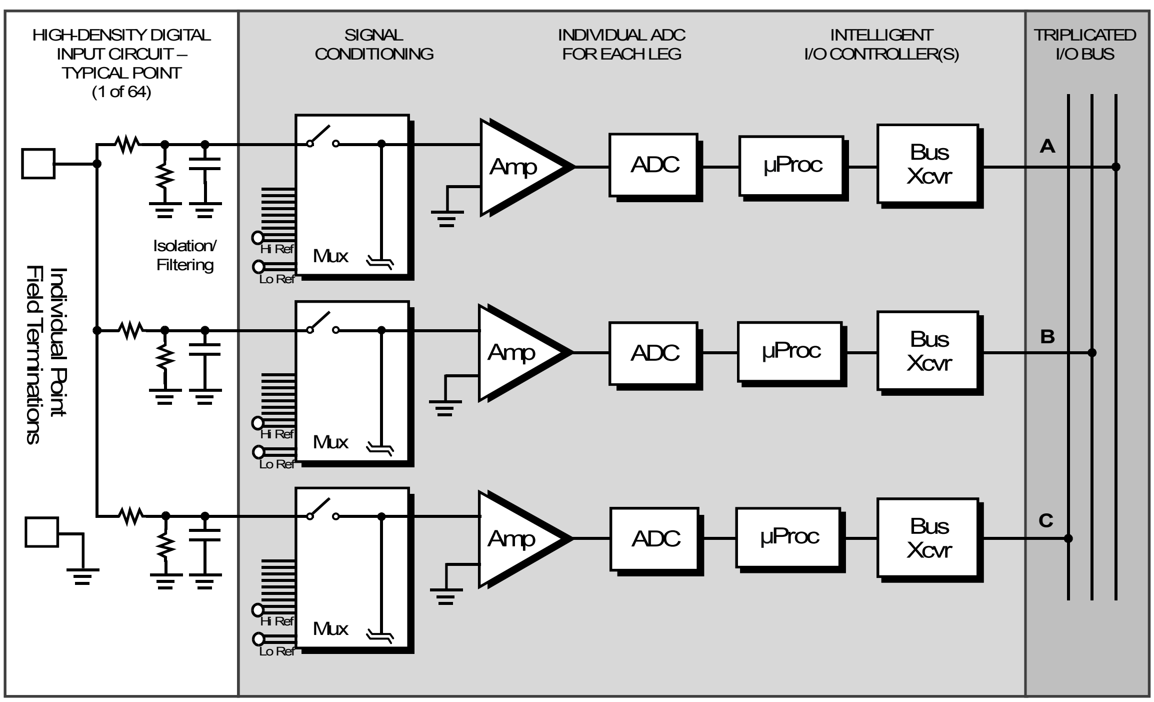


Figure 39 3504E Simplified Schematic

This figure shows the front panel of Model 3504E.

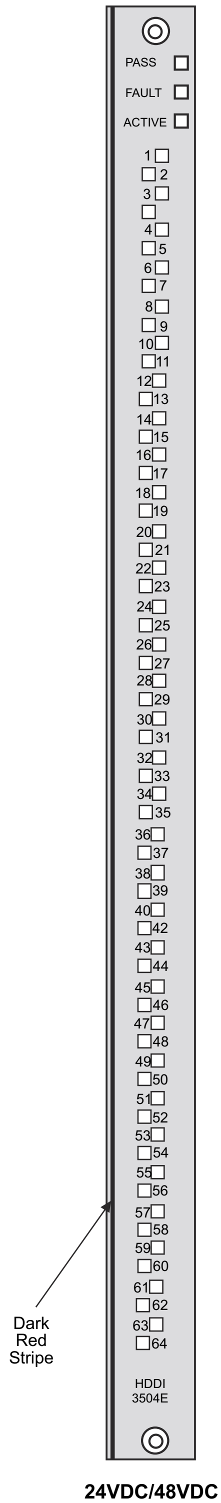


Figure 40 3504E Front Panel

3504E Specifications

This table lists the specifications for Model 3504E, which is a high-density TMR Digital Input Module with an nominal input voltage of 24 or 48 VDC.

Table 34 3504E Digital Input Specifications

Feature	Specification
Color code	Dark red
Number of input points	64, commoned, DC-coupled
Input voltage range: 24 VDC[a]	20–36 VDC
Input voltage range: 48 VDC[1]	40–72 VDC
Input over-range protection	115 VAC continuous, 150 VDC continuous
Switching level for 24 VDC: Off to On	15 VDC typical, 18 VDC worst-case, 4 VDC typical hysteresis
Switching level for 24 VDC: On to Off	8 VDC typical, 6 VDC worst-case, 4 VDC typical hysteresis
Switching level for 48 VDC: Off to On	27 VDC typical, 32 VDC worst-case, 7 VDC typical hysteresis
Switching level for 48 VDC: On to Off	14 VDC typical, 11 VDC worst-case, 7 VDC typical hysteresis
Input delay: Off to On	< 10 ms
Input delay: On to Off	< 10 ms
Status indicator: On or Off state	1 per point
Status indicator: Module status	Pass, Fault, Active
Input impedance[b]	> 30 kΩ nominal
Logic power	< 10 watts
Input diagnostic fault coverage[c]:	
Maximum input toggle rate	Once every 100 ms
Minimum input toggle rate	Not required
Diagnostic glitch duration	1 ms every 2–3 seconds
Output voltage	0 VDC or 5 VDC typical
Output impedance	100 kΩ typical

a. Specified in TriStation 1131.

b. A ballast resistor is installed on the external termination panel to lower the input impedance equivalent to other Triconex Digital Input Modules. For more information, see the *Field Terminations Guide for Tricon v9–v11 Systems*.

c. The maximum input toggle rate enables proper operation of I/O diagnostics and detection of all normally detectable faults. The minimum toggle rate provides fault coverage of normally undetectable faults within 10 percent of the calculated mean-time-between-faults (MTBF) for the module.

24 VDC Single Digital Input Modules

This figure is a simplified schematic for Model 3564, which is a Single Digital Input Module.

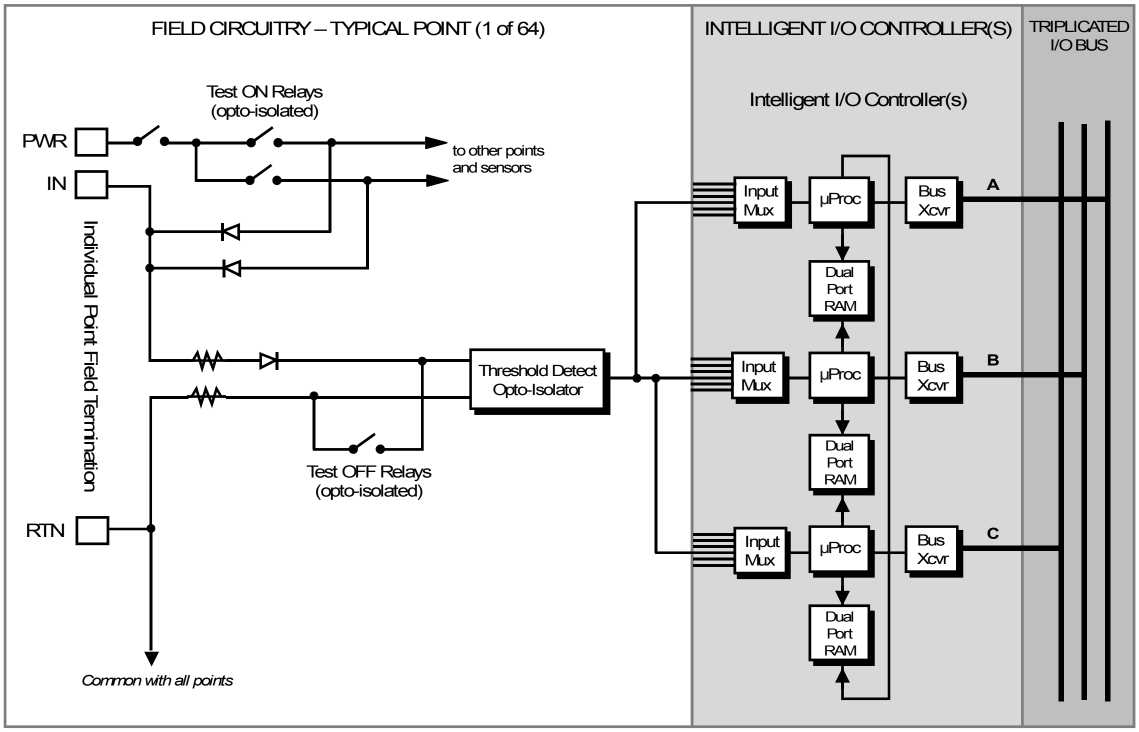


Figure 41 3564 Simplified Schematic

This figure shows the front panel of Model 3564.

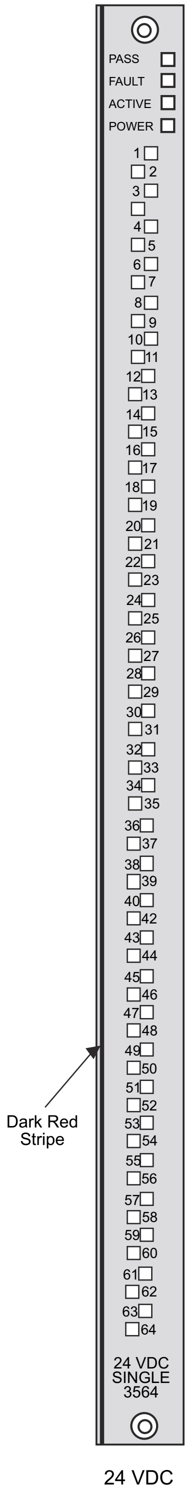


Figure 42 3564 Front Panel

3564 Specifications

This table lists the specifications for Model 3564, which is a Single Digital Input Module with an nominal voltage range of 24 VDC. This module is fail-safe, however, it does not have the same level of availability and reliability as a TMR module.

CAUTION

If a hot-spare module is installed, a normal switch-over to the healthy module occurs in a few seconds. During this switch-over period, the input value is reported to the control program. The control program, within its own constraints, must handle this potential "glitch Off" condition in such a way as to maximize system availability.

Table 35 3564 Digital Input Specifications

Feature	Specification
Color code	Dark red
Number of input points	64, commoned
Recommended input range	15–30 VDC
Maximum voltage	36 VDC
Switching level:	
Off to On	12 VDC typical 15 VDC worst-case
On to Off	8 VDC typical, 6 VDC worst-case
Typical hysteresis	4 VDC
Nominal turn-on	2 mA to 3 mA
Input impedance	> 3.0 kΩ nominal
Input delay:	
Off to On	< 2 ms
On to Off	< 2 ms
Point isolation, opto-isolated	1,500 VDC minimum
Status indicator: On or Off State	1 per point
Status indicator: Module status	Pass, Fault, Active, Power
Logic power	< 10 watts
Nominal field power load	0.2 watts per On point, 0.5 watts @ maximum field voltage
Leakage current to chassis @ 60 Hz	Not applicable
Input toggle rates[a]:	
Maximum	Every 100 ms
Minimum, On state	Not required
Minimum, Off state	Not required

Table 35 3564 Digital Input Specifications *(continued)*

Feature	Specification
On glitch of Off point[b]:	
Duration	< 2 ms maximum
Voltage	< V_{IN}
Duty cycle	50%, typical
Impedance	< 10 Ω
Input behavior under fault conditions[c]:	
Input value, before fault	Input state, On or Off
Input value, after fault	Unknown, depends on type of fault
Input value, after 500 ms	Off, de-energized

a. The maximum input toggle rate enables proper operation of I/O diagnostics and detection of all normally detectable faults. The minimum toggle rate provides fault coverage of normally undetectable faults within 10 percent of the calculated mean-time-between-faults (MTBF) for the module.

b. V_{IN} is the field voltage. Output voltage is noticeable on the field circuit of an Off input point for the duration of the diagnostic glitch. Be advised that the glitched output may falsely energize the paralleled input of another piece of equipment.

c. Each channel of the Single DI module independently performs a complete set of diagnostics on each input point every 500 milliseconds. Upon detection of a fault, each point which does not pass 100 percent of the diagnostic tests is reported as Off to the Main Processor by each channel. Faults in the non-redundant input circuitry affect the value reported by all three channels, whereas faults that affect only one channel affect only the value reported by that channel.

Digital Output Modules

This section describes the Digital Output Modules available for use with Tricon v9–v11 systems, which include TMR and Single (non-triplicated) modules. For field wiring information, see Digital Output Field Wiring Precautions on page 248.

Table 36 Digital Output Modules

Model	Voltage	Type
3601E/T	115 VAC	16-point TMR, Non-Commoned
3603B	120 VDC	16-point TMR, Non-Commoned
3603E/T	120 VDC	16-point TMR, Commoned
3604E	24 VDC	16-point TMR, Non-Commoned
3607E	48 VDC	16-point TMR, Non-Commoned
3611E	115 VAC	8-point TMR Supervised, Commoned
3613E	120 VDC	8-point TMR Supervised, Commoned
3614E	24 VDC	8-point TMR Supervised, Commoned
3615E	24 VDC	8-point TMR Supervised, Low Power, Commoned
3617E	48 VDC	8-point TMR Supervised, Commoned
3623/T	120 VDC	16-point TMR Supervised, Commoned
3624	24 VDC	16-point TMR Supervised, Commoned
3625/A[a]	24 VDC	32-point TMR Supervised/Non-Supervised, Commoned[b]
3636R/T	Relay, NO	32-point Non-Triplicated, Non-Commoned
3664	24 VDC	32-point Dual Output, Commoned
3674	24 VDC	32-point Dual Output, Commoned

a. The 3625 and 3625A modules can be installed only in Tricon v10.2 and later systems.

b. For the 3625A module, power is commoned in groups of 16 points and is separated by termination panels.

Each Digital Output Module houses the circuitry for three identical, isolated channels. Each channel includes an I/O microprocessor which receives its output table from the I/O communication processor on its corresponding Main Processor. All 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 dual Digital Output Modules provide a single parallel or series path, with the 2-out-of-3 voting process applied individually to each switch.

The quadruplicated output circuitry provides multiple redundancy for all critical signal paths, guaranteeing safety and maximum availability. The dual output module provides just enough redundancy to ensure safe operation. Dual modules are optimized for those safety-critical applications where low cost is more important than maximum availability.

Digital Output Modules include the hot-spare feature, which allows online replacement of a faulty module. Like all I/O modules, Digital Output Modules require a separate field termination assembly with a cable interface to the Tricon controller backplane. Each module is mechanically keyed to prevent improper installation in a configured chassis.

Digital Output Modules are designed to source the current to field devices. Field power must be wired to each output point on a field termination module.

OVD (Output Voter Diagnostics)

Each type of Digital Output Module executes a particular type of Output Voter Diagnostic for every point. In general, during OVD execution the commanded state of each point is momentarily reversed on one of the output drivers, one after another. Loopback on the module allows each microprocessor to read the output value for the point to determine whether a latent fault exists within the output circuit. Because OVD forces a simulated failure, it glitches the attached load.

Invensys guarantees that an OVD-forced glitch has the following durations:

- For AC modules, no longer than 1/2 AC cycle.
- For DC modules, less than 2 milliseconds (typically 500 microseconds), which is a period that is tolerated well by electro-mechanical devices such as relays, solenoids, and contactors.

If required by the controlled process, OVD can be disabled; however, it must be periodically cycled to both the On and Off states to ensure 100 percent fault coverage. For devices that cannot tolerate a signal transition of any length, OVD on both AC and DC voltage Digital Output Modules can be disabled.

For more information, see Disabling Output Voter Diagnostics on DO Modules on page 283.

AC Voltage Digital Output Modules

On AC voltage Digital Output Modules, a fault switch identified by the OVD process causes the output signal to transition to the opposite state for a maximum of 1/2 an AC cycle. This transition may not be transparent to all field devices. Once a fault is detected, the module discontinues further iterations of OVD. If required by the controlled process, OVD can be disabled; however, it must be periodically cycled to both the On and Off states to ensure 100 percent fault coverage.

DC Voltage Digital Output Modules

DC voltage Digital Output Modules are specifically designed to control devices which hold points in one state for long periods of time. The OVD strategy for a DC voltage Digital Output Module ensures full fault coverage even if the commanded state of the points never changes. On this type of module, the output signal transition normally occurs during OVD execution, but is guaranteed to be less than 2 milliseconds (500 microseconds is typical) and is transparent to most field devices. If required by the controlled process, OVD can be disabled; however, it must be periodically cycled to both the On and Off states to ensure 100 percent fault coverage.

Relay Output Modules

Relay Output (RO) Modules are non-triplicated modules for use on non-critical points which are not compatible with *high-side* solid-state output switches, such as annunciator panels. Relay Output Modules receive 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. Ongoing diagnostics test the operational status of the RO Module, which is not intended for use on critical points or switching of field loads.

Supervised Digital Output Modules

Supervised Digital Output (SDO) Modules provide both voltage and current loopback, allowing complete fault coverage for both energized-to-trip and de-energized-to-trip conditions. SDO modules supervise the field circuit so these field faults can be detected: loss of power or blown fuse, open or missing load, field short resulting in the load being energized in error, and shorted load in the de-energized state. Any loss of field load is annunciated by the module.

115 VAC Digital Output Modules

This figure is a simplified schematic for Models 3601E and 3601T, which are TMR Digital Output Modules.

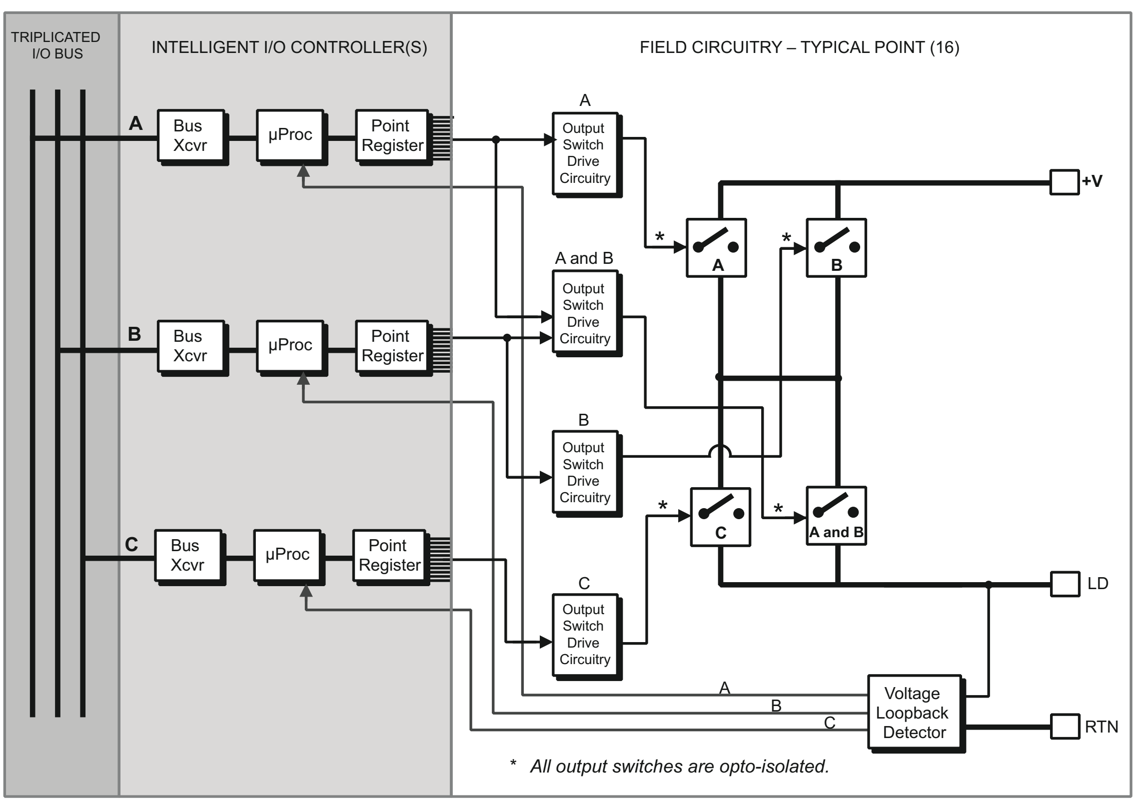


Figure 43 3601E and 3601T Simplified Schematic

This figure shows the front panels of Models 3601E and 3601T.

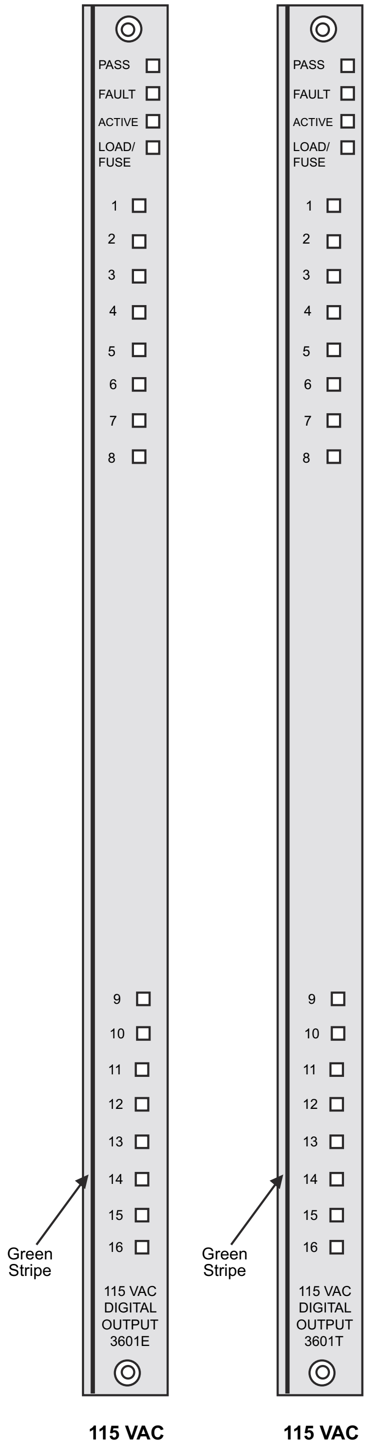


Figure 44 3601E and 3601T Front Panels

3601E and 3601T Specifications

This table lists the specifications for Models 3601E and 3601T, which are 16-point, opto-isolated TMR Digital Output Modules with an nominal voltage of 115 VAC. Model 3601T has a higher point-isolation minimum.

Table 37 3601E and 3601T Digital Output Specifications

Feature	Specification
Color code	Green
Number of output signals	16, non-commoned
Input frequency range	47-63 Hz
Voltage range	80–155 VAC
Logic power	< 10 watts
Current ratings, maximum	2 amps/point, 12 amps surge/cycle
Leakage current to load @ 60 Hz	2 mA maximum @ 60 Hz
Leakage current to chassis @ 60 Hz	4 mA maximum @ 60 Hz
Fuses (on field termination module)	1 per output, 3 amps, fast-acting
Status indicator: On or Off state	1 per point
Status indicator: Module status	Pass, Fault, Active
Status indicator: Field alarm[a]	Load/fuse
Point isolation: 3601E	1,000 VAC minimum, 1,500 VDC minimum
Point isolation: 3601T	1,780 VAC minimum, 2,500 VDC minimum
Output diagnostic fault coverage:	
Maximum output toggle rate[b]	Every 100 ms plus one scan
Minimum output toggle rate	Every 24 months (manually toggled by the user)[c]
Diagnostic glitch duration[d]	1/2 AC cycle maximum
On-state voltage drop:	
At backplane	< 2 VAC typical @ 100mA, < 3 VAC maximum @ 2A
With external termination, 10-foot cable	< 3 VAC typical @ 100mA, < 5 VAC maximum @ 2A
With external termination, 99-foot cable	< 4 VAC typical @ 100mA, < 11 VAC maximum @ 2A
Inductive kick-back protection (reverse EMF)	Zero-crossing TRIACs

a. Power must be supplied to all points, including unused points on non-commoned panels.
b. The maximum output toggle rate enables proper operation of I/O diagnostics and detection of all normally detectable faults.
c. For more information, see Toggling Field I/O Points on page 288.
d. Diagnostic glitching can be disabled by using the OVD disable function.

24 to 120 VDC Digital Output Modules

This figure is a simplified schematic for Models 3603B, 3603E, 3603T, 3604E, and 3607E, which are TMR Digital Output Modules.

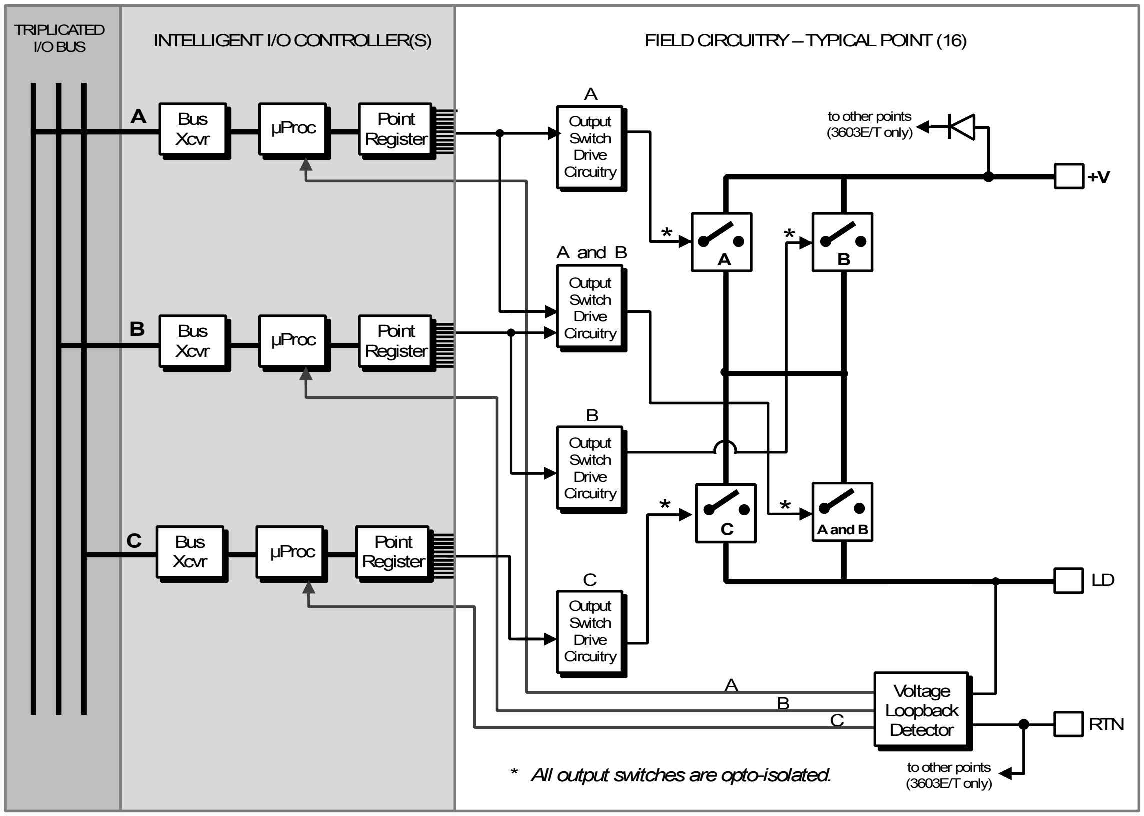


Figure 45 3603B, 3603E, 3603T, 3604E, and 3607E Simplified Schematic

This figure shows the front panels of Models 3603B, 3603E, 3603T, 3604E, and 3607E.

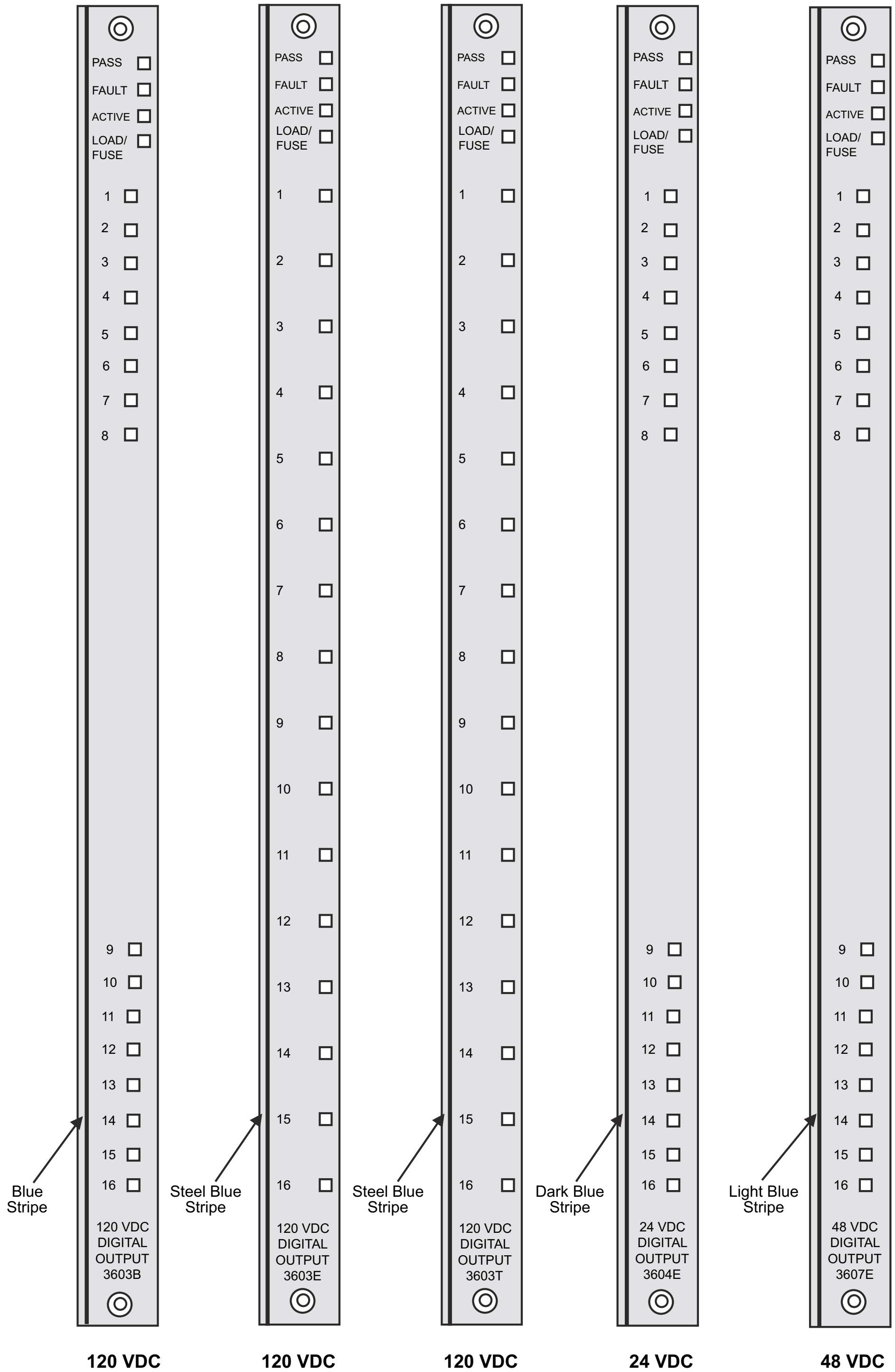


Figure 46 3603B, 3603E, 3603T, 3604E, and 3607E Front Panels

3603B Specifications

This table lists the specifications for Model 3603B, which is a TMR Digital Output Module with a nominal output voltage of 120 VDC.

CAUTION Model 3603B, 3603E, and 3603T Digital Output Modules should not be mixed in the same logical slot.

Table 38 3603B Digital Output Specifications

Feature	Specification
Color code	Blue
Number of output signals	16, non- commoned
Minimum load required	20 kΩ, installed as standard on all field termination modules
Voltage range	99–155 VDC
Power module load	< 10 watts
Current ratings, maximum	0.8 amps/point, 4 amps surge/10 ms
Leakage current to load	2 mA, maximum
Fuses, field termination module	1 per output, 1 amp, fast-acting
Status indicator: On or Off state	1 per point
Status indicator: Module status	Pass, Fault, Active
Status indicator: Field alarm[a]	Load/Fuse
Point isolation	1,000 VDC minimum
Output diagnostic fault coverage[b]:	
Maximum output toggle rate	Every 100 ms plus one scan
Minimum output toggle rate	Not required
Diagnostic glitch duration[c]	2 ms, maximum
On-state voltage drop:	
At backplane	< 0.5 VDC typical @ 250mA, < 0.5 VDC maximum @ 1A
With external termination, 10-foot cable	< 2 VDC typical @ 250mA, < 3 VDC maximum @ 1A
With external termination, 99-foot cable	< 3 VDC typical @ 250mA, < 6 VDC maximum @ 1A
Inductive kick-back protection (reverse EMF)	Reverse diode on I/O module

a. Power must be supplied to all points, including unused points on non-commoned panels.

b. The maximum output toggle rate enables proper operation of I/O diagnostics and detection of all normally detectable faults. The minimum toggle rate provides fault coverage of normally undetectable faults within 10 percent of the calculated mean-time-between-faults (MTBF) for the module.

c. Diagnostic glitching can be disabled by using the OVD disable function.

Note The Model 3603B DO Module may not meet all of the latest requirements of various regulatory standards, and has not been certified by third parties for compliance in the following areas: ordinary location, hazardous location, functional safety, and EMC.

3603E and 3603T Specifications

This table lists the specifications for Models 3603E and 3603T, which are TMR Digital Output Modules with a nominal voltage of 120 VDC.

CAUTION

Model 3603B, 3603E, and 3603T Digital Output Modules should not be mixed in the same logical slot.

Invensys highly recommends that you perform compatibility testing before selecting the Model 3603T module for use in applications that have any of the following:

- Field wiring lengths over 328 feet (100 meters)
- Cable that is not twisted pair
- Atypical loads such as smart devices, strobe lights, or klaxons

Model 3603T may experience Output Voter Diagnostic (OVD) failures when used with a 1600 meter cable and a low-watt solenoid.

Table 39 3603E and 3603T Digital Output Specifications

Feature	Specification
Color code	Steel blue
Number of output signals	16, commoned
Voltage range	90–150 VDC
Maximum voltage	160 VDC
Logic power	< 10 watts
Current ratings, maximum	0.8 amp/point, 4 amps surge/10 ms
Leakage current to load	2 mA, maximum
Fuses (field termination module)	1 per output (1 amp, fast-acting)
Status indicator: On or Off state	1 per point
Status indicator: Module status	Pass, Fault, Active
Status indicator: Field alarm[a]	Load/Fuse
Point isolation: 3603E	1,500 VDC minimum
Point isolation: 3603T	2,500 VDC minimum
Output diagnostic fault coverage[b]:	
Maximum output toggle rate	Every 100 ms plus one scan
Minimum output toggle rate	Not required
Diagnostic glitch duration[c]	2 ms, maximum, 500 µsec, typical

Table 39 3603E and 3603T Digital Output Specifications *(continued)*

Feature	Specification
On-state voltage drop:	
At backplane	< 0.5 VDC typical @ 250mA; < 0.5 VDC maximum @ 1A
With external termination, 10-foot cable	< 1.5 VDC typical @ 250mA; < 2.5 VDC maximum @ 1A
With external termination, 99-foot cable	< 2.5 VDC typical @ 250mA, < 5.5 VDC maximum @ 1A
Inductive kick-back protection (reverse EMF)	Reverse diode on I/O module

a. Power must be supplied to all points, including unused points on non-commoned panels.

b. The maximum output toggle rate enables proper operation of I/O diagnostics and detection of all normally detectable faults. The minimum toggle rate provides fault coverage of normally undetectable faults within 10 percent of the calculated mean-time-between-faults (MTBF) for the module.

c. Diagnostic glitching can be disabled by using the OVD disable function.

3604E Specifications

This table lists the specifications for Model 3604E, which is a TMR Digital Output Module with a nominal voltage of 24 VDC.

Table 40 3604E Digital Output Specifications

Feature	Specification
Color code	Dark blue
Number of output signals	16, non-commoned
Voltage range	22–45 VDC
Logic power	< 10 watts
Current ratings, maximum	2 amps/point, 10 amps surge/10 ms
Leakage current to load	2 mA, maximum
Fuses (field termination module)	1 per output (2.5 amps fast-acting)
Status indicator: On or Off state	1 per point
Status indicator: Module status	Pass, Fault, Active
Status indicator: Field alarm[a]	Load/Fuse
Point isolation	1,500 VDC minimum
Output diagnostic fault coverage[b]:	
Maximum output toggle rate	Every 100 ms plus one scan
Minimum output toggle rate	Not applicable
Diagnostic glitch duration[c]	2 ms maximum, 500 µs typical

Table 40 3604E Digital Output Specifications *(continued)*

Feature	Specification
On-state voltage drop:	
At backplane	< 3 VDC typical @ 500mA, < 3 VDC maximum @ 2A
With external termination, 10-foot cable	< 4 VDC typical @ 500mA, < 5 VDC maximum @ 2A
With external termination, 99-foot cable	< 6 VDC typical @ 500mA, < 11 VDC maximum @ 2A
Inductive kick-back protection (reverse EMF)	Reverse diode on I/O module

a. Power must be supplied to all points, including unused points on non-commoned panels.

b. The maximum output toggle rate enables proper operation of I/O diagnostics and detection of all normally detectable faults. The minimum toggle rate provides fault coverage of normally undetectable faults within 10 percent of the calculated mean-time-between-faults (MTBF) for the module.

c. Diagnostic glitching can be disabled by using the OVD disable function.

3607E Specifications

This table lists the specifications for Model 3607E, which is a TMR Digital Output Module with a nominal voltage of 48 VDC.

Table 41 3607E Digital Output Specifications

Feature	Specification
Color code	Light blue
Number of output signals	16, non-commoned
Voltage range	44–80 VDC
Logic power	< 10 watts
Current ratings, maximum	1 amp/point, 5 amps surge/10 ms
Leakage current to load	2 mA, maximum
Fuses (field termination module)	1 per output (1.25 amps fast-acting)
Status indicator: On or Off state	1 per point
Status indicator: Module status	Pass, Fault, Active
Status indicator: Field alarm[a]	Load/Fuse
Point isolation	1500 VDC minimum
Output diagnostic fault coverage[b]:	
Maximum output toggle rate	Every 100 ms
Minimum output toggle rate	Not applicable
Diagnostic glitch duration[c]	2 ms maximum, 500 µs typical

Table 41 3607E Digital Output Specifications *(continued)*

Feature	Specification
On-state voltage drop:	
At backplane	< 2 VDC typical @ 250mA, < 3 VDC maximum @ 1A
With external termination, 10-foot cable	< 3 VDC typical @ 250mA, < 4 VDC maximum @ 1A
With external termination, 99-foot cable	< 4 VDC typical @ 250mA, < 7 VDC maximum @ 1A
Inductive kick-back protection (reverse EMF)	Reverse diode on I/O module

a. Power must be supplied to all points, including unused points on non-commoned panels.

b. The maximum output toggle rate enables proper operation of I/O diagnostics and detection of all normally detectable faults. The minimum toggle rate provides fault coverage of normally undetectable faults within 10 percent of the calculated mean-time-between-faults (MTBF) for the module.

c. Diagnostic glitching can be disabled by using the OVD disable function.

24 to 120 VDC Supervised Digital Output Modules

This figure is a simplified schematic for Models 3623, 3623T, and 3624, which are TMR Supervised Digital Output Modules.

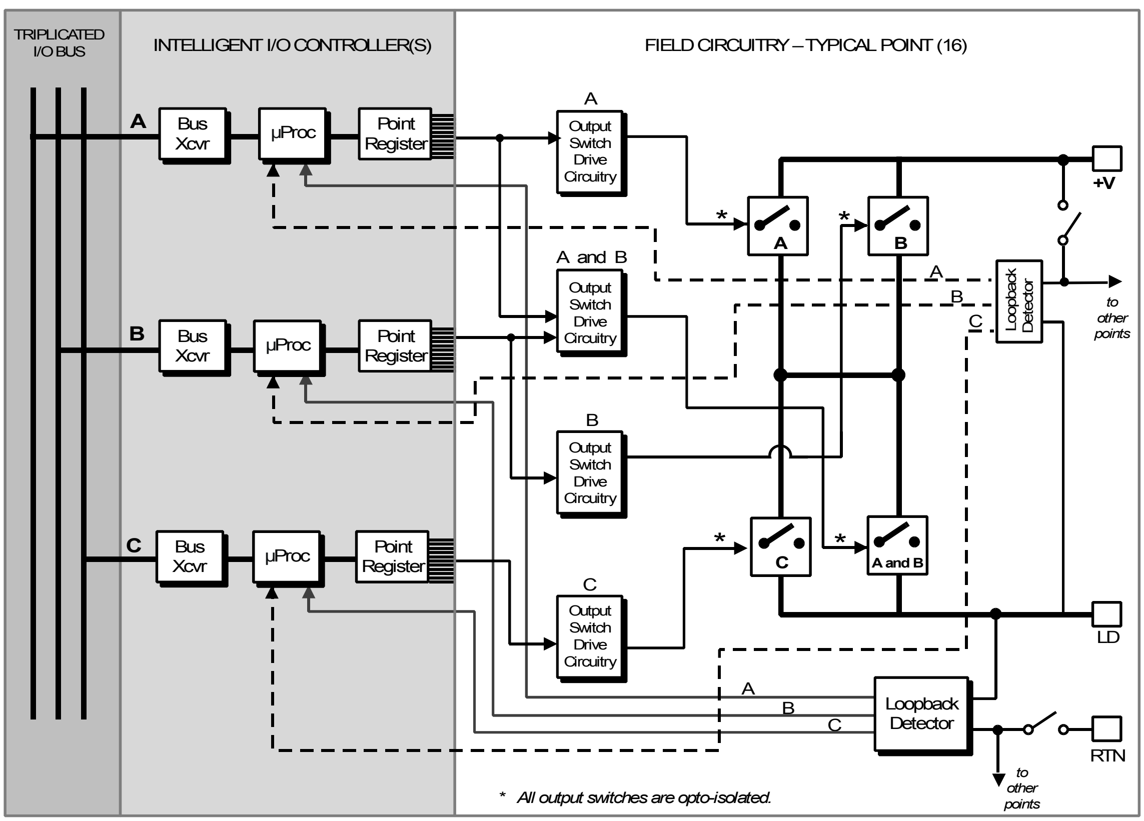


Figure 47 3623, 3623T, and 3624 Simplified Schematic

This figure shows the front panels of Models 3623, 3623T, and 3624.

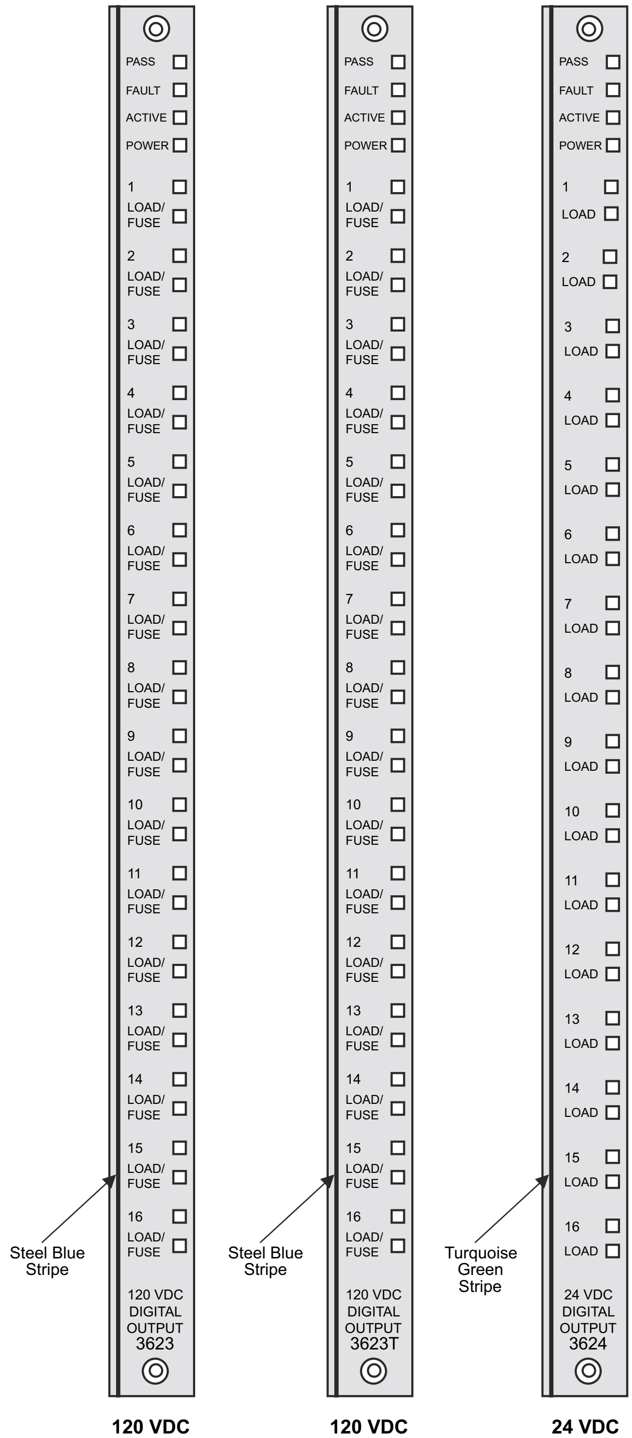


Figure 48 3623, 3623T, and 3624 Front Panels

Note The Model 3623, 3623T, and 3624 modules will not assert point LEDs for both primary and spare modules. Only the primary module will assert point LEDs.

3623 and 3623T Specifications

This table lists the specifications for Models 3623 and 3623T, which are TMR Supervised Digital Output Modules with a nominal voltage of 120 VDC. Model 3623 has a point isolation of 1,500 VDC; Model 3623T has a point isolation of 2,500 VDC.

CAUTION

Invensys highly recommends that you perform compatibility testing before selecting the Model 3623T module for use in applications that have any of the following:

- Field wiring lengths over 328 feet (100 meters)
- Table that is not twisted pair
- Atypical loads such as smart devices, strobe lights, or klaxons

Table 42 3623 and 3623T Supervised Digital Output Specifications

Feature	Specification
Color code	Steel blue
Number of output signals	16, commoned
Recommended voltage range	90–150 VDC
Maximum voltage	160 VDC
Logic power	< 10 watts
Current ratings, maximum	0.8 amps/point, 4 amps surge/10 ms
Minimum required load	30 mA
Leakage current to load	4 mA, maximum
Fuses (field termination)	1 per output (1 amp, fast-acting)
Status indicator: On or Off state	1 per point
Status indicator: Module status	Pass, Fault, Active
Status indicator: Field alarm[a]	Power, Load/Fuse (1 Per Point)
Point isolation: 3623	1,500 VDC minimum
Point isolation: 3623T	2,500 VDC minimum
Short-circuit detection threshold in Off state	< 24 Ω
Output diagnostic fault coverage[b]:	
Maximum output toggle rate	Every 100 ms
Minimum output toggle rate	Not applicable
Diagnostic glitch duration[c]	2 ms maximum, 500 µsec typical
On-state voltage drop:	
At backplane	< 1.0 VDC typical @ 250mA, < 1.0 VDC maximum @ 1A
With external termination, 10-foot cable	< 2.0 VDC typical @ 250mA, < 2.5 VDC maximum @ 1A
With external termination, 99-foot cable	< 2.5 VDC typical @ 250mA, < 6.0 VDC maximum @ 1A

Table 42 3623 and 3623T Supervised Digital Output Specifications *(continued)*

Feature	Specification
Inductive kick-back protection (reverse EMF)	Reverse diode on I/O module

a. Power must be supplied to all points, including unused points on non-commoned panels.

b. The maximum output toggle rate enables proper operation of I/O diagnostics and detection of all normally detectable faults. The minimum toggle rate provides fault coverage of normally undetectable faults within 10 percent of the calculated mean-time-between-faults (MTBF) for the module.

c. OVD glitching cannot be disabled.

3624 Specifications

This table lists the specifications for Model 3624, which is a TMR Supervised Digital Output Module with a nominal voltage of 24 VDC.

Table 43 3624 Supervised Digital Output Specifications

Feature	Specification
Color code	Turquoise green
Number of output signals	16, commoned
Recommended voltage range	16–30 VDC
Maximum voltage	36 VDC
Logic power	< 10 watts
Current ratings, maximum	0.7 amps/point, 4.8 amps surge/10 ms
Minimum required load	30 mA
Leakage current to load	4 mA, maximum
Fuses (field termination)	Not required; output switches are self-protected against over-voltage, over-temperature, and over-current
Status indicator: On or Off state	1 per point
Status indicator: Module status	Pass, Fault, Active
Status indicator: Field alarm[a]	Power, Load (1 per point)
Point isolation	1,500 VDC minimum
Short-circuit detection threshold in Off state[b]	< 10 Ω typical, 5–22 Ω worst-case
Output diagnostic fault coverage[c]:	
Maximum output toggle rate	Every 100 ms plus one scan
Minimum output toggle rate	Not required
Diagnostic glitch duration[d]	2 ms maximum, 500 µs typical

Table 43 3624 Supervised Digital Output Specifications *(continued)*

Feature	Specification
On-state voltage drop:	
At backplane	< 1.0 VDC typical @ 500mA, < 1.0 VDC @ 1A
With external termination, 10-foot cable	< 2.0 VDC typical @ 500mA, < 2.5 VDC @ 1A
With external termination, 99-foot cable	< 2.5 VDC typical @ 500mA, < 6.0 VDC @ 1A
Inductive kick-back protection (reverse EMF)	Reverse diode on I/O module

a. Power must be supplied to all points, including unused points on non-commoned panels.

b. Worst-case conditions are high temperature with 30V loop power.

c. The maximum output toggle rate enables proper operation of I/O diagnostics and detection of all normally detectable faults. The minimum toggle rate provides fault coverage of normally undetectable faults within 10 percent of the calculated mean-time-between-faults (MTBF) for the module.

d. OVD glitching cannot be disabled.

115 VAC Supervised Digital Output Modules

This figure is a simplified schematic for Model 3611E, which is a TMR Digital Output Module with a nominal voltage range of 115 VAC.

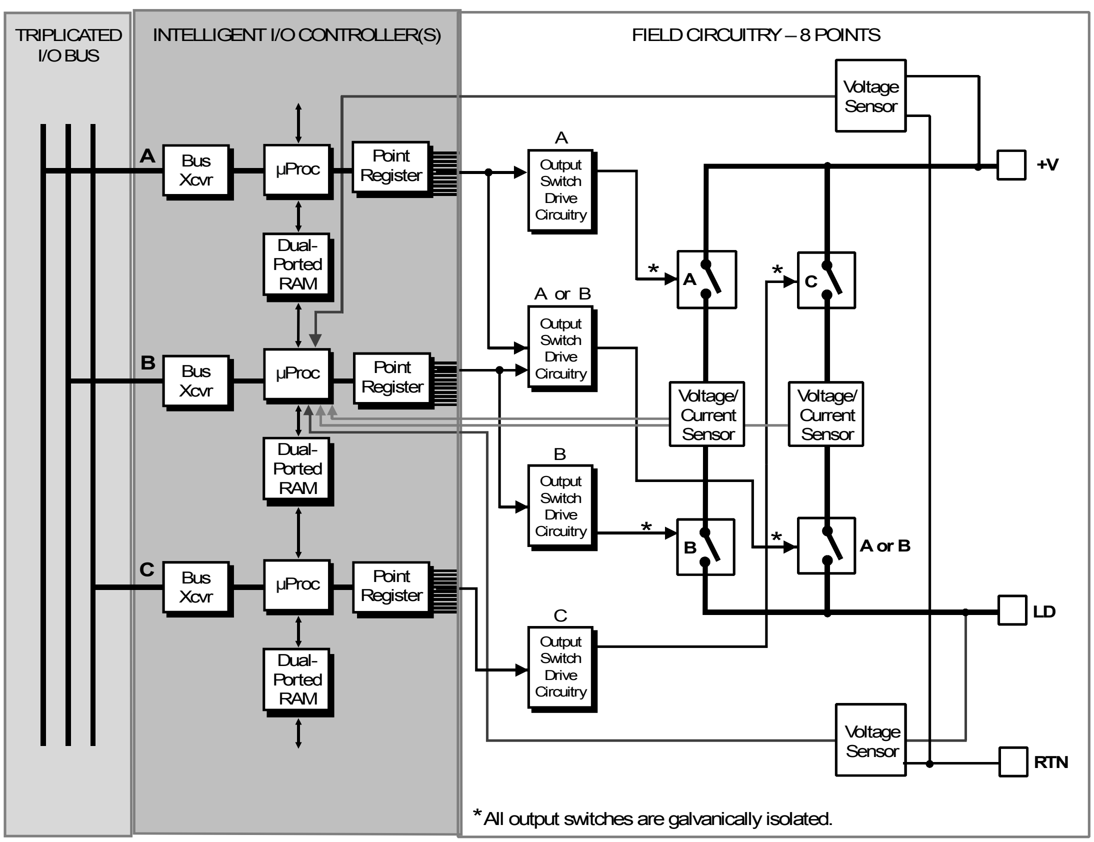


Figure 49 3611E Simplified Schematic

This figure shows the front panel of Model 3611E.

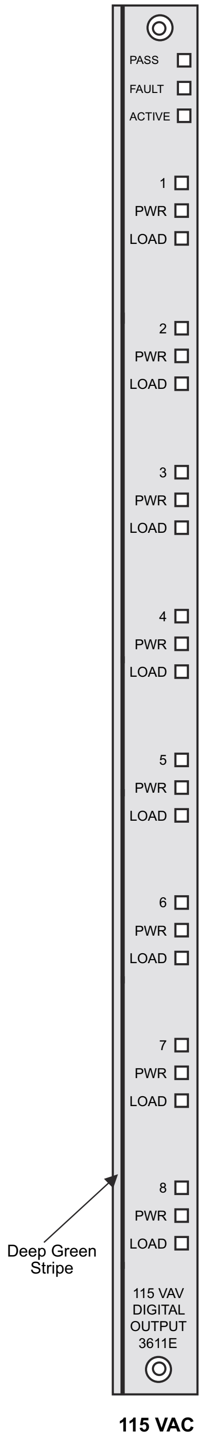


Figure 50 3611E Front Panel

3611E Specifications

This table lists the specifications for Model 3611E, which is a TMR Digital Output Module with a nominal voltage of 115 VDC.

Table 44 3611E Digital Output Specifications

Feature	Specification
Color code	Deep green
Number of output signals	8, commoned
Input frequency range	47-63 Hz
Voltage range	90–155 VAC
Carry current ratings, maximum	2 amps/point, 10 amps surge/ 1 AC cycle
Switching power, maximum *See Switching Power on page 142*	2,000 VAC (resistive)
Maximum output cycle rate	< 20 cycles per second
Expected life at maximum rated load	> 10,000 cycles
Minimum required load[a]	50 mA
Leakage current to load (Off state)	4 mA maximum
Leakage current to chassis @ 60 Hz	1 mA maximum
Fuses (on field termination module)	1 per output (2.5 amps fast-acting)
Status indicator: On or Off state per point	Point
Status indicator: Power alarm per point	Power
Status indicator: Load alarm per point	Load
Status indicator: Module status	Pass, Fault, Active
Point isolation	1,500 VDC minimum
Logic power	< 15 watts
Shorted load detection in Off state	Not applicable
Output diagnostic fault coverage[b]: Maximum output toggle rate Minimum output toggle rate	 Every 100 ms plus one scan Not applicable
Diagnostic glitch duration	Not applicable
On-state voltage drop: With external termination, 10-foot cable With external termination, 99-foot cable	 < 2 VAC typical @ 100m, < 6 VAC maximum @ 2A < 3 VAC typical @ 100m, < 12 VAC maximum @ 2A
Inductive kick-back protection (reverse EMF)	Tranzorb on termination panel

a. Proper operation of this module can be assured only if all installation guidelines and restrictions are observed. For more information, see Application Note 8, *Supervised Digital Output Modules* available from the Global Customer Support (GCS) center.

b. The maximum output toggle rate enables proper operation of I/O diagnostics and detection of all normally detectable faults. The minimum toggle rate provides fault coverage of normally undetectable faults within 10 percent of the calculated mean-time-between-faults (MTBF) for the module.

Switching Power

When switching reactive loads, you should de-rate the switching power of the outputs to 25 percent of maximum, which is 500 VAC applications. This restriction does not apply to inductive loads because all supervised digital outputs are protected against inductive kick-back (reverse EMF).

When switching incandescent lamps, the inrush current can be 10 to 15 times the rated nominal load current of the lamp. The inrush current must be used when calculating the required output switching power. For detailed specifications regarding inrush amplitude and duration, contact the lamp manufacturer.

28 to120 VDC Supervised Digital Output Modules

This figure is a simplified schematic for Models 3613E, 3614E, 3615E, and 3617E, which are 8-point TMR Supervised Digital Output Modules.

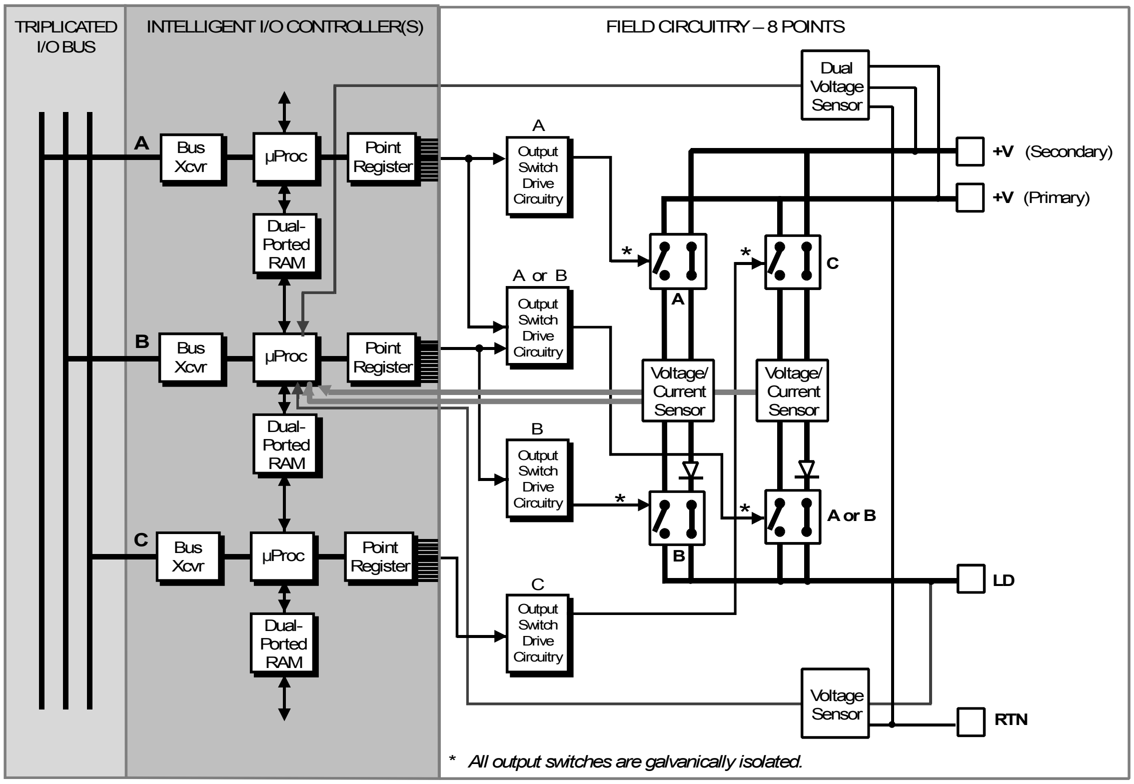


Figure 51 3613E, 3614E, 3615E, and 3617E Simplified Schematic

This figure shows the front panels of Models 3613E, 3614E, 3615E, and 3617E.

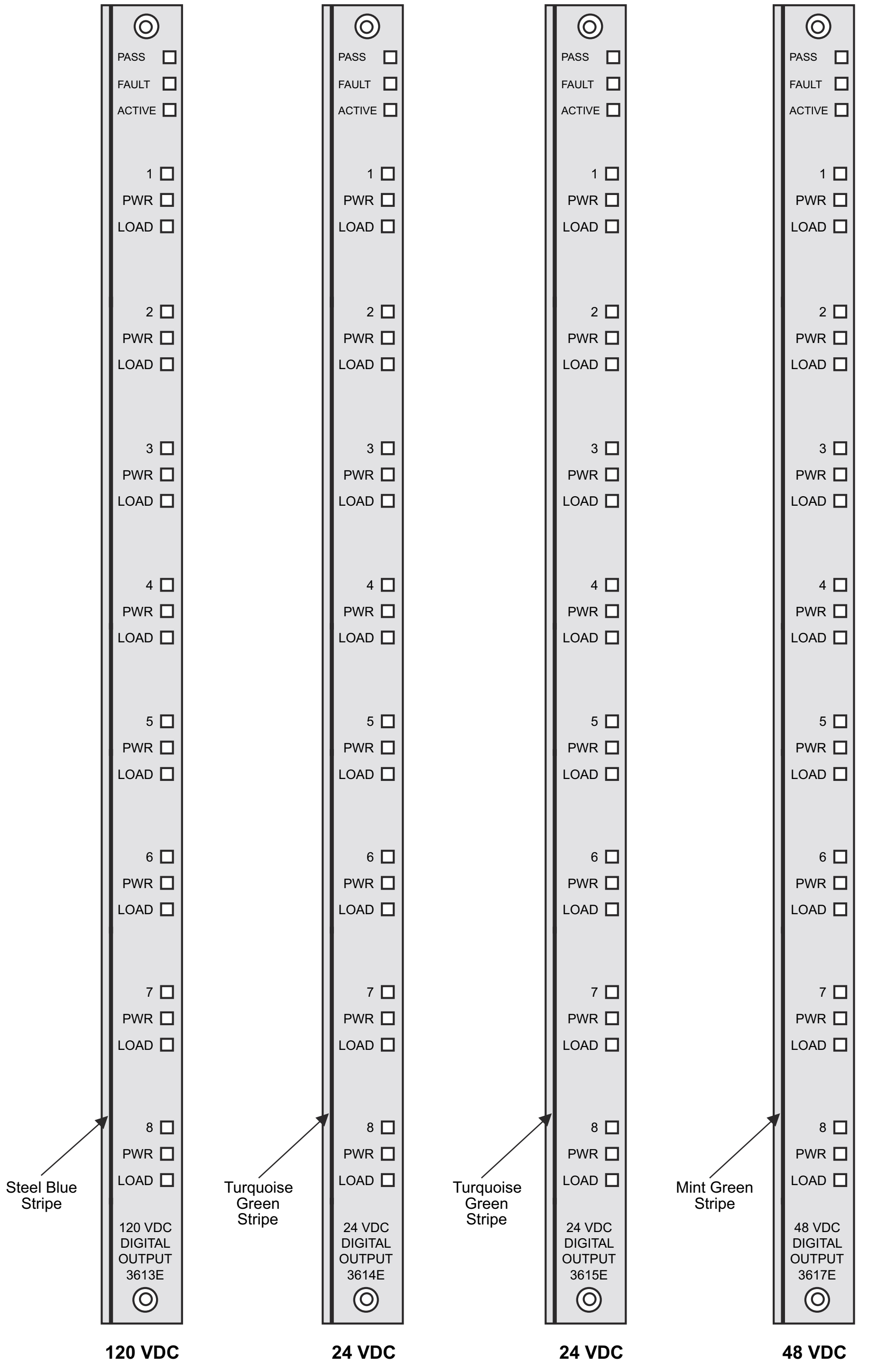


Figure 52 3613E, 3614E, 3615E, and 3617E Front Panels

3613E Specifications

This table lists the specifications for Model 3613E, which is a TMR Supervised Digital Output Module with a nominal range of 120 VDC.

Table 45 3613E Supervised Digital Output Specifications

Feature	Specification
Color code	Steel blue
Number of output signals	8, commoned
Voltage range	90 to 155 VDC
Carry current ratings, maximum	0.5 amps/point, 4 amps surge/10 ms
Switching power, maximum *See Switching Power on page 146*	150 watts (resistive)
Maximum output cycle rate	< 20 cycles per second
Expected life at maximum rated load	> 10,000 cycles
Minimum required load[a]	50 mA
Leakage current to load (Off state without secondary power supply)	4 mA maximum
Primary fuse on field termination module (2 per output)	1.0 amp, fast-acting
Secondary fuse on field termination module (2 per output)	0.125 amp, fast-acting
Status indicator: On or Off state per point	Point
Status indicator: Power alarm per point	Power
Status indicator: Load alarm per point	Load
Status indicator: Module status	Pass, Fault, Active
Point isolation	1,500 VDC, minimum
Logic power	< 15 watts
Short-circuit detection threshold in Off state[b]	< 24 Ω, with installation of secondary field power supply
Voltage range of secondary power supply	5.00 VDC ± 0.25 VDC
Current range of secondary power supply	3 amps minimum
Output diagnostic fault coverage[c]:	
Maximum output toggle rate	Every 100 ms plus one scan
Minimum output toggle rate	Not applicable
On-state voltage drop:	
With external termination, 10-foot cable	< 2 VDC typical @ 100mA, < 4 VDC maximum @ 0.5A
With external termination, 99-foot cable	< 3 VDC typical @ 100mA, < 6 VDC maximum @ 0.5A

Table 45 3613E Supervised Digital Output Specifications *(continued)*

Feature	Specification
Inductive kick-back protection (reverse EMF)	Reverse diode on termination panel

a. Proper operation of this module can be assured only if all installation guidelines and restrictions are observed. For more information, see Application Note 8, *Supervised Digital Output Modules* available on the Global Customer Support (GCS) center website at http://support.ips.invensys.com.

b. To select short-circuit detection for an SDO module, you must select a module name which includes the abbreviation "SCD" must be included in the hardware configuration in the TriStation 1131 project.

c. The maximum output toggle rate allows proper operation of I/O diagnostics and detection of all normally detectable faults. The minimum toggle rate provides fault coverage of normally undetectable faults within 10 percent of the calculated mean-time-between-faults (MTBF) for the module.

Switching Power

When switching reactive loads, you should de-rate the switching power of the outputs to 25 percent of maximum, which is 37.5 watts for DC applications. When switching incandescent lamps, the inrush current can be 10 to 15 times the rated nominal load current of the lamp. For detailed specifications regarding inrush amplitude and duration, contact the lamp manufacturer. The inrush current must be used when calculating the required output switching power.

3614E Specifications

This table lists the specifications for Model 3614E, which is a TMR Supervised Digital Output Module with a nominal range of 24 VDC.

CAUTION The Model 3614E is not recommended for use with shunt-diode intrinsic safety barriers. For these applications, Invensys recommends the Model 3615E.

Table 46 3614E Supervised Digital Output Specifications

Feature	Specification
Color code	Turquoise green
Number of output signals	8, commoned
Voltage range	20 to 36 VDC
Carry current ratings, maximum	0.5 amps/point, 4 amps surge/10 ms
Switching power, maximum *See* Switching Power on page 147	150 watts (resistive)
Maximum output cycle rate	< 20 cycles per second
Expected life at maximum rated load	> 10,000 cycles
Minimum required load[a]	50 mA

Table 46 3614E Supervised Digital Output Specifications *(continued)*

Feature	Specification
Leakage current to load (Off state, without secondary power supply)	4 mA maximum
Primary fuse on field termination module (2 per output)	0.5 amp, fast-acting
Secondary fuse on field termination module (2 per output)	0.125 amp, fast-acting
Status indicator: On or Off state per point	Point
Status indicator: Power alarm per point	Power
Status indicator: Load alarm per point	Load
Status indicator: Module status	Pass, Fault, Active
Point isolation	1500 VDC, minimum
Logic power	< 15 watts
Short-circuit detection in Off state[b]	< 24 Ω, with installation of secondary field power supply
Voltage range of secondary power supply[2]	5.00 VDC ± 0.25 VDC
Current range of secondary power supply	3 amps, minimum
Output diagnostic fault coverage[c]:	
Maximum output toggle rate	Every 100 ms plus one scan
Minimum output toggle rate	Not applicable
On-state voltage drop:	
With external termination, 10-foot cable	< 2 VDC typical @ 100mA, < 4 VDC maximum @ 0.5A
With external termination, 99-foot cable	< 3 VDC typical @ 100mA, < 6 VDC maximum @ 0.5A
Inductive kick-back protection (reverse EMF)	Reverse diode on termination panel

a. Proper operation of this module can be assured only if all installation guidelines and restrictions are observed. For more information, see Application Note 8, *Supervised Digital Output Modules* available on the Global Customer Support (GCS) center website at http://support.ips.invensys.com.

b. To select short-circuit detection for an SDO module, you must select a module name which includes the abbreviation “SCD” in the hardware configuration in the TriStation 1131 project.

c. The maximum output toggle rate allows proper operation of I/O diagnostics and detection of all normally detectable faults. The minimum toggle rate provides fault coverage of normally undetectable faults within 10 percent of the calculated mean-time-between-faults (MTBF) for the module.

Switching Power

When switching reactive loads, you should de-rate the switching power of the outputs to 25 percent of maximum, which is 37.5 watts for DC applications. When switching incandescent lamps, the inrush current can be 10 to 15 times the rated nominal load current of the lamp. For detailed specifications regarding inrush amplitude and duration, contact the lamp manufacturer. The inrush current must be used when calculating the required output switching power.

3615E Specifications

This table lists the specifications for Model 3615E, which is a low-power TMR Supervised Digital Output Module with a nominal range of 24 VDC.

Table 47 3615E Supervised Digital Output Specifications

Feature	Specification
Color code	Turquoise green
Number of output signals	8, commoned
Voltage range	20–36 VDC
Carry current ratings, maximum	0.1 amp/point, 2 amps surge/10 ms
Switching power, maximum	150 watts (resistive)
Maximum output cycle rate	< 20 cycles per second
Expected life at maximum rated load	> 10,000 cycles
Minimum required load[a]	10 mA
Leakage current to load (Off state, without secondary power supply)	4 mA maximum
Primary fuse on field termination module (2 per output)	0.5 amp, fast-acting
Secondary fuse on field termination module (2 per output)	0.125 amp, fast-acting
Status indicator: On or Off state per point	Point
Status indicator: Power alarm per point	Power
Status indicator: Load alarm per point	Load
Status indicator: Module status	Pass, Fault, Active
Point isolation	1,500 VDC, minimum
Logic power	< 15 watts
Short-circuit detection threshold in Off state[b]	< 24 Ω, with installation of secondary field power supply
Voltage range of secondary power supply[2]	5.00 VDC ± 0.25 VDC
Current range of secondary power supply	3 amp minimum
Output diagnostic fault coverage[c]:	
Maximum output toggle rate	Every 100 ms plus one scan
Minimum output toggle rate	Not applicable
On-state voltage drop:	< 1 VDC typical @ 30mA
With external termination, 10-foot cable	< 3 VDC maximum @ 100mA

Table 47 3615E Supervised Digital Output Specifications *(continued)*

Feature	Specification
On-state voltage drop: With external termination, 99-foot cable	< 1 VDC typical @ 30mA < 4 VDC maximum @ 100mA
Inductive kick-back protection (reverse EMF)	Reverse diode on termination panel

a. Proper operation of this module can be assured only if all installation guidelines and restrictions are observed. For more information, see Application Note 8, *Supervised Digital Output Modules* available on the Global Customer Support (GCS) center website at http://support.ips.invensys.com.

b. To select short-circuit detection for an SDO module, you must select a module name which includes the abbreviation "SCD" in the hardware configuration in the TriStation 1131 project.

c. The maximum output toggle rate allows proper operation of I/O diagnostics and detection of all normally detectable faults. The minimum toggle rate provides fault coverage of normally undetectable faults within 10 percent of the calculated mean-time-between-faults (MTBF) for the module.

3617E Specifications

This table lists the specifications for Model 3617E, which is a TMR Supervised Digital Output Module with a nominal range of 48 VDC.

Switching Power

When switching reactive loads, you should de-rate the switching power of the outputs to 25 percent of maximum, which is 37.5 watts for DC applications. When switching incandescent lamps, the inrush current can be 10 to 15 times the rated nominal load current of the lamp. For detailed specifications regarding inrush amplitude and duration, contact the lamp manufacturer. The inrush current must be used when calculating the required output switching power.

Table 48 3617E Supervised Digital Output Specifications

Feature	Specification
Color code	Mint green
Number of output signals	8, commoned
Voltage range	36–72 VDC
Carry current ratings, maximum	1 amp/point, 5 amps/surge 10 ms
Switching power, maximum *See Switching Power on page 149*	150 watts (resistive)
Maximum output cycle rate	< 20 cycles per second
Expected life at maximum rated load	> 10,000 cycles
Minimum required load[a]	100 mA
Leakage current to load (Off state, without secondary power supply)[1]	4 mA maximum

Table 48 3617E Supervised Digital Output Specifications *(continued)*

Feature	Specification
Primary fuse on field termination module (2 per output)	1.25 amps, fast-acting
Secondary fuse on field termination module (2 per output)	0.125 amp, fast-acting
Status indicator: On or Off state per point	Point
Status indicator: Power alarm per point	Power
Status indicator: Load alarm per point	Load
Status indicator: Module status	Pass, Fault, Active
Point isolation	1,500 VDC, minimum
Logic power	< 15 watts
Short-circuit detection threshold in Off state[b]	< 24 Ω, with installation of secondary field power supply
Voltage range of secondary power supply[2]	5.00 VDC ± 0.25 VDC
Current range of secondary power supply	3 amps minimum
Output diagnostic fault coverage[c]:	
Maximum output toggle rate	Every 100 ms
Minimum output toggle rate	Not applicable
Diagnostic glitch duration	Not applicable
On-state voltage drop: With external termination, 10-foot cable	< 2 VDC typical @ 250mA < 4 VDC maximum @ 1A
On-state voltage drop: With external termination, 99-foot cable	< 3 VDC typical @ 250mA < 7 VDC maximum @ 1A
Inductive kick-back protection (reverse EMF)	Reverse diode on termination panel

a. Proper operation of this module can be assured only if all installation guidelines and restrictions are observed. For more information, see Application Note 8, *Supervised Digital Output Modules* available on the Global Customer Support (GCS) center website at http://support.ips.invensys.com.

b. To select short-circuit detection for an SDO module, you must select a module name which includes the abbreviation "SCD" in the hardware configuration in the TriStation 1131 project.

c. The maximum output toggle rate allows proper operation of I/O diagnostics and detection of all normally detectable faults. The minimum toggle rate provides fault coverage of normally undetectable faults within 10 percent of the calculated mean-time-between-faults (MTBF) for the module.

Switching Power

When switching reactive loads, you should de-rate the switching power of the outputs to 25 percent of maximum, which is 37.5 watts for DC applications. When switching incandescent lamps, the inrush current can be 10 to 15 times the rated nominal load current of the lamp. For detailed specifications regarding inrush amplitude and duration, contact the lamp manufacturer. The inrush current must be used when calculating the required output switching power.

24 VDC Supervised or Non-Supervised Digital Output Modules

This figure is a simplified schematic for Models 3625 and 3625A, which are 32-point TMR Supervised or Non-Supervised Digital Output Modules with nominal ranges of 24 VDC.

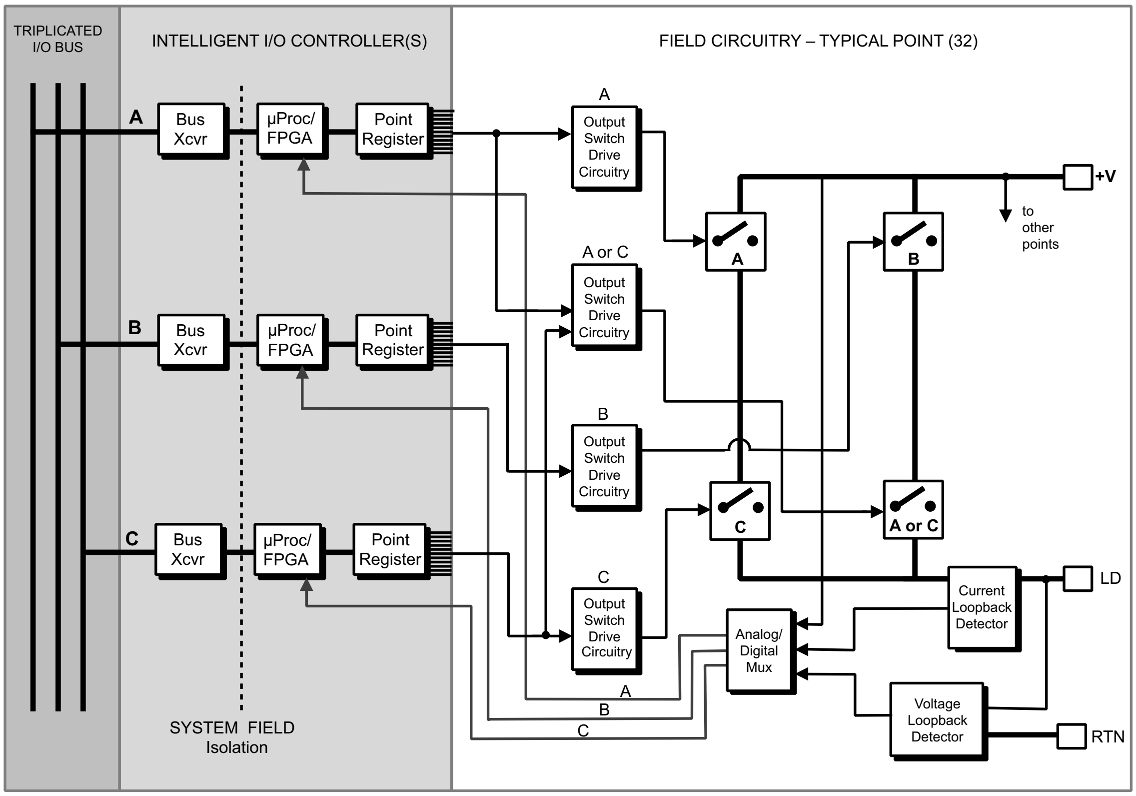


Figure 53 3625 and 3625A Simplified Schematic

Note For the 3625 module, field power is commoned to all points, so that if power is present on one point, it is present on all points. For the 3625A module, power is commoned in groups of 16 points and is separated by termination panels.

This figure shows the front panels of Model 3625 and Model 3625A.

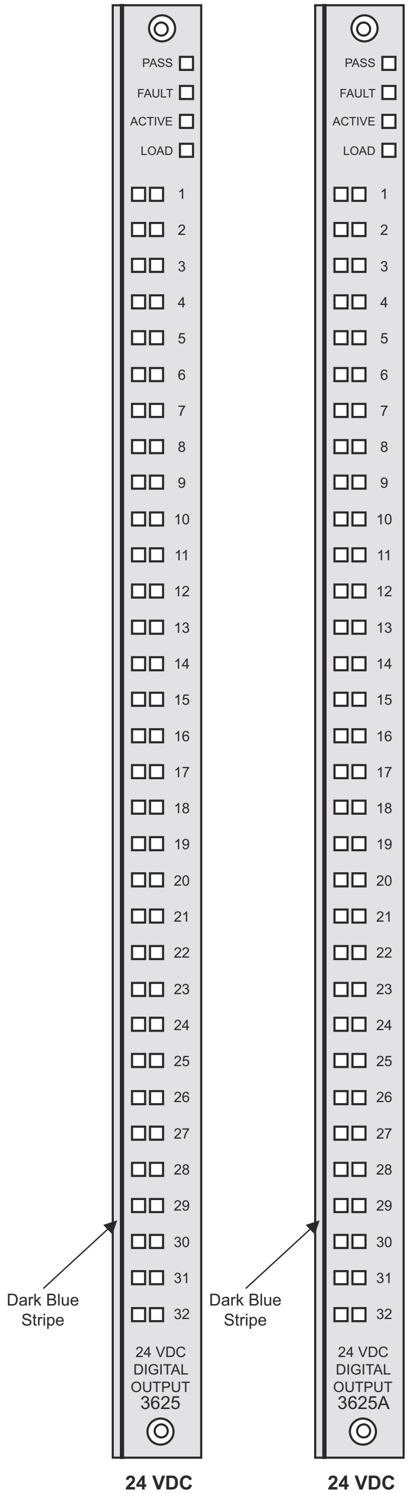


Figure 54 3625 and 3625A Front Panels

3625 and 3625A Specifications

This table lists the specifications for Models 3625 and 3625A, which are 32-point TMR Supervised or Non-Supervised Digital Output Modules. These modules are compatible with 16-point commoned field termination panels, and are intended for energize-to-trip and de-energize-to-trip applications. The 3625 and 3625A modules can be installed only in Tricon v10.2 and later systems.

The 3625A module has been modified to separate the field power supply into groups of 16 points while maintaining a common return. The 3625A module is fully compatible for use in all applications of the 3625 module.

CAUTION

Invensys recommends that the termination panels for the 3625 and 3625A modules are wired in parallel and powered from a single set of redundant field power sources. The 3625A module may be powered from four independent field power sources, but only if the voltage from those sources is within 5% of the highest voltage supplied. If this restriction is not followed, the module will still operate but may experience voter faults and generate an alarm.

Table 49 3625 and 3625A Digital Output Specifications

Feature	Specification
Color code	Dark blue
Number of output signals	32, commoned[a]
Recommended voltage range	16–32 VDC
Nominal voltage	24 VDC
Maximum voltage	36 VDC
Logic power	< 13 watts
Current ratings, maximum	1.70 ± 10%amps/point, 5 amps surge/7 ms
Total module output current (all points)	10 amps/termination panel
Minimum required load	10 mA
Maximum output leakage	2.0 mA @ 24 VDC 2.5 mA @ 32 VDC
Fuses (field termination module)	Not required; output switches are self-protected against over-voltage, over-temperature, and over-current
Status indicator: On or Off state	1 per point
Status indicator: Module status	Pass, Fault, Load, Active
Status indicator: Field alarm[b]	Load (1 per point)
System-to-field isolation	1,500 VDC minimum
Point supervision	Can be programmed per point
Short/Open circuit detection threshold	Programmable per supervised point

Table 49 3625 and 3625A Digital Output Specifications *(continued)*

Feature	Specification
Output diagnostic fault coverage[c]: Maximum output toggle rate	 Every 60 ms
Diagnostic glitch duration	2 ms maximum, 200 µs typical
On-state voltage drop: At backplane	< 0.16 VDC typical @ 250mA < 1.12 VDC typical @ 1.7A
On-state voltage drop: With external termination, 10-foot cable	< 1.15 VDC typical @ 250mA < 3.33 VDC typical @ 1.7A
On-state voltage drop: With external termination, 99-foot cable	< 2.71 VDC typical @ 250mA < 8.92 VDC typical @ 1.7A
Inductive kick-back protection (reverse EMF)	Output switches are self-protected

a. For the 3625 module, field power is commoned to all points, so that if power is present on one point, it is present on all points. For the 3625A module, field power is commoned in groups of 16 points and is separated by termination panels.

b. Power must be supplied to all points, including unused points on non-commoned panels.

c. The maximum output toggle rate enables proper operation of I/O diagnostics and detection of all normally detectable faults.

Note The 3625 and 3625A modules can be installed in low-density systems that have been upgraded to v10.2.x or later. For more information, see “Appendix I, Low-Density Chassis I/O Module Compatibility” in the *Field Terminations Guide for Tricon v9–v11 Systems*.

32-Point Relay Output Modules

This figure is a simplified schematic for Models 3636R and 3636T, which are non-triplicated Relay Output Modules.

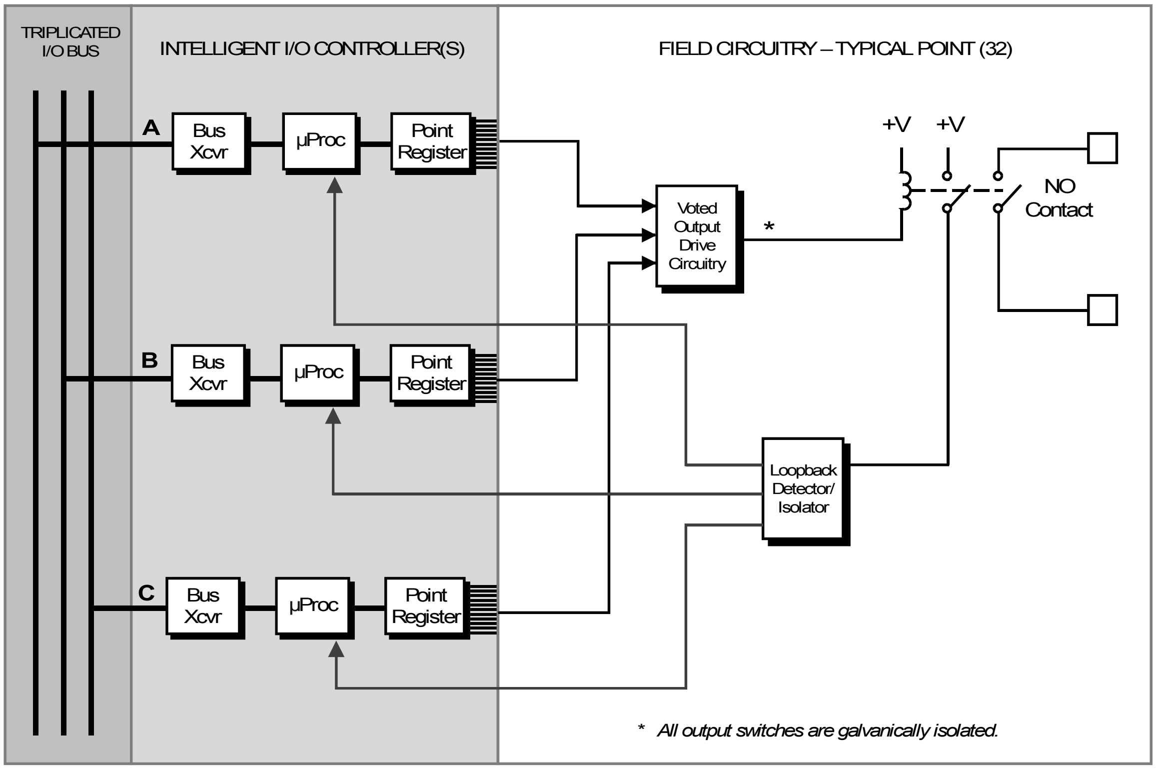


Figure 55 3636R and 3636T Simplified Schematic

This figure shows the front panels of Models 3636R and 3636T.

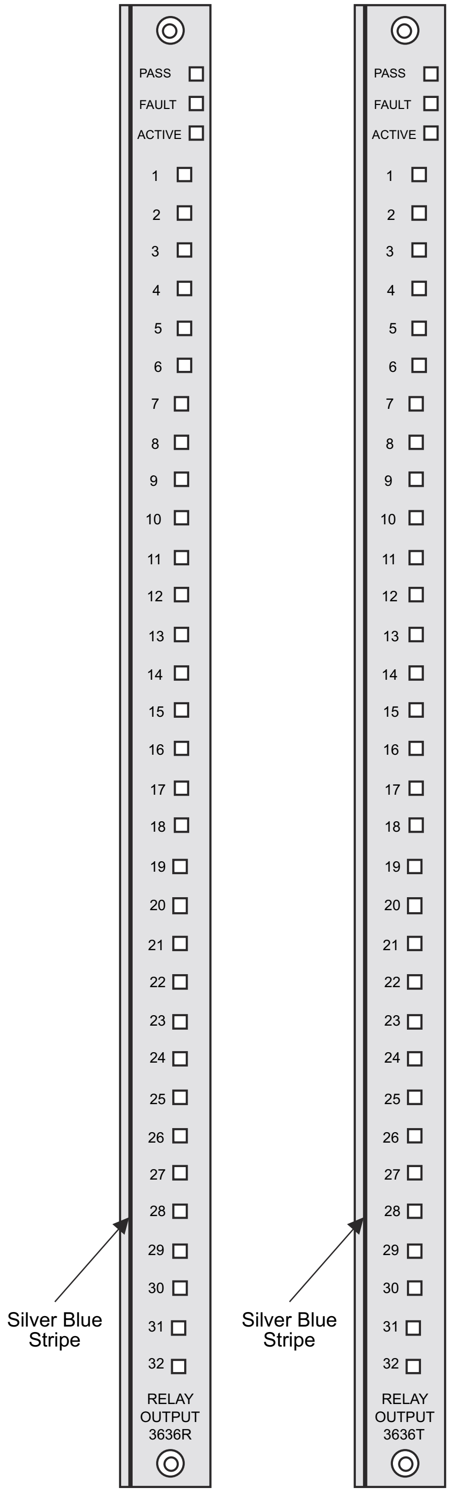


Figure 56 3636R and 3636T Front Panels

Note The Model 3636R and 3636T modules will not assert point LEDs for both primary and spare modules. Only the primary module will assert point LEDs.

3636R and 3636T Specifications

This table lists the specifications for Models 3636R and 3636T, which are Non-Triplicated Relay Output Modules. Point isolation varies by model, as specified in this table.

Table 50 3636R and 3636T Specifications

Feature	Specification
Output contact	NO, normally open
Color code	Silver blue
Number of output points	32, non-commoned
Voltage range	125 VAC/VDC, maximum
Current load	2 amps maximum
Minimum permissible load	10 mA, 5 VDC
Switching power, resistive *See Switching Power on page 157*	2,000 VAC, 150 watts maximum
Maximum output cycle rate	< 30 cycles per second
Expected life at maximum rated load	> 10,000 cycles
Fuses	1 per output, 2.5 amps fast-acting
Status indicator: On or Off state	1 per point
Status indicator: Module status	Pass, Fault, Active
Point isolation: 3636R	1,500 VDC minimum
Point isolation: 3636T	1,900 VDC minimum
Logic power: All points Off	< 10 watts
Logic power: All points On	< 30 watts

Switching Power

When switching reactive loads, you should de-rate the switching power of the outputs to 25 percent of maximum, which is 37.5 watts for DC applications. When switching incandescent lamps, the inrush current can be 10 to 15 times the rated nominal load current of the lamp. For detailed specifications regarding inrush amplitude and duration, contact the lamp manufacturer. The inrush current must be used when calculating the required output switching power.

24 VDC Dual Digital Output Modules

This figure is a simplified schematic for Models 3664 and 3674, which are Digital Output Modules.

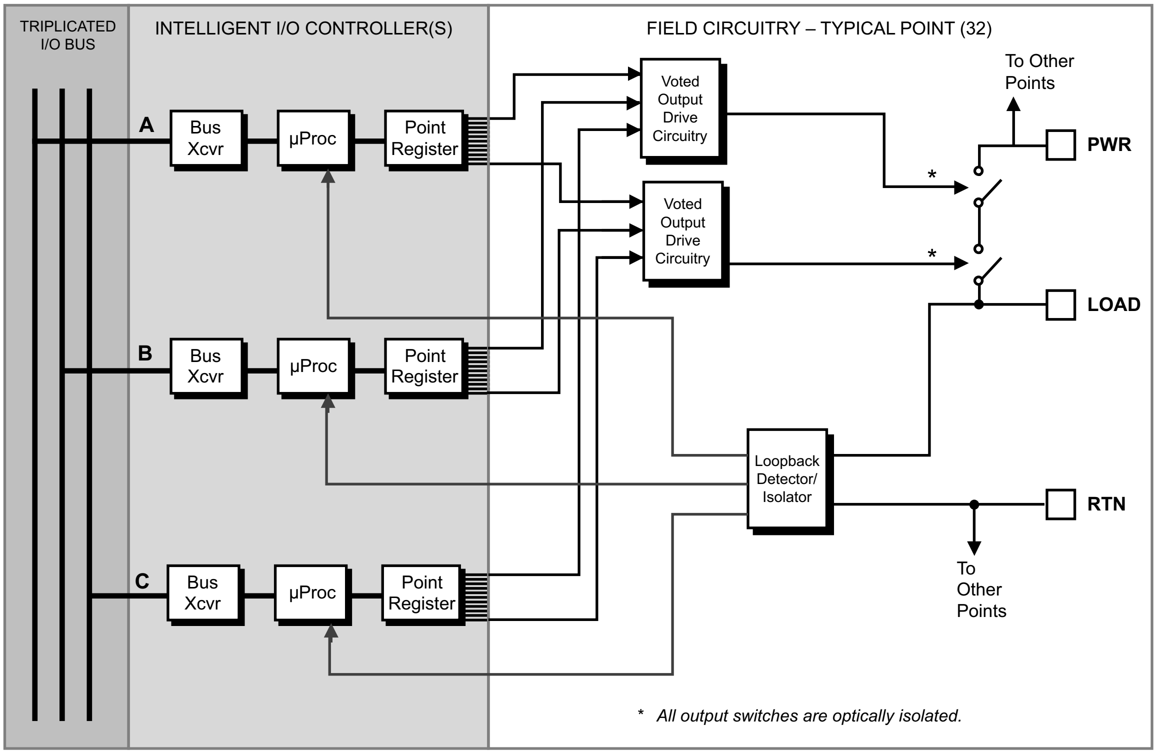


Figure 57 3664 and 3674 Simplified Schematic

This figure shows the front panels of Models 3664 and 3674.

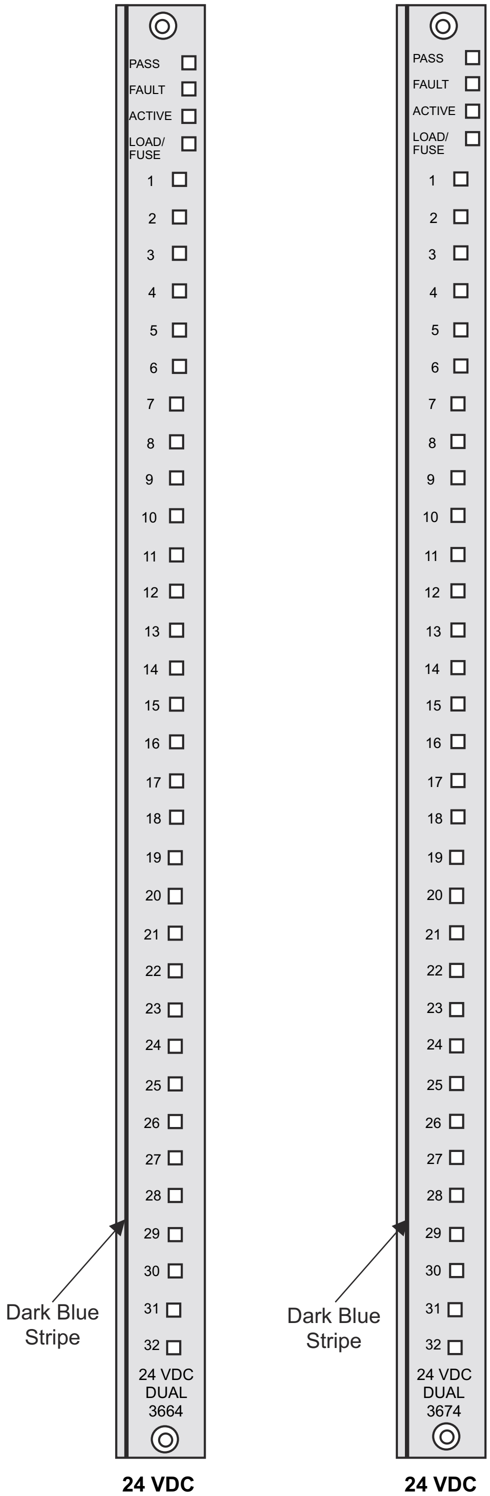


Figure 58 3664 and 3674 Front Panels

3664 and 3674 Specifications

This table lists the specifications for Models 3664 and 3674, which are Dual Digital Output Modules with a nominal voltage range of 24 VDC.

CAUTION Models 3664 and 3674 are not recommended for use in energize-to-trip applications because specific hardware faults may cause its outputs to be stuck-Off (de-energized).

Table 51 3664 and 3674 Dual Digital Output Specifications

Feature	Specification
Color code	Dark blue
Number of output signals	32, commoned
Output Configuration	Dual, serial
Recommended voltage range	16–30 VDC
Maximum voltage	36 VDC
Logic power	< 10 watts
Current ratings, maximum	2 amps/point, 10 amps surge/10 ms
Leakage current to load	2 mA, maximum
Fuses (field termination)	Not required; output switches are self-protected against over-voltage, over-temperature, and over-current
Status indicator: On or Off state	1 per point
Status indicator: Module status	Pass, Fault, Active
Status indicator: Field alarm[a]	Load/fuse
Point isolation	1,500 VDC minimum
Diagnostic glitch duration[b]	2 ms maximum, 500 µs typical
Output diagnostic fault coverage[c]:	
Maximum output toggle rate	Every 100 ms plus one scan
Minimum output toggle rate	Not required
Output behavior under *fault* conditions[d]:	
Output value before fault	Commanded state—On or Off
Output value after stuck-On fault	Commanded state—On or Off
Output value after stuck-Off fault[e]	Off (de-energized)
Output value after all other faults	Commanded state—On or Off
Output behavior under *field fault* conditions:	
Load alarm, output stuck-On: (Model 3664)	Stuck point On, all others commanded state—On or Off
Load alarm, output stuck-On: (Model 3674)	Stuck point On, all others Off (de-energized)
Load alarm, output stuck-Off: (Models 3664 and 3674)	Stuck point Off, all others commanded state—On or Off

Table 51 3664 and 3674 Dual Digital Output Specifications *(continued)*

Feature	Specification
On-state voltage drop:	
At backplane	< 0.5 VDC typical @ 500mA, < 0.5 VDC maximum @ 2A
With external termination, 10-foot cable	< 1.5 VDC typical @ 500mA, < 2.5 VDC maximum @ 2A
With external termination, 99-foot cable	< 3.5 VDC typical @ 500mA, < 8.5 VDC maximum @ 2A
Inductive kick-back protection (reverse EMF)	Output switches are self-protected

a. Power must be supplied to all points, including unused points on non-commoned panels.

b. Diagnostic glitching can be disabled by using the OVD disable function.

c. The maximum output toggle rate enables proper operation of I/O diagnostics and detection of all normally detectable faults. The minimum toggle rate provides fault coverage of normally undetectable faults within 10 percent of the calculated mean-time-between-faults (MTBF) for the module.

d. The Dual DO module performs a complete set of diagnostics on each output point periodically. All faults are 100 percent detectable and are independently reported to the Main Processor by each channel. Specific faults in the output circuitry can force the output to the Off (de-energized) state.

e. A stuck-Off fault results in both a Load/Fuse alarm and a fault in the Dual DO Module. If a Load/Fuse alarm is detected by the Dual DO Module, normal switch-over to a hot-spare module is disabled. This action prevents the output from being forced Off by a stuck-Off fault and then forced back On after the switch-over a few seconds later. To allow switch-over to a healthy module, re-seat the spare module.

Pulse Input Modules

This section describes the Pulse Input Modules available for use with Tricon v9–v11 systems. For important operational restrictions, see Pulse Input Module Installation and Operation on page 248.

Table 52 Pulse Input Modules

Model	Points	Type	Module Description
3510	8	TMR	Pulse Input
3511	8	TMR	Pulse Input

Pulse Input Modules provide eight very sensitive, high-frequency inputs, which are used 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. The transitions are accumulated during a selected window of time (rate measurement), and 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 microsecond resolution.

The type of speed sensor typically used with the Pulse Input Module consists of an inductive coil and rotating teeth. The sensor is physically close to the teeth of a gear on the rotating shaft. As the shaft rotates and the teeth move past the sensor, the resulting change in the magnetic field causes a sinusoidal signal to be induced in the sensor. The magnitude of the output voltage depends on how fast the teeth pass the sensor, the distance between the sensor and the teeth, and the construction of the sensor. A typical gear has 30 to 120 teeth spaced at equal distances around its perimeter. The output frequency is proportional to the rotational speed of the shaft and the number of teeth.

CAUTION

Pulse Input Modules use fully differential, input-signal-conditioning circuitry which is AC-coupled and of high bandwidth. The circuitry is designed for high-frequency operation and is sensitive to any type of waveform distortion which could result in erroneous measurements. The modules count transitions by examining only one edge of each pulse, which means that ringing on the input signal can result in many additional transitions being counted. The module is capable of counting over 20,000 transitions per second.

Pulse Input Modules have three isolated input channels. Each input channel independently processes all data input to the module and passes the data to the Main Processors, where it is voted just prior to processing to ensure the highest integrity.

Each module provides complete ongoing diagnostics on each channel. Failure of any diagnostic on any channel activates the module’s Fault indicator, which in turn activates the chassis alarm signal. The 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.

Pulse Input Modules include the hot-spare feature and require a separate field termination (a cable interface to a remotely located External Termination Panel). Each Pulse Input Module is mechanically keyed to prevent improper installation in a configured chassis.

Pulse Input Schematic

This figure is a simplified schematic for Models 3510 and 3511, which are Pulse Input Modules.

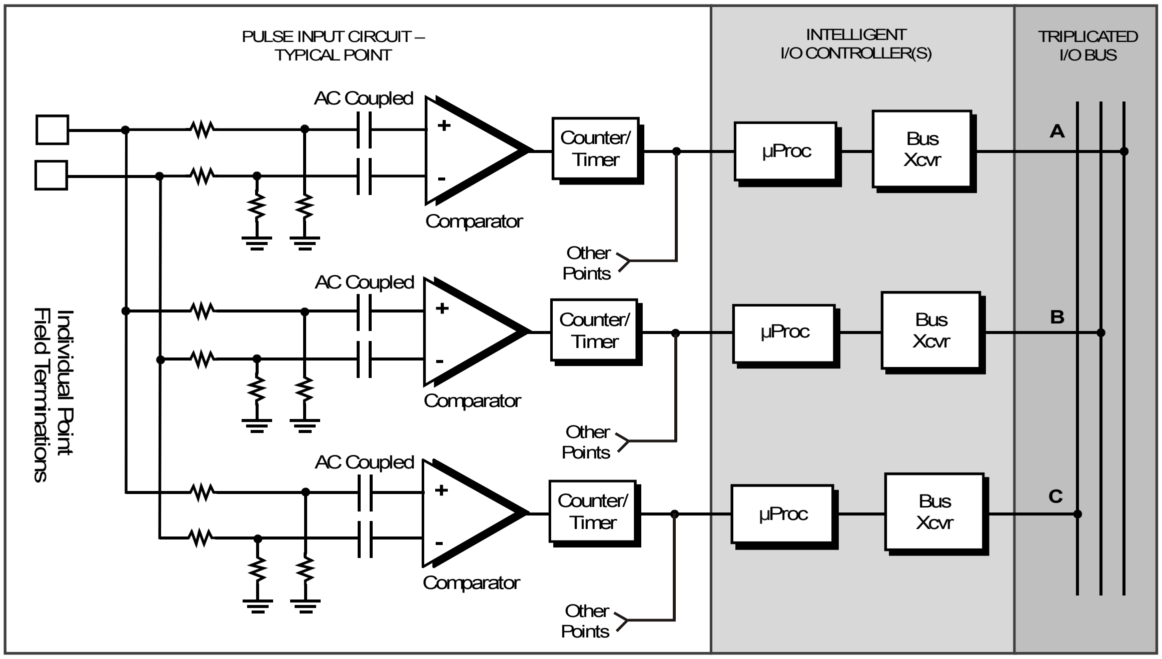


Figure 59 3510 and 3511 Simplified Schematic

Pulse Input Front Panels

This figure shows the front panels of Models 3510 and 3511.

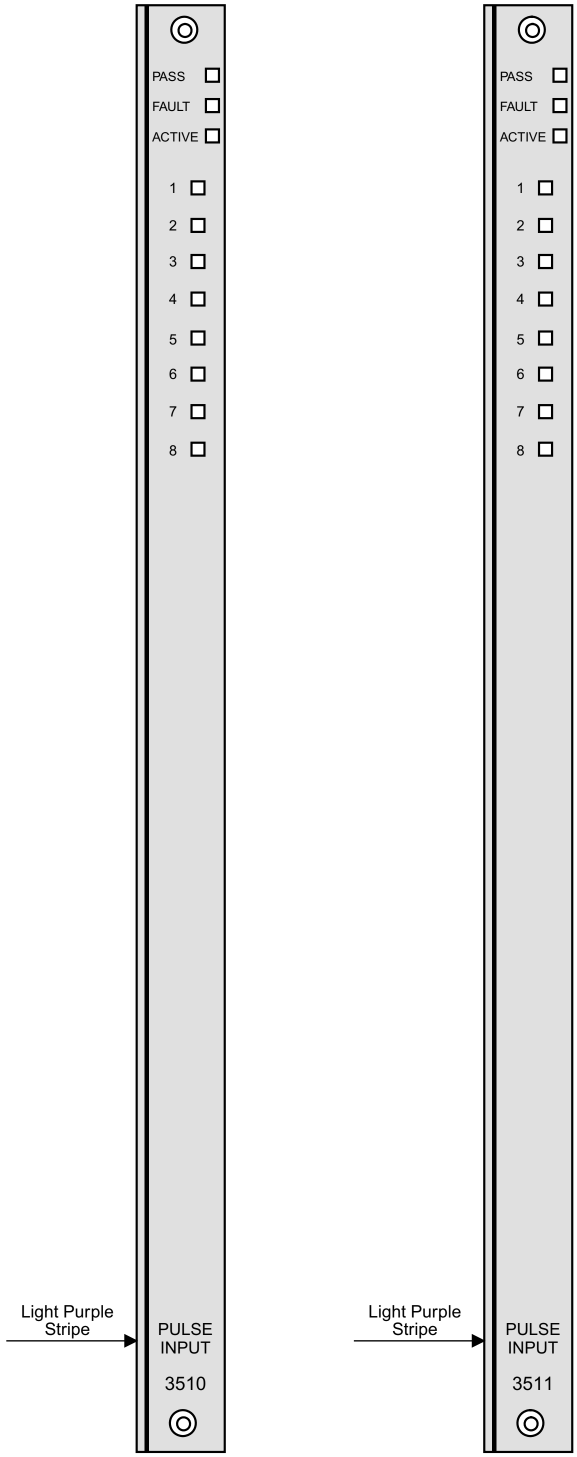


Figure 60 3510 and 3511 Front Panels

3510 Specifications

This table lists the specifications for Model 3510, which is a Pulse Input Module. Although the input frequency range for the module is 20 to 20,000 hertz, operation below 20 hertz and above 20,000 hertz is possible. For expected accuracy and input sensitivity, contact the Global Customer Support (GCS) center.

CAUTION

- Rapidly or continuously changing inputs may cause mis-compare readings because the measured values of the three channels may in fact be different by more than 0.5 percent of full scale, which can sometimes cause a fault to be declared in error.
- If the input readings differ by a minimum of 0.5 percent of full scale and continue for a minimum period of 10 input samples, the probability of a fault increases.

Table 53 3510 Pulse Input Specifications

Feature	Specification
Color code	Light purple
Number of input signals	8, non-commoned
Input frequency range	20 Hz to 20,000 Hz
Accuracy: @ 1,000 Hz to 20,000 Hz	±0.01%
Accuracy: @ 100 Hz to 999 Hz	±0.1%
Accuracy: @ 20 Hz to 99 Hz	±1.0%
Input diagnostic fault coverage	
Minimum input change	0.5% of full scale
Input change sample period	1 scan or 210 ms, whichever is greater
Minimum period of mis-compares	10 samples
Status indicator: Input activity	1 per point
Status indicator: Module status	Pass, Fault, Active
Logic power	< 20 watts
Input characteristics (AC-coupled, balanced differential):	
Update rate	50 ms, typical
Load impedance	> 8 kΩ, 20K typical
Common mode range	-100V to +100V peak-to-peak
Normal mode range	2.0 V to 200 V peak-to-peak, below 20 Hz 1.5 V to 200 V peak-to-peak, 20 Hz to 15000 Hz 2.0 V to 200 V peak-to-peak, above 15000 Hz
Over-range protection	±150 VDC continuous
Hysteresis	150 millivolts, typical

3511 Specifications

This table lists the specifications for Model 3511, which is a Pulse Input Module. Although the input frequency range for the module is 20 to 20,000 hertz, operation below 20 hertz and above 20,000 hertz is possible. For expected accuracy and input sensitivity, contact the Global Customer Support (GCS) center.

CAUTION

- Rapidly or continuously changing inputs may cause mis-compare readings because the measured values of the three channels may in fact be different by more than 0.5 percent of full scale, which can sometimes cause a fault to be declared in error.
- If the input readings differ by a minimum of 0.5 percent of full scale and continue for a minimum period of 10 input samples, the probability of a fault increases.

Table 54 3511 Pulse Input Specifications

Feature	Specification
Color code	Light purple
Number of input signals	8, non-commoned
Input frequency range	20 Hz to 20,000 Hz
Accuracy:@ 1,000 Hz to 20,000 Hz	±0.01%
Accuracy:@ 100 Hz to 999 Hz	±0.01%
Accuracy:@ 20 Hz to 99 Hz	±1.0%
Input diagnostic fault coverage	
Minimum input change	0.5% of full scale
Input change sample period	1 scan or 210 ms, whichever is greater
Minimum period of mis-compares	10 samples
Status indicator: Input activity	1 per point
Status indicator: Module status	Pass, Fault, Active
Logic power	< 20 watts
Input characteristics (AC-coupled, balanced differential):	
Update rate	25 ms, typical
Load impedance	> 8 kΩ, 20K typical
Common mode range	-100V to +100V peak-to-peak
Normal mode range	1.5V to 200V peak-to-peak
Over-range protection	±150 VDC continuous
Hysteresis	150 millivolts, typical
Sensitivity	Typical: 0.5V peak-to-peak, sine wave Worst case: 1.5V peak-to-peak, sine wave

Pulse Totalizer Input Module

This section describes the Pulse Totalizer Input Module available for use with Tricon v9–v11 systems. For important operational restrictions, see Pulse Totalizer Input Module Installation and Operation on page 249.*Field Terminations Guide for Tricon v9–v11 Systems*

Table 55 Pulse Totalizer Input Module

Model	Voltage	Points	Type	Module Description
3515	24 VDC	32	TMR	Pulse Totalizer Input

The Model 3515 Pulse Totalizer Input (PTI) Module includes 32 individual 31-bit counters that each 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 control program, the Main Processors can clear a single counter or all counters. Typically, the PTI module is used for batch processes. To avoid counter overflow, the control program should clear each counter before the start of each batch.

The PTI module has three isolated input channels. Each input channel independently processes all input data and passes the data 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 module’s 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.

Pulse Totalizer Schematic

This figure is a simplified schematic for Model 3515, which is a Pulse Totalizer Input Module.

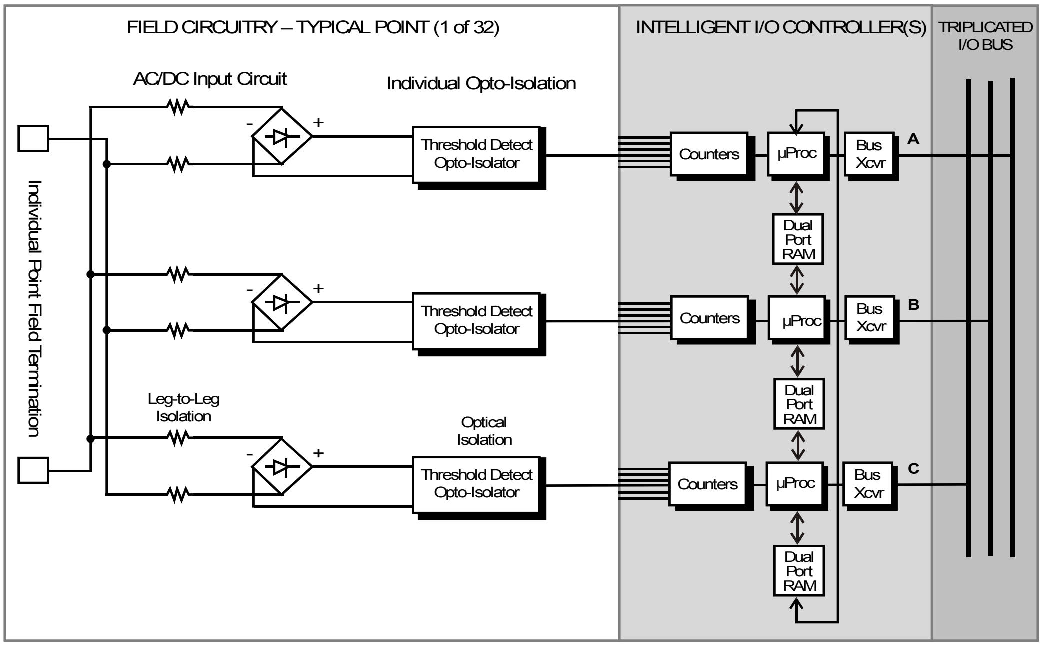


Figure 61 3515 Simplified Schematic

Pulse Totalizer Input Front Panel

This figure shows the front panel of Model 3515.

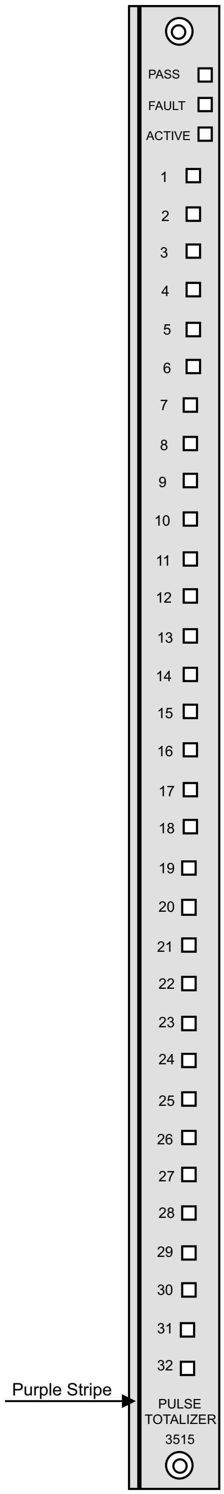


Figure 62 3515 Front Panel

3515 Specifications

This table lists the specifications for Model 3515, which is a Pulse Totalizer Input Module.

Table 56 3515 Pulse Totalizer Input Specifications

Feature	Specification
Color Code	Purple
Number of input points	32, non-commoned
Input frequency range	0 Hz to 1 KHz
Minimum input pulse width	300 µs
Accuracy: Active module	+/- 2 counts
Accuracy: 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 reset	Individual reset per counter
Recommended input voltage range	20–42.5 VDC
Maximum input voltage	42.5 VDC
Count up switching level	Rising edge, Off to On
Switching voltage: Off to On	15 VDC typical, 18 VDC worst case
Switching voltage: On to Off	8 VDC typical, 6 VDC worst case
Typical hysteresis	4 VDC
Normal turn-on current	6 mA to 9 mA
Count input delay	< 15 ms
Point isolation, opto-isolated	1000 VAC minimum 1500 VDC minimum
Status indicator: On or Off state	1 per point
Status indicator: 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

Thermocouple Input Modules

This section describes the Thermocouple Input Modules available for use with Tricon v9— v11 systems. For important operational restrictions, see Thermocouple Input Module Installation and Operation on page 250.

Table 57 Thermocouple Input Modules

Model	Module Description	Type
3706A	Non-Isolated Thermocouple Input	TMR
3708E	Isolated Thermocouple Input	TMR

A Thermocouple Input Module has 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. To ensure correct data for every scan, a value is selected using a mid-value selection algorithm.

Each module is configured in TriStation 1131 for the thermocouple type and engineering units you select. Each module can support one of a variety of thermocouple types, as indicated in the specifications. Engineering units are in Celsius or Fahrenheit.

TriStation 1131 programs the Isolated Thermocouple Module for upscale or downscale burnout detection depending on the hardware specification in the TriStation 1131 control program. The Non-Isolated Thermocouple Module provides upscale or downscale burnout detection depending on the field termination selected. If a thermocouple burnout occurs, the Main Processors receive the integer value +32,767 for upscale burnout detection or –32,767 for downscale. If a thermocouple input voltage goes out of range, the Main Processors receive the integer value +32,767.

Triplicated temperature transducers residing on the field termination module support cold-junction compensation. Each channel of a thermocouple module performs auto-calibration and reference-junction compensation every five seconds using internal-precision voltage references. On the Isolated Thermocouple Module, a cold-junction indicator announces the failure of a cold-junction transducer. On the Non-Isolated Thermocouple Module, a Fault indicator announces a transducer fault.

Sensing of each thermocouple input is performed in a manner which prevents a single failure on one channel from affecting another channel. Each module performs complete ongoing diagnostics on each channel.

Thermocouple Input Modules include the hot-spare feature, which allows online replacement of a faulty module. Like all I/O modules, Thermocouple Input Modules require a cable interface to a remotely located external termination panel. Each module is mechanically keyed to prevent improper installation in a configured chassis.

32-Point Thermocouple Modules

This figure is a simplified schematic for Model 3706A, which is a non-isolated Thermocouple Input Module.

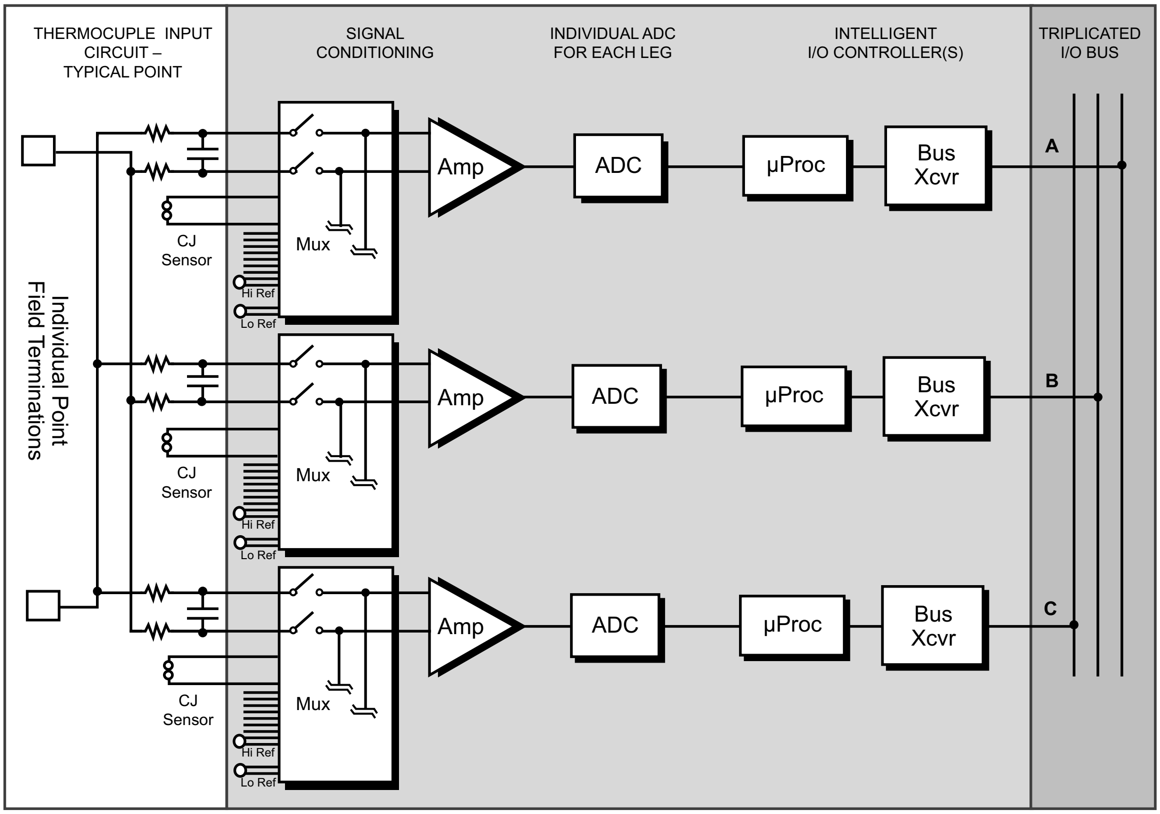


Figure 63 3706A Simplified Schematic

This figure shows the front panel of Model 3706A.

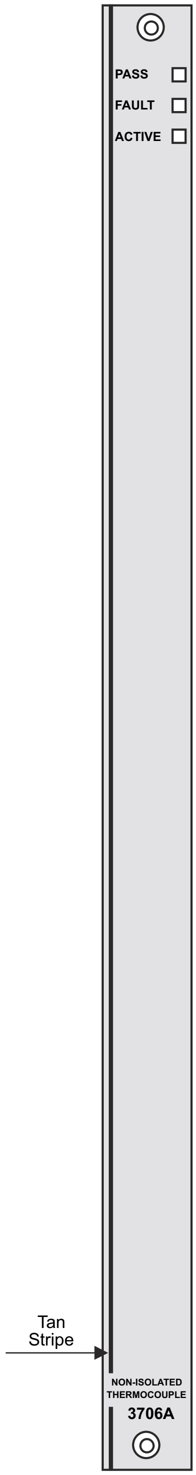


Figure 64 3706A Front Panel

3706A Specifications

This table lists the specifications for Model 3706A, which is a Thermocouple Input Module.

WARNING If the common mode voltage range of a channel is exceeded, Invensys does not guarantee proper operation of the module and accuracy of other channels.

CAUTION Rapidly or continuously changing inputs may cause mis-compare readings because the measured values of the three channels may be different by more than 0.5 percent of full scale, which may cause a fault to be declared in error.

Table 58 3706A Thermocouple Input Specifications

Feature	Specification
Color code	Tan
Thermocouple types supported	J, K, T
Open detect	Upscale/downscale selected on termination module
Number of input signals	32 differential, DC-coupled
Input update rate[a]	50 ms maximum
Accuracy of thermocouple types and temperature ranges supported	See Table 59 Accuracy of Model 3706A Thermocouple Types (page 175).
Input resistance (load)	22 MΩ (DC), typical
Input point protection	110 VAC continuous without damage
Noise rejection: Common mode	-85 dB @ 0 – 60 Hz minimum -95 dB @ 60 Hz typical
Noise rejection: Normal mode	-17 dB @ 60 Hz
Common mode range (*See above Warning*)	±10 VDC maximum (channel-to-channel or channel-to-ground)
Channel-to-channel isolation	200 kΩ, typical
Reference-junction compensation range	32° to 140° F (0° to 60° C)
Module status indicators	Pass, Fault, Active
Input diagnostic fault coverage[b]:	
Minimum input change	0.5% of full scale
Input change sample period	50 milliseconds
Minimum period of mis-compares	256 samples
Logic power	< 10 watts

a. Later versions of NITC firmware (meta 4873 or greater) freeze inputs for one second upon detection of hot-spare insertion.
b. If the input readings differ by a minimum of 0.5 percent of full scale and continue for a minimum period of 256 input samples, the probability of a fault increases.

Note For information about compliance with IEC 61508, Parts 1-7:2010, see TÜV Rheinland on page 22.

3706A Accuracy

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 thermocouple terminations. Customers are responsible for maintaining a uniform temperature across the Thermocouple Field Termination Module.

Table 59 Accuracy of Model 3706A Thermocouple Types

TC Type	Temperature Range	Accuracy @ 32° to 140° F (0° to 60° C)	
		Ta=77° F (25° C)	Ta=32° to 140° F (0° to 60° C)
		Typical	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)

16-Point Isolated Thermocouple Modules

This figure is a simplified schematic for Model 3708E, which is an isolated Thermocouple Input Module.

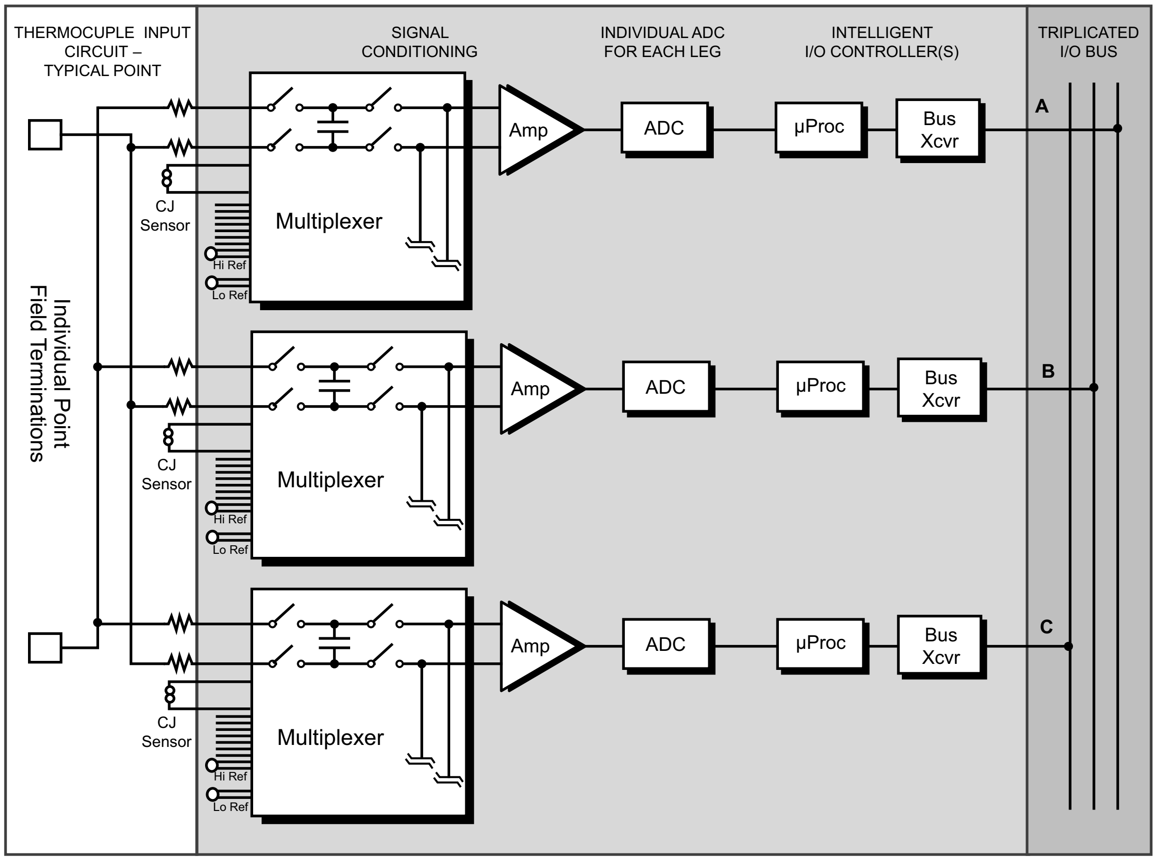


Figure 65 3708E Simplified Schematic

This figure shows the front panel of Model 3708E.

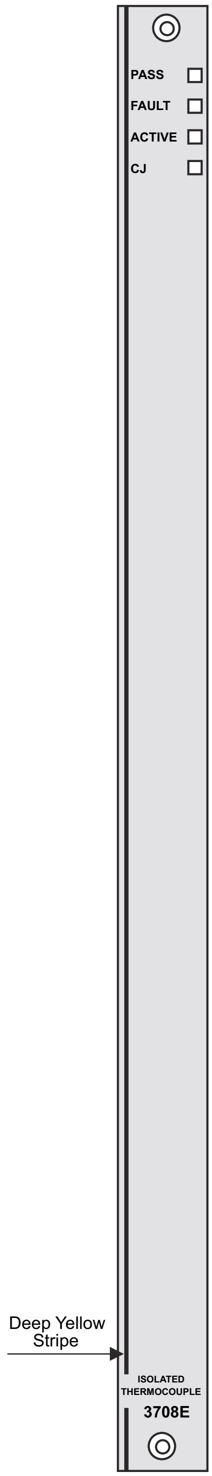


Figure 66 3708E Front Panel

3708E Specifications

This table lists the specifications for Model 3708E, which is an isolated TMR Thermocouple Input Module.

WARNING If the common mode voltage range of a channel is exceeded, Invensys does not guarantee proper operation of the module and accuracy of other channels.

CAUTION If the input readings differ by a minimum of 0.5 percent of full scale and continue for a minimum period of 256 input samples, the probability of a fault increases.

Table 60 3708E Thermocouple Input Specifications

Feature	Specification
Color code	Deep yellow
Thermocouple types supported	J, K, T, E
Open detect	Upscale, Downscale, (configure in TriStation 1131)
Number of input signals	16 differential, isolated
Input update rate	50 ms maximum
Accuracy of thermocouple types and temperature ranges supported	See table, Table 61 Accuracy of Model 3708E Thermocouple Types (page 179).
Input resistance (load)	30 MΩ (DC) minimum
Input point protection	110 VAC continuous without damage
Noise rejection: Common mode	-100 dB @ DC minimum -90 dB @ 60 Hz minimum
Noise rejection: Normal mode	-3 dB @ 8 Hz typical -17 dB @ 60 Hz typical
Common mode range (*See above Warning*)	±200 VDC maximum (channel-to-channel or channel-to-ground)
Channel-to-channel isolation	20 kΩ, typical
Reference-junction compensation range	32° to 140° F (0° to 60° C)
Status indicator: Module status	Pass, Fault, Active
Status indicator: Cold Junction sensor status	CJ (On = CJ Fault)
Input diagnostic fault coverage:	
Minimum input change	0.5% of full scale
Input change sample period	50 ms
Minimum period of mis-compares	256 samples

Table 60 3708E Thermocouple Input Specifications *(continued)*

Feature	Specification
Logic power	< 15 watts

Note For information about compliance with IEC 61508, Parts 1-7:2010, see TÜV Rheinland on page 22.

3708E Accuracy

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 thermocouple terminations. The customer is responsible for maintaining a uniform temperature across the Thermocouple Field Termination Module.

Table 61 Accuracy of Model 3708E Thermocouple Types

TC Type	Temperature Range	Accuracy @ 32° to 140° F (0° to 60° C)	
		Ta=77° F (25° C)	Ta=32°to 140° F (0-60° C)
		Typical	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 1251.1° 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)

HART Interface Modules

This section describes Highway Addressable Remote Transducer (HART) interface modules available for use with Tricon v10.4 or later systems.

HART is an industry standard field bus that superimposes a Frequency Key Shifted (FSK) signal onto the 4-20 mA loop. The Tricon 2071H HART Multiplexer Module that is incorporated into each of the HART Interface Modules capacitively couples the HART signal to the AI or AO signals. The HART signals are approximately ±0.5 mA at 1,200 and 2,200 Hz. These frequencies are high enough that the low-bandwidth loop is unaffected and the HART electronics can impose and extract the HART signals easily.

HART communication through the HART multiplexer is separate from the Tricon system and is certified not to interfere with the 4-20 mA safety signals of the Analog Input and Analog Output modules.

Table 62 HART Interface Modules

Model	Interface Module Description	Compatible I/O Modules	Type
2770H	HART Analog Input Interface Module	3700A, 3721	TMR
2870H	HART Analog Output Interface Module	3805E, 3805H	TMR

For installation information, see Installing HART Interface Modules in the Model 8121 Enhanced Low-Density Expansion Chassis on page 251, and Installing HART Interface Modules in Systems Upgraded from v6–v8 on page 255.

Chassis Requirements for HART Communication

Only Tricon v10.4.x and later systems can use HART interface modules; earlier Tricon systems must upgrade to Tricon v10.4.x systems. The chassis requirements for using HART interface modules in a system upgraded to Tricon v10.4.x systems differ depending on the original system version, as described in this table.

Table 63 Tricon Chassis Usage for HART Communication

If Your Original System Version Is...	Upgrade to System Version...	Install HART Interface Modules in Chassis...
Tricon v10.4.x or later (High-Density)	n/a	• Model 8121 Enhanced Low-Density Expansion Chassis
Tricon v10.0.x – 10.3.x (High-Density)	Tricon v10.4.x	• Model 8121 Enhanced Low-Density Expansion Chassis
Tricon v9.x (High-Density)	Tricon v10.4.x	• Model 8121 Enhanced Low-Density Expansion Chassis
Tricon v6.x – v10.x (Low-Density)	Tricon v10.4.x	• Model 8100-1 Main Chassis • Model 8101 Low-Density Expansion Chassis • Model 8102 Low-Density RXM Chassis • Model 8121 Enhanced Low-Density Expansion Chassis

HART Analog Input Interface Modules

This is a simplified schematic of the Model 2770H HART Analog Input Interface Module from the field device to the HART controller.

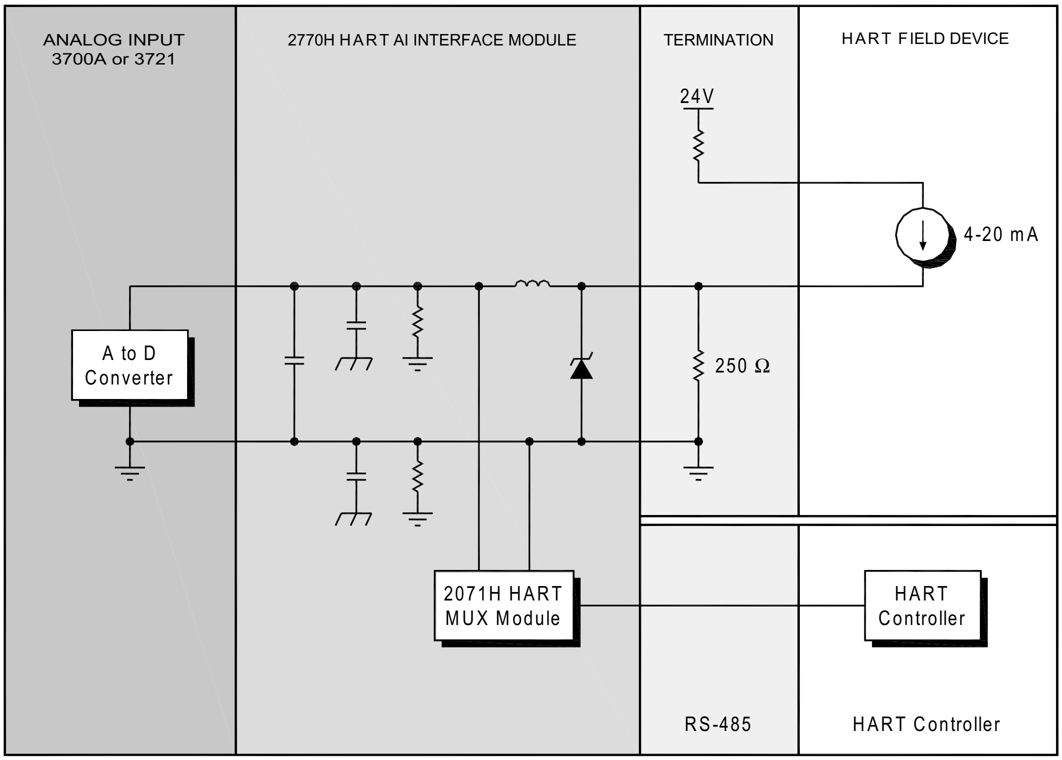


Figure 67 2770H Simplified Schematic

This figure shows the front panel of the Model 2770H HART Analog Input Interface Module.

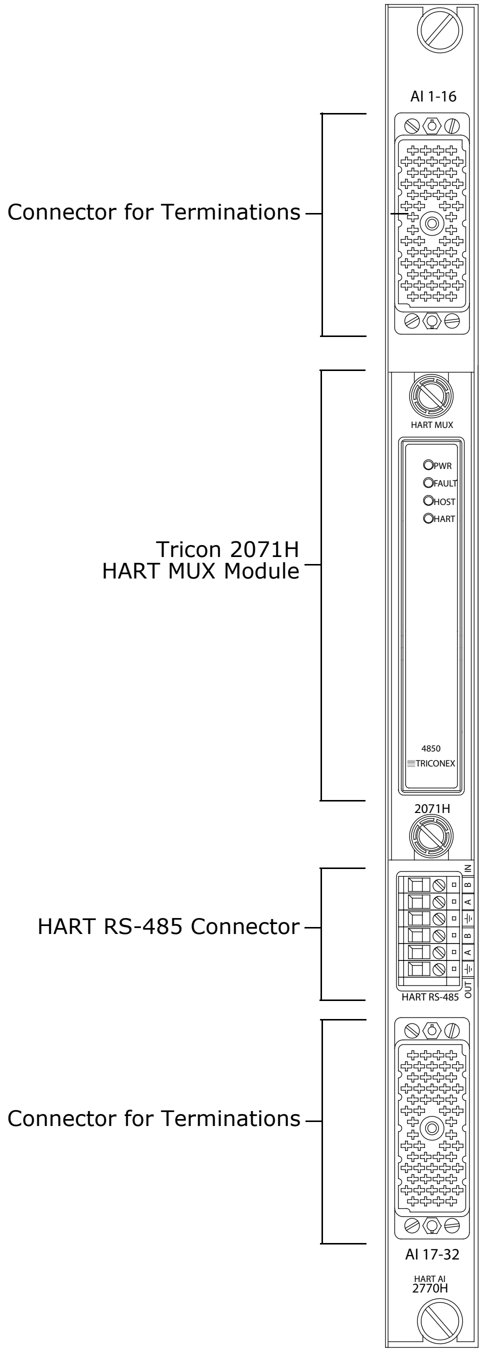


Figure 68 2770H Front Panel

2770H Specifications

This section includes specifications for Model 2770H, which is an Analog Input Interface Module that provides HART communication to field devices connected to Model 3700A and 3721 Analog Input Modules.

Table 64 2770H HART Analog Input Interface Module Specifications

Feature	Specification
Compatible Analog Input Modules	3700A, 3721
Number of input signals	32
Input type	4-20 mA, 0 to 5 VDC
HART MUX Module[a]	2071H (includes the Triconex 4850 HART Multiplexer)
Status indicator: HART MUX module[a]	PWR, FAULT, HOST, HART
HART protocol	HART Field Communication Protocol, Revision 5.0–7.0
Logic power	< 5 Watts

a. For more information about the Triconex 4850 HART Multiplexer, including PC software installation and configuration, see the *Triconex 4850 HART Multiplexer Instruction Manual, INM4850-TR*.

HART Analog Output Interface Modules

This is a simplified schematic of the Model 2870H HART Analog Output Interface Module from the AO module to the field device.

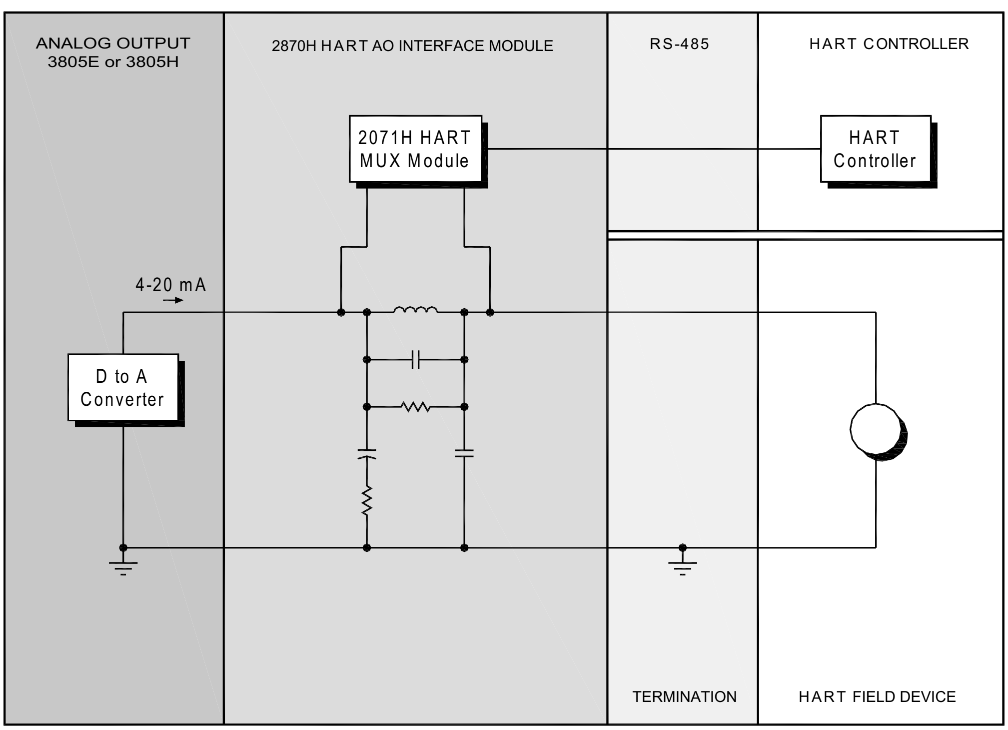


Figure 69 2870H Simplified Schematic

This figure shows the front panel of the Model 2870H HART Analog Output Interface Module.

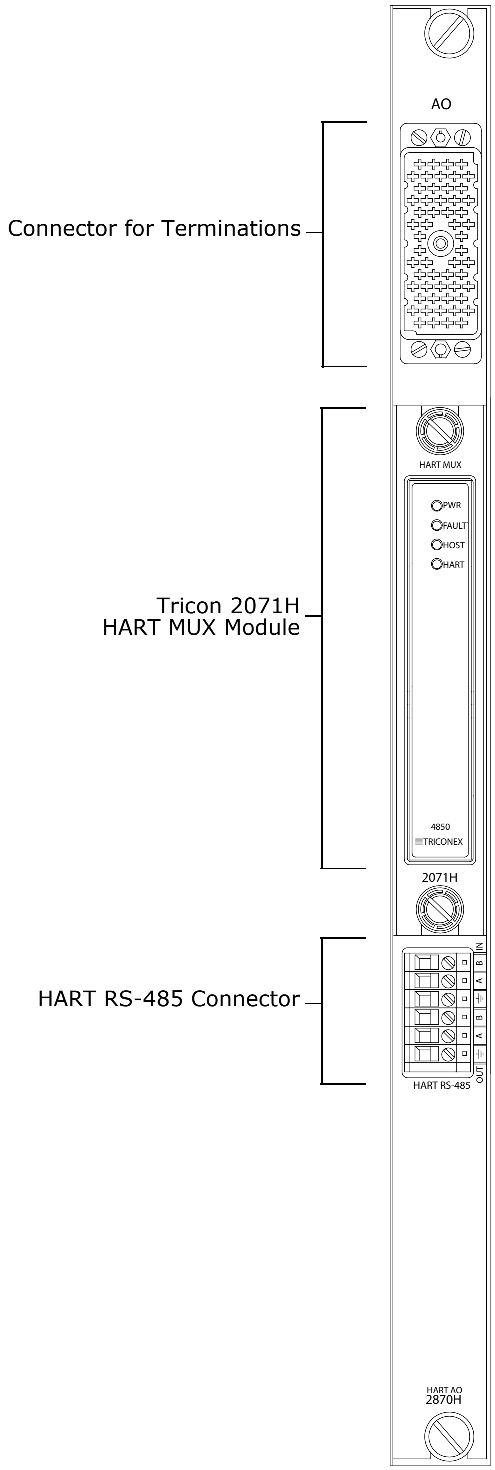


Figure 70 2870H Front Panel

2870H Specifications

This section includes specifications for Model 2870H, which is an Analog Output Interface Module that provides HART communication to field devices connected to Model 3805E or 3805H Analog Output Modules.

Table 65 2870H HART Analog Output Interface Module Specifications

Feature	Specification
Compatible Analog Output Modules	3805E, 3805H
Number of output signals	8
Output type	4-20 mA, 0 to 5 VDC
HART MUX Module[a]	2071H (includes the Triconex 4850 HART Multiplexer)
Status indicator: HART MUX module[a]	PWR, FAULT, HOST, HART
HART protocol	HART Field Communication Protocol, Revision 5.0–7.0
Logic power	< 5 Watts

a. For more information about the Triconex 4850 HART Multiplexer, including PC software installation and configuration, see the Triconex 4850 HART Multiplexer Instruction Manual, INM4850-TR.

Communication Modules

This section describes the Communication Modules available for use with Tricon v9–v11 systems.

Table 66 Communication Modules for Tricon Controllers

Model	Module Description	System Version Compatibility
4609	Advanced Communication Module (ACM)	10.x or earlier
4119, 4119A	Enhanced Intelligent Communication Module (EICM)	10.x or earlier
4509	Hiway Interface Module (HIM)	10.x or earlier
4329, 4329G	Network Communication Module (NCM)	10.x or earlier
4409	Safety Manager Module (SMM)	9–11.x
4351, 4352	Tricon Communication Module (TCM)	10.0
4351A, 4352A	Tricon Communication Module (TCM)	10.1–11.x
4351B, 4352B, 4353, 4354	Tricon Communication Module (TCM)	10.3–11.x
4610	Unified Communication Module (UCM)	v11.x

Advanced Communication Module (ACM)

The Advanced Communication Module (ACM) acts as an interface between a Tricon controller and a Foxboro Intelligent Automation (I/A) Series DCS, 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 DCS, transmitting all Tricon controller 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 includes these features:

- Handling of critical I/O points and passing of results to the I/A Series system using the Object Management Database (OMDB).
- Processing of Tricon alarms and propagation to user-defined I/A Series destinations, such as consoles and printers.
- Propagation of Tricon alarms as I/A Series messages.
- Reading and writing of aliased data to satisfy I/A Series system requests.
- Enabling of Time Synchronization from the I/A Series environment.
- Retrieval of Tricon sequence of events (SOE) data.
- Display of Tricon diagnostic data on I/A Series workstations.
- Write protection to lock out changes to the Tricon controller from all I/A Series sources.
- Hot-spare module capability for redundant communication with the I/A Series Nodebus.

For more information, see the *ACM User's Guide* and *Communication Guide for Tricon v9–v11 Systems*. For additional requirements, see Replacing ACMs on page 295.

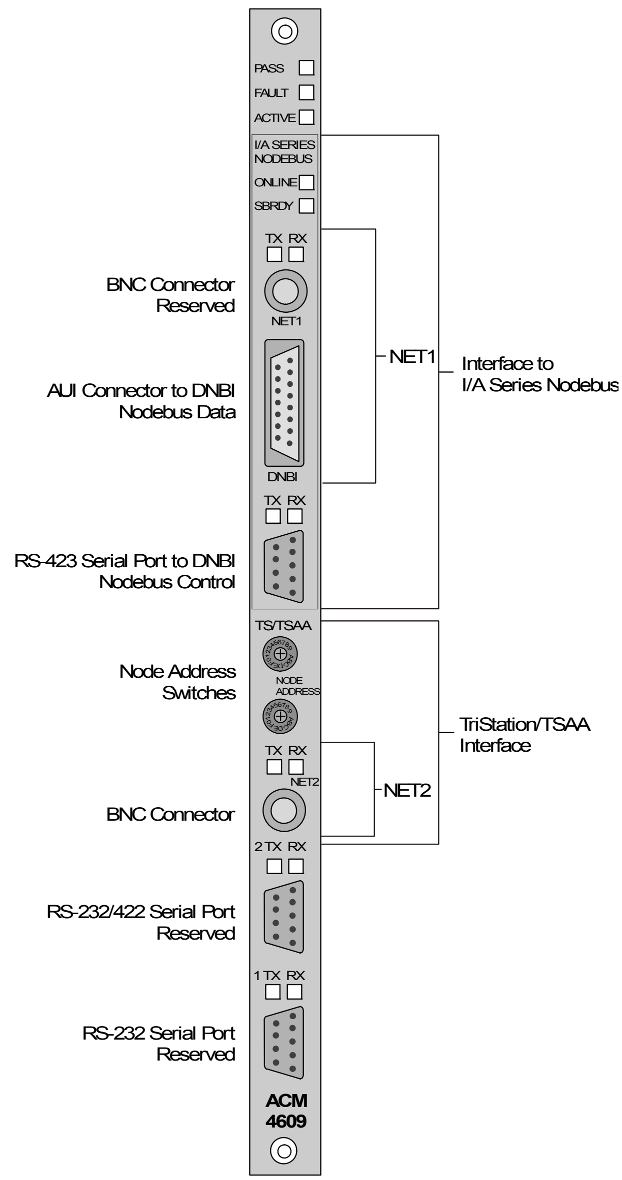


Figure 71 ACM Front Panel

ACM and I/A Series Connection

The ACM connection to the I/A Series Nodebus is through two dedicated ports—one for Nodebus data and one for Nodebus control. The ACM also includes a network port labeled TS/TSAA, which can be used for communication with a TriStation PC.

WARNING

- Invensys strongly recommends that you install a hot-spare for each ACM in your Tricon controller. Because the ACM is not a TMR module, a single fault can cause a momentary loss of communication with the distributed control system (DCS)—until the spare ACM becomes active. Without a spare, communication can be lost until the ACM is replaced and initialized from the DCS. (Failure of the ACM does not compromise the operation of the rest of the Tricon controller.)
- In hazardous indoor locations, apparatus used with the ACM must be FM-certified for Class I, Division II.

For more information about communication setup, see the *Communication Guide for Tricon v9–v11 Systems*.

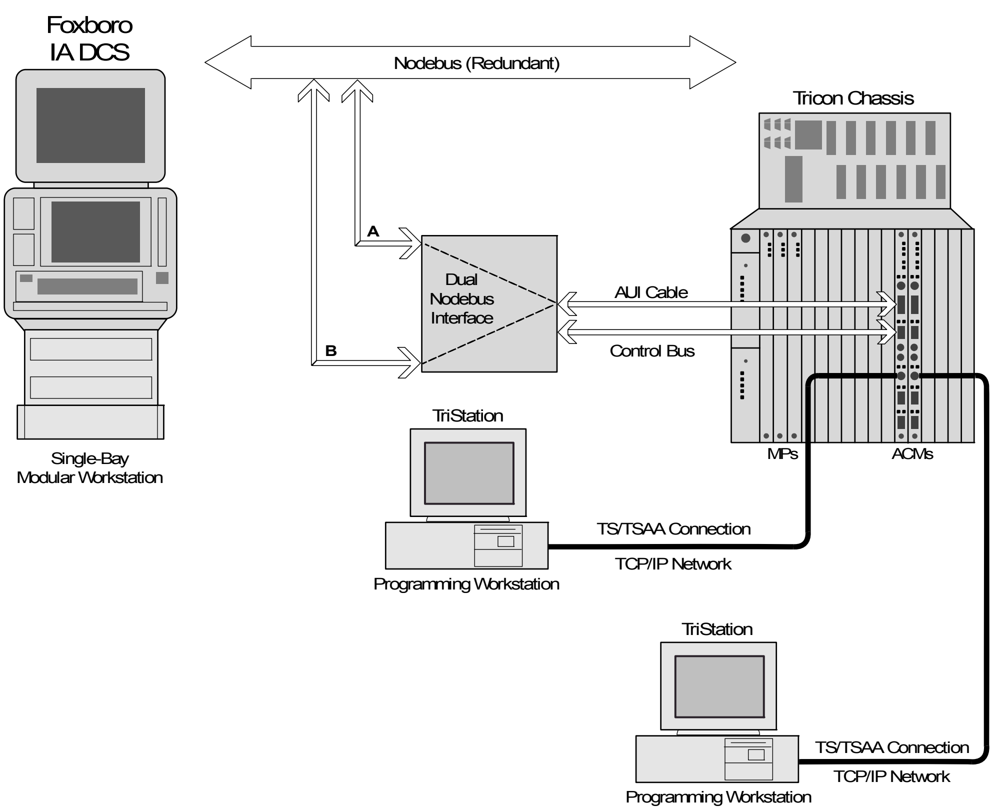


Figure 72 Tricon ACM and Foxboro I/A DCS Interface

4609 Specifications

This table lists the specifications for the ACM Model 4609.

Table 67 4609 ACM Specifications

Feature	Specification
Nodebus port:	
BNC connector	1 for RG-58, 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
TS/TSAA port	1 BNC connector for RG58, 50-ohm thin cable to network
Serial port (reserved):	
9-pin serial ports	RS-232/RS-422 (reserved)
Port isolation	500 VDC (network and RS-232 ports)
Communication speed:	
BNC connectors	10 megabits
15-pin D connector	10 megabits
9-pin Nodebus connector	2400 baud
Status indicator:	
Module status	Pass, Fault, Active
Nodebus activity	ONLINE
Nodebus spare	SBRDY
Port activity	TX (Transmit) — 1 per port
	RX (Receive) — 1 per port
Logic power	< 20 watts
System version compatibility	Tricon v10.x or earlier systems

Enhanced Intelligent Communication Module (EICM)

The Enhanced Intelligent Communication Module (EICM) enables a Tricon controller to communicate with Modbus devices (masters or slaves), with a TriStation PC, and with a printer. A single Tricon High-Density controller supports up to two EICM modules which reside in one logical slot. This arrangement provides a total of six Modbus ports, two TriStation ports, and two printer ports. (The hot-spare feature is not available for the EICM, though you *can* replace a faulty EICM while the controller is online.)

Each EICM has four serial ports and one parallel port which can operate concurrently. The four serial ports are uniquely addressed and support 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, which means the total data rate for all four ports must be less than or equal to 57.6 kilobits per second.

Any standard Modbus device can communicate with a Tricon controller using the EICM provided that aliases are assigned to the tagnames (points) used in the control program. For more information, see the *TriStation 1131 Developer's Guide*.

For additional information, see the *Communication Guide for Tricon v9–v11 Systems* and Replacing EICMs on page 296.

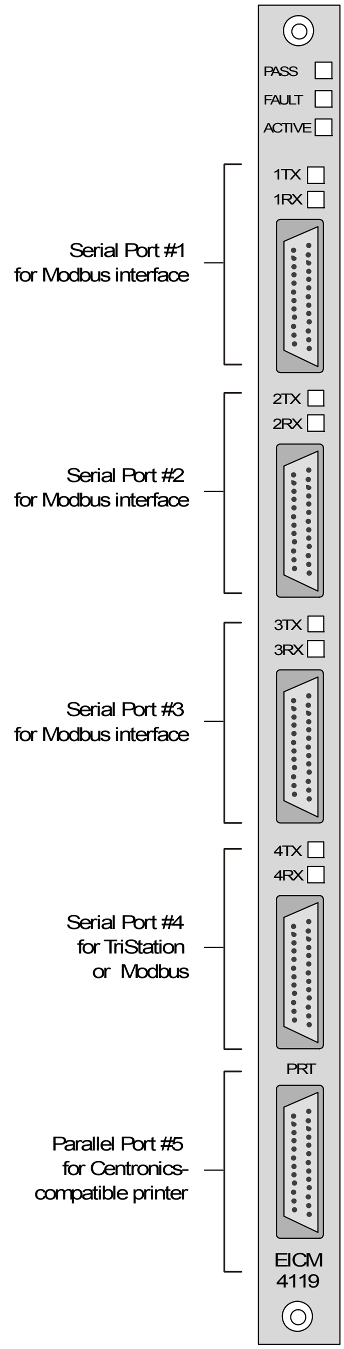


Figure 73 EICM Front Panel

4119 and 4119A Specifications

This table lists the specifications for the Model 4119 and 4119A EICM.

Table 68 4119 and 4119A EICM Specifications

Feature	Specification	
Serial port	RS-232, RS-422 or RS-485, isolated to 500 VDC	
Parallel ports	Centronics, isolated to 500 VDC	
Protocol	TriStation, Modbus	
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	1200, 2400, 9600 or 19,200 baud	
Status indicator: Module status	Pass, Fault, Active	
Status indicator: Port activity	TX (Transmit)—1 per port RX (Receive)—1 per port	
Status indicator: Logic power	< 10 watts	
System version compatibility	Tricon v10.x or earlier systems	

Hiway Interface Module (HIM)

The 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 a Honeywell 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 a Tricon controller. The HIM module allows redundant BNC connections directly to the Data Hiway and has the same functional capacity as up to 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. Although the HIM is not a TMR module, it fully supports the hot-spare feature, which allows online replacement of a faulty module.

For more information, see the *HIM User's Guide*.

For additional information, see Replacing HIMs on page 297.

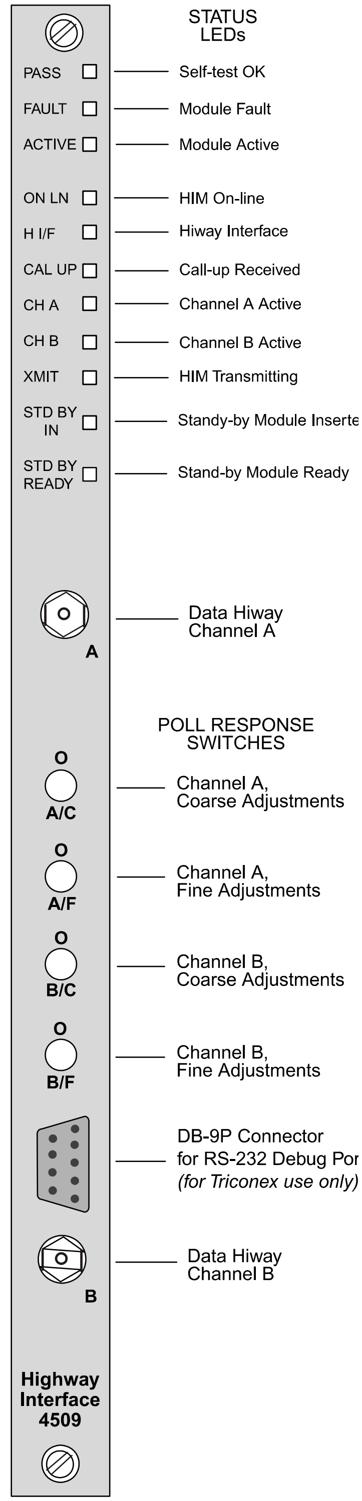


Figure 74 HIM Front Panel

4509 Specifications

This table lists the specifications for the HIM Model 4509.

Table 69 HIM Model 4509 Specifications

Feature	Specification
Data hiway channels	2 isolated (AC-coupled)
Poll response switches	2 per channel
Baud rate	250 Kbaud
Status indicator: Module status	Pass, Fault, Active
Status indicator: HIM on-line	On Ln
Status indicator: Hiway interface	H I/F
Status indicator: Call-up received	Cal Up
Status indicator: Channel A active	Ch A
Status indicator: Channel B active	Ch B
Status indicator: HIM transmitting	Xmit
Status indicator: Standby module inserted	Std By In
Status indicator: Standby module ready	Std By Ready
Power Module load	< 10 watts
Isolation	500 VDC
System version compatibility	Tricon v10.x or earlier systems

Network Communication Module (NCM)

The Network Communication Module (NCM) enables a Tricon controller to communicate with other Tricons and with external devices on an Ethernet network. 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 1131, SOE, OPC Server, and DDE Server) or user-written applications.

The NCMG module has the same functionality as the NCM as well as the ability to synchronize time based on a GPS system.

The NCM is compatible with Ethernet (IEEE 802.3 electrical interface) and operates at speeds up to 10 megabits. The NCM and the host computer can be connected by 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) cabling. For more information, contact the Global Customer Support (GCS) center.

Two NCMs can be placed in one logical slot of the Tricon controller chassis, but they function independently, *not* as hot-spare modules.

The Main Processors typically refresh data on the NCM once per scan.

For additional information, see the *Communication Guide for Tricon v9–v11 Systems* and Replacing NCMs on page 298.

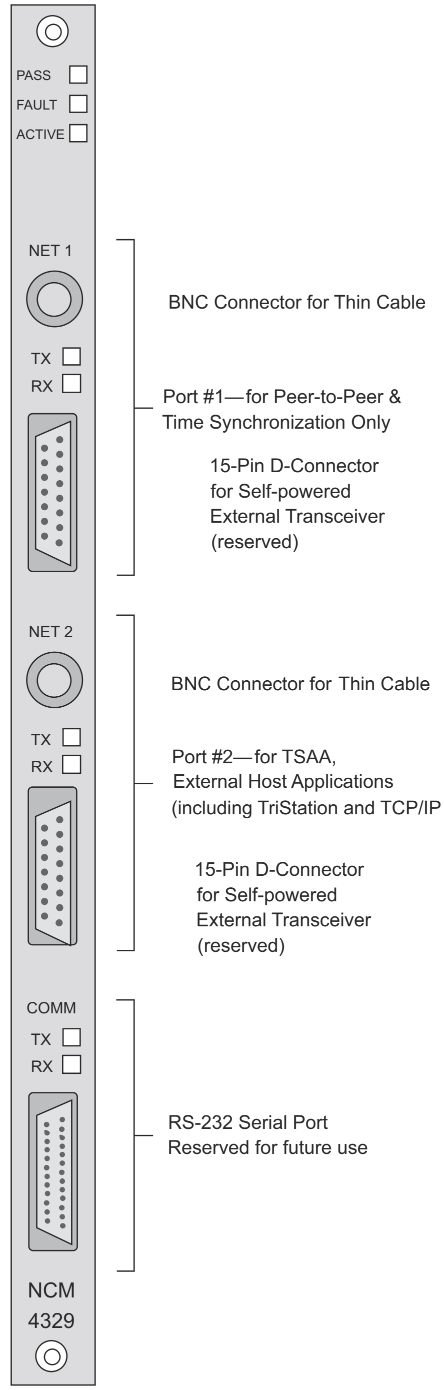


Figure 75 NCM Front Panel

4329 and 4329G Specifications

This table lists the specifications for NCM Models 4329 and 4329G.

Table 70 NCM Model 4329 and 4329G Specifications

Feature	Description
Network ports	Two BNC connectors using RG58 50-ohm thin cable
External transceiver ports	Not used
Serial port	One RS-232-compatible port
Port isolation	500 VDC, network and RS-232 ports
Protocols supported	Peer-to-Peer, Time Synchronization, TriStation, and TSAA
Communication speed	10 megabits
Status indicator: Module status	Pass, Fault, Active
Status indicator: Port activity	TX (Transmit) — 1 per port RX (Receive) — 1 per port
Logic power	< 20 watts
System version compatibility	Tricon v10.x or earlier systems

Safety Manager Module (SMM)

The Safety Manager Module (SMM) acts as an interface between a Tricon controller and a Honeywell Universal Control Network (UCN), which is one of three principal networks of the TDC-3000 Distributed Control System.

The SMM appears to the Honeywell system as a safety node on the UCN and communicates process information at full network data rates for use anywhere on the TDC-3000. The SMM transmits all Tricon controller aliased data (including system variables and system aliases) and diagnostic information to operator workstations in display formats that are familiar to Honeywell operators.

For supported TDC-3000 release levels, contact the Global Customer Support (GCS) center or the Honeywell Tac Center. For more information, see the *SMM User's Guide*.

The SMM includes these features:

- Handles critical I/O points and passes results to the DCS
- Processes Tricon controller alarms and propagates them to user-defined DCS destinations
- Reads/writes aliased data to satisfy DCS requests
- Reads Tricon controller diagnostics for display by the DCS
- Write protection to lock out changes to the Tricon controller from all TDC-3000 sources
- Time Synchronization from the DCS
- Peer-to-Peer communication for plants with many Tricon controllers, each containing an SMM—the DCS can use shared data to alert downstream Tricon controllers of significant process changes
- Sequence of Events—transmits Tricon controller 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

For additional requirements, see Replacing SMMs on page 299.

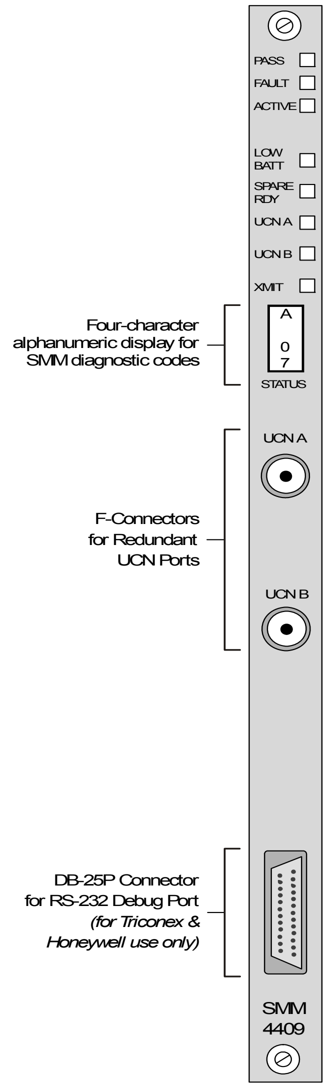


Figure 76 SMM Front Panel

4409 Specifications

This table lists the specifications for the SMM Model 4409.

Table 71 4409 SMM Specifications

Feature	Description
UCN ports	2 isolated, AC-coupled
UCN data rate	5 MB per second
Status indicator: Module status	Pass, Fault, Active
Status indicator: Low Battery	Fault Batt
Status indicator: Hot-spare ready	Spare Rdy
Status indicator: Port activity	UCN A, UCN Port A Active UCN B, UCN Port B Active
Status indicator: SMM transmitting	Xmit
Status indicator: Module node and diagnostic information	Status
Logic power	< 20 watts
Isolation (all ports)	500 VDC
Battery backup for database memory	6 months, typical

Tricon Communication Module (TCM)

The Tricon Communication Module (TCM), which is compatible with only Tricon v10.0 and later systems, allows the Tricon controller to communicate with TriStation 1131, 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 Invensys 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 system 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 system. An alias number is assigned in TriStation.

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

Each Tricon system supports a total of 16 Modbus masters or slaves—this total includes network and serial ports.

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

Each TCM contains two network ports—NET 1 and NET 2. Models 4351, 4351A, 4351B, and 4353 have two copper Ethernet ports. Models 4352, 4352A, 4352B, and 4354 have two fiber-optic Ethernet ports. See Table 74 for a list of supported protocols on the TCM network ports.

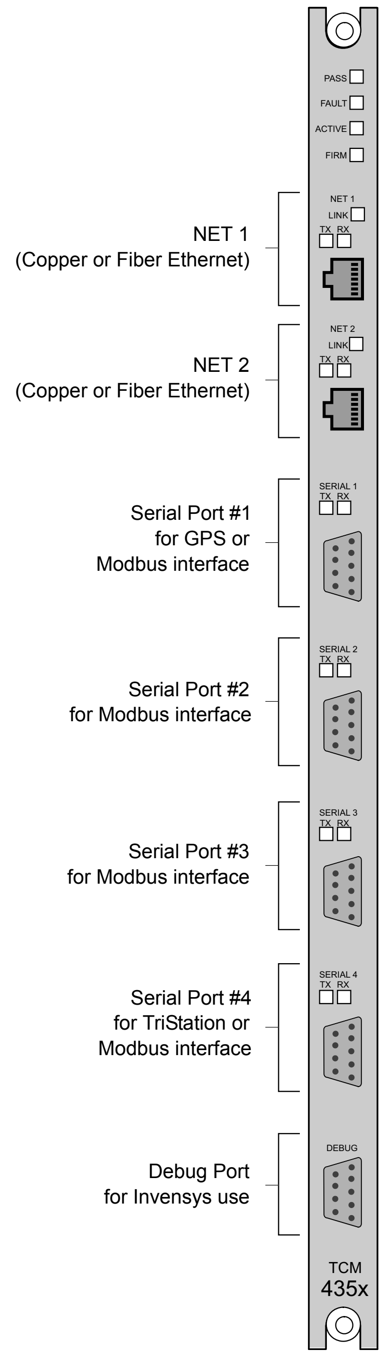


Figure 77 TCM Front Panel

The fiber-optic Ethernet ports on Models 4352, 4352A, 4352B, and 4354 use 1300 nanometer optical transceivers, which are fully compliant with the Optical Performance Requirements of the 100Base-FX version of IEEE 802.3u and ANSI X3.166 - 1990 standards.

A single Tricon v10.x or v11.x system supports a maximum of four TCMs, which must reside in two logical slots located in chassis 1 or chassis 2 only. You cannot install model 4351/4352 TCMs in a system that also has model 4351A/B, 4352A/B, or 4353/4354 TCMs installed, even if they are installed in different chassis.

Additionally, different TCM models cannot be mixed in the same logical slot. Exceptions to this rule are the 4351A/B and 4352A/B modules, where A and B modules with the same model number can be installed in the same slot.

The hot-spare feature is not available for the TCM, though you can replace a faulty TCM while the controller is online.

This table describes TCM model and Tricon system version compatibility.

Table 72 TCM Model and Tricon System Version Compatibility

Tricon System Version	Compatible TCM Models
10.0	4351, 4352
10.1 or later	4351A, 4352A
10.3 or later	4351B, 4352B, 4353, 4354

For complete compatibility information, see the Tricon Product Release Notices available on the Global Customer Support (GCS) center website. For additional information, see the *Communication Guide for Tricon v9–v11 Systems* and Replacing TCMs on page 300.

TCM Specifications

This table lists the specifications for TCM Models 4351, 4351A, 4351B, 4352, 4352A, 4352B, 4353, and 4354.

CAUTION Different TCM models cannot be mixed in the same logical slot. Exceptions to this rule are the 4351A/B and 4352A/B modules, where A and B modules with the same model number can be installed in the same slot.

Table 73 TCM Specifications

Feature	Description	
Serial ports	4, RS-232/RS-485 ports, DB-9 connectors	
Network ports	2, 10/100BaseT Ethernet ports, RJ-45 connectors (Models 4351, 4351A, 4351B, and 4353) 2, fiber-optic mode Ethernet ports, MT-RJ connectors with 62.5/125 um fiber cables (Models 4352, 4352A, 4352B, and 4354)	
Port isolation	500 VDC	
Communication protocols	TriStation, Embedded OPC Server (Models 4353 and 4354), Modbus, Modbus TCP, TCP/IP, SNTP, TSAA (with support for IP Multicast), Trimble GPS, Peer-to-Peer, Triconex 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 (Model 4353 only supports 100 Mbps connections) Fiber Ethernet ports: 100 Mbps Serial ports: up to 115.2 Kbps per port, aggregate data rate of 460.8 Kbps for all four ports	
Status indicators	PASS, FAULT, ACTIVE, FIRM LINK—1 per network port TX (Transmit)—1 per port RX (Receive)—1 per port	
Logic power	< 10 watts	

This table lists the protocols and standards supported on TCM ports for Models 4351, 4351A, 4351B, 4352, 4352A, 4352B, 4353, and 4354.

Table 74 TCM Protocols/Standards

Protocol or Standard	Network Ports (Models 4351 and 4352)	Network Ports (Models 4351A, 4351B, 4352A, and 4352B)	Network Ports (Models 4353 and 4354)	Serial Ports (All Models)
TriStation	NET 2	NET 1, NET 2	NET 1, NET 2	Port 4
TSAA (UDP/IP)	NET 2	NET 1, NET 2	NET 1	—
TSAA with IP Multicast (UDP/IP)	—[a]	NET 1, NET 2 (Models 4351B and 4352B)	NET 1	—
Peer-to-Peer (UDP/IP)	NET 1	NET 1, NET 2	NET 1	—
Peer-to-Peer (DLC)	NET 1	NET 1	NET 1	—
Embedded OPC Server (OPC Data Access and OPC Alarms and Events)	—	—	NET 2	—
Modbus Slave (ASCII or RTU)	—	—	—	Any port
Modbus Master (RTU)	—	—	—	Any port
Modbus Master or Slave (TCP)	NET 2	NET 1, NET 2	NET 1	—
GPS Time Synchronization	—	—	—	Port 1
Triconex Time Synchronization via DLC	NET 1	NET 1	NET 1	—
Triconex Time Synchronization via UDP/IP	NET 1	NET 1, NET 2	NET 1	—
SNTP Triconex Time Synchronization	NET 2	NET 1, NET 2	NET 1, NET 2	—
Network Printing using Jet Direct	NET 2	NET 1, NET 2	NET 1	—

a. — means the protocol or standard is not supported on these ports.

Fiber-Optic Cables

If you are installing a TCM with fiber connectors (Model 4352, 4352A, 4352B, or 4354), you will need to provide your own fiber-optic cables, because Invensys does not sell them.

The fiber cable you purchase should have these qualities:

- be a multimode 62.5/125 um cable
- have a maximum length of 1.24 miles (2 kilometers)
- comply with ANSI/TIA/EIA-568-B.3 standards

Unified Communication Module (UCM)

The Unified Communication Module (UCM) acts as an interface between a Tricon controller and the Foxboro Evo™ Process Automation System. Appearing as a control station on the mesh network, the UCM transmits Tricon controller aliased data as a peer on the mesh network. The Field Device System Integrator (FDSI) in the UCM is also displayed on the control station. For more information, see the *Field Device System Integrators (FBM230/231/232/233) User's Guide* (B0700AH).

The UCM is compatible with only Tricon v11.x systems that use the Model 8120E Enhanced Performance Main Chassis and the Model 3009 Main Processor. A single Tricon controller supports up to two UCMs, which must reside in the COM 2 slot of the Model 8120E Enhanced Performance Main Chassis. You cannot install the UCM in the COM 1 slot.

Each UCM contains two serial ports, four fiber-optic Ethernet network ports, one Infrared port, one Time Synchronization port, and one debug port (for Invensys use).

The serial ports are uniquely addressed and are mounted on the backplane of the Model 8120E Enhanced Performance Main Chassis.

Each serial port can be used for Modbus or TriStation communication at speeds up to 115 Kbps per port. Serial port 1 supports the Modbus interface and serial port 2 supports either the Modbus or the TriStation interface.

The serial ports can be configured as a Modbus master or slave. Each Tricon controller supports a total of 18 Modbus masters or slaves, this total includes network ports and serial ports.

Programs for the Tricon system 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 system. An alias number is assigned in TriStation.

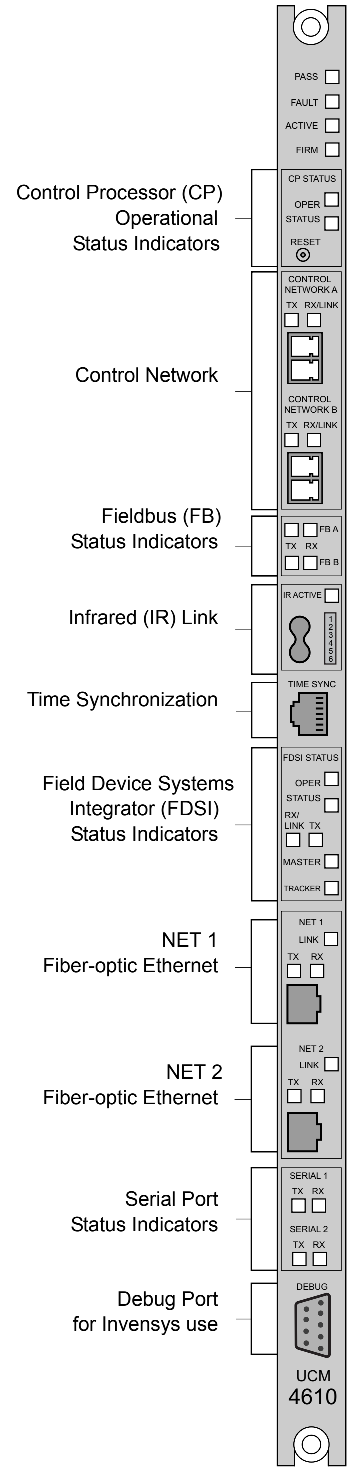


Figure 78 UCM Front Panel

Any standard Modbus device can communicate with the Tricon controller through the UCM, provided that aliases are assigned to the Tricon variables. Alias numbers must also be used when host computers access the Tricon system through other communication modules, such as the TCM.

Each UCM contains four fiber-optic Ethernet network ports. Two of the network ports—NET 1 and NET 2—are for safety network connectivity. See Table 76 for a list of supported protocols on the UCM safety network ports. The other two ports are for control network connectivity. For more information about the control network ports, see the *Field Control Processor 270 (FCP270) User's Guide* (B0700AR).

The fiber-optic Ethernet ports on the Model 4610 UCM use 1300 nanometer optical transceivers, which are fully compliant with the Optical Performance Requirements of the 100Base-FX version of IEEE 802.3u and ANSI X3.166 - 1990 standards.

The Infrared (IR) port is used to assign or read the Control Processor Letterbug identifier—an alphanumeric string that identifies a station in a Foxboro Evo System. For more information, see the *Letterbug Configurator User's Guide* (B0700AY).

The Time Synchronization port can be used to provide timestamps through an external time source for data reporting from the Control Processor. For more information, see the *Time Synchronization User's Guide* (B0700AQ).

Two UCMs form a redundant pair for control communications on the mesh network, and an independent pair for communications on the safety network. You can replace a faulty module while the controller is online.

Related documents:

- *Field Control Processor 270 (FCP270) User's Guide* (B0700AR)
- *Field Device System Integrators (FBM230/231/232/233) User's Guide* (B0700AH)
- *Letterbug Configurator User's Guide* (B0700AY)
- *Time Synchronization User's Guide* (B0700AQ)

This figure depicts a typical Tricon UCM and Foxboro Evo Control System interface.

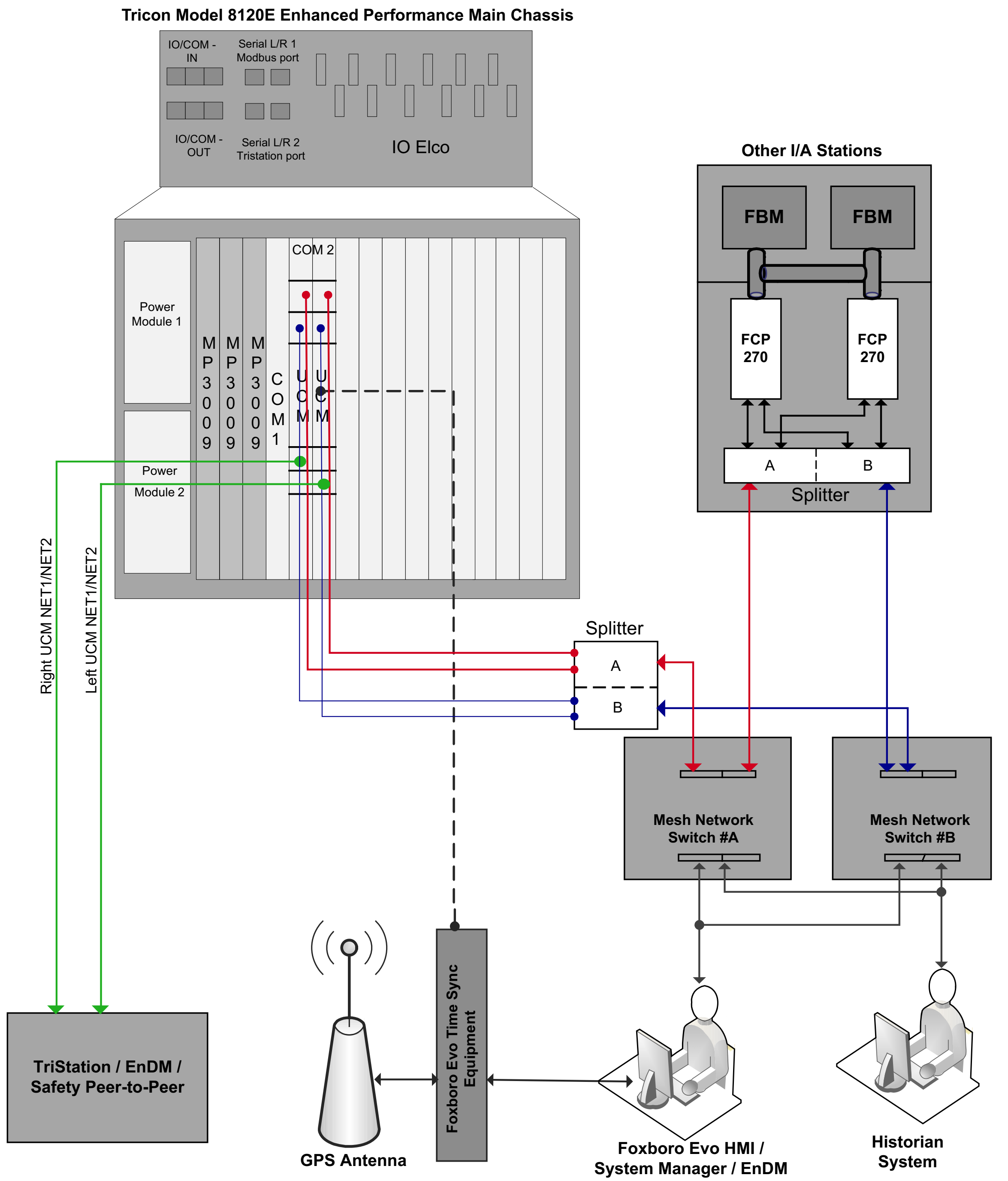


Figure 79 Tricon UCM and Foxboro Evo Control System Interface

For more information, see UCM Protocols/Standards on Safety Network Ports on page 207.

UCM Specifications

This table lists the specifications for the Model 4610 UCM.

Table 75 UCM Specifications

Feature	Description	
Serial ports	2, RS-232/RS-485 ports, DB-9 connectors	
Network ports	2, fiber-optic mode Ethernet ports, LC connectors 2, fiber-optic mode Ethernet ports, MT-RJ connectors	
Port isolation	500 VDC	
Communication protocols	TriStation, Modbus, Modbus TCP, TCP/IP, SNTP, TSAA (with support for IP Multicast), Peer-to-Peer, Triconex 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	Fiber Ethernet ports: 100 Mbps Serial ports: up to 115 Kbps per port, aggregate data rate of 230 Kbps for both ports	
Status indicators:		
Module status	Pass, Fault, Active, Firm	
Control Processor (CP) status	Operational Status	
Field Device Systems Integrator (FDSI) status	Operational Status, Link/Act, Master, Tracker	
Port activity	LINK—1 per network port TX (Transmit)—1 per port RX (Receive)—1 per port	
Logic power	< 30 watts	

This table lists the protocols and standards supported on UCM safety network ports.

Table 76 UCM Protocols/Standards on Safety Network Ports

Protocol or Standard	Network Ports	Serial Ports
TriStation	NET 1, NET 2	Port 2
TSAA (UDP/IP)	NET 1, NET 2	—[a]
TSAA with IP Multicast (UDP/IP)	NET 1, NET 2	—
Peer-to-Peer (UDP/IP)	NET 1, NET 2	—
Modbus Slave (ASCII or RTU)	—	Any port
Modbus Master (RTU)	—	Any port
Modbus Master or Slave (TCP)	NET 1, NET 2	—
Triconex Time Synchronization via UDP/IP	NET 1, NET2	—
SNTP Triconex Time Synchronization	NET 1, NET2	—
Network Printing using Jet Direct	NET 1, NET2	—

a. — means the protocol or standard is not supported on these ports.

For information about the control network ports, see the *Field Control Processor 270 (FCP270) User's Guide* (B0700AR).

Fiber-Optic Cables

This section contains information about the fiber-optic cables used for the safety network ports and the control network ports.

Fiber-Optic Cables for Safety Network Ports

You will need to provide your own fiber-optic cables for the safety network ports, because Invensys does not sell them.

The fiber-optic cables you purchase should have these qualities:

- be a multimode 62.5/125 um cable
- have a maximum length of 1.24 miles (2 kilometers)
- comply with ANSI/TIA/EIA-568-B.3 standards

Fiber-Optic Cables for Control Network Ports

For information about fiber-optic cables for the control network ports, see the *Field Control Processor 270 (FCP270) User's Guide* (B0700AR).

3

Installation and Maintenance

System Configuration

This section includes specifications for a Tricon system, which includes a Main Chassis and additional Expansion or Remote Expansion (RXM) Chassis, as required.

Topics include:

Configuration Specifications

This table includes specifications for determining the number and types of components that can be installed in a Tricon high-density and low-density system. A low-density system uses a pre-v9 chassis, which means fewer I/O modules can be included in a system.

Table 77 Configuration Guidelines

Component	High-Density Configuration	Low-Density Configuration
Maximum number of chassis	15	15
Maximum number of I/O and communication modules	118 • Model 8110 Main Chassis = 6 modules with hot-spares and 1 communication module • Model 8120E Enhanced Performance Main Chassis = 5 modules with hot-spares and 2 communication modules (one with hot-spare and one without hot-spare) • Expansion Chassis = 8 modules with hot-spares • RXM Chassis = 6 modules with hot-spares	76 • Main Chassis = 4 modules with hot-spares • Expansion Chassis = 5 modules with hot-spares • RXM Chassis = 4 modules with hot-spares
Communication modules	Must be installed in the Main Chassis or Chassis 2, except for UCMs, which must be installed in the Model 8120E Enhanced Performance Main Chassis. Chassis 2 must be an Expansion or primary RXM Chassis.	
Maximum I/O Bus length	100 feet (30 meters)	100 feet (30 meters)
Analog Input points (includes Thermocouple Input and Pulse Totalizer Input points)	1,024	1,024
Analog Output points	512	512
Digital Input points	2,048	2,048

Table 77 Configuration Guidelines *(continued)*

Component	High-Density Configuration	Low-Density Configuration
Digital Output points	2,048	2,048
Pulse Input points	80	80

Communication Configuration

This table describes rules and guidelines for using communication modules. For more information, including installation and configuration instructions, see the *Communication Guide for Tricon v9–v11 Systems*.

Table 78 Communication Rules

Component	Description
Chassis	At least one communication module (TCM, UCM, ACM, EICM, or NCM) must be included in the Main Chassis or in Chassis 2, because these modules enable the TriStation PC to communicate with the Tricon controller. However, UCMs can be installed only in the Main Chassis. • If communication modules are housed in Chassis 2, this chassis must be an I/O Expansion Chassis or a primary RXM Chassis that is connected directly to the Main Chassis using I/O communication cables (Model 9001) rather than standard I/O bus cables. • You cannot install an NCM in a Tricon system that also has a TCM and/or a UCM. • You cannot install an EICM in a Tricon system that also has a TCM and/or a UCM. • You cannot install an ACM in a Tricon system that also has a UCM. • You cannot install more than four communication modules in a Tricon system.
COM Slot	In a Model 8110 Main Chassis, the COM 1 slot can be used only for a TCM, EICM, or NCM. In a Model 8120E Enhanced Performance Main Chassis, the COM 1 slot can be used only for a TCM, and the COM 2 slot can be used only for UCMs.
TCM	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. Model 4351A, 4351B, 4352A, and 4352B TCMs cannot be installed into a system with Model 4351 or 4352 TCMs, even if they are installed in different chassis.
UCM	One logical slot is available for UCMs. Matched pairs of UCMs can be installed in the left and right positions of the COM 2 slot in only the Model 8120E Enhanced Performance Main Chassis. Up to one additional slot is available for TCMs, so you will be limited to one TCM if you install it in the COM 1 slot.
NCM	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 Slots 6 and 7 in the Main Chassis, and Peer-to-Peer cannot be used.
EICM and ACM	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.
HIM	Up to two logical slots can be configured for HIMs. Both slots must be in the Main Chassis.
SMM	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.

Planning Power for a Tricon System

The Tricon Power Modules provide adequate support for most controller configurations; however, limitations may apply to a Main Chassis containing multiple communication modules because these modules consume more power than others. This section explains how to determine the logic power consumption and cooling requirements of a Tricon controller.

Data in this section is based on a fault condition where only one of the redundant Power Modules is operational. Under normal operating conditions, both Power Modules share the load.

WARNING Do not use the Model 8312 Power Module in Tricon systems that are located in hazardous locations and must meet ATEX requirements. If you have 230 V line voltage and your system must meet ATEX requirements, use the Model 8311 24 VDC Power Module along with any ATEX-certified 24 VDC power supply, such as one from Phoenix Contact—part number QUINT-PS-100-240AC/24DC/10/EX.

Determining Logic Power for Tricon Controller Chassis

Logic power refers to the number and kinds of modules that the Power Modules of a chassis can support without being overloaded. Table 79 on page 214 identifies the logic power for each module. The total cannot exceed 175 watts, because each Power Module supplies a maximum of 175 watts at the rated maximum temperature of 140° F (60° C).

This calculation is based on the assumption that only one of the redundant Power Modules is operational. Under normal operating conditions, both Power Modules share the load and make more power available at all temperatures. This load-sharing allows the Power Modules to normally run at less than 50 percent of their rated maximum output, thereby significantly increasing their service lifetime.

CAUTION Avoid putting multiple high-power I/O modules into a Main Chassis. Each Main Chassis must house three Main Processors and a communication module which means multiple high-power I/O modules could exceed logic power limitations.

To determine logic power, add:

- logic power for all primary modules
- logic power for all hot-spare modules

Determining Cooling Requirements

Cooling requirements are determined by calculating the heat load dissipated by all the Tricon modules in the system. Table 79 on page 214 identifies logic and field power usage for each module. For maximum reliability of the Tricon controller, the ambient temperature must be below 104° F (40° C). Please contact Invensys for further assistance with cooling needs.

To determine cooling requirements, add:

- logic power and field power for all primary modules
- logic power and field power for all hot-spare modules

Table 79 Logic and Field Power of Tricon Modules

Type	Model No.	Maximum Logic Power (Watts)[a]	Maximum Field Power Primary/Spare (Watts, Typical)[b]
Main Processor	3009 3008 3006/3007	14 10 15	—
Power Modules	8310, 8311, 8312	—	30 (15)[c]
RXM Modules	420x, 421x	5	—
Analog Input	370x/A	10	Negligible
Analog Input (High-Density)	3704E	10	Negligible
Analog Input (Isolated)	3703E	15	Negligible
Analog Input	3720, 3721	12	Negligible
Analog Output	3805E/H	15	22 (6) / 22 (6)
Analog Output	3806E	15	27 (12) / 27 (12)
Analog Output, Bipolar	3807	20	27 (12) / 27 (12)
Digital Input (High-Density)	3504E	10	Negligible
Digital Input (Single)	3564	10	39 (16) / 39 (16)
Digital Input (TMR)	350xE/T	10	96 (48) / 96 (48)
Digital Output (AC)	360xE/T	10	112 (20) / 32 (10)
Digital Output (DC)	360xE/T	10	112 (20) / 32 (10)
Digital Output (Dual)	3664	10	52 (16) / 20 (8)
Digital Output (Supervised, 16 points)	3624	10	32 (16) / Negligible
Digital Output (Supervised, 8 points)	361xE	10	26 (8) / 10 (4)
Digital Output (Supervised or Non-Supervised, 32 points)	3625/A	13	40
Pulse Input	351x	20	Negligible
Pulse Totalizer Input	3515	10	96 (24) / 96 (24)
Relay Output	3636R/T	30	Negligible
Thermocouple (Isolated)	3708E	15	Negligible
Thermocouple (Non-Isolated)	3706A	10	Negligible

Table 79 Logic and Field Power of Tricon Modules *(continued)*

Type	Model No.	Maximum Logic Power (Watts)[a]	Maximum Field Power Primary/Spare (Watts, Typical)[b]
HART Analog Input Interface	2770H	5	Negligible
HART Analog Output Interface	2870H	5	Negligible
Advanced Communication Module	4609	15	—
Enhanced Intelligent Communication Module	4119, 4119A	10	—
Hiway Interface Module	4509	10	—
Network Communication Module	4329, 4329G	20	—
Safety Manager Module	4409	20	—
Tricon Communication Module	4351, 4351A, 4351B, 4352, 4352A, 4352B, 4353, 4354	7	—
Unified Communication Module	4610	30	—

a. To convert watts to British thermal units, use the formula: BTU = watts x 3.414.

b. Hot-spare Digital Output Modules consume less field power than primary Digital Output Modules.

c. Represents power loss internal to the Power Modules.

Security Considerations

When using the Tricon in your environment, you should assess the security threats to your system within the context of the overall plant architecture, any applicable standards, industry best practices, and your corporate practices. This section contains guidelines for securing file backups, access to controllers, networks, and project files.

Topics include:

Workstation and File Security

To reduce the security risks associated with the TriStation 1131 PC and project file, follow these guidelines:

- Enable Enhanced Security, which authenticates the user against the Windows®-based PC or domain. If you use a domain controller/Active Directory, follow Microsoft's recommended practices for security.
- Create a user account for each person who will be working with the TriStation 1131 project and do not allow sharing of user accounts. Periodically review user accounts and their roles and privileges to ensure compliance with your organization's policy.
- Back up the project file (.pt2) regularly and store it in a secure, separate, non-shared location.
- Store original and backup copies of certificates and private keys in a secure, separate, non-shared location.
- Disable unused USB ports.
- Install OS patches and anti-virus software updates on the TriStation PC, as they are released.
- Periodically collect and review the following items for unusual activity related to the controller or the TriStation 1131 PC:
  - Logs in the Enhanced Diagnostic Monitor
  - Enhanced Security Mode logs in the Event Viewer on the TriStation 1131 PC

Controller Security

To reduce the security risks associated with the Triconex controller, follow these guidelines:

- Use the Access Control List in the TriStation 1131 software to control access to TCM or UCM resources. For more information, see the *TriStation 1131 Developer's Guide*.
- Design your control application so that it reads and reports the position of the keyswitch to the operator.

- Keep the controller in Run mode or Remote mode.
- Implement organizational procedures to control access to the key that unlocks the cabinet/enclosure that contains the Triconex controller. Consider keeping a log of the personnel who are granted physical access to the Triconex controller.

Network Security

This section includes guidelines for securing networks.

Open Network

To reduce the security risks associated with an open network, follow these guidelines:

- Secure the host PCs (that run Modbus, TSAA, or OPC clients to communicate with the Tricon controller) by keeping the user authentication strong and the anti-virus software up-to-date.
- Limit writes to the Tricon controller by using organizationally defined policies and by controlling access to the keyswitch.
- Physically isolate (sometimes referred to as an air gap) the Tricon controller and its networks from the rest of the networks in your plant or facility.
- Limit network traffic by using external firewalls.
- Use redundant TCMs/UCMs with network redundancy to external clients.

Safety Peer-to-Peer Network

To reduce the security risks associated with a safety peer-to-peer network, follow these guidelines:

- Configure network switches and routers in a manner that limits the addition of unauthorized network nodes.
- Use external firewalls to limit the network traffic to only safety peer-to-peer network traffic.
- Use TCMs that are dedicated to the safety peer-to-peer network.
- Use redundant TCMs/UCMs with network redundancy to other Tricon controllers.

Installation Guidelines

This section includes installation guidelines for the Tricon controller.

Topics include:

General Installation Guidelines

Due to the critical applications the Tricon controller is typically used in, it has been designed to operate under worst-case conditions in the harsh environments typically found in industrial environments.

To ensure adequate operational margins are maintained even under these worst-case conditions, the Tricon controller should be installed in a controlled environment per the general guidelines contained in: IEC 61131, Part 4, Programmable controllers, User Guidelines

Section 7 of this standard includes checklists to help control the following environmental conditions:

- Temperature
- Contaminants
- Shock and vibration
- Electromagnetic interference

Typical guidelines include:

- Locate the Tricon controller away from obvious sources of heat: space heaters, solar radiation, etc.
- Locate or isolate the Tricon controller from obvious sources of corrosive gases or dust.
- Locate or isolate the Tricon controller from obvious sources of shocks or periodic vibrations: rotating machinery, engines, compressors, presses, etc.
- Locate or isolate the Tricon controller from obvious sources of electromagnetic interference: large motors or motor controllers, power converters, radio controlled equipment, welding equipment, etc.

Electrostatic Discharge Recommendations

An electrostatic discharge into the controller keyswitch that is above the limits published in Table 2 General Environmental and EMC Specifications for the Tricon Controller (page 38), can cause a reset of the installed Main Processors if the keyswitch plate screws and keyswitch nut are loose. To reduce the chances of this occurring, do the following:

- Inspect the keyswitch plate screws (2) and hand-tool tighten any that are loose. This can be done while the controller is operational.
- Inspect the keyswitch nut and tighten it if it is loose. This should be done when the controlled process is offline—for example, during a normally scheduled maintenance period.
- Always use good electrostatic discharge prevention practices when contacting exposed metal surfaces.

Plant Power and Grounding

All plant and control room power distribution and safety grounding (protective earthing) must be done per the applicable national electric codes. Typical examples include:

IEC 60364, Electrical Installations of Buildings

National Fire Protection Association, 2002 Edition of the National Electrical Code Handbook

For new construction, or where simple retrofits are feasible, the plant and/or control room safety grounding system should employ a supplemental Zero Reference Signal Plane or Grid (ZRSG). Installation of such a system for the plant or control room is not required for a successful Tricon application, but does represent modern best industry practice and should be followed wherever possible. Even when not implemented at the plant or control room level, the concepts of a modern ZRSG should be included in the Tricon cabinet and interconnecting cable routing. The ZRSG implementation should be extended to include all equipment racks and interconnecting cable paths: metal conduits, cable trays, wireways, etc. Detailed installation guidelines can be found in:

EPRI TR- 102400, Volume 2, Handbook for Electromagnetic Compatibility of Digital Equipment in Power Plants, Implementation Guide for EMI Control

IEC 61000, Part 5, Section 2, Electromagnetic compatibility (EMC), Installation and mitigation guidelines, Earthing and cabling

IEEE Std 1100-1999, IEEE Recommended Practice for Powering and Grounding Electronic Equipment

Tricon Field, Power, and Ground Wiring

All Tricon power distribution and safety grounding (protective earthing) must be done per the applicable national electric codes, plus the information contained in this manual. Typical examples include:

IEC 60364, Electrical Installations of Buildings

National Fire Protection Association, 2002 Edition of the National Electrical Code Handbook

Typically, the Tricon controller will be installed in an equipment rack or cabinet located in a control room. All wiring internal to that cabinet and leading to/from that cabinet should be segregated into different types and bundled accordingly. For example:

- Measurement signals—typically very sensitive, low-voltage signals from sensors: RTDs, TCs, speed or flow sensors, and so on. Invensys recommends that these signals always use shielded twisted-pair cabling.
- Measurement and low power control signals—typically sensitive, low-voltage signals to/from intelligent sensors or control devices: 4-20 mA loops, 24 VDC discrete signals, and so on. Invensys recommends that these signals always use twisted-pair cabling.
- High-power control signals and conditioned power distribution—typically not sensitive, higher voltage signals: 48-120 volt discrete signals, 24-120 VDC I/O power distribution, and so on. Invensys recommends that these signals always use twisted-pair cabling.
- Input coming power and miscellaneous circuits—typically noisy, higher power circuits: 115 VAC discrete signals, AC power distribution, cabinet fans or lights, and so on. Invensys recommends that these signals always use twisted-pair cabling.

All cable routing and installation should be done to minimize EMI. Detailed guidelines can be found in:

EPRI TR- 102400, Volume 2, Handbook for Electromagnetic Compatibility of Digital Equipment in Power Plants, Implementation Guide for EMI Control

IEC 61000-5-2, Electromagnetic compatibility (EMC), Installation and mitigation guidelines, Earthing and cabling

IEEE Std 1100-1999, IEEE Recommended Practice for Powering and Grounding Electronic Equipment

Typical guidelines include the following:

- Use ferrous metal cabinets, cable trays, and conduits.
- When the RS-485 I/O Bus is used to connect to a remote Expansion Chassis, the I/O Bus cables must be routed in dedicated metallic conduit, or equivalently isolated from other noise sources.
- Electrically bond all surfaces of the cabinet and its contents together with multiple conductive metal strapping, not simple wire. Particular attention should be paid to doors and removable panels. In turn, the cabinet must be bonded to the control room or plant safety ground system or ZRSG.

- Routinely use twisted pair cabling; use shielded twisted pair cabling for all sensitive signals. Allow the minimum amount of un-twisted wire that accommodates connection.
- Signals of different types should never be bundled together.
- Bundles of different types should be separated by a minimum of 10 times the largest lead diameter.
- Bundles of different types of signals should only cross at right angles to each other.
- All wires and/or bundles should be routed along the ZRSG; for example, along the cabinet walls, within a cable tray or conduit, along building steel or the floor ground grid.
- Where an inline filter or power conditioning is used, the input and output leads should never be routed in the same bundle.
- Maintain shield continuity and ensure that shield leads are not broken. Allow the minimum amount of unshielded wire that accommodates connection. Terminate the shield at both ends and use capacitive coupling at one end if potential ground loops are suspected.
- Where ferrites or line filters are to be installed on signals or cables entering or leaving the cabinet, they must be installed as close to the cabinet egress point as possible. Cables must be routed to minimize coupling between the filtered and non-filtered signals. The non-filtered wire lengths in the cabinet must be minimized to the maximum extent possible.

CAUTION For applications with uninterruptible power supplies (UPS) that use AC inverters, Invensys recommends that you install an AC line filter at the cabinet power entry point for each AC power source. Select the size of the filter based on the worst-case AC load in the cabinet, and install the filter according to guidelines in Tricon Field, Power, and Ground Wiring on page 220. Suitable filters include the Schaffner FN 350 series, or the Corcom SK series.

WARNING Always turn field power off before removing ELCO connectors from the backplane of the Tricon chassis. Dangerous voltage may be present when field power is on and can cause damage to the Tricon backplane and termination panel.

Application-Specific Installation Guidelines

The following guidelines apply when installing the Tricon controller in these application-specific locations:

- Class 1 Division 2 Hazardous Locations on page 222
- Zone 2 European Hazardous Locations on page 225
- European Union Applications on page 227
- Marine Environment Applications on page 227
- Fire and Gas Detection Applications on page 228
- Functional Safety Applications on page 228
- Nuclear 1E Applications on page 228
- Semiconductor Manufacturing - Health and Safety Applications on page 229

Class 1 Division 2 Hazardous Locations

For North American hazardous location applications, the Tricon controller and associated equipment must be mounted in an enclosure that provides protection from fire and from personal injury resulting from access to live parts. The enclosure must require access via a tool, and if non-metallic, have the appropriate flammability rating.

The chassis alarm contacts must not be used in hazardous locations.

The replacement of batteries, fuses, I/O Modules, Main Processors, Power Modules, Communication Modules, or I/O Interface cables must not be attempted unless the area is known to be free of ignitable gas concentrations.

All communication cabling connected to the Main Processor and Communication modules must be nonincendive as described in Appendix D, Nonincendive Circuit Parameters. Communication cabling that extends through a hazardous area must be certified as being nonincendive. Any signal going to or through a hazardous atmosphere must use hazardous location protection, such as an IS Barrier.

In North America, the field signals used with ATEX-compliant external termination panels are certified for Class 1, Division 2, Groups C and D.

Only these components, which are approved for use in Class 1 Division 2 hazardous locations, can be used:

- 2770H, HART Analog Input Interface Module
- 2870H, HART Analog Output Interface Module
- 3006, Main Processor
- 3008, Main Processor
- 3502E, 48 V Digital Input Module
- 3503E, 24 V Digital Input Module
- 3504E, 24 V High-Density Digital Input Module

- 3505E, 24 V Low Threshold Digital Input Module
- 3511, Pulse Input Module
- 3515, Pulse Totalizer Module
- 3564, Single 24 V Digital Input Module
- 3604E, 24 VDC Digital Output Module
- 3607E, 48 VDC Digital Output Module
- 3614E, 24 VDC Supervised Digital Output Module
- 3615E, 24 VDC Low Power Supervised Digital Output Module
- 3617E, 48 VDC Supervised Digital Output Module
- 3624, 24 VDC Supervised Digital Output Module
- 3625/A, 24 VDC Supervised/Non-Supervised Digital Output Module
- 3664, 3674; 24 V Dual Digital Output Module
- 3700A, 0-5 V Analog Input Module
- 3701, 0-10 V Analog Input Module
- 3703E, Isolated Analog Input Module
- 3704E, 0-5/0-10 VDC Analog Input
- 3706A, Thermocouple Input Module
- 3708E, Isolated Thermocouple Input Module
- 3720, 3721; Analog Input Module
- 3805E/H, Analog Output Module
- 3806E, High-Current Analog Output Module
- 3807, Bipolar Analog Output Module
- 4119A, Enhanced Intelligent Communication Module
- 4200, 4201; Fiber Optic Remote Extender Module
- 4210, 4211; Single Mode Fiber Optic Remote Extender Module
- 4329, 4329G; Network Communication Module
- 4351, 4351A, 4351B, 4352, 4352A, 4352B, 4353, 4354; Tricon Communication Module
- 4409, Safety Manager Module
- 4509, Highway Interface Module
- 4609, Advanced Communication Module
- 8110, Main Chassis
- 8112, RXM Chassis
- 8111, Expansion Chassis
- 8121, Enhanced Low-Density Expansion Chassis
- 8310, 120 V Power Module

- 8311, 24 VDC Power Module
- 8312, 230 VAC Power Module
- v9–v11 External Termination Panels compatible with the above I/O modules

Note Conformal coated versions of the products listed above also are approved for use in Class 1 Division 2 hazardous locations. The model numbers of these components have a "C" suffix.

WARNING You must take additional explosion protection measures for field circuits when the field apparatus are in a hazardous area.

Zone 2 European Hazardous Locations

For European (ATEX) hazardous location applications, the Tricon controller and associated equipment must be installed in an enclosure that provides an IP54 minimum degree of protection per the requirements of EN 60529, Specification of protection provided by enclosures (IP Code). Simply stated, the enclosure must provide protection against dust and splashing water.

Additionally, the enclosure must meet the applicable requirements of EN 60079-15 or EN 50021. The following points must be taken into account:

- Mechanical strength
- Non-metallic enclosures and non-metallic parts of enclosures
- Earthing or equipotential bonding connection facilities

The following warning label must be placed on the outside of the enclosure:

DO NOT REMOVE OR REPLACE MODULES OR CABLES WHILE ENERGIZED UNLESS THE AREA IS KNOWN TO BE FREE OF IGNITABLE GAS CONCENTRATIONS.

All connecting screws must be securely tightened, so that loosening and separating are prevented.

The chassis alarm contacts must not be used in hazardous locations.

Male ELCO connectors must have a gasket installed, and it must be replaced before the end of its five-year life span. (Invensys part number 3000793-001 is a kit containing 25 gaskets.)

The replacement of batteries, fuses, I/O Modules, Main Processors, Power Modules, Communication Modules, or I/O Interface cables must not be attempted unless the area is known to be free of ignitable gas concentrations.

All communication cabling connected to the Main Processor and Communication modules must be nonincendive as described in Appendix D, Nonincendive Circuit Parameters. Communication cabling that extends through a hazardous area must be certified as being nonincendive.

Only these components, which are approved for use in Zone 2 hazardous locations, can be used:

- 2770H, HART Analog Input Interface Module
- 2870H, HART Analog Output Interface Module
- 3008, Main Processor
- 3503E, 24 V Digital Input Module
- 3504E, 24 V High-Density Digital Input Module
- 3505E, 24 V Low Threshold Digital Input Module
- 3511 Pulse Input Module
- 3515, Pulse Totalizer Module
- 3564, Single 24 V Digital Input Module
- 3604E, 24 VDC Digital Output Module

- 3624, 24 VDC Supervised Digital Output Module
- 3625/A, 24 VDC Supervised/Non-Supervised Digital Output Module
- 3664, 3674; 24 V Dual Digital Output Module
- 3700A, 0-5 V Analog Input Module
- 3703E, Isolated Analog Input Module
- 3706A, Thermocouple Input Module
- 3708E, Isolated Thermocouple Input Module
- 3720, 3721; Analog Input Module
- 3805E/H, Analog Output Module
- 3806E, High-Current Analog Output Module
- 3807, Bipolar Analog Output Module
- 4119A, Enhanced Intelligent Communication Module
- 4200, 4201; Fiber Optic Remote Extender Module
- 4210, 4211; Single Mode Fiber Optic Remote Extender Module
- 4351, 4351A, 4351B, 4352, 4352A, 4352B, 4353, 4354; Tricon Communication Module
- 4329, 4329G; Network Communication Module
- 4409, Safety Manager Module
- 4509, Highway Interface Module
- 4609, Advanced Communication Module
- 8110ATEX, Main Chassis
- 8111ATEX, Expansion Chassis
- 8112ATEX, RXM Chassis
- 8121, Enhanced Low-Density Expansion Chassis
- 8310, 120 V Power Module
- 8311, 24 VDC Power Module
- v9–v11 External Termination Panels compatible with the above I/O modules

Note Conformal coated versions of the products listed above also are approved for use in Zone 2 hazardous locations. The model numbers of these components have a “C” suffix.

European Union Applications

WARNING

- You must take additional explosion protection measures for field circuits when the field apparatus are in a hazardous area.
- When the Model 8121 Enhanced Low-Density Expansion Chassis is used in Zone 2 hazardous locations, the signal ground and the chassis ground must be bridged together.
- In Zone 2 hazardous locations, an isolator must be used with the Model 2870H HART Analog Output Interface Module.

To ensure compliance with European Low Voltage and EMC Directives, follow these installation guidelines:

- Any Tricon chassis containing an SMM or SRXM must be installed in an EMI/RFI shielded cabinet, and EMI/RFI filtering must be installed on all cables entering or leaving those cabinets. All other chassis can be installed in standard metal enclosures.
- Field power supplies must be approved for use in safety extra-low-voltage (SELV) circuits according to the requirements of EN 61010-1, Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements.

Acceptable EMI/RFI cabinets and cable filters include the following:

- Rittal PS or TS cabinet with EMI/RFI shielding (for example, TS8), or equivalent
- Fair-Rite Products snap-on ferrite suppression cores (type 43 material) or equivalent (a separate snap-on filter is required for each cable entering or leaving the EMI/RFI cabinet)

Marine Environment Applications

To ensure compliance with Bureau Veritas Rules for the Classification of Steel Ships, follow and be aware of these installation guidelines and limitations:

- Bureau Veritas approval is valid for ships intended to be granted with the following additional class notations: AUT-UMS, AUT-CCS, AUT-PORT, and AUT-IMS.
- Bureau Veritas Environmental Category, EC Code is: 31C.
- The equipment must be installed in a metallic enclosure with a metallic or glass front door and connected with an EMI Filter (Corcom part number 20ERK1, Corcom part number 20VSK6, or equivalent) on the field power lines.
- The equipment fulfills the EMC requirements for installation in General Power Distribution Zone.
- Each application and configuration must be submitted to the Society's examination prior to fitting on board.
- The equipment, once installed on board ship, must be tested in accordance with the above referred Regulations under the supervision of a Society's Surveyor.

- Only hardware and software successfully tested together in compliance with Bureau Veritas Rules for the Classification of Steel Ships and IEC 61508 are covered by the Type Approval Certificate from Bureau Veritas.
- The title and version of each software element included in the installed software system shall be either marked or presented on a display of the equipment.
- Correct configuration and setup for each delivery must be tested during commissioning after installation.
- Factory Acceptance and On-board Tests must be performed in accordance with requirements for Category III Equipment.
- The model numbers of the modules to be delivered in accordance with this certificate have a “C” suffix.

For a list of the Tricon products that are certified by Bureau Veritas for use in marine environments, see Tricon Equipment Certified for Use in Marine Environments on page 41.

For information about the Type Approval Certificate from Bureau Veritas, contact the Global Customer Support (GCS) center.

Fire and Gas Detection Applications

For all fire and gas detection applications, refer to the *Safety Considerations Guide for Tricon v9–v11 Systems* for additional installation guidelines.

For fire and gas detection applications, redundant field and system power sources and/or supplies must be used.

Functional Safety Applications

For all functional safety applications, refer to the *Safety Considerations Guide for Tricon v9–v11 Systems* for additional installation guidelines.

Nuclear 1E Applications

For all nuclear 1E applications, contact the Global Customer Support (GCS) center for the latest detailed installation instructions.

Only those modules qualified for nuclear 1E applications can be used; contact the Global Customer Support (GCS) center for the latest items on the Nuclear Qualified Equipment List (NQEL).

Semiconductor Manufacturing - Health and Safety Applications

For semiconductor manufacturing applications, compliance with these additional installation guidelines is highly recommended:

- Field and logic power supplies should be approved for use in safety extra-low-voltage (SELV) circuits according to the requirements of IEC 61010-1.
- For installations with voltages greater than 30 Vrms/36 VDC, the controller and associated equipment must be installed in a locked cabinet restricting access to trained personnel only, with a hazardous-voltage warning label attached prominently.
- For installations with ambient temperatures exceeding 94° F (35° C), the controller and associated equipment should be installed in a locked cabinet restricting access to trained personnel only, with a hot-surface warning label attached prominently.
- For applications in which continuous, correct system operation must be assured, the controller and associated equipment should be installed in a locked cabinet restricting access to trained personnel only, with a general-hazard warning label attached prominently.

For a physical description of labels, see Appendix C, Warning Labels.

Chassis and Module Installation

This section explains how to mount the chassis, modules, and other Tricon components. When unpacking the Tricon controller, check the items in the package against the shipping list to verify that everything you ordered is included. Keep the boxes and packing materials in case you need to return items to Invensys for any reason.

WARNING For ATEX applications, male ELCO connectors must have a gasket installed, and it must be replaced before the end of its five-year life span. (Invensys part number 3000793-001 is a kit containing 25 gaskets.)

CAUTION The Tricon controller can be repaired while operating. However, the integrity of the controller can only be assured if the operator follows repair procedures correctly. If in doubt about the procedures, the operator should take whatever steps are necessary to ensure the safety of the plant and personnel, then call Invensys for assistance in implementing the repair procedures.

Topics include:

Rear-Mounting the Chassis

Commonly, one or more Tricon chassis are rear-mounted on a subplate with the mounting brackets installed at the rear of the chassis. The subplate is then put into a 20 inches (51 centimeters) deep industrial enclosure built to NEMA Type 12 specifications. A Tricon chassis (either the Main Chassis or an Expansion Chassis) requires a footprint of 19 inches wide by 22.75 inches high (48.3 centimeters wide by 57.8 centimeters high) on a subplate or panel.

Rack-Mounting the Chassis

A Tricon chassis can be rack-mounted on a standard 19 inches (47.5 centimeters) EIA (Electronics Industries Association) Standard #RS-310-C rack by installing the mounting brackets at the front of the chassis. When there is more than one Tricon chassis in an enclosure, Invensys recommends having at least 1.75 inches (4.45 centimeters) vertical clearance between them for cables. Figure 80 shows dimensions and clearances for Tricon chassis installation.

Invensys offers auxiliary Chassis Mounting Brackets (Model 8405) for rack-mounted installations. This pair of brackets provides additional rear support to the chassis during shipment of pre-mounted chassis enclosure controllers.

CAUTION

- Auxiliary mounting brackets are intended only to provide additional support at the rear of a front rack-mounted chassis. Do not use auxiliary brackets in place of Invensys-supplied standard chassis-mounting brackets.
- Do not tighten the hex head screws securing the adjustable mounting brackets to the rear of the chassis until you have fully secured the chassis by the front mounting brackets and secured the auxiliary brackets to the rear mounting rails. Failure to comply with this procedure could result in a deformed chassis which can cause improper seating of modules.

Dimensions and Clearances for Installation

This figure shows the dimension of the chassis and the required clearances. When mounting a chassis into vented or unvented enclosures, sufficient clearance must be provided so that the ambient temperature of the Tricon controller is not exceeded. For more information, see Heat Management Instructions on page 233.

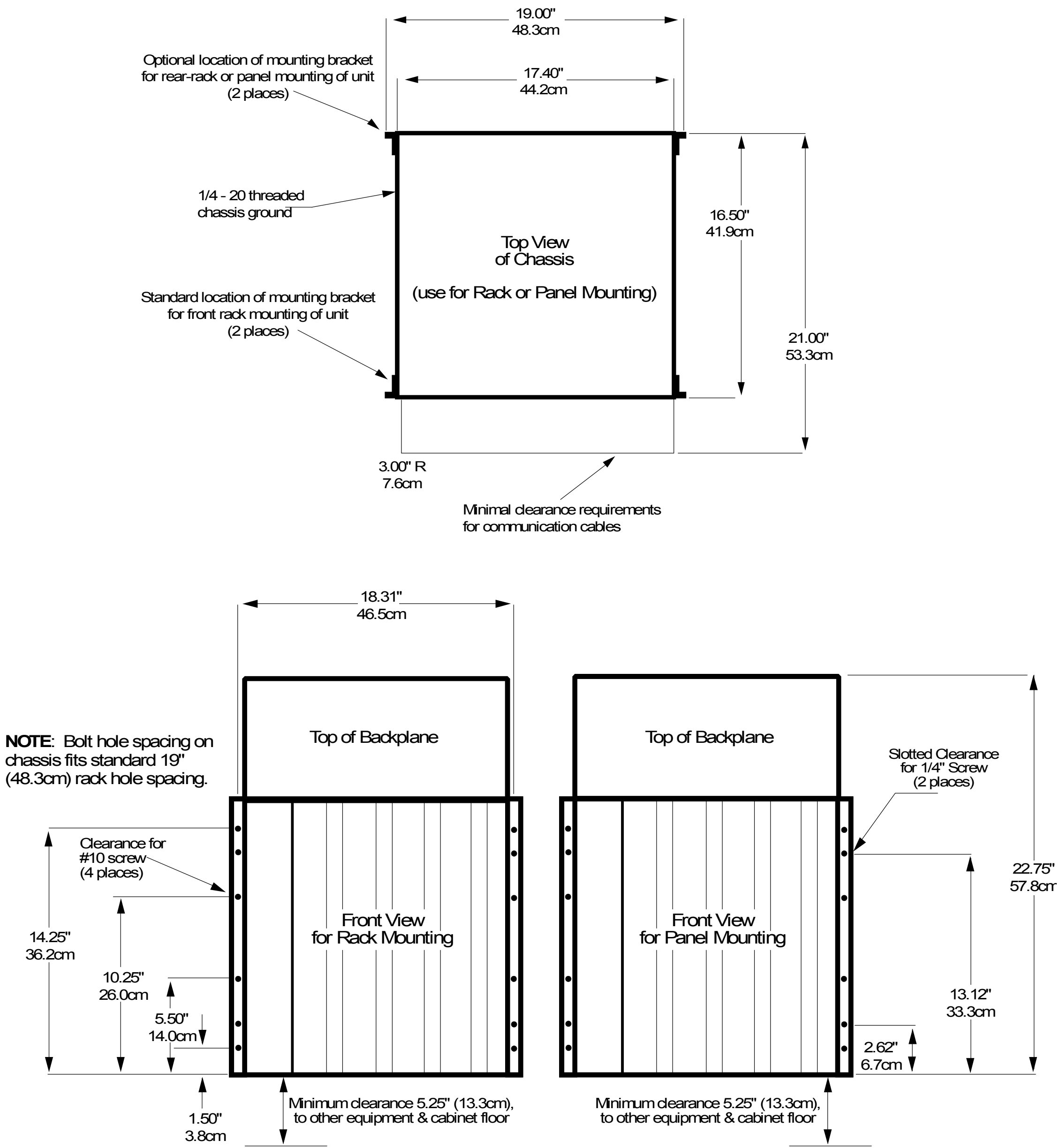


Figure 80 Dimensions and Clearances for Chassis Installation

Heat Management Instructions

When mounting Tricon chassis in vented or unvented enclosures, you and the integration engineer are responsible for providing for sufficient heat management. To establish cooling requirements, determine the total amount of heat to be generated for dissipation by the following components in the enclosure:

- All modules installed.
- Power modules to be installed.
- All additional heat-generating devices.

For the calculated values of heat dissipation of each module, see the specifications for each module in System Components. The amount of dissipated heat affects the type of heat management techniques appropriate for the Tricon system.

There are numerous heat management techniques available for both rack-mounted and panel-mounted chassis. The following sections provide requirements and guidelines for managing the heat in your Tricon system.

Topics include:

Mandatory Requirements

All enclosure installations must meet these two requirements:

- The temperature rise through each chassis must not exceed 27° F (15° C), as measured at the screened area at the top of the chassis at all points.
- The inlet temperature into the screened area at the bottom of each chassis must not exceed 140° F (60° C) at all points.

Guidelines for Convection (Natural) Cooling

These guidelines suggest how to manage heat through the natural process of convection. If you are using natural cooling to manage the temperature of the chassis, adherence to these guidelines is encouraged, but not required.

The chassis that generates the least amount of heat or that is the most temperature-sensitive should be the lowest chassis in a multi-chassis installation. The chassis that generates the most amount of heat or that is the least temperature-sensitive should be the highest chassis.

For optimal performance, the inlet temperature into the screened area at the bottom of each chassis should be below 95° F (35° C).

Choosing Clearances

Invensys recommends that you leave a minimum of 5.25 inches (13.3 centimeters) of space between the enclosure panels and the bottom screen, sides, and front of each chassis, and a minimum of 5.25 inches (13.3 centimeters) of space between the top screen of each chassis and any obstructions to airflow. When the ambient temperature of the enclosure is around 72° F (22° C), these clearances allow for the adequate convection cooling of all the chassis and create an acceptable inlet air temperature (below 140° F) into the highest chassis in the enclosure.

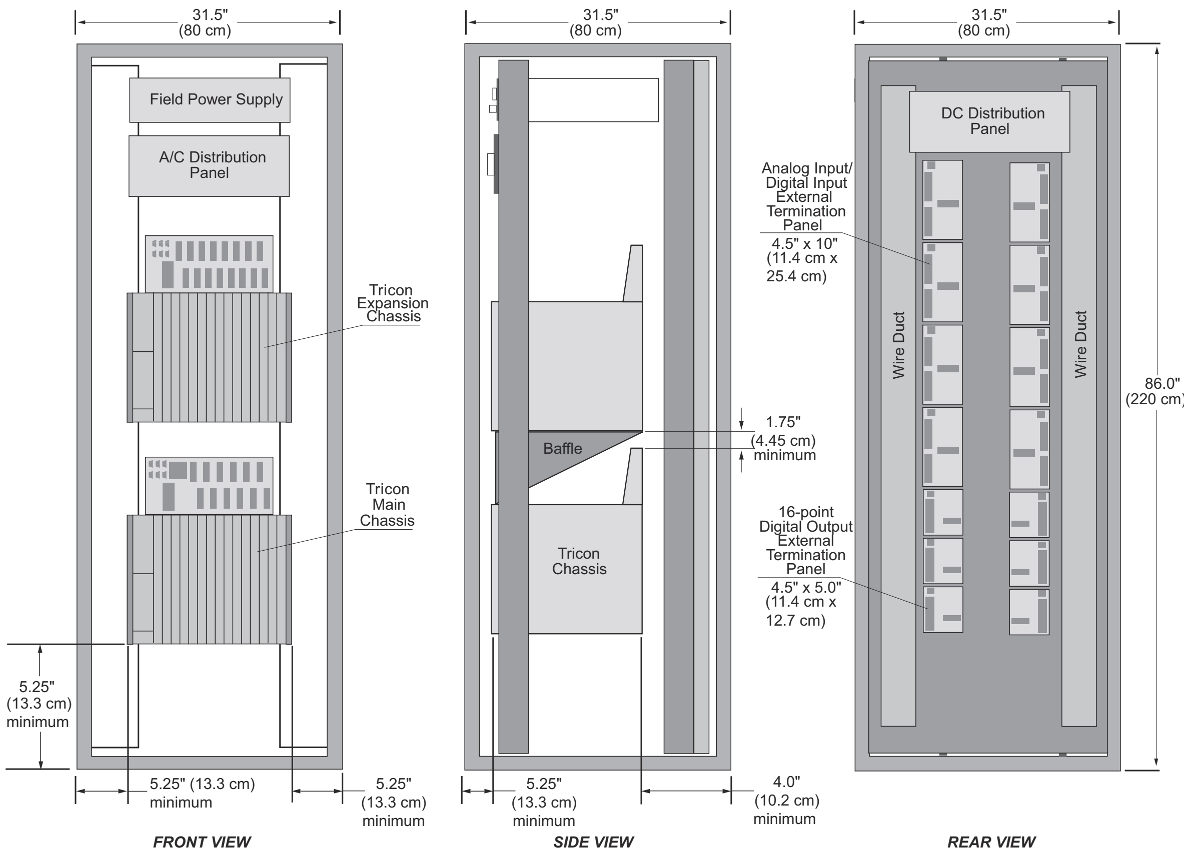


Figure 81 Typical Dimensions and Clearances for Chassis Installation with External Termination Panels

Up to 30% of the volume created by these clearances may be consumed with non-heat-generating equipment such as cables, structural components of the enclosure, and wiring panels, provided that each component remains at least 1.75 inches (5 centimeters) away from the bottom and top screen areas of the chassis and does not block airflow to and from the screen areas.

If the clearances between the enclosure panels and chassis sides and front are reduced, the installation should ensure that airflow is not restricted to any chassis and that the maximum allowable temperatures into and through the chassis are not exceeded. The open space between the enclosure walls and the fronts and sides of all the chassis minimizes the direct flow of heated air exhaust from the bottom chassis up through the higher chassis.

Using Heat Management Components

When the ambient temperature of the enclosure is above 86° F (30° C), Invensys recommends that you install baffles (Invensys part number 2000361-001) and use an enclosure with either a pagoda top or top and bottom vented louvers. The baffles first direct air from the space in front of the chassis into the bottom screen of each chassis and then direct the exhaust air to the space on both sides of the chassis. If an installation requires filters, the vented louvers must be enlarged to accommodate the restricted airflow.

When the ambient temperature of the enclosure is above 104° F (40° C), the enclosure should contain baffles, louvers, and a pagoda top. As the enclosure ambient temperature approaches 122° F (50° C), you should install other appropriate heat management products, such as enlarged front and rear louvers, a raised pagoda top, and lower-density filters.

Note If additional heat-generating equipment is to be installed in the enclosure, then the configuration should be limited to just two chassis.

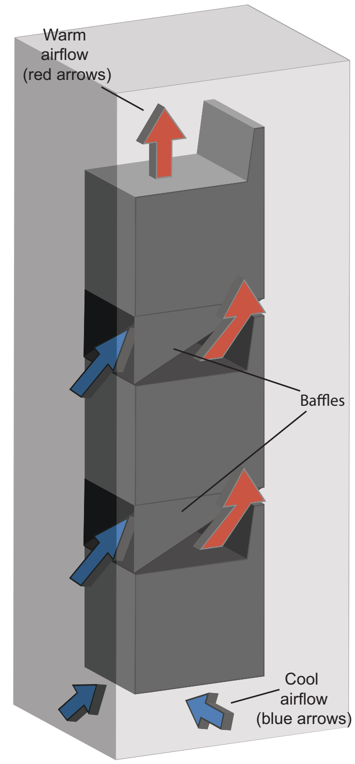


Figure 82 Diagram of Warm and Cool Airflow in Enclosure with Baffles

Guidelines for Forced Air (Fan) Cooling

These guidelines suggest how to manage heat by using fans and other heat management products. If you are using fans to manage the temperature of the chassis, adherence to these guidelines is encouraged, but not required.

Exhaust air fans may be implemented at the top of the enclosure with adequate louvers at the bottom sides of the enclosure. If filters are required, the louvers must be enlarged to accommodate the restricted airflow. Fan airflow should ensure that the allowable maximum air temperature into and through the chassis is not exceeded. The determination of the required cubic feet per minute (CFM) with margin of the fans is achieved by the establishment of cooling requirements for the amount of heat that must be dissipated.

For optimal performance, the inlet temperature into the screened area at the bottom of each chassis should be below 95° F (35° C).

Note Components used in forced air cooling techniques are usually obstacles to airflow during convection cooling. Therefore, you should not rely on convection cooling techniques when forced air cooling components are installed.

Choosing Clearances

When using fans in an enclosure, you should leave a minimum of 5.25 inches (13.3 centimeters) between enclosure panels or other non-heat-generating equipment and the bottom and top screen areas of each chassis. There should be a minimum of 3.5 inches (9 centimeters) between the enclosure panels or other non-heat-generating equipment and the sides and front of the chassis. Up to 30% of the volume created by these clearances may be consumed with non-heat-generating equipment such as cables, structural components of the enclosure, and wiring panels, provided that each component remains at least 1.75 inches (5 centimeters) away from the bottom and top screen areas of the chassis and does not block airflow to and from these screen areas.

Directing Airflow

The installation should ensure that forced airflow is through and not around the chassis. Directing airflow with fans in a three-chassis cabinet is particularly challenging due to the column effect caused by the fans. The column effect occurs when the fans at the top of the enclosure pull heated exhaust air from the bottom chassis up through the top chassis. This may cause the middle chassis to be hotter than under convection cooling conditions, especially if the enclosure ambient temperature exceeds 86° F (30° C). This issue can be mitigated by using baffles to direct airflow. Baffles create a source of cool intake air in front of the cabinet for all chassis while the fans draw the hot exhaust air away from the sides of the cabinet.

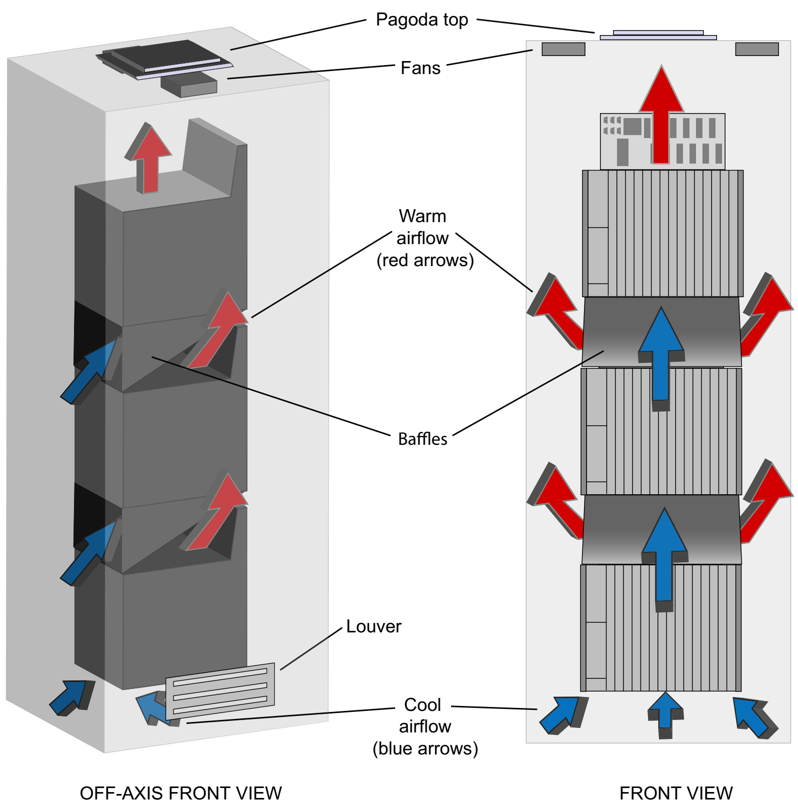


Figure 83 Diagram of Warm and Cool Airflow in an Enclosure with Cooling Products

Using Sensors

Using temperature and fan airflow sensors ensures compliance with the chassis temperature requirements. Sensors should be properly located at the top and bottom of each chassis in order to notify you if the enclosure fans or facility air-conditioning fail. In the event of either failure occurring, the inlet air temperature to the chassis and the temperature rise within the chassis may exceed the allowable maximum temperatures.

Connecting Multiple Chassis

When a system requires more than a Main Chassis, each additional chassis must be connected by using a set of three cables that allow a physical extension of the triplicated I/O bus. Each chassis includes six I/O ports, which means each chassis can be connected to two other chassis. The communication speed between the I/O ports is 375 kilobits per second, which is the same rate as the internal Tricon controller I/O bus. This means the three control channels are physically and logically extended to the Expansion Chassis without sacrificing performance.

These cables can be used:

- Model 9000 is the I/O Bus Expansion Cable used to connect Expansion Chassis or a primary RXM Chassis to the Main Chassis.
- Model 9001 is the I/O COMM Bus Expansion Cable used when communication modules are housed in Expansion Chassis 2. The I/O communication cables are available only in a length of six feet.

If the distance between chassis is greater than 100 feet (30 meters), fiber-optic cables can be used to connect to an RXM Chassis.

Using Slot Covers

All unused chassis slots should be covered with Blank I/O Slot Panels (Model 8105) to minimize exposure to dust and other particulate matter, and to minimize electromagnetic and radio-frequency interference (EMI/RFI).

I/O Bus Address of Chassis

The I/O bus address identifies the chassis number in a Tricon system and is set with jumpers on the backplane. Typically, each Tricon chassis shipped from the factory has a different address for each chassis based on the sales order.

The address of the Main Chassis is always set to 1 and should not be changed. The address of an Expansion or RXM Chassis can be from 2 to 15. If necessary, Invensys recommends the chassis be returned to the factory to change the setting.

This figure shows the location of the jumpers on the backplane and an example of the jumper settings. Table 80 on page 239 shows the binary addresses and jumper settings for each address.

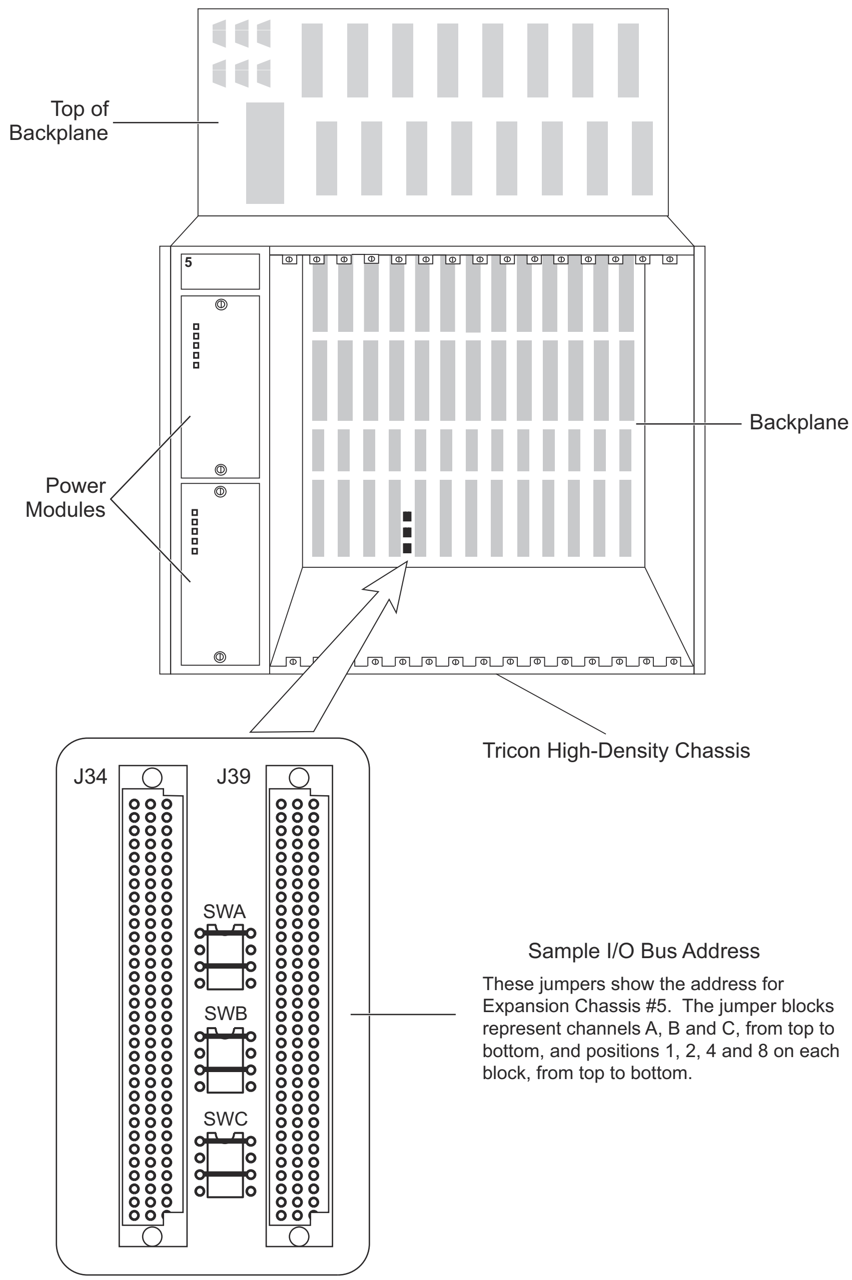
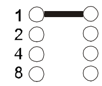
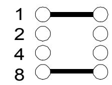
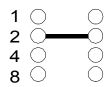
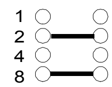
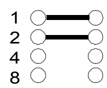
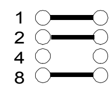
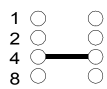
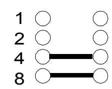
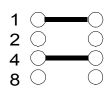
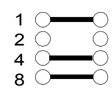
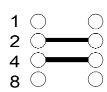
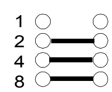
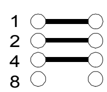
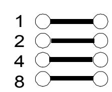
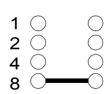


Figure 84 Example of I/O Bus Address for Chassis 5

Jumper Settings for the I/O Bus Address

The I/O bus address is represented as a binary number which is set on three jumper blocks on the backplane of the chassis. This table lists the binary number for each chassis address and shows the jumper installation for the setting.

Table 80 I/O Bus Address in Binary and as a Jumper Setting

Chassis Address	Address in Binary	Jumper Setting	Chassis Address	Address in Binary	Jumper Setting
1	0001		9	1001	
2	0010		10	1010	
3	0011		11	1011	
4	0100		12	1100	
5	0101		13	1101	
6	0110		14	1110	
7	0111		15	1111	
8	1000				

Power Module Installation

Each Tricon chassis (Main, Expansion, and RXM) includes two Power Modules, which can be any combination of models (8310, 8311, or 8312). Under normal circumstances, both Power Modules are active, and each contributes power to the Tricon controller; only the Pass and Status indicators are On. Either Power Module is capable of running the Tricon controller for an indefinite length of time.

If one of the Power Modules or its supporting power line fails, the second module increases its output to maintain power for the Tricon controller. If incoming power is interrupted or if one of the modules fails, its Fault indicator goes On. You can disconnect a failed Power Module from field power, remove it from the Tricon controller chassis, and replace it without shutting down the Tricon controller.

A minimum of 240 watts of incoming power is required for each Power Module in a chassis.

CAUTION To maintain security and integrity, source each Power Module separately, and provide independent circuit breakers or switches for each circuit.

Alarm Circuitry on Power Modules

The alarm circuitry on each Power Module operates independently. You should wire the warning system in a dual-redundant configuration, so that activation does not depend upon power from only one power source. This figure provides an example of this type of wiring.

WARNING Do not use alarm contacts in hazardous locations.

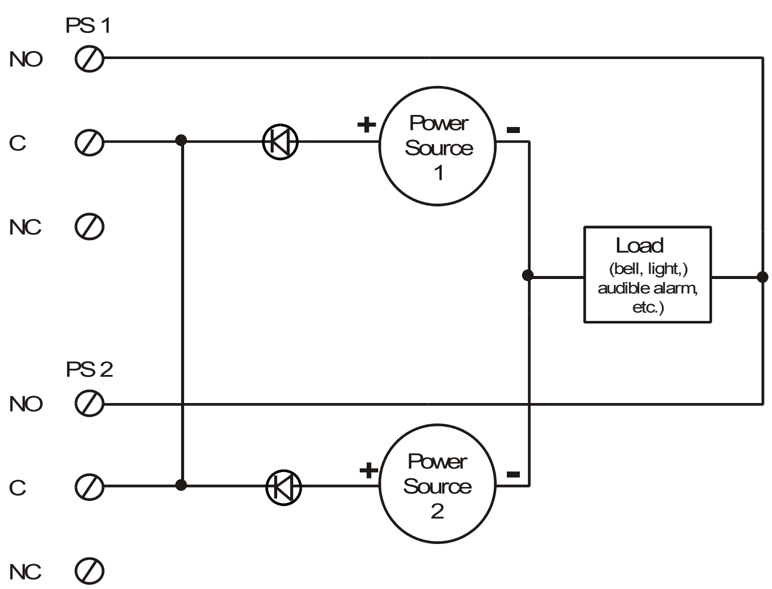


Figure 85 Alarm Sample Wiring

For specifications, see Power Modules on page 64.

Wiring to a Separate Power Source

To ensure the advantages of dual redundant and independent Power Modules, each Power Module should be wired to a separate power source. Wiring to a separate power source permits the replacement of one Power Module, without interrupting field power to the other, so that the Tricon controller can continue operations without a break in service.

The terminals for incoming power and alarm applications are on the backplane above the Power Modules.

Each independent power source, equipped with its own fuse and switch, can be shared by multiple Tricon controller chassis. You should connect every chassis to two independent power sources.

Wiring to a UPS

In critical applications, it is best to connect at least one Power Module to an Uninterruptible Power Supply (UPS) which can be shared by multiple Tricon chassis. The UPS must be rated for the total number of chassis to be powered, and for the duration of the maximum expected down time.

Supply Wiring Specifications

Supply wiring should be sized according to applicable local electrical codes, taking into account the current ratings (as specified in 120 Volt Power Module Specifications on page 67), temperatures, wiring lengths, and other applicable considerations.

WARNING Do not operate the Tricon controller without a safety earth.

Alarm Wiring

Each system includes two sets of redundant alarm contacts, one per Power Module, that can be specified as needed. Typically, alarm wiring is connected to a local or remote annunciator. These devices can be wired in parallel with the alarm wiring so that the designated alarm goes off whenever either Power Module signals an alarm condition.

WARNING Do not use alarm contacts in hazardous locations.

These are the alarm contacts:

- Normally open contact
- Common
- Normally closed contact

This figure shows typical power wiring.

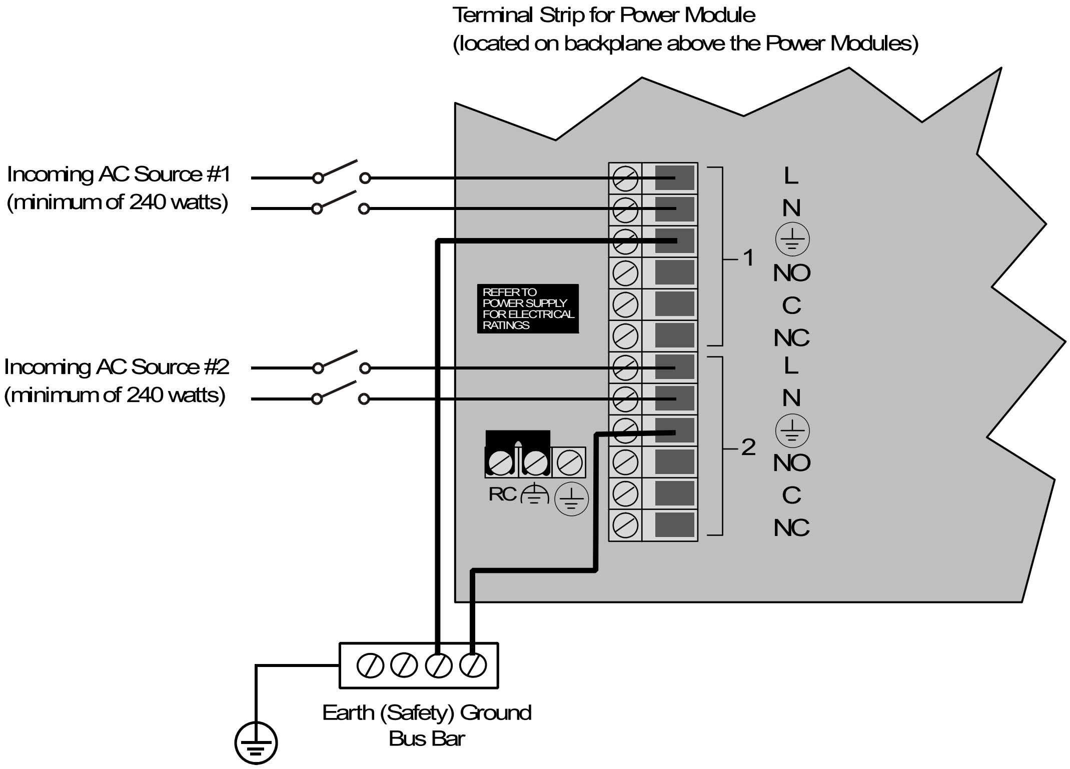


Figure 86 Typical Power Module Wiring

Slot Keys for Modules

Each slot in the Tricon chassis is fitted with metal slot keys to restrict the type of module that can be installed. The keys correspond to slotted spaces on each module. The spacers are located about 2 inches (5 centimeters) in from the module front panel between the aluminum spine and the printed circuit board. All modules of a particular type, for example, all 24-volt Digital Input Modules, are identically keyed.

If you try to install a module in an incorrect slot, the module does not slide the last 2 inches (5 centimeters) into the chassis. *Do not apply force to overcome the obstruction caused by the keys.*

Installing Power Module Keys

Each Power Module slot is fitted at the top with a key that allows only one type of module to be installed. If you replace the installed Power Modules with a different voltage model, you must install the appropriate keys for the new modules. To do so, remove the screws for the existing keys and pull the keys off their shelves. Then place each new key onto its shelf, insert the two screws, and screw them upward from the bottom of the shelf.

Table 81 Power Module Key Positions

Model	Module Name	Top Key
8310	120 VAC/VDC Power Module	001
8311	24 VDC Power Module	003
8312	230 VAC Power Module	004

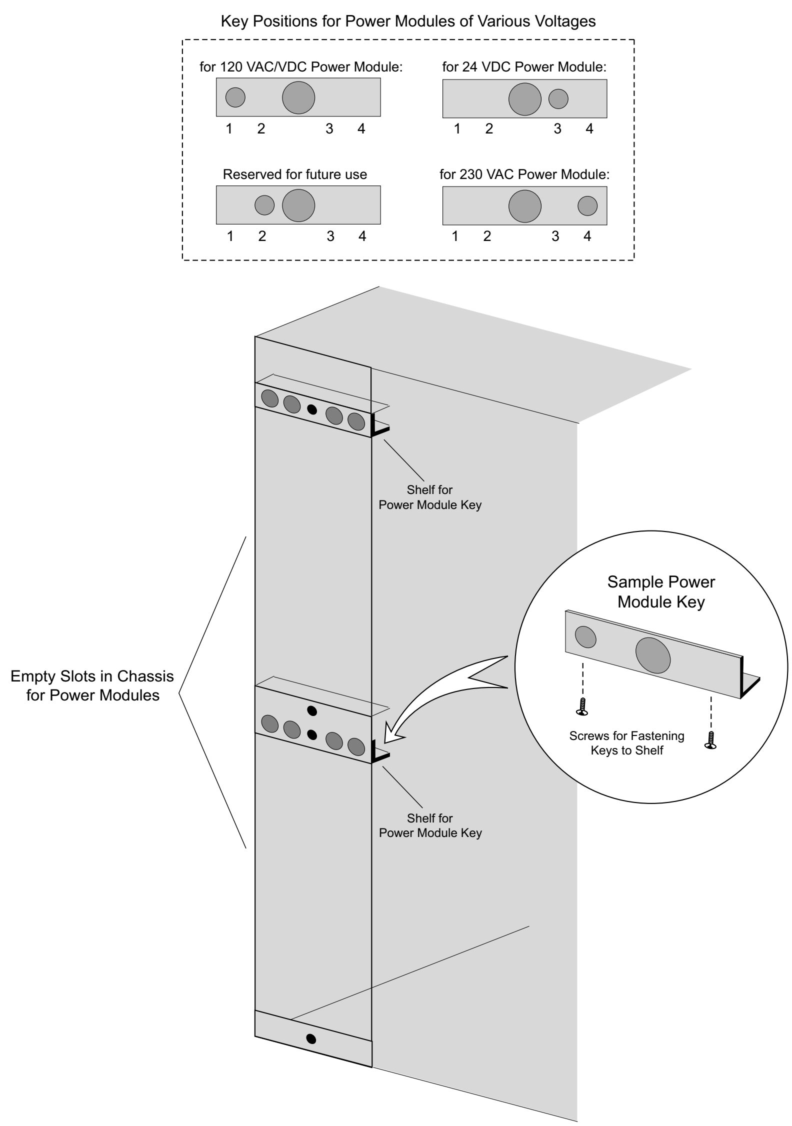


Figure 87 Power Module Key Positions

Installing Single and Dual Keys

Each Main Processor slot, COM slot, and Interface Module slot is fitted at the top and bottom with single keys. Each I/O and Communication Module slot is fitted at the top and bottom with dual keys.

To install a new module that uses different keys, remove the screws for the existing keys, then install the keys that come with the new module. Screw the keys for the top of the slot downward through the top of the chassis; screw the keys for the bottom of the slot upward from the bottom of the chassis, as shown in this figure.

For slot key numbers by module, see Slot Key Numbers on page 245.

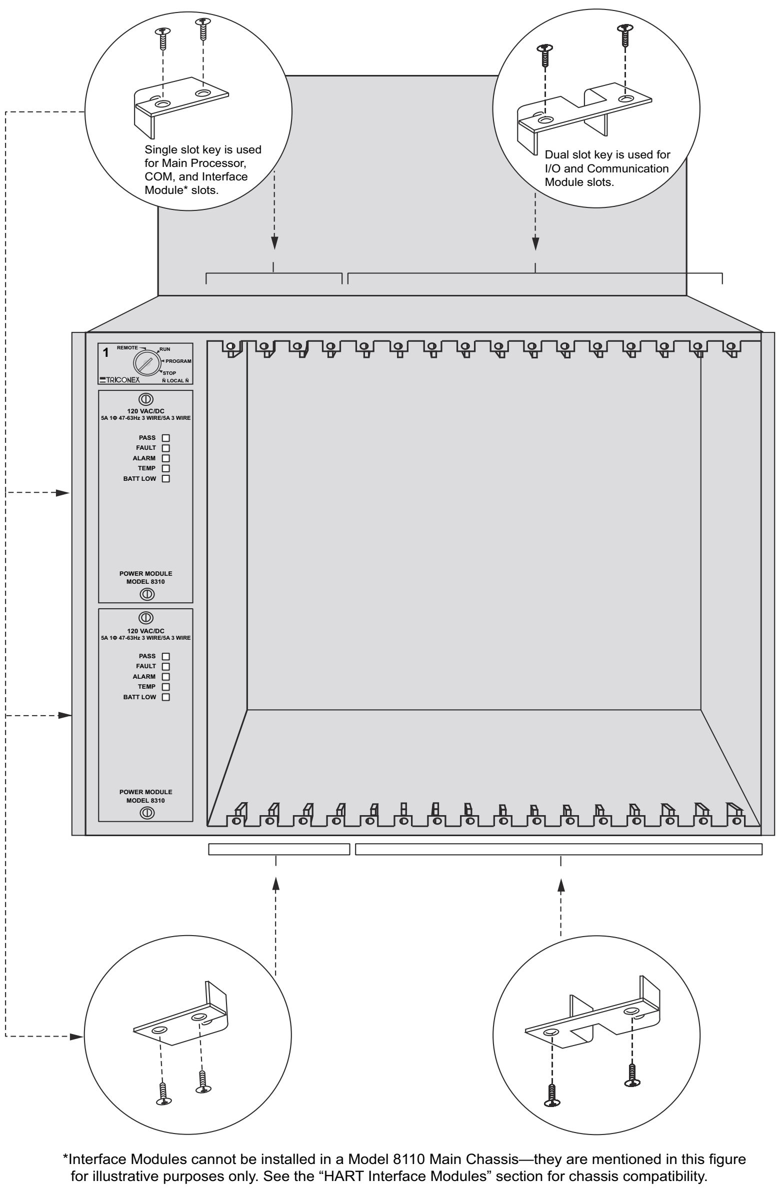


Figure 88 Keys for Single and Dual Slots

Slot Key Numbers

This table lists the keys for the Main Processors, the UCMs, and the COM (used for TCM, EICM, or NCM) slots.

Table 82 Main Processor, UCM, COM, and Blank Slot Keys

Model	Module Name	Top Key	Bottom Key
3008, 3009	Main Processor (MP) Module	007	002
3006, 3007	Main Processor (MP) Module	007	007
4610	UCM (logical slot)	001	003
	COM Slot (TCM, EICM, or NCM)	001	003
	Blank Logical Slot[a]	001	008

a. Use this key combination to prevent the insertion of modules into any unused slots in your controller.

This table lists the keys for I/O and communication module slots.

Table 83 I/O and Communication Module Slot Keys

Model	Module Name	Top Key	Bottom Key
3501E/T	115 VAC/DC Digital Input (TMR)	004	004
3502E	48 VAC/DC Digital Input with Self-Test (TMR)	004	005
3503E	24 VAC/DC Digital Input with Self-Test (TMR)	004	006
3504E	24 VDC /48 VDC High-Density Digital Input (TMR)	004	007
3505E	24 VDC Low Threshold Digital Input with Self-Test (TMR)	004	006
3510	Pulse Input, AC Coupled (TMR)	004	001
3511	Pulse Input, AC Coupled (TMR)	004	001
3515	Pulse Totalizer Input	004	002
3564	24 VDC Digital Input (Single)	004	006
3601E/T	115 VAC Digital Output (TMR)	006	004
3603B	120 VDC Digital Output (TMR), non-commoned	006	006
3603E/T	120 VDC Digital Output (TMR), commoned	006	006
3604E	24 VDC Digital Output (TMR)	006	007
3607E	48 VDC Digital Output (TMR)	006	003
3611E	115 VAC Supervised Digital Output (TMR)	005	002
3613E	120 VDC Supervised Digital Output (TMR)	005	005
3614E	24 VDC Supervised Digital Output (TMR)	005	004
3615E	24 VDC Low-Power Supervised Digital Output (TMR)	005	004

Table 83 I/O and Communication Module Slot Keys *(continued)*

Model	Module Name	Top Key	Bottom Key
3617E	48 VDC Supervised Digital Output (TMR)	005	003
3623/T	120 VDC Supervised Digital Output (TMR)	005	005
3624	24 VDC Supervised Digital Output (TMR)	005	004
3625/A	24 VDC Supervised or Non-Supervised Digital Output (TMR)	006	007
3664/3674	24 VDC Digital Output (Dual)	006	007
3636R	Relay Output, N0 (SIMPLEX)	006	002
3700	0–5 VDC Analog Input (TMR)	003	004
3700A	0–5 VDC Analog Input (TMR)	003	006
3701	0–10 VDC Analog Input (TMR)	003	003
3703E	0–5, 0–10 VDC Isolated Analog Input (TMR)	005	006
3704E	0–5, 0–10 VDC High-Density Analog Input (TMR)	006	008
3706A	Non-Isolated Thermocouple Input (TMR)	003	002
3708E	Isolated Thermocouple Input (TMR)	005	007
3720	0–5 VDC Single-Ended Analog Input (TMR)	006	008
3721	0 to 5 or -5 to +5 VDC Differential Analog Input (TMR)	003	004
3805E/H	4–20 mA Analog Output (TMR)	003	008
3806	6 outputs @ 4–20mA, 2 outputs @ 8–320 mA, Analog Output (TMR)	003	008
3807	-60 to +60 mA Bipolar Analog Output (TMR)	003	008
4119	Enhanced Intelligent Communication (EICM)	001	003
4119A	Enhanced Intelligent Communication (EICM)	001	003
4200-3	Primary RXM Multi-Mode Fiber-Optic Module Set	002	003
4201-3	Remote RXM Multi-Mode Fiber-Optic Module Set	002	003
4210-3	Primary SRXM Single-Mode Fiber-Optic Module Set	002	003
4211-3	Remote SRXM Single-Mode Fiber-Optic Module Set	002	003
4329, 4329G	Network Communication (NCM) and NCMG (GPS)	001	003
4351, 4351A, 4351B, 4352, 4352A, 4352B, 4353, 4354	Tricon Communication Module (TCM)	001	003
4409	Safety Manager Module (SMM)	001	003
4509E	Hiway Interface Module (HIM)	001	004
4609	Advanced Communication Module (ACM)	001	003

This table lists the keys for interface module slots.

Table 84 Interface Module Slot Keys

Model	Module Name	Top Key	Bottom Key
2770H	HART Analog Input Interface Module	005	006
2870H	HART Analog Output Interface Module	005	004

Configuring the MP Node Setting

The SW1 and SW0 settings on the front panel of the MP identify the node of the controller on a network. The factory setting is node 1, which is SW1=0 and SW0=1. The setting can be from 1 to 31. The MP node setting must match the node setting for the communication module (ACM or NCM). You must also ensure the node setting is configured in TriStation 1131. TCMs and UCMs automatically obtain the node setting from the MP.

CAUTION The physical node setting for the MP, ACM, or NCM, and the node setting configured in TriStation 1131 must match.

This table identifies the possible node settings.

Table 85 Main Processor Node Settings

Node Number	SW1	SW0	Node Number	SW1	SW0
1	0	1	17	1	1
2	0	2	18	1	2
3	0	3	19	1	3
4	0	4	20	1	4
5	0	5	21	1	5
6	0	6	22	1	6
7	0	7	23	1	7
8	0	8	24	1	8
9	0	9	25	1	9
10	0	A	26	1	A
11	0	B	27	1	B
12	0	C	28	1	C
13	0	D	29	1	D
14	0	E	30	1	E
15	0	F	31	1	F
16	1	0			

Installing Modules

This procedure explains how to install a module.

WARNING Do not install more than one module at the same time. You must push the first module in and wait until the Active indicator goes on, then install the next module.

Procedure

1. Ensure that the slots have been fitted for the appropriate module. For details, see Slot Keys for Modules on page 242.
2. Install the module and push the module in until it is firmly seated. Tighten the retractable fasteners of the module to 10 inch-pounds.
3. If using a redundant module, install an identical type module in the empty slot and push the module in until it is firmly seated. Tighten the retractable fasteners of the module to 10 inch-pounds.

Digital Output Field Wiring Precautions

When installing field wiring for Digital Output Modules, Invensys recommends that you do not make parallel connections or series connections to digital output points. These types of connections can cause the commanded state and the measured state of points to disagree, resulting in Load/Fuse alarms and limited effectiveness of Output Voter Diagnostics (OVD).

For more information about OVD, see Disabling Output Voter Diagnostics on DO Modules on page 283.

Pulse Input Module Installation and Operation

Pulse Input Module installation includes these requirements for proper operation.

Installation Requirements

- Wire each point with individually shielded, twisted-pair cable. Keep the wire as short as possible. Connect the shield to earth ground at the sensor *or* the controller. Where possible, route the cable away from all noise sources.
- To minimize signal reflections, put a termination resistor (1 to 10 kilohms) on each input signal. Mount the termination resistor at the termination panel across the positive (+) and negative (–) input terminals.
- Short together the positive (+) and negative (–) terminals of all unused inputs.

Using with Amplified Sensors or Laboratory Pulse Generators

- Where possible, use an amplifier or pulse generator with a fully balanced output (an isolated output stage). When using an amplified speed sensor, a lower-value termination resistor is acceptable (50 to 150 ohms).

- If the output stage of the amplifier is not isolated, use a dedicated power source to power the amplifier, allowing the output of this supply to float with respect to ground. This simulates an amplifier with an isolated output.

If you cannot obtain a floating output, you must assure a solid signal-ground connection between the amplifier and the module. Connect the return side of the amplifier power source (its signal return point) to the PS1- terminal on the external termination panel.

Pulse Totalizer Input Module Installation and Operation

Pulse Totalizer Input (PTI) Module installation includes these requirements for proper operation.

Installation Requirements

- Initially, the control program must clear the counters before you can obtain accurate counts. The initial power-up count is 2,147,479,552. However, this does not apply to your hot-spare module, which re-educates its count from the active module.
- Connect each point with individually shielded, twisted-pair cable, keeping the cable as short as possible. Connect the shield to earth ground at the sensor or at the Tricon controller chassis. Where possible, route the cable away from all noise sources.
- If possible, avoid unshielded, multi-twisted-pair cable with an overall outer shield only. If this type of cable is used, cable length should be limited to 50 feet to minimize point-to-point cross-talk that can occur inside the cable bundle.
- The PTI module is designed to count pulses up to 1 KHz, which is in the frequency range of some types of EMI, such as lightning. Excessive EMI, coupled directly into the PTI point inputs or coupled through poorly grounded cable shields, may cause inaccurate count readings and false indications of PTI module faults. This type of fault can be cleared by issuing a counter reset from the control program and then using the TriStation Diagnostic Monitor or Enhanced Diagnostic Monitor to clear the fault.
- Short together the positive (+) and negative (-) terminals of all unused inputs, or keep unused counters cleared by means of control program instructions.
- Connect PTI module points to solid state sensors, preferably the push-pull output type. Do not connect PTI module points to mechanical relay or switch contacts, because mechanical contact bounce may cause inaccurate count readings and false indications of faults.
- If you use high-side or low-side solid state switches to drive PTI module points instead of a push-pull output, the maximum count frequency may be reduced in proportion to the cable length.
- Do not exceed the maximum count rate by more than 10 percent or induce glitches to the points. Excessive frequency or glitches cause inaccurate count readings and false indication of faults.

Proof Testing for Counter Overflow

When a counter overflows, its value becomes negative. You can test this condition quickly by installing the PTI module in a Tricon controller chassis without a hot-spare module and not allowing the control program to reset the counter values to zero. After the PTI module powers up and passes its self-test, it initializes its counters to 2,147,479,552—only 4,096 counts away from overflow.

Thermocouple Input Module Installation and Operation

Thermocouple Input Module installation includes these requirements for proper operation.

WARNING

- Proper operation of a Thermocouple Input Module requires that you install and connect its field termination panel. Otherwise, fault conditions occur. Unused thermocouple inputs should be shorted.
- On the Non-Isolated Thermocouple Input Module, a Fault condition may be caused by a faulty cold-junction transducer. If the fault is not fixed by replacing the module, then replace the field termination module.

For fault indicators, see CJ (Cold Junction) Indicator on page 313.

Model 3807 Bipolar Analog Output Module Installation

Model 3807 Bipolar Analog Output Module installation includes this requirement for proper operation.

CAUTION

If the I/O cable (the cable that connects the termination panel to the Tricon backplane) is routed outside the cabinet that houses the Tricon chassis, the I/O cable should be routed in a metal conduit.

Installing HART Interface Modules in the Model 8121 Enhanced Low-Density Expansion Chassis

To prepare the Model 8121 Enhanced Low-Density Expansion Chassis for installation of HART interface modules, mount, power, and ground the chassis the same as you would for any other Tricon chassis, as described throughout this chapter.

Use the Model 9000 I/O Bus Expansion Cable to connect the I/O bus between chassis.

WARNING The Model 9001 I/O COMM Bus Expansion Cable *cannot* be used in the Model 8121 Low-Density Expansion Chassis. HART Interface Modules use channel C COMM bus lines for RS-485 communication and connecting them outside the chassis will interfere with the COMM bus and HART communication.

This figure shows an example of HART Communication using HART Interface Modules installed in the Model 8121 Enhanced Low-Density Expansion Chassis.

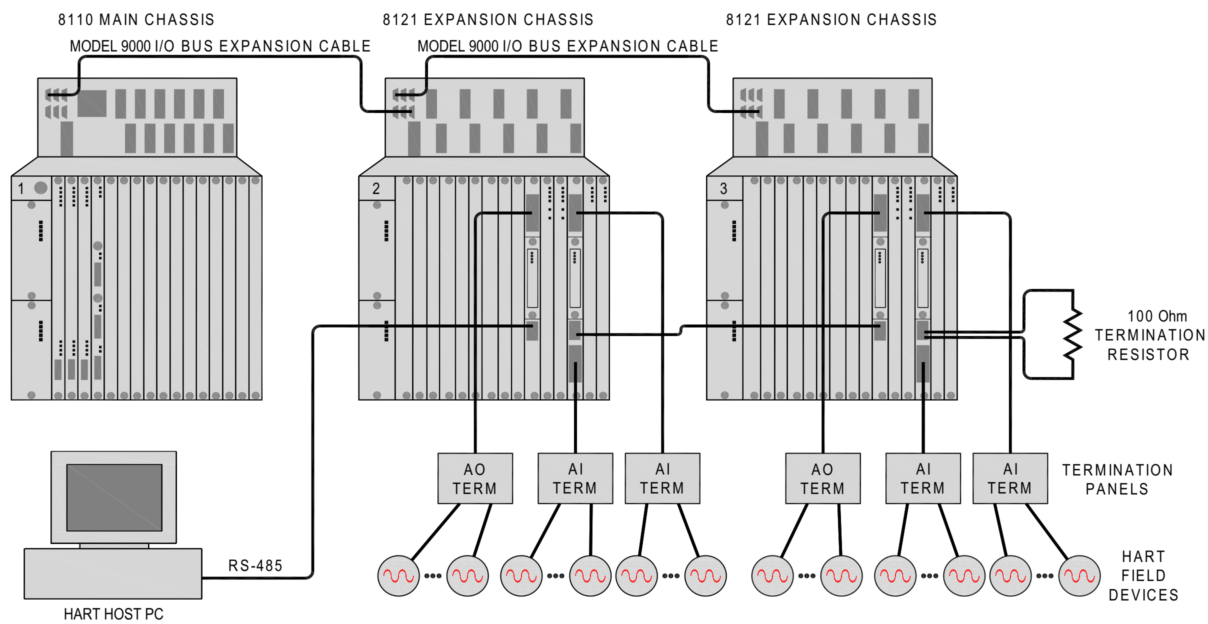


Figure 89 Typical HART Installation Using Model 8121 Enhanced Low-Density Expansion Chassis

Attach interface cables from termination panels to the ELCO connectors on the front of the HART Interface Modules.

Note Analog Input Interface modules in Model 8101 Low-Density Expansion Chassis used an Amp connector. To allow for the replacement of Model 8101 Low-Density Expansion Chassis with Model 8121 Enhanced Low-Density Expansion Chassis with no modifications to existing wiring, an adapter cable (4000171-002) is available.

CAUTION The ELCO connectors at the top of the chassis will provide a connection for the 4-20 mA signals to and from the AI and AO modules; however, they will not provide a path for HART communication. Always make field connections to the front of the HART Interface Modules for HART communication.

WARNING For ATEX applications, male ELCO connectors must have a gasket installed, and it must be replaced before the end of its five-year life span. (Invensys part number 3000793-001 is a kit containing 25 gaskets.)

As shown in Figure 89, communication with the HART host PC is made using an RS-485 connection to the first HART Interface Module in the first expansion chassis, a connection between all subsequent chassis, and a terminating resistor on the final chassis. No interconnection between HART Interface Modules in the same chassis is needed because the RS-485 connection is made over the Model 8121 Enhanced Low-Density Expansion Chassis backplane.

The RS-485 connector on HART Interface Modules has six contacts; A, B and RS-485 ground for input and output. Connect the RS-485 ground to chassis ground unless there is a potential difference between the chassis ground and the RS-485 ground of the HART controller.

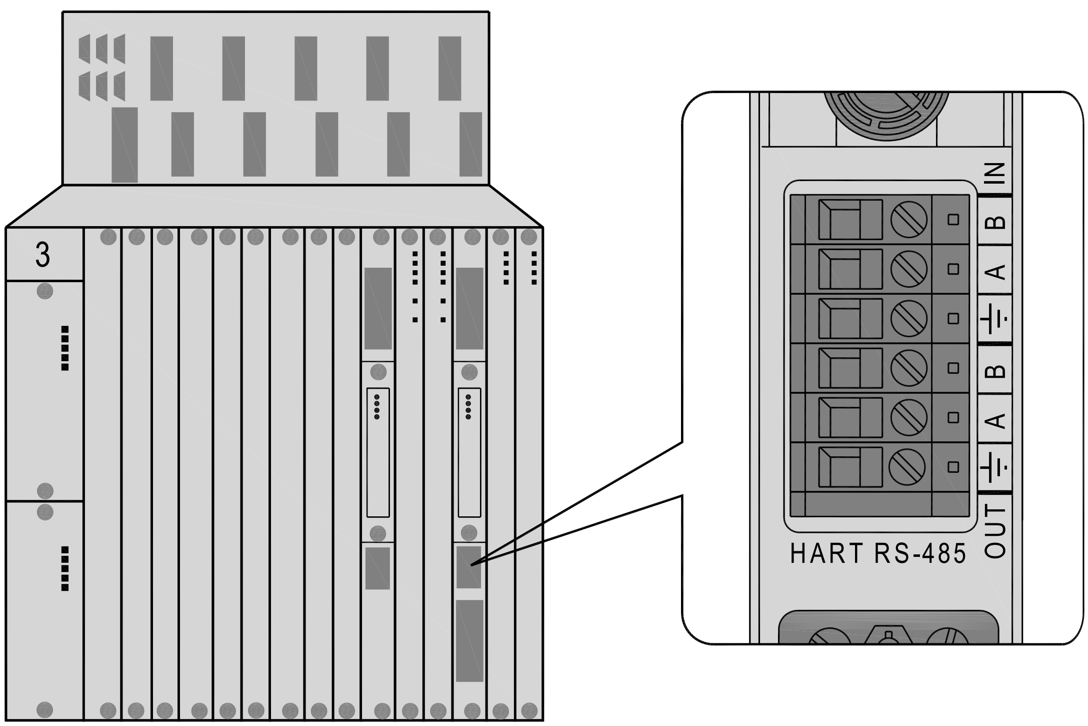


Figure 90 HART Interface Module RS-485 Connector

When using the Model 8121 Enhanced Low-Density Expansion Chassis, the RS-485 port address of the HART multiplexer (MUX) is determined by the number of the Expansion Chassis (see I/O Bus Address of Chassis on page 238) and the slot number that the connected HART Interface Module is in.

Port addresses may only be in the range of 0-63 and a Tricon system may accommodate a maximum of 70 HART interface modules, so it is not possible for a single RS-485 network to accommodate all of the chassis in a full Tricon system. Table 86 on page 253 shows that the addresses for chassis 1-7 are repeated in chassis 9-15.

Note To ensure that RS-485 port addresses are correctly auto-assigned, confirm that all of the DIP switches for the Slot Address (SW1) and Chassis Address (SW2) are set to the OFF position. These DIP switches are located on the 2071H HART MUX Module, which is a removable sub-component of the HART Interface Module.

Table 86 RS-485 Port Addresses

Chassis Number	Slot Number	Port Address
1[a]	1	8
1[a]	2	9
1[a]	3	10
1[a]	4	11
1[a]	5	12
2[b]	1	16
2[b]	2	17
2[b]	3	18
2[b]	4	19
2[b]	5	20
3	1	24
3	2	25
3	3	26
3	4	27
3	5	28
4	1	32
4	2	33
4	3	34
4	4	35
4	5	36
5	1	40
5	2	41
5	3	42
5	4	43
5	5	44
8	4	3
8	5	4
9	1	8
9	2	9
9	3	10
9	4	11
9	5	12
10	1	16
10	2	17
10	3	18
10	4	19
10	5	20
11	1	24
11	2	25
11	3	26
11	4	27
11	5	28
12	1	32
12	2	33
12	3	34
12	4	35
12	5	36
13	1	40
13	2	41
13	3	42

Table 86 RS-485 Port Addresses *(continued)*

Chassis Number	Slot Number	Port Address
6	1	48
6	2	49
6	3	50
6	4	51
6	5	52
7	1	56
7	2	57
7	3	58
7	4	59
7	5	60
8	1	0
8	2	1
8	3	2
13	4	43
13	5	44
14	1	48
14	2	49
14	3	50
14	4	51
14	5	52
15	1	56
15	2	57
15	3	58
15	4	59
15	5	60

a. In a Tricon v10.x or v11.x system that contains a Model 8110 Main Chassis, chassis 1 is available only as a Main Chassis with no physical slots for interface modules. In a system that has been upgraded from v6-v8 and contains an older Main Chassis, the Main Chassis *does* have logical slots with physical slots for interface modules and can accept HART Interface Modules.

b. Chassis 2 may be used with HART Interface modules unless it contains communication modules.

WARNING If RS-485 port addresses are duplicated on a network there will be failures in communication with the HART controller. Be sure to design a Tricon system with HART Interface Modules that do not duplicate port addresses. Note that the addresses for chassis 1 through 7 are repeated in chassis 9 through 15.

For information on HART communication and the Triconex 4850 HART Multiplexer (a component in the HART Interface Modules), including PC software installation and configuration, see the *Triconex 4850 HART Multiplexer Instruction Manual*.

If you are using HART communication in a safety-related application, see the *Safety Considerations Guide for Tricon v9–v11 Systems* for more information.

Installing HART Interface Modules in Systems Upgraded from v6–v8

In Tricon systems that have been upgraded from v6–v8, these chassis are compatible with HART Interface Modules:

- Model 8100-*x* Main Chassis
- Model 8101 Low-Density Expansion Chassis
- Model 8102 RXM Expansion Chassis

Throughout this section, the chassis above are referred to as "HART compatible chassis."

The HART compatible chassis provide only power, ground, and field connections to interface modules. They do not connect the RS-485 signal over the backplane, so each HART Interface Module must have a connection from the previous module and a connection to the next module as shown in this figure.

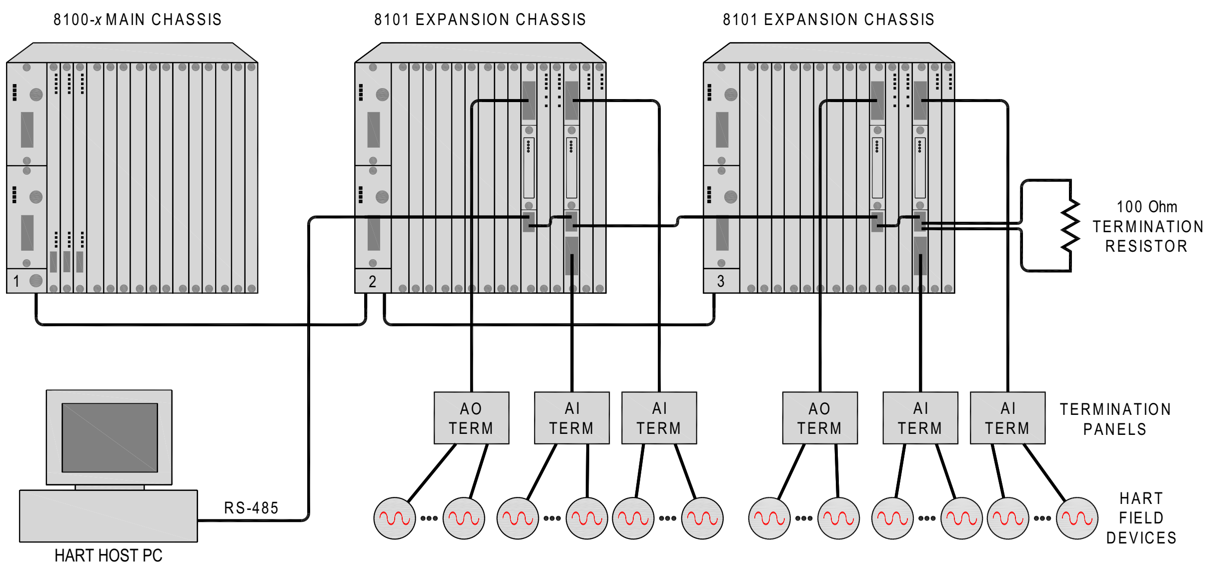


Figure 91 Typical HART Installation Using Model 8101 Low-Density Expansion Chassis

There are no restrictions on the type of chassis or the type of modules that may share a chassis with the HART Interface Modules because the COMM bus is not connected to the HART Interface Modules. Also, there are no restrictions on the type of cable that may interconnect chassis.

The HART compatible chassis do not provide interface modules with the chassis and slot addresses for determining the RS-485 port address for the HART multiplexer (MUX). In these chassis, the chassis and slot addresses are set with DIP switches on the 2071H HART MUX Module, a removable sub-component of the HART Interface Module. The DIP switches are set correctly at the factory, but if a MUX Module needs to be replaced, the DIP switches can be set by the user.

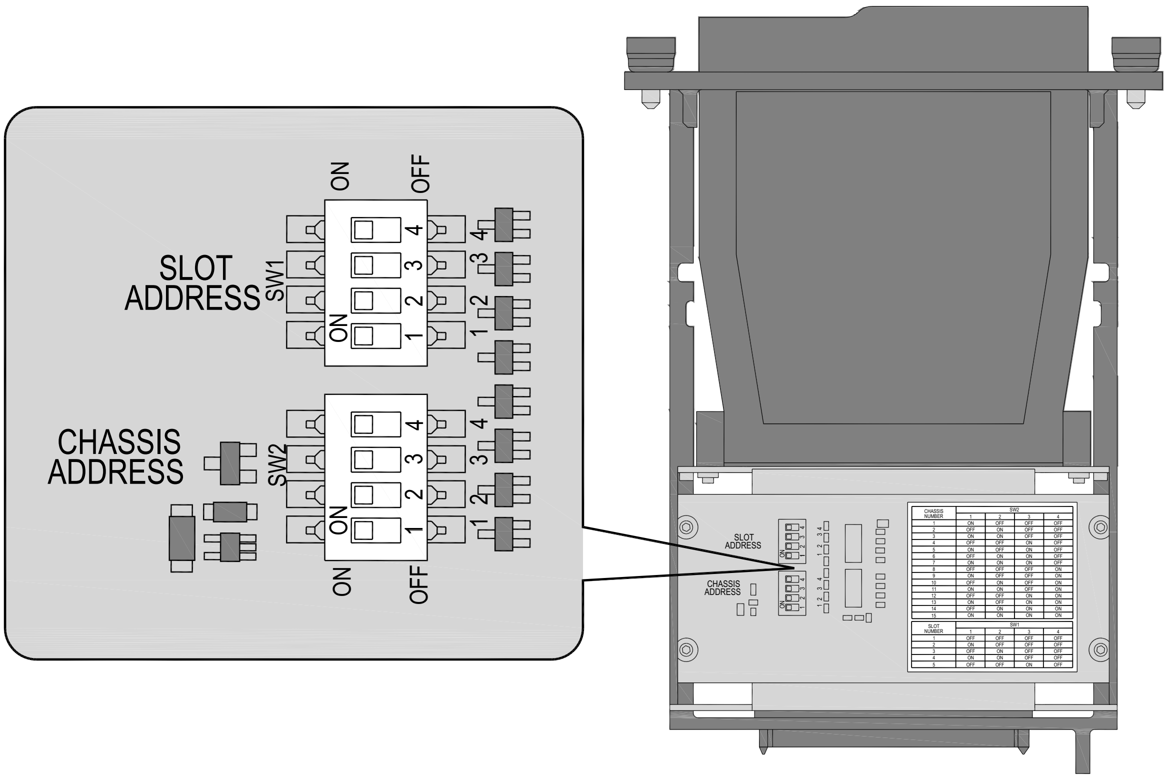


Figure 92 2071H HART MUX Module Slot and Chassis Addressing

There are two DIP switches in the HART MUX Module; one sets the slot address and one sets the chassis address. On the circuit board, the slot address DIP switch is marked “SW1” and “SLOT ADDRESS” and the chassis address DIP switch is marked “SW2” and “CHASSIS ADDRESS.” Each DIP switch has four switches numbered 1 through 4. The “ON” and “OFF” directions for the switches are marked on the switch itself and on the circuit board next to each switch.

Table 87 on page 257 shows the correct slot address switch settings and Table 88 on page 257 shows the correct chassis address switch settings. Once the DIP switches are set correctly, the RS-485 port address will be as indicated in Table 86 on page 253.

Table 87 Slot Address DIP Switch Settings

Slot Address	SW1			
	1	2	3	4
1	OFF	OFF	OFF	OFF
2	ON	OFF	OFF	OFF
3	OFF	ON	OFF	OFF
4	ON	ON	OFF	OFF
5	OFF	OFF	ON	OFF

Table 88 Chassis Address DIP Switch Settings

Chassis Address	SW2			
	1	2	3	4[a]
1	ON	OFF	OFF	OFF
2	OFF	ON	OFF	OFF
3	ON	ON	OFF	OFF
4	OFF	OFF	ON	OFF
5	ON	OFF	ON	OFF
6	OFF	ON	ON	OFF
7	ON	ON	ON	OFF
8	OFF	OFF	OFF	ON
9	ON	OFF	OFF	ON
10	OFF	ON	OFF	ON
11	ON	ON	OFF	ON
12	OFF	OFF	ON	ON
13	ON	OFF	ON	ON
14	OFF	ON	ON	ON
15	ON	ON	ON	ON

a. At the time of this writing, DIP switch 4 is not used for RS-485 port addressing but Invensys recommends that you set it to ON for chassis 8 through 15.

WARNING

- If RS-485 port addresses are duplicated on a network there will be failures in communication with the HART controller. Be sure to design a Tricon system with HART Interface Modules that does not duplicate port addresses. Note that the addresses for chassis 1 through 7 are repeated in chassis 9 through 15.
- The RS-485 port addresses are determined by the slot address switches and switches 1, 2, and 3 of the chassis address.

For information on HART communication and the Triconex 4850 HART Multiplexer (a component in the HART Interface Modules), including PC software installation and configuration, see the *Triconex 4850 HART Multiplexer Instruction Manual*.

If you are using HART communication in a safety-related application, see the *Safety Considerations Guide for Tricon v9–v11 Systems* for more information.

Enclosing the Chassis

Invensys will mount Tricon chassis in any of the industry-standard enclosures listed below. Please contact Invensys regarding other enclosures, available for additional engineering and documentation charges.

Table 89 Chassis Enclosures

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)

RXM Chassis Installation

This section describes how to install an RXM Chassis (Model 8112), which is typically used to extend the system to remote locations. Each RXM Chassis must include a set of RXM Modules, which include three identical modules that extend the Tricon controller I/O bus and provide ground loop isolation. An RXM Chassis with a Primary RXM Set must be connected no more than 100 feet (30 meters) from the Main Chassis. From this Primary RXM Chassis, RXM Chassis with Remote RXM Sets can be located as far away as 1.2 miles (2 kilometers) from the Main Chassis, and RXM chassis with Remote SRXM Sets can be located as far away as 7.5 miles (12 kilometers) from the Main Chassis.

WARNING Each RXM Chassis must include at least one I/O module, otherwise a faulty power supply in that chassis will not be detected.

This figure depicts a typical configuration in which additional RXM or Expansion Chassis are connected to an RXM Chassis which is connected to the Main Chassis. For information on other configurations, contact the Global Customer Support (GCS) center.

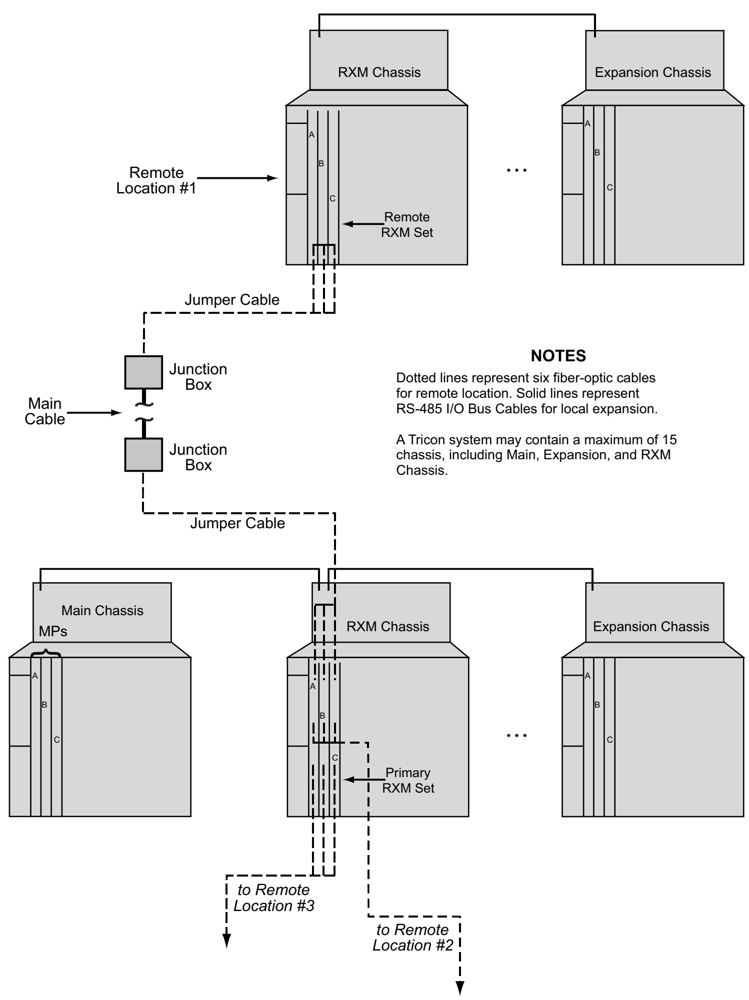


Figure 93 Typical Configuration for Remote Locations

Each RXM Chassis can include:

- A Primary RXM Set (Model 4200-3 or 4201-3) or Remote RXM Set (Model 4210-3 or 4211-3)
- Two Power Modules
- Six I/O module slot sets (Each RXM Chassis must include at least one I/O module.)

This table includes the specifications for I/O Bus cabling used with RXM Chassis.

Table 90 RXM Chassis Cable Specifications

Item	Specification
I/O Bus Cabling	
Local Expansion	Multi-drop twisted-pair cabling
	RS-485 ports
Remote Expansion	Point-to-point fiber-optic cabling
	Fiber-optic modem ports
I/O Bus Length	
Standard RS-485[a]	100 feet (30 meters) maximum
Multi-mode fiber-optic	1.2 miles (2 kilometers) maximum
Single-mode fiber-optic	7.5 miles (12 kilometers) maximum

a. Contact the Global Customer Support (GCS) Center for assistance when configuring a system that exceeds 100 feet (30 meters) of I/O bus cable length.

Typical Fiber-Optic Components

This section describes typical components in a fiber-optic installation, which include:

- Guidelines for Fiber-Optic Cables on page 261
- Main Fiber-Optic Cable on page 261
- Junction Boxes on page 261
- Jumper Cables on page 262
- Connectors on page 262

Guidelines for Fiber-Optic Cables

The selection and installation of the fiber-optic cabling used with RXM and SRXM Modules requires special knowledge, training, and tools. In the United States, Canada, and Western Europe, fiber-optic cabling is widely used in the telecommunications industry, and a wide choice of vendors is available to aid in the selection and installation of it. For example, in the United States, AT&T Network Services has been used with great success in many Tricon controller installations.

Invensys recommends that, whenever possible, the services of a qualified vendor should be utilized for the selection and installation of fiber-optic cabling. The *Directory of Instrumentation* published by the Instrumentation Society of America (ISA), and distributed annually to ISA members, provides a list of United States vendors specializing in industrial applications.

Multi-Mode Fiber Alternatives

In parts of the world where the above services are not readily available, or in those installations where it is desirable to have in-house personnel install and maintain the cabling, other multi-mode fiber alternatives exist. For more information, contact the Global Customer Support (GCS) center.

Main Fiber-Optic Cable

Several types of cable core and sheath designs are available from various vendors. Selection of the cable sheath must be based on the physical and environmental requirements of the application. Indoor cable is available for general usage, riser, and plenum applications. Outdoor cable is available for cable tray, aerial, underground, directly buried, or underwater uses. Outdoor cable with protective over-sheath coverings for lightning and rodent protection is also available.

An RXM installation requires a total of six fibers (a Transmit and Receive for each channel) between the primary and remote locations. If you use a single primary cable, then you should select a cable with six fibers plus spares.

For very critical applications, where loss of communication to the remote location cannot be tolerated and the physical integrity of the RXM cable cannot be assured, use a separate cable for each channel. In this case, a total of three main cables is required, each having two fibers plus spares. Route each cable between the primary and remote location along a different path to provide additional protection.

Invensys recommends installing cables with spare fibers in all cases. The cost of additional fibers in a cable is small compared to the cost of installing a new cable in the event that a single fiber is accidentally damaged.

Junction Boxes

A junction box is typically used to terminate each end of the main cable. Each fiber in the cable must be individually mated to an ST connector. The type of junction box and the mounting location depend on the requirements of the application.

Jumper Cables

Use a general-purpose jumper cable with ST connectors on each end to make connections between the junction box and the RXM modules.

Connectors

Twelve ST connectors are required for each remote connection. Connectors should be bayonet type with a ceramic tip plug.

Installing an RXM Chassis

This procedure explains how to install a typical configuration which includes an RXM Chassis located near the Main Chassis and additional RXM and Expansion Chassis connected to this RXM Chassis. The configuration cannot exceed 15 chassis.

WARNING During installation of RXM modules and after each maintenance activity, make sure that all fiber-optic ST connectors are fully seated and engaged. Because ST connectors from different manufacturers may exhibit minor variations, close inspection is necessary to verify proper engagement of the ST locking mechanism. Failure to properly secure a connector could result in unreliable operation of the Tricon controller and could ultimately lead to a false plant trip.

Procedure

1. For the RXM Chassis located near the Main Chassis, use I/O bus cables (Model 9000) to connect to the I/O Bus Connectors on the backplanes of each chassis. The length between the Main Chassis and the last RXM or Expansion Chassis cannot exceed 100 feet (30 meters).
2. In this RXM Chassis, install a Primary RXM Set (Model 4200-3 or 4210-3) immediately to the right of the Power Modules. Install I/O modules, as needed. At least one I/O module must be configured in the RXM Chassis., The Primary RXM Set can support up to three RXM or Expansion Chassis. To set up more than three remote locations in a single Tricon controller, please contact the Global Customer Support (GCS) center.
3. For each RXM Chassis at a remote location, install Remote RXM Sets (Model 4201-3 or 4211-3). Install I/O modules, as needed.
4. Connect each RXM Chassis at remote locations with the RXM Chassis located near the Main Chassis using fiber-optic cables to connect to the Transmit and Receive paths for each channel. This connection can be as far as 7.5 miles (12 kilometers) from the Main Chassis. See Figure 94 for a diagram of this wiring.
5. Install I/O modules, as needed.
6. Add Expansion Chassis as needed in both local and remote locations. The I/O Bus length between the chassis cannot exceed 100 feet (30 meters).
7. Ground the remote RXM chassis. See Controller Grounding on page 264.

Fiber-Optic Wiring for RXM Modules

This figure shows the wiring between a Primary RXM Set and a Remote RXM Set, which connects a Receive (RX) to a Transmit (TX) for each channel.

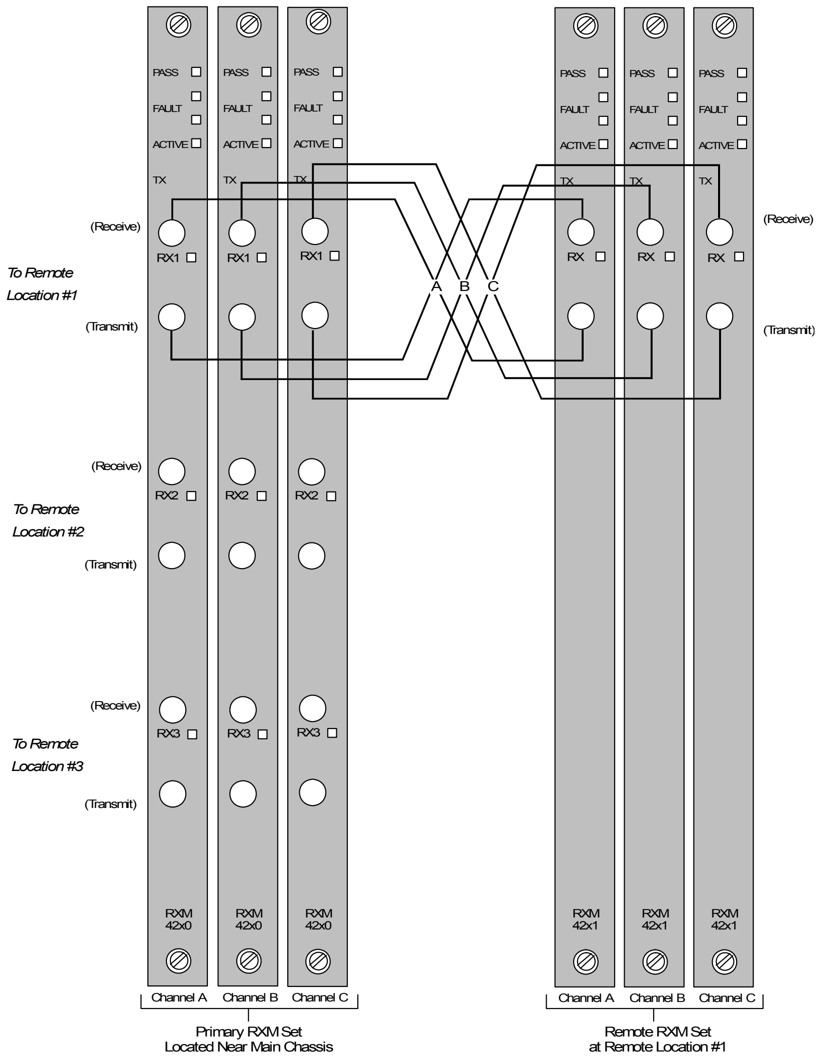


Figure 94 Simplified Fiber-Optic Wiring for One Remote Location

Controller Grounding

This section explains how to properly ground a Tricon controller, which is essential to the safety of plant personnel as well as to the proper operation and protection of the Tricon controller.

Topics include:

Introduction to Grounding

Grounding (earthing) is a term that has many different facets, depending on the application. Some of the reasons for grounding systems and equipment are to:

- Limit the voltage imposed by lightning, line surges, or unintentional contact with higher voltages, and stabilize the voltage to ground under normal operation.
- Establish an effective path for fault current that is capable of safely carrying the maximum fault current with sufficiently low impedance to facilitate the operation of over-current devices under fault conditions.
- Increase the protection of people and equipment from shock or damage.

In the power quality field, grounding plays an important part in the proper operation of "sensitive" equipment. Of all the power and grounding problems affecting electronic load equipment, almost 90% are caused by electrical power and grounding conditions inside the facility in which the equipment is used. More importantly, almost 75% of the power quality problems inside the facility relate to grounding, which makes it the single most important factor, from a facility standpoint, in having reliable equipment operation.

A grounding system has several key components: the connection to ground (often the grounding grid or electrodes); the grounding conductor (typically called the green wire); the bonding jumper that connects the grounding conductor to the grounded conductor (often referred to as the neutral); and the connection of the equipment connected to the grounding system.

The ground system operates under the same rules as the normal current-carrying conductors, namely Ohm's Law (voltage equals current multiplied by impedance) and Kirchoff's Laws (sum of the voltage drops around a closed circuit equals zero, or the sum of all currents at a node equals zero). For a lightning protection system, the currents involved are tremendous, measured often in tens of thousands of amperes. The lowest impedance path possible is desirable to minimize the voltage rise between different parts of the electrical system when there is a direct strike or induced voltage from lightning. Similarly, for the fault protection to work properly, the fault current must travel through an effectively low impedance path to cause the breaker or fuse to operate properly and to reduce the touch potential hazard when equipment insulation failures occur.

Grounding the system properly often means having equipment that is interconnected, such as computers and printers, at the same potential (referred to as *equipotential bonding*). This may mean eliminating ground loops that can result in different voltage potentials, minimizing "noisy" current flowing in the equipment grounding conductor, and providing a lower impedance path to the system ground to reduce disruptive voltages.

Some of the ways that this is accomplished is to make sure that there is a single, continuous electrical path for the grounding and grounded (neutral) conductors back to the point where they are bonded together. This point is usually at the service entrance. The impedance of concern is not just at 60 hertz, but also at the harmonic frequencies and even the very high (100 kilohertz to 10 megahertz) transient frequencies.

Monitoring Ground Current

Use of a power quality monitor can be used to monitor the ground current and analyze both the amplitude and frequencies present, as well as transient and noise signals. Monitoring the neutral-to-ground voltage at a distribution panel can indicate that there may be a poor ground path (occurs when voltage is greater than 3 volts) or an illegal bond (occurs when voltage is less than 0.2 volts). Improving the grounding system in the facility mat not only provide for more reliable equipment operation, but also a safe environment.

Grounding Tricon Systems

Tricon systems must be grounded (earthed) according to prevailing electrical codes. The particular application and the international, national, regional, and local electrical codes dictate the specific grounding configuration. The safety ground (green wire or green/yellow wire), required to protect personnel, must be installed according to international, national, regional, and local electrical codes. Installing the safety ground is your responsibility.

You must meet the following objectives when implementing Tricon system grounding:

- Ensure that all exposed non-current carrying conductive surfaces are effectively interconnected and tied to ground per applicable codes.
- Ensure that the electrical system and equipment are protected, and establish a zero-voltage reference point (system ground) for Tricon system operation.

Here are some general grounding considerations to follow:

- The particular application and international, national, regional, and local electrical codes dictate the specific grounding requirements.
- Sources of the electrical noise should be kept to a minimum, and it is important to understand where noise can be produced and its impact. An example of a noise source is power line transients, which can be caused by lightning, line switching, load switching, and so on.
- Connect the power source to ground (hence the name "Neutral" for the return conductor).

The Tricon controller includes three separate ground systems:

- Protective earth ⏚ —safety or chassis ground
- Signal or instrument ground ⏚ —a functional earth
- Shield ground ⏚ —a functional earth

WARNING You must permanently connect the Tricon controller to safety ground to protect operations and maintenance personnel from electrical shock, and to protect the control system from damage caused by lightning or other electrical noise transients.

The digital and analog portions of each Tricon module use separate isolated signal return paths, which are connected together to form the Tricon controller signal ground. The chassis ground (sheet metal) of the Tricon controller acts as an electrostatic shield for the digital and analog circuitry. (All communication cable shields are terminated to the chassis ground.)

The sheet metal of the Tricon controller is connected to the safety ground. The Tricon controller is normally delivered with the safety ground connected to the signal ground by means of a resistor-capacitor (RC) network. This network can be disconnected to allow for alternative grounding implementations or *floating ground* applications. For guidelines when installing a Tricon controller as part of a floating system, see Application Note 14, *Floating DC Systems, Ground Fault Detectors and the Tricon* available on the Global Customer Support (GCS) center website at http://support.ips.invensys.com.

Achieving a Zero-Voltage Ground Reference

Achieving a zero-voltage ground reference at the earth bus is essential to proper system grounding. This figure lists the values for a ground grid or other acceptable ground points for a Tricon system.

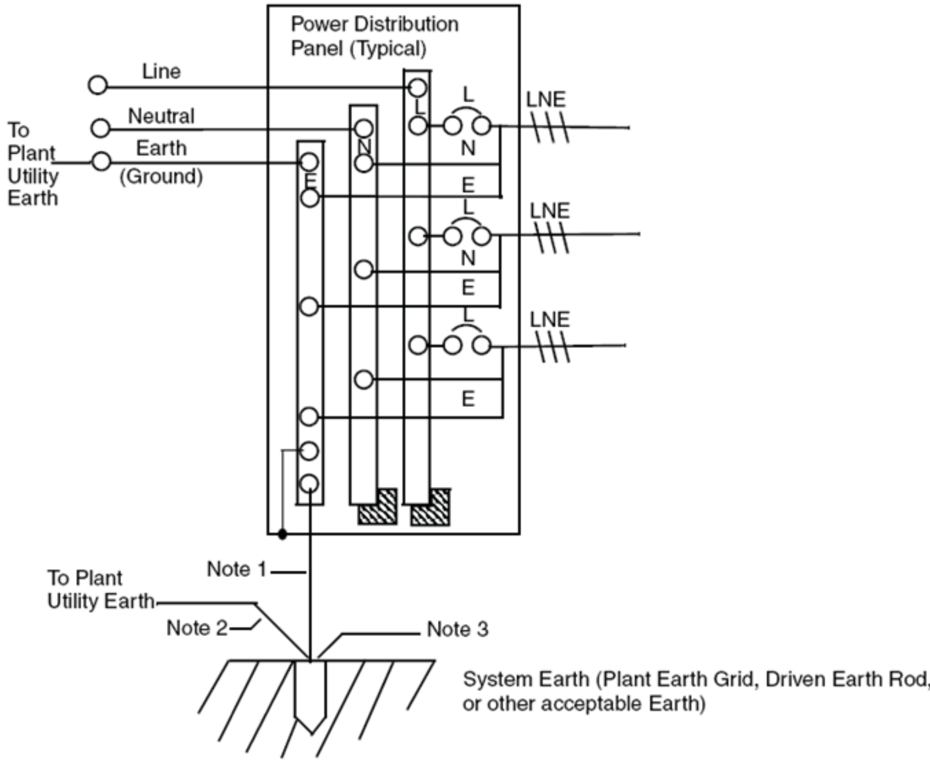


Figure 95 System Ground Values

Notes on Figure 95:

1. Insulated wire, size per local code.

2. When using a dedicated system ground, and when galvanic connection to plant utility ground is required, this connection must have an inductance greater than or equal to 20 microhenries, with low stray capacitance. A suitable high frequency choke, or an insulated conductor of 6 AWG (16 square millimeters) minimum, with a length of 60 feet (20 meters), may be used for this purpose.

3. Each separately derived power source for Tricon equipment must return to a single grounding point, such as the ground grid or other acceptable ground. The following ground resistance values must be adhered to and maintained per IEEE Standard 142:

- For power plant applications, ground resistance must be equal to or less than 1 ohm.
- For industrial plants, ground resistance must be less than or equal to 5 ohms.

Connecting to a Grid

Power consumers may share the same grid with more sensitive electronics. This mandates harmonic discipline for all involved parties. This section describes elementary rules of good engineering.

Grid connections for high-energy devices must be made in such a way that grid currents are minimized and have no adverse effect on sensitive electronics. This requires the implementation of a Transformer Neutral (TN-S) power scheme, which is the most optimal solution for EMC. A TN-S system provides a reliable low-impedance earth connection. In a TN-S system, the neutral of the supply transformer is grounded and equipment frames are connected with a protective earth (PE) conductor between the source and load. The prime function for the PE conductor is safety and to provide a good interference return path. The intended currents flow only in the line (L) and neutral (N) conductors.

This diagram shows a TN-S power scheme.

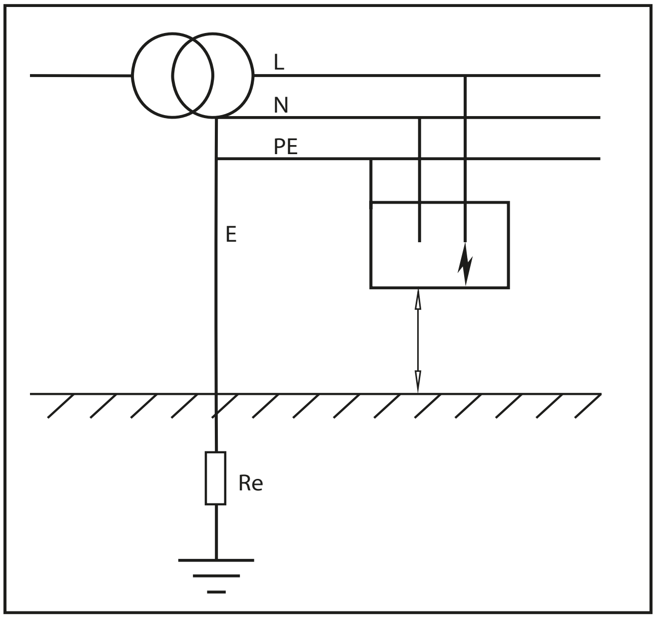


Figure 96 TN-S Power System Diagram

Sensitive systems must have a single grid connection for electronics. This is best achieved by the installation of all devices on a copper bus structure inside a single enclosure (or adjacent enclosures).

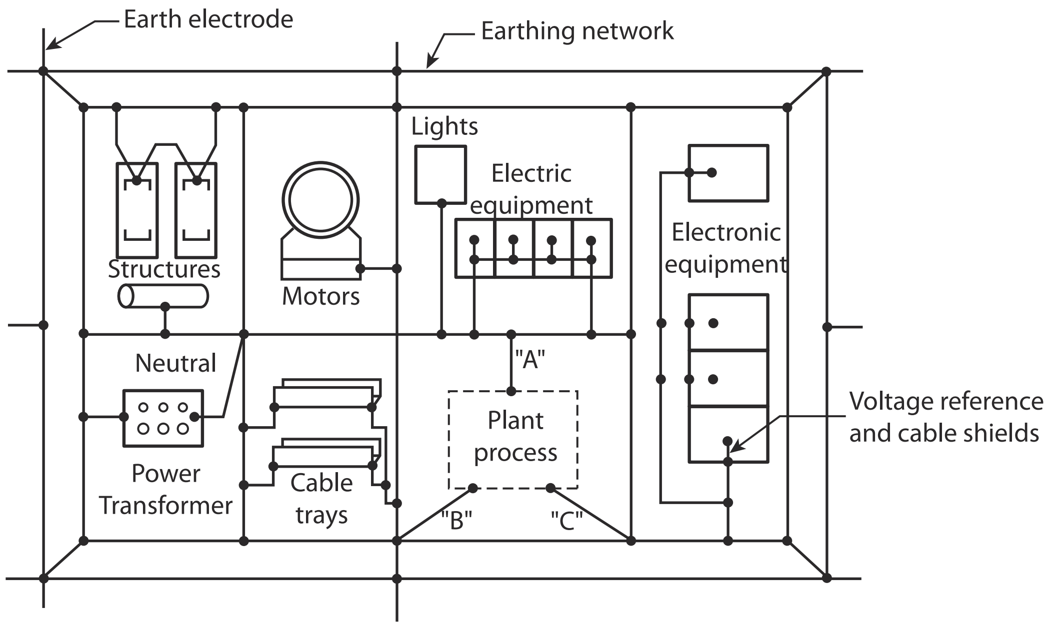
Communication between parts of a system must minimally be based on galvanic isolation, but fiber-optic technology is superior.

Ground connections must be kept as short as possible.

Ground loops must be prevented for all signals to permit undisturbed transmission for analog and digital signals.

Connection of electronic equipment is made at one vertical point in the grid as close as possible to the nearest earth ground. When electronic equipment is located on more than one floor of the building, the same vertical interconnecting ground grid should be used to connect the electrical equipment on each floor. Communications between the electronic equipment on two or more floors should be accomplished using fiber-optic cable or shielded cable.

This figure shows how to connect electronic equipment to the grid.



NOTE - The topology of connections "B" and "C" provides better EMC performance than the topology "A". Details of connections may vary with specific cases.

Figure 97 General Principle for Connecting Equipment to a Grid

Connecting a System to Safety Ground

This section explains how to make a permanent, redundant connection to safety ground. You can make a temporary connection to safety ground using the ground terminal on the panel portion of the chassis backplane.

WARNING **Do not operate a Tricon controller without connecting each Main and Expansion Chassis to safety ground (protective earth)** with a low-impedance cable. Improper grounding creates the potential for dangerous electrical shock—the Tricon controller can produce significant leakage currents which must be connected to ground.

WARNING To ensure that your Tricon controller and the equipment connected to it operate safely, you must follow all applicable local and national codes and standards. At a minimum, these include national fire and electrical codes. Since codes and standards vary geographically and change over time, it is your responsibility to determine which standards apply to your specific case, and comply with them. If necessary, please contact your local Fire Marshall and Electrical Inspector for assistance.

Procedure

1 For each Main Chassis and Expansion Chassis, connect a cable from the 1/4–inch bolt on the left side of the chassis. The cable should be a heavy solid or stranded, bare or insulated cable, such as 8-gauge (8.367 mm2) or larger, using a crimped ring lug. If you use an insulated cable, it should be green with a yellow stripe.

2 Connect the other end of the cable to a common tie point such as a copper bar.

3 Connect the copper bar to safety ground according to the applicable national and local electrical codes.

   You can use the same copper bar to provide a safety ground connection for the cabinet, field devices, and wiring in the control system.

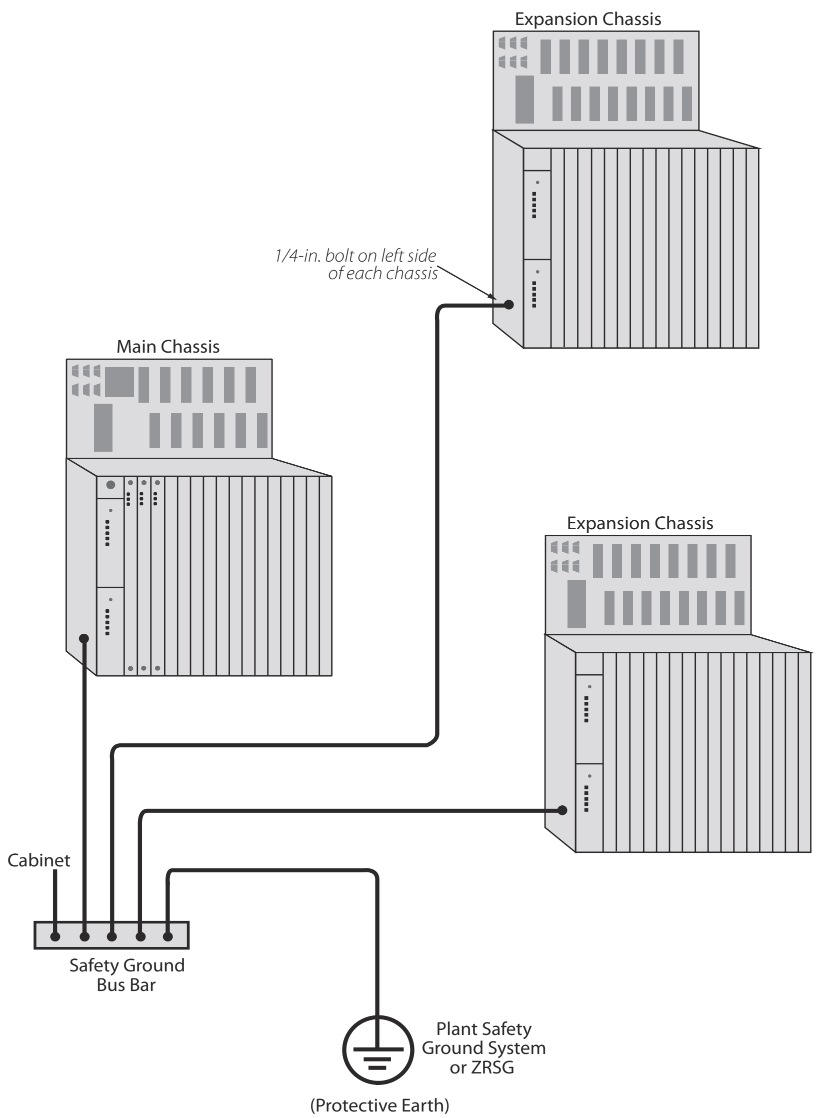


Figure 98 Connecting a Tricon System to Safety Ground

Connecting a System to Signal Ground

The signal ground (functional earth) for a Tricon controller is allowed to float with respect to the safety ground. Each Tricon controller Power Module is equipped with an internal RC network to limit the potential voltage differences between the signal ground and safety ground.

In most installations, it is best to tie the signal ground and safety ground together *at one and only one point.* These sections provide installation guidelines based on controller configurations.

- Single Controller with Only Digital Modules on page 271
- Single Controller with Only Analog, or Both Analog and Digital Modules on page 272
- Controller Included in DCS on page 273

Single Controller with Only Digital Modules

If the controller configuration includes only digital modules, using the internally-supplied RC network is sufficient. No further grounding is required.

The RC network is connected when a jumper is installed between RC and ⏚, as shown in this figure.

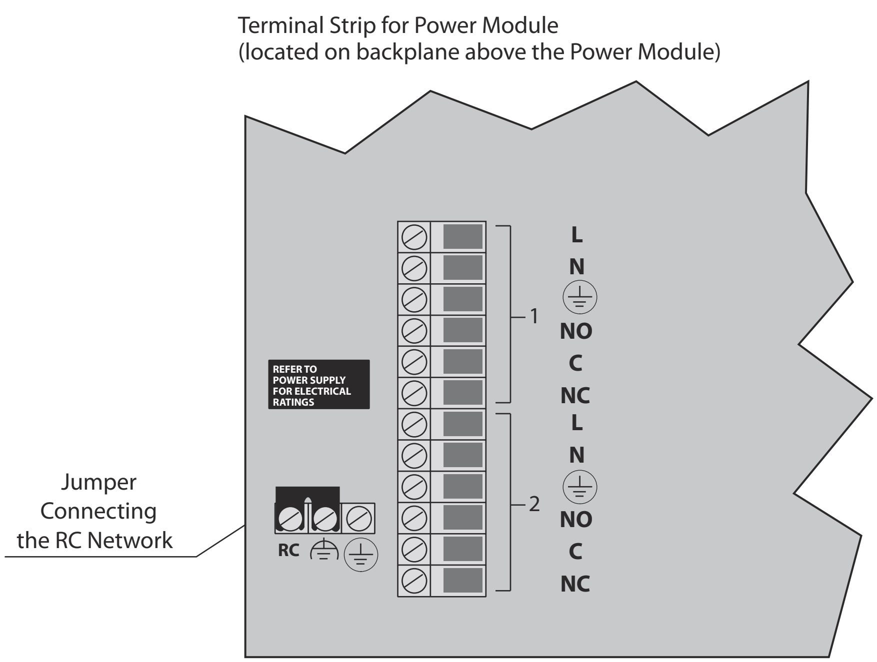


Figure 99 Connecting to Signal Ground Via the RC Network

Single Controller with Only Analog, or Both Analog and Digital Modules

If the controller configuration includes only analog, or both analog and digital modules, and a single controller, using the internally-supplied RC network is sufficient. No further action is required.

The analog loop power supplies are connected to the internal signal ground on the termination modules, as shown in Figure 100.

Optionally, you can make a connection between the Tricon controller signal ground and a dedicated instrument ground or the common tie point of a DCS, as shown in Figure 101.

Notes To use the internal RC network, install the jumpers on the Power Module., Isolated power supplies used for isolated digital points must be connected to a Safety Ground Bus Bar or similar means to the Plant Safety Ground System or ZRSG.

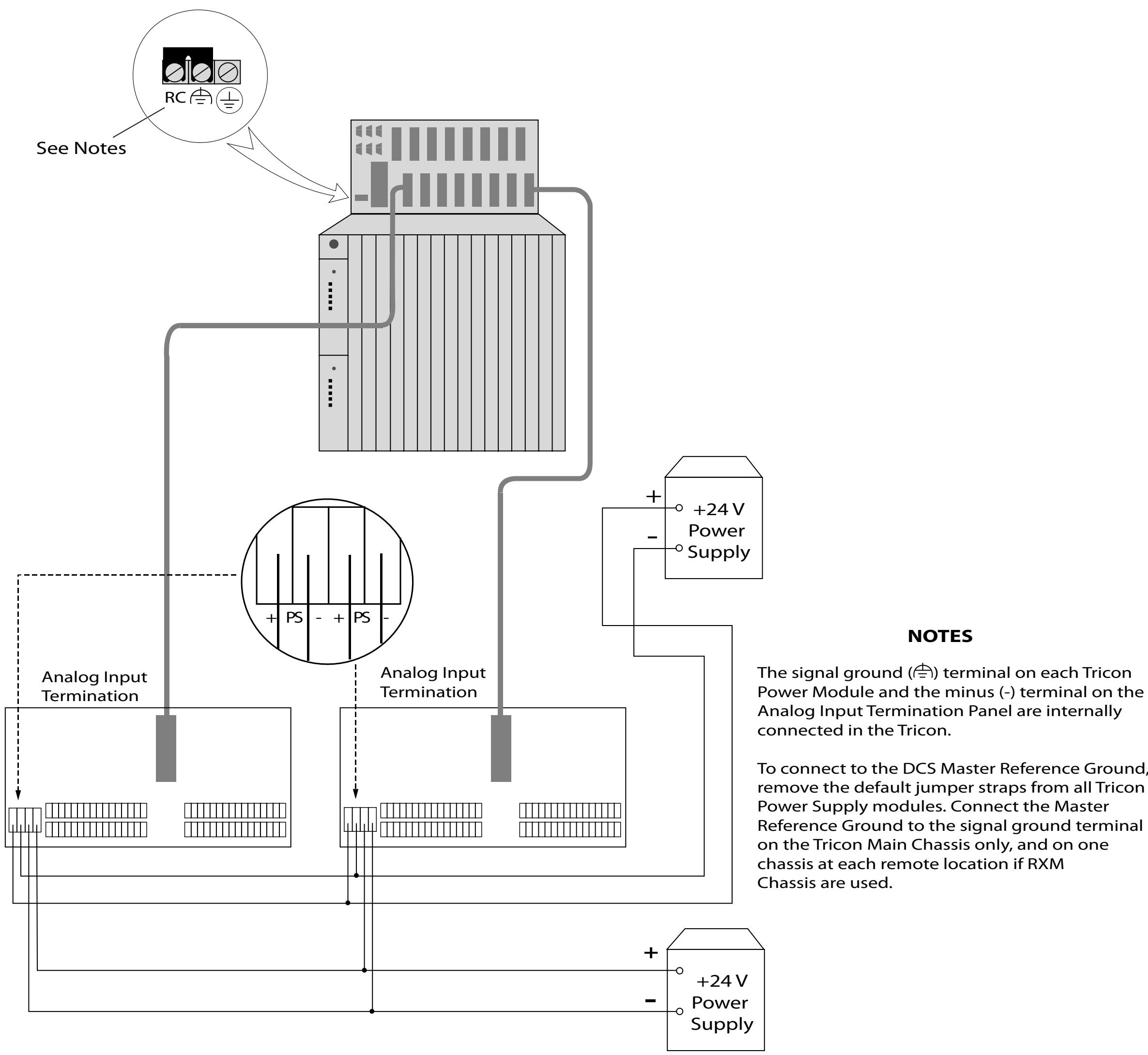


Figure 100 Connecting to Safety Ground Via the Internal RC Network

Controller Included in DCS

If the Tricon controller includes only digital modules, the internally supplied RC network is sufficient. No further action is required.

If the configuration includes a single Tricon controller with only analog or analog and digital modules, a connection must be made between the Tricon controller signal ground and the common tie point of the DCS signal ground, as shown in Figure 101.

Note The DCS common tie point may be the safety ground tie point of the control room. Use a separate wire—do not share a safety ground connection.

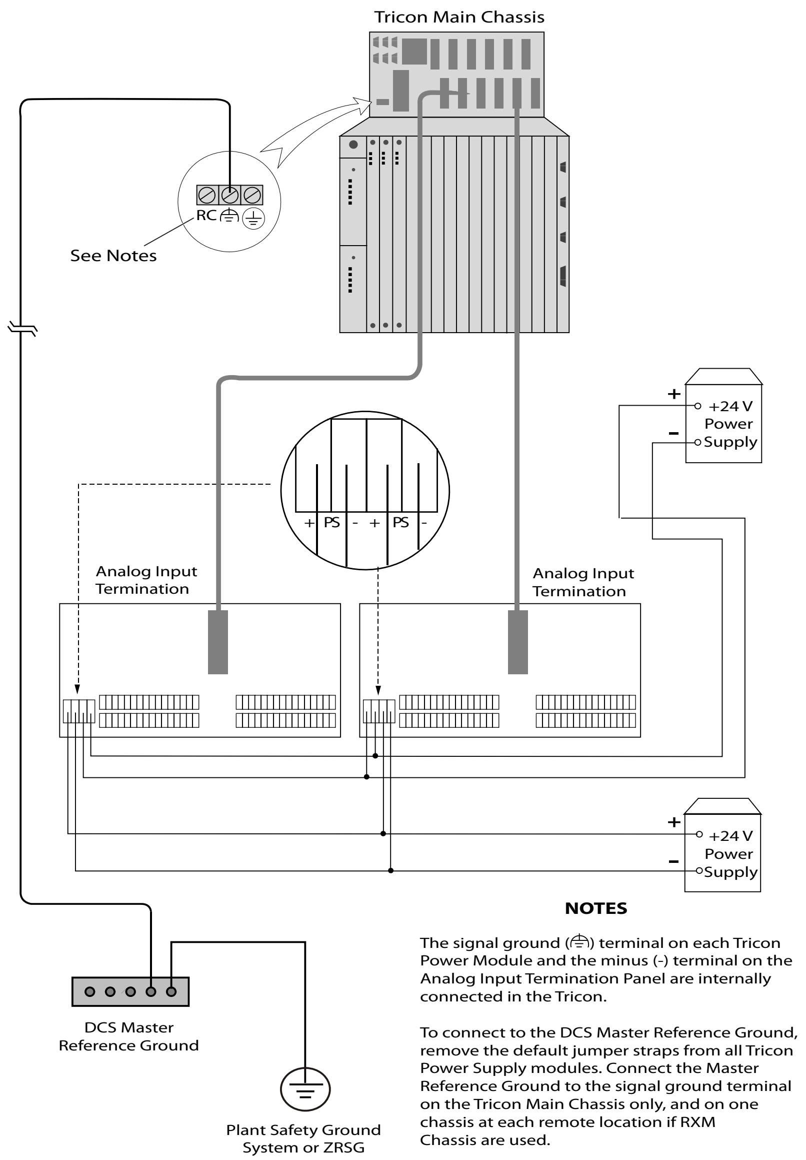


Figure 101 Connecting to Dedicated Earth or DCS Master Reference Ground

Connecting Shields to Earth Ground

For configurations that use analog modules, cable shields should be installed on one end of the cable, typically at the field device. If you must use the controller instead, you should provide a connection near the termination panel using an external shield bus bar. Such bus bars are available from Phoenix Contact or other terminal block suppliers. You must individually connect each shield bus bar to a suitable quiet ground point such as a dedicated earth ground or a DCS Master Reference Ground as shown in Figure 102.

For details on bus bar wiring, see the *Field Terminations Guide for Tricon v9–v11 Systems,* or contact the Global Customer Support (GCS) center.

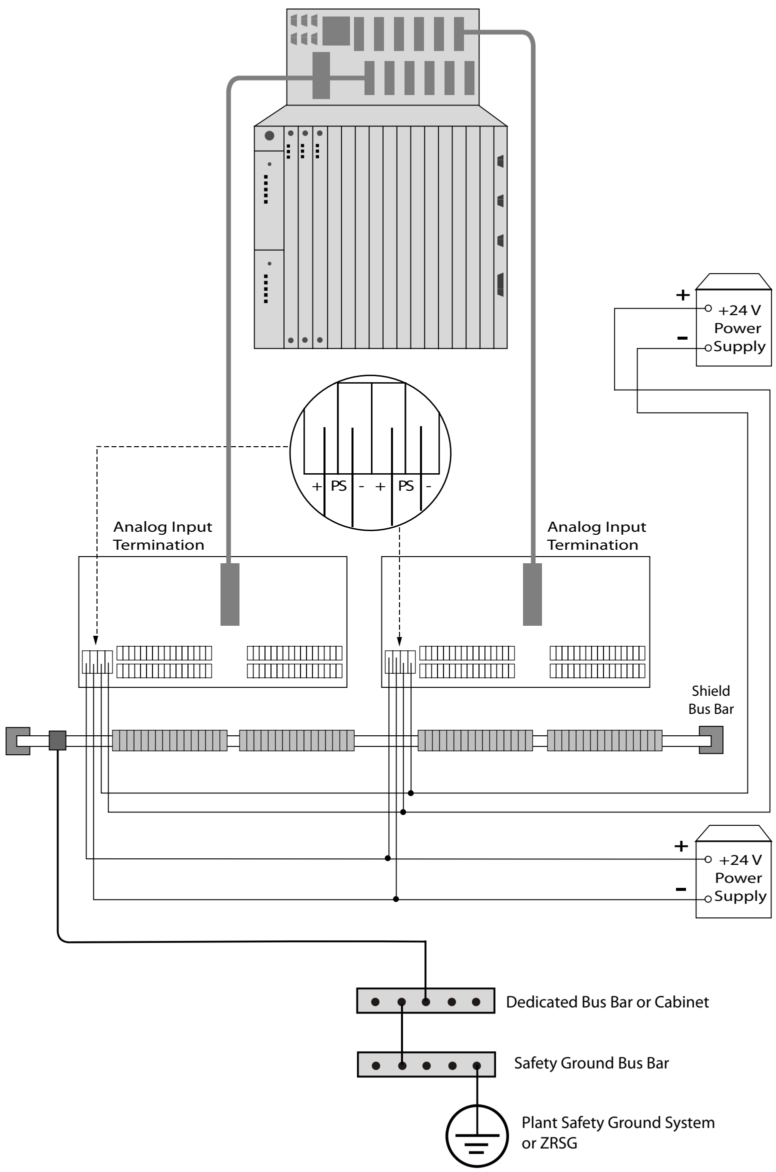


Figure 102 Connecting Shield Ground to Ground Point

AC Power and Distribution Panels

This section provides guidelines for AC power, AC power distribution, and the installation of power distribution panels for the Tricon system.

Topics include:

Introduction

Tricon systems must be powered and protected according to prevailing electrical codes. The particular application and the international, national, regional, and local electrical codes dictate the specific configuration. The safety ground (green wire or green/yellow wire), required to protect personnel, must be installed according to international, national, regional, and local electrical codes.

The following objectives must be met when implementing power distribution in a Tricon system:

- Ensure that all exposed non-current carrying conductive surfaces are effectively interconnected and tied to ground per applicable codes. Painted metal enclosures are considered to be exposed non-current carrying conductive surfaces.
- Ensure the protection of the electrical system and equipment, and establish a zero-voltage reference point (system ground) for Tricon system operation.

Power requirements are specified in the following EMC standards:

- IEC 61000-6-1 for residential, commercial, and light industrial equipment
- IEC 61000-6-2 for industrial equipment

The quality of the supplied power must conform to the requirements of these standards. Exceeding design specifications may cause random problems or even damage to equipment. As such, it is important that the supplied utility power has a minimal quality level. This is not the lower level from the standard, say the –10% for voltage, because all distribution networks face voltage fluctuations due to load switching and so forth. The minimal quality level depends on actual site conditions.

The following general recommendations apply to all installations:

- Three phase transformers should have DELTA-to-WYE conversion. The primary DELTA winding will considerably attenuate disturbing harmonic voltage. The star point of the secondary WYE winding should be connected to ground. This will considerably attenuate interference levels.

- All equipment feeders must use three conductor cables (Line, Neutral, and Earth). This provides a defined return path for power line interference and as a result optimizes the efficiency of line filters inside Invensys equipment.
- Dedicated distribution panels (boards) are recommended to reduce interference impact from other equipment.

WARNING Invensys does not recommend using 2-wire power cabling (for example, cabling without ground wiring) or steel conduit as the ground conductor.

Ordinary power at a location may be polluted by other connected (industrial) equipment, switching transients, lighting, and so forth. The electrical pollution may exceed the requirements for the connected equipment. It is good practice to monitor the site power prior to system installation.

Power Distribution

You must only use power distribution panels, circuit breakers, fuses, interconnecting power cables, connection equipment, and safety devices according to international, national, regional, and local electrical codes. Unless otherwise indicated, all wire sizes must meet local electrical codes. The voltage drop along the length of any power distribution wire must not exceed 3% of nominal VAC. The voltage drop along the length of any power distribution wire must not exceed 2% when using an AC transfer switch.

If you are planning for uninterruptible power supply (UPS) requirements, please see Uninterruptible Power Supplies (UPS) on page 279 for more information.

Dedicated Power Distribution for Control Systems

Dedicated power is normally derived from the secondary side of an ultra isolation transformer or an uninterruptible power supply (UPS).

CAUTION This dedicated power is commonly used for other equipment that may introduce unacceptable power pollution levels. Because of this, dedicated power sources should be considered.

Dedicated Power Distribution Panels

Dedicated power distribution means that the power is used only for the process control system only. Dedicated power distribution panels are highly recommended.

CAUTION Connecting other equipment to the same distribution panel may introduce unacceptable power noise pollution levels. There is a higher chance of power noise pollution when using the same distribution panel than when sharing the power source. The interference coupling mechanism is the most common impedance between the source and distribution panel.

Power Cables

Power wiring (cabling) is divided into two classifications that, for safety reasons, must be physically isolated from each other and from all signal cables using mutually exclusive pipe, conduit, troughs, raceways, or runs, as well as separate cable entries into enclosures. These cable classifications are:

- High-voltage power wires, which carry power at voltage levels equal to or greater than 30 VAC or 60 VDC.
- Low-voltage power wires, which carry power at voltage levels less than 30 VAC or 60 VDC

WARNING Failure to separate the two classifications of power wiring from each other and from signal wiring may result in injury to personnel.

CAUTION Equipment used in Europe requires shielded power cables.

Circuit Breakers and Fuses

All circuit breakers and fuses must be slow to allow for equipment inrush currents up to 16 times the nominal current.

Coordination between fuses and upstream circuit breakers (also called selectivity) requires careful engineering to assure that only the affected group is cleared and that other groups continue to operate unaffected. This applies both to over-current and short-circuit situations.

Coordination between fuses and upstream fuses is normally guaranteed for value ratios of 1.6 and higher, providing that identical I squared t (I^2t) characteristics are used.

Coordination between circuit breakers and upstream fuses is feasible, but care must be taken that the resulting voltage dip duration does not exceed the maximum power interruption time for the connected loads.

Coordination between circuit breakers and upstream circuit breakers is much more difficult to obtain and requires careful engineering when demanded. The basic problem is that both circuit breakers sense the same high short-circuit current and initiate the mechanical release or trip. One response is to delay the trip function for the upstream circuit breaker. This response has the following disadvantages:

- The required delay time may exceed the maximum time permitted in IEC 60479-1.
- The resulting voltage dip duration will be longer when the upstream circuit trips. This further increases the possibility that the connected loads sense a power interruption. This is the most difficult case to assure that the voltage dip duration does not exceed the handling capabilities of other loads.

Recommended Power Supply and Fusing for Externally Powering Field Circuits

When supplying power to field circuits, Invensys highly recommends that separate auxiliary supplies and fuses be incorporated to power the field. This minimizes the possible effects of external plant influences on the module's termination panel and eliminates the possibility of Tricon equipment shutting down or becoming physically damaged due to an improper field connection. Auxiliary power supplies provide a more reliable system installation, which can help limit a circuit fault to a single field instrument loop.

Nominal Voltage

The specified nominal voltage is the average operating voltage. The specified tolerance is intended to handle normal line voltage fluctuations in the distribution network. Continuous operation near the lower limit often increases the amount of power failures, while continuous operation near the upper limit reduces power supply reliability.

The voltage drop between the source and the connected equipment must not exceed 3%.

CAUTION The source should be designed to compensate for cable loss.

Service Outlets

Non-standard service outlets are recommended to prevent pollution of the dedicated power by foreign consumers like vacuum cleaners.

Inrush Current

System components should have an inrush current of about 10-15 times the rated current. Exceptions are:

- Computer monitors (CRTs): the degauss circuit can consume very high currents for a short period of time.
- Soft start: some equipment has soft start circuitry. Note that these circuits have no effect after initial power on. Current spikes are likely to occur during voltage sags and surges.

Uninterruptible Power Supplies (UPS)

Uninterruptible power supply (UPS) refers to a wide range of power protection products. There are three basic UPS design types, each offering more power protection then the preceding. The three types are:

- Offline standby backup supply (SBS), the lowest grade
- Line-interactive SBS, the middle grade
- Online UPS, the highest grade

Offline and Line-Interactive SBSs

Standby backup supplies (SBSs) offer simple surge protection and battery backup capabilities which solve only a minimal number of power quality problems. The two types of SBSs are the *offline SBS* and the *line-interactive SBS*.

Offline and line-interactive SBS designs pass the polluted utility power directly through the unit during the time the utility is present. These SBS designs offer no more during normal utility operation than a surge-protected plug strip. Only when utility power is lost do they switch to their internal AC inverter to provide backup power. Should an offline SBS be selected for a location with extended brownout or low-utility-voltage conditions, it would not solve the intended problem.

Most offline and many line-interactive SBSs, while running on battery, have inverter outputs that are not true sine waves, but are referred to as square waves, modified square waves, or quasi-square waves. These types of output waveforms may be incompatible with some equipment.

Online UPS

An online UPS is a sophisticated state-of-the-art power protection system that is capable of removing or eliminating most power quality problems. For industrial and process control applications, the online UPS is the best choice.

With the online design, the incoming AC utility power continually converts to a DC that is easily cleaned by filtering out most unwanted power problems. The cleaned DC feeds to a continuous duty true sine wave inverter that regenerates new, tightly-regulated AC power devoid of all incoming utility power problems. When the utility power shuts off, the battery takes over as the power source without any interruption at the UPS output. Therefore, the online UPS offers a much greater level of protection. Most current Tricon system equipment operates on power at 50 or 60 hertz.

The online UPS has a wide input voltage range (±25% typical) with a tightly-regulated output voltage (±2% typical). This makes the online UPS ideal for use in applications where power pollution could affect equipment. Since the inverter for the online UPS is designed to provide output power continuously, whether it is operating from utility or battery, it may be connected to larger battery packs, extending the battery backup time to many hours.

To simplify and reduce the number of UPSs needed, multiple pieces of equipment may be connected to a single UPS rated large enough to support the combined equipment.

When using a UPS, please be advised of the following:

- A UPS only provides protection against brownouts and longer interruptions as long as the battery lasts.
- A UPS generates interference. This interference level may exceed the capabilities of nearby electronic equipment.

CAUTION The maximum interference level permitted by UPS standards depends on the UPS power rating.

- Other loads connected to the same UPS may pollute the UPS voltage. This is mainly due to internal impedance and limited electronic control capabilities.
- The electrical pollution of the UPS power may exceed the requirements, particularly when operated in "Bypass" mode.
- A UPS has limited circuit breaker and fuse clearing capabilities, particularly when "Bypass" power is absent.

Ultra Isolation Transformer

The ultra isolation transformer is used only in rare cases, for instance, to support conditions such as floating factory power and factory power quality not meeting IEC requirements.

General Isolation Transformer Theory

Due to the remote locations of process control equipment sensors and the amount of interconnected equipment, process control equipment is susceptible to common mode noise problems. This problem is caused by unwanted currents flowing from the utility neutral and ground across the cabling of the interconnected equipment. If the interconnected equipment is powered by differing building service panels, or is located in different buildings, common currents can actually flow across sensor, network, or device control wiring. When this problem occurs, it results in reliability problems or causes the interconnected equipment to fail. This problem can manifest itself as a continuous or an intermittent problem, with the continuous problem the easiest to locate.

Intermittent common mode noise problems are often the most difficult to determine. A standby backup supply (SBS) or an uninterruptible power supply (UPS) without galvanic isolation will not solve this problem, because in most UPS designs, the utility neutral and ground feed directly through the SBS or UPS to its output. Galvanic Isolation consists of a simple isolation transformer that isolates your equipment from the utility neutral and provides a new neutral at the power input of your equipment. Since the neutral line is now isolated, the path for common mode noise is eliminated. To be effective, galvanic isolation should be installed on every piece of interconnected equipment. With the high potential for a common mode noise problem in large networks, it is best to reduce or eliminate the source of the problem wherever possible.

The ultra isolation transformer is a purposely-designed transformer optimized toward attenuation of common mode interference. Its major characteristic is the extremely low coupling capacitance between primary and secondary connections (0.005 picofarad). This is a standard requirement for systems with common mode interference problems and is easy to implement on systems with dedicated power distribution panels.

CAUTION The secondary neutral of the isolation transformer must be connected to earth.

The main benefit of using an isolation transformer with a rack of equipment is the enhanced control of currents in the equipment shields. The isolation transformer allows these ground currents to be directed through a portion of the rack's shielding, which will not affect the operation of sensitive circuits and completely isolates these currents from the internal equipment reference conductors.

As with any transformer, isolation transformers radiate magnetic fields. Physically locating the transformer adjacent to, or connected to, a room may increase, rather than decrease, ambient noise. Since the physical case of a transformer, as well as the primary winding shield, is normally connected to the third-wire power ground of the supplied power, the secondary shield must be isolated from the transformer case and connected only to the conduit shield going to the shielded room to achieve proper ground isolation. The conduit acts as an RF shield for the room's power and completes the connection between the shielded room and the secondary winding shield in the transformer.

If the transformer is three phase and supplies more than one room, the best application for isolation between rooms is to use only one phase for each room, with a limit of three rooms per transformer. With this approach, power line filters will effectively isolate the room while providing practical noise attenuation.

Power Isolation Transformer Connections

In most applications, an isolation transformer is connected between the power distribution panel and the Tricon system enclosure.

This figure shows a typical isolation transformer.

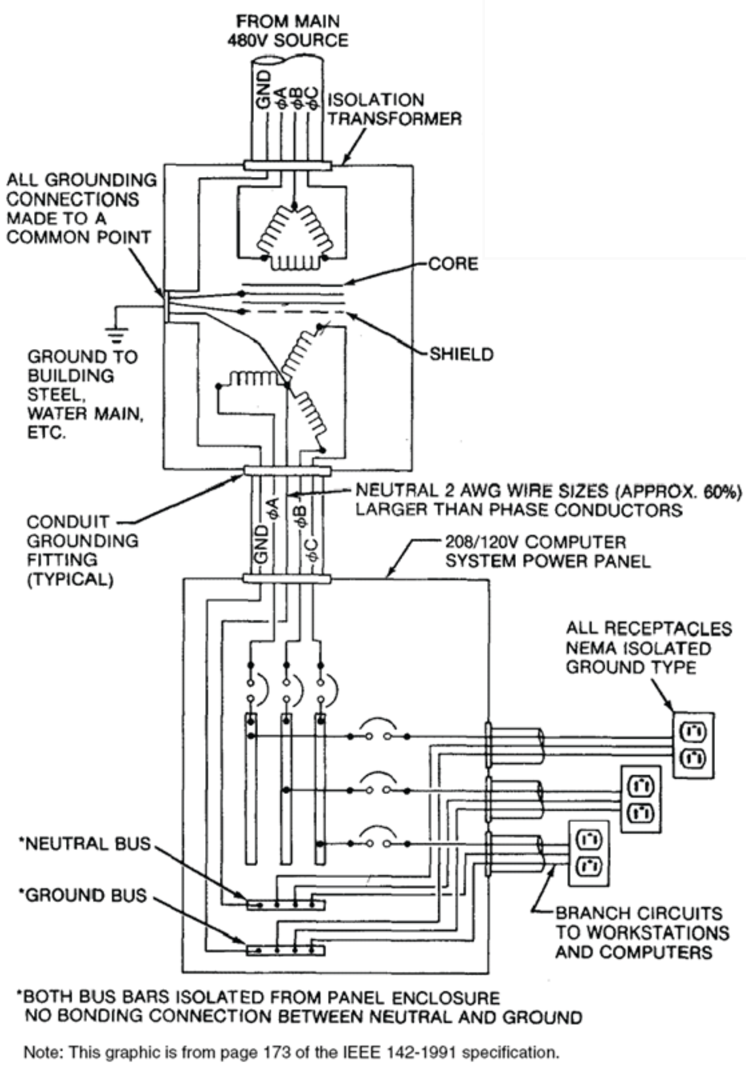


Figure 103 Typical Power Isolation Transformer Connections

Implementation and Maintenance

This section includes information about implementation and maintenance that should be considered when installing a Tricon system. To ensure maximum safety and long service, Invensys recommends that you establish a schedule for routine maintenance at the time the Tricon controller is installed and then adhere to that schedule.

Topics include:

Disabling Output Voter Diagnostics on DO Modules

Output Voter Diagnostics (OVD) is a set of tests that detect failures in the quad-output voting mechanism of all Digital Output Modules except Relay Output Modules. Because of glitches caused by forcing simulated failures, OVD may affect the controlled process. If this is not acceptable, OVD can be disabled, but should be enabled every three months. To ensure safety, you should analyze the sensitivity of each load device attached to the Tricon controller for proper operation.

WARNING For safety programs, disabling the Output Voter Diagnostics is not recommended; however, if it is required due to process interference concerns, it can be done if, and only if, the DO is proof tested every three to six months.

Invensys guarantees that an OVD-forced glitch has the following durations:

- For AC modules, no longer than 1/2 AC cycle.
- For DC modules, less than 2 milliseconds, which is a period that is tolerated well by electro-mechanical devices such as relays, solenoids, and contactors.

For assistance with load devices that might be sensitive to such glitches, please contact the Global Customer Support (GCS) center.

Procedure

1. From TriStation 1131, disable OVD on all or on specific Digital Output Modules. For instructions, see the *TriStation 1131 Developer's Guide* for the version of TriStation being used.

2 Log the date when OVD was disabled so that you can re-enable the OVDs for 10 minutes every three months. If this is not possible due to process concerns, do one of the following:

- Replace the module, while it is online, with one that has been operated without the OVDs disabled.
- Reserve a slot in a chassis as an OVD test slot and rotate modules through the OVD test slot every three months.

For information on OVD enabling, see Enabling "Disabled" Output Voter Diagnostics on page 287.

Checking Controller Power Sources

Typically, Tricon controllers use redundant sources to power the controller and field circuitry. Under normal operating conditions, the required power is shared between the two power sources. Under abnormal conditions, one of the power sources may be required to provide 100 percent of the controller power.

If you wish to verify the integrity of the power source and the Power Modules, you may periodically test each power source for its ability to provide power for the entire system, when the redundant source is disabled, according to the proof testing guidelines below. Proof testing is not strictly required.

This table describes the maximum interval between optional proof tests of Model 8310 Power Modules.

Table 91 Model 8310 Power Module Proof Test Intervals

Year Shipped	For an RRF > 1000, the maximum interval between proof tests is...	For an RRF > 100, the recommended interval between proof tests is...
1996–1998	2 years	5 years
1999	1 year	2 years
2000–2002	5 years	—
2003 or later	10 years	—

This table describes the maximum interval between optional proof tests of Model 8311 Power Modules.

Table 92 Model 8311 Power Module Proof Test Intervals

Year Shipped	For an RRF > 1000, the maximum interval between proof tests is...	For an RRF > 100, the maximum interval between proof tests is...
1996–2002	2 years	5 years
2003 or later	10 years	—

This table describes the maximum interval between optional proof tests of Model 8312 Power Modules.

Table 93 Model 8312 Power Module Proof Test Intervals

Year Shipped	For an RRF > 1000, the maximum interval between proof tests is...	For an RRF > 100, the maximum interval between proof tests is...
1996–1998	2 years	5 years
1999 or later	10 years	—

Notes

- RRF = Risk Reduction Factor. Although this is a simple economic calculation, an RRF of > 1000 is roughly equivalent to the risk reduction required for SIL3 safety applications. An RRF of > 100 is required for SIL2 applications.
- Overall, the reliability of the 1996-1998 modules has proven to be approximately equal to the original design estimate, with a MTBF (mean-time-between-failure) of approximately one failure per million hours of operation. Later units have proven to be very reliable, with actual MTBF of > 8 million hours.

This procedure explains how to test the power sources used for the Tricon controller. Ideally, this test is performed when the controlled process is offline—for example, during a normally scheduled plant maintenance period.

Procedure

1. If possible, take the control process offline.
2. Turn off one of the power sources and leave it off for several minutes.
3. After restoring power, repeat the test for the other power source.
4. Turn on both power sources prior to restarting the controlled process.

For information on replacing Power Modules, see Replacing Power Modules on page 292.

Replacing the Main Chassis Batteries

This procedure explains how to replace the Main Chassis batteries, which are located on the backplane next to the I/O expansion ports. If a total power failure occurs, these batteries can maintain data and programs for a cumulative time period of six months.

Each battery has a shelf-life of 8-10 years. Invensys recommends that the batteries be replaced either every 8-10 years or after they accumulate six months of use, whichever comes first. You should replace the batteries during scheduled, offline maintenance periods by using the following procedure.

For specifications and part numbers, see Appendix E, Recommended Replacement Parts.

WARNING Replace a battery only with the same or equivalent type recommended by the manufacturer. Dispose of used batteries according to the manufacturer's instructions.

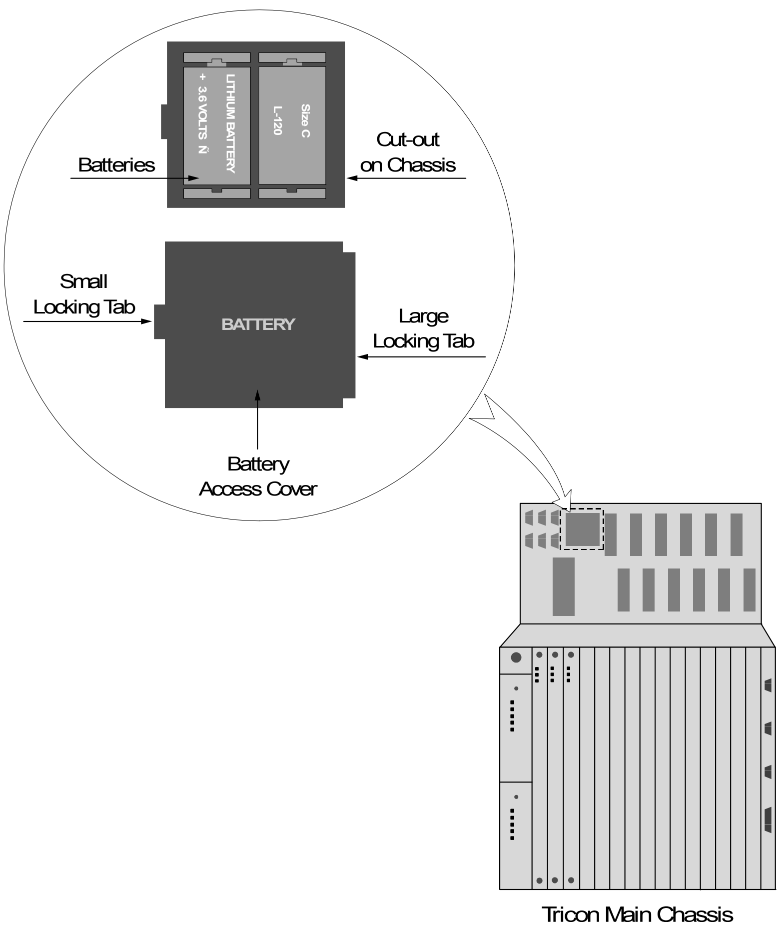


Figure 104 Battery Location and Access Cover

Procedure

1 Before starting, ensure you have a screwdriver.

2 Remove the battery access cover by squeezing the left side of the cover with your hand to detach the small locking tab.

3 Noting the orientation of the batteries, remove each one with your hand. If necessary, use a screwdriver to detach each battery from its position, then remove with your hand.

4 Insert the replacement batteries in the same orientation as the originals—with the positive terminal facing the top of the chassis. Snap each battery firmly in place.

5 Replace the battery access cover by:

- Inserting the large locking tab under the right edge of the battery cut-out.
- Squeezing the left side of the battery access cover with your hand and inserting the small locking tab into the left edge of the battery cut-out.
- Pressing the cover firmly to ensure it is locked in place.

Enabling “Disabled” Output Voter Diagnostics

This procedure explains how to enable “disabled” Output Voter Diagnostics (OVD) used by Digital Output Modules. In some systems, these diagnostics can cause glitches that affect the controlled process. If OVD has been disabled, it should be enabled periodically.

This action provides 100 percent failure detection for all components, particularly those that remain in a single state for long periods of time. For example, if an output is always On, OVD cannot determine if faults are present that would prevent the output from being turned Off.

WARNING For safety programs, disabling the Output Voter Diagnostics is not recommended; however, if it is required due to process interference concerns, it can be done if, and only if, the DO is proof tested every three to six months.

Procedure

1 Ensure the controlled process is shut down. (Do not stop the control program from running.)

2 In TriStation 1131, go to the Controller Panel > Commands menu and enable the disabled OVD modules.

3 Leave OVD enabled for several minutes to verify the stability of the modules.

4 If required, disable OVD.

Toggling Field I/O Points

To guarantee complete fault coverage of the digital circuitry in the modules listed in Table 94, do the following:

- Toggle the field points from the normal operational state to the opposite state (this is done by "forcing" the points).
- Leave each point in the opposite state for several minutes.
- Toggle the field points at least as frequently as the Minimum Toggle Rate identified in the specifications for the module.

Ideally, this type of testing is performed with the controlled process offline.

For instructions on how to toggle field points, see "Forcing Points" in the *TriStation 1131 Developer's Guide*.

Table 94 DI Modules and DO Modules that Require Field Points to be Toggled

Model	Description
3501E/T	115 VAC/VDC Digital Input
3502E	48 VAC/VDC Digital Input, normally off points only
3503E	24 VAC/VDC Digital Input, normally off points only
3505E	24 VDC Digital Input, normally off points only
3601E	115 VAC Digital Output

Verifying Spare Modules

The Tricon controller automatically tests all modules installed in the system. The only action needed to guarantee the integrity of a spare module is to periodically install it in an online system. Spare I/O modules should be installed as hot-spare modules because the controller automatically shifts control between the active and hot-spare modules.

Control between active and hot-spare modules changes as follows:

- Periodically, approximately once an hour
- After a power failure
- After an MP re-education

Spare MP and I/O modules that are not installed in the system should be periodically rotated into an online system to ensure the integrity of spare inventory. A rotation schedule should be established so that a spare module is not allowed to sit on the shelf more than six months.

Performance Proof Testing Model 3807 Bipolar Analog Output Modules

Invensys recommends that BPAO modules used in critical control applications be performance proof tested during scheduled maintenance. The amount of time between proof tests should not exceed 10 years. To ensure TMR operation of the BPAO module, the test should check the accuracy of each output point by confirming that +60 mA and -60 mA output current values can be maintained for at least 60 seconds.