Trident
Version 1.2

Planning and Installation Guide

Triconex
An Invensys Company

Document No. 9720070-003

Printed in the United States of America.

CONTENTS

Preface

This guide provides information for the planning and installation of a Trident system. Topics include:

- System description
- Theory of operation
- Configuration
- Installation and maintenance
- Responding to alarm conditions

How This Guide Is Organized

This manual is organized into the following chapters:

- Chapter 1, "Theory of Operation" — Describes the theory of operation supporting the controller.
- Chapter 2, "International Approvals" — Describes compliance with third-party agencies.
- Chapter 3, "System Description" — Provides descriptions, illustrations, specifications, and simplified schematics for components of the controller.
- Chapter 4, "Installation and Maintenance" — Provides guidelines for the person responsible for installing and maintaining a controller.
- Chapter 5, "Fault and Alarm Indicators" — Provides information on responding to alarm conditions.
- Appendix A, "Pin-Outs for Cables and Connectors"— Provides pin-outs for the standard cables and adapters used with the controller.
- Appendix B, "Recommended Parts for Replacement"— Lists the parts recommended by Triconex to replace existing parts and to customize your system.
- Appendix C, "Recommended Wiring Methods"— Provides information for proper wiring.
- Appendix D, "Non-Incendive Circuit Parameters"— Describes the parameters to be used for non-incendive communication circuits in the field.
- Appendix E, "Upgrades and Repairs"— Provides information on upgrade procedures and special cables.
- Appendix F, "Mounting Panel Drill Template" — Provides a template for drilling holes on a mounting panel.
- Appendix G, "EU Declaration of Conformity"— Provides a copy of the EC Declaration of Conformity.
- Appendix H, "Warning Labels"— Provides a physical description of warning labels required for systems in which certain hazards may occur.
- "Glossary"— Provides information for terms and topics used throughout the manual.

Related Documents

The following Triconex manuals contain information that is relevant to the use of a Trident controller:

- *TriStation 1131 Developer's Guide for Trident Systems*
- *TriStation 1131 Getting Started for Trident Users*
- *TriStation 1131 Triconex Libraries Reference*

How to Contact Triconex

You can obtain sales information and technical support for Triconex products from any regional customer center or from corporate headquarters. To locate regional centers, go to the *Global Locator* page on the Triconex Web site at: **http://www.triconex.com**.

Requesting Technical Support

You can obtain technical support from any regional center and from offices in Irvine, California and Houston, Texas. If you require emergency or immediate response and are not a participant in the System Maintenance Program (SMP), you may incur a charge. After-hours technical support is billed at the rate specified in the current *Customer Satisfaction Price List*.

Requests for support are prioritized as follows:

- Emergency requests are given the highest priority
- Requests from SMP participants and customers with purchase order or charge card authorization are given next priority
- All other requests are handled on a time-available basis

Gathering Supporting Documentation

Before contacting corporate technical support, please try to solve the problem by referring to the Triconex documentation. If you are unable to solve the problem, obtain the following information:

- Error messages and other indications of the problem
- Sequence of actions leading to the problem
- Actions taken after the problem occurred
- If the problem involves a Triconex controller, obtain the model numbers and revision levels for all affected items. This information can be found on the modules, in the System Log Book, or on the TriStation Diagnostic Panel.
- If the problem involves software, obtain the product version number by selecting the *About* topic from the Help menu.

Contacting Triconex Technical Support

If possible, you should contact your regional customer center for assistance. If you cannot contact your regional center, contact technical support for the type of system you are using, either ESD systems or Turbomachinery systems.

Please include the following information in your message:

- Your name and your company name
- Your location (city, state, and country)
- Your phone number (area code and country code, if applicable)
- The time you called
- Whether this is an emergency

Note If you require emergency support and are not an SMP participant, please have a purchase order or credit card available for billing.

Emergency calls are responded to on a 24-hour daily basis.

Telephone

Toll-free number 866-PHON IPS (866-746-6477), or
Toll number 508-549-2424

Fax

Send your request to the Technical Support Manager.

Toll-free number	800-325-2134, or
Toll number	949-885-3375

E-mail

ips.csc@invensys.com

Training

In addition to this documentation, Triconex offers in-house and on-site training. For information on available courses, please contact your regional customer center.

CHAPTER 1

Theory of Operation

This chapter provides an overview of the Trident controller.

Topics include:

Controller Features

To ensure the highest possible system integrity at all times, the Trident controller includes the following features:

- Provides Triple Modular Redundant (TMR) architecture, whereby each of three identical channels independently executes the application, and specialized hardware and software mechanisms vote all inputs and outputs.
- Withstands harsh industrial environments.
- Integrates the I/O module with the termination assembly.
- Enables field installation and repair to be done at the module level while the controller remains online without disturbing field wiring.
- Supports up to 14 I/O modules. (If the controller includes AO or PI Modules, up to 10 modules are supported.)
- Provides TriStation and Modbus communication directly from the Main Processor (MP) or from the Communication Module (CM).
- Executes applications developed and debugged using TriStation.
- Provides a dedicated co-processor which controls the input and output modules to reduce the workload of the MP. Each I/O module is supported by custom application-specific integrated circuits (ASICs), which scan inputs and perform diagnostics to detect hardware faults. Output module ASICs do the following:
  - Supply information for voting of output data.
  - Check I/O loop-back data from the output terminal for final validation of the output state.
  - Perform diagnostics to detect hardware and field-wiring problems.
- Provides integral online diagnostics with adaptive-repair capabilities.
- Allows normal maintenance while the controller is operating, without disturbing the controlled process.
- Supports hot-spare I/O modules for critical applications for which prompt service may not be possible.
- Provides integral support for redundant field and logic power sources.

Fault Tolerance

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

The Trident controller provides fault tolerance through TMR architecture. The controller consists of three identical channels (except for the power modules which are dual-redundant). Each channel independently executes an application in parallel with the other two channels. 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. Repair consists of removing and replacing the failed module in the faulty channel while the controller is online and without process interruption.

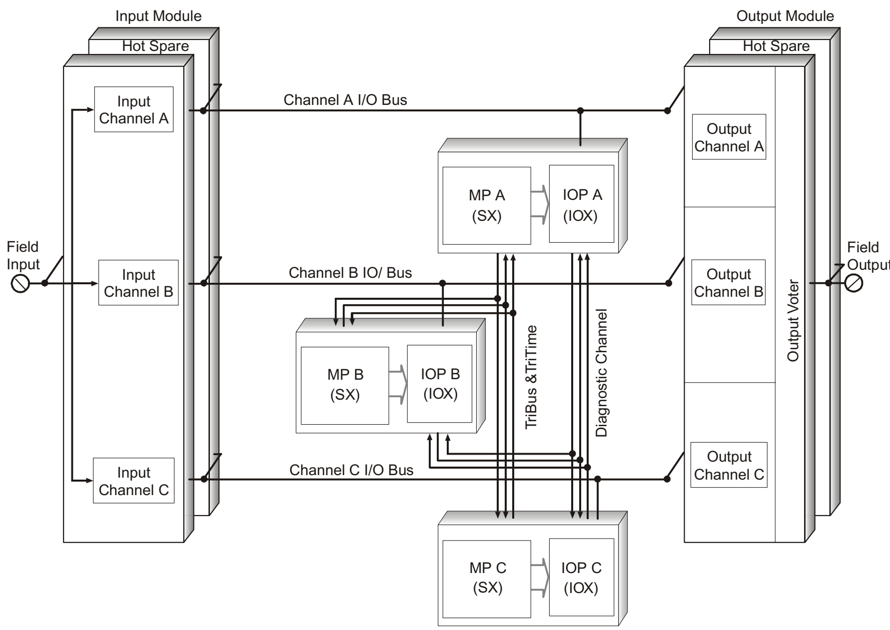
Extensive diagnostics on each channel, module, and functional circuit immediately detect and report operational faults by means of indicators or alarms. All diagnostic fault information is accessible by the application and the operator. The operator can use the diagnostic information to modify control actions or direct maintenance procedures.

Controller Architecture

The controller features TMR architecture to ensure fault tolerance and error-free, uninterrupted control in the event of hard failures of components or transient faults from internal or external sources.

Each 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 MP. The three MPs communicate with each other using a proprietary, high-speed bus called the TriBus.

Simplified Block Diagram



Once per scan, the MPs synchronize and communicate with their neighbors over the TriBus. The TriBus forwards copies of all analog and digital input data to each MP and compares output data from each MP. The MPs vote the input data, execute the application, and send outputs generated by the application to the output modules. In addition, the controller votes the output data on the output modules as close to the field as possible to detect and compensate for any errors that could occur between the TriBus voting and the final output driven to the field.

For each I/O module, the controller can support an optional hot-spare module. If present, the hot-spare takes control if a fault is detected on the primary module during operation. The hot-spare position is also used for the online hot repair of a faulty I/O module.

Main Processor Architecture

A controller contains three MPs. Each MP controls a separate channel and operates in parallel with the other two MPs.

A dedicated I/O control processor on each MP manages the data exchanged between the MP and the I/O modules. A triplicated I/O bus, located on the baseplates, extends from one column of I/O modules to another column of I/O modules using I/O bus cables.

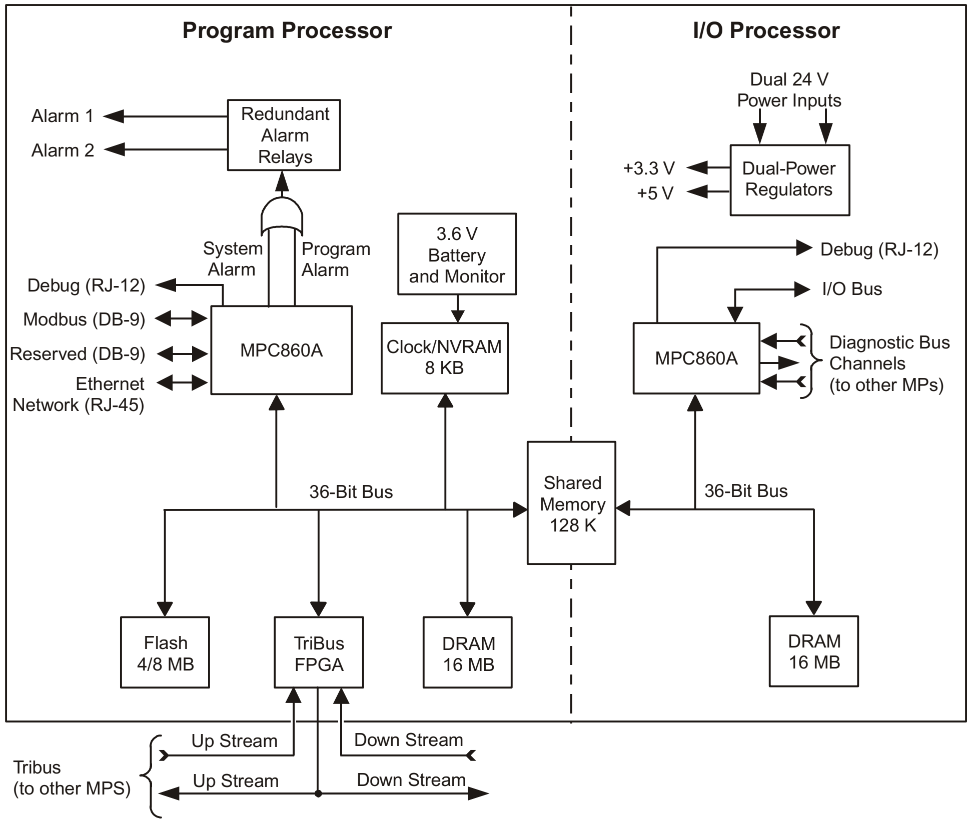
As each input module is polled, the appropriate channel of the I/O bus transmits new input data to its MP. The input data is assembled into a table in the MP and is stored in memory for use in the voting process.

The individual input table in each MP is transferred to its neighboring MP over the TriBus. After this transfer, voting takes place. The TriBus uses a programmable device with direct memory access to synchronize, transmit, and compare data among the three MPs.

If a disagreement occurs, the signal value found in two 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 MP maintains data about necessary corrections in local memory. Any disparity is flagged and used at the end of the scan by the built-in fault analyzer routines to determine whether a fault exists on a particular module.

The MPs send corrected data to the application. The 32-bit MP executes the application in parallel with the neighboring MPs and generates a table of output values that are based on the table of input values according to user-defined rules.The I/O control processor on each MP manages the transmission of output data to the output modules by means of the I/O bus.

Main Processor Architecture



Using the table of output values, the I/O control processor generates smaller tables, each corresponding to an individual output module. Each small table is transmitted to the appropriate channel of the corresponding output module over the I/O bus. For example, MP 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.

Each MP provides a 16-megabyte DRAM for the user-written application, sequence-of-events (SOE) and I/O data, diagnostics, and communication buffers. (For more information about SOE, see the *Sequence of Events Recorder User's Manual*.) The application is stored in flash EPROM and loaded in DRAM for execution. The MPs receive power from redundant 24 volts DC power sources. If an external power failure occurs, all critical retentive data is stored in NVRAM. A failure of one power source does not affect controller performance. If the controller loses power, the application and all critical data are retained indefinitely.

Bus and Power Distribution

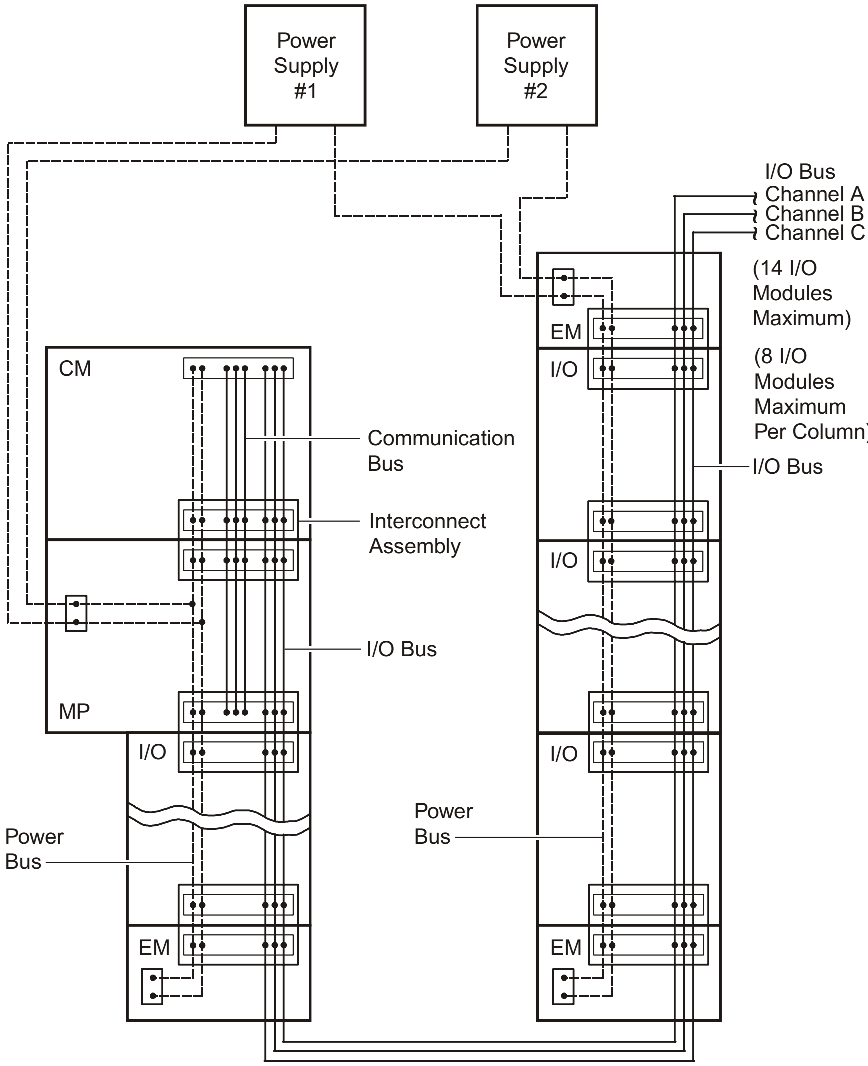
The triplicated I/O bus, as shown on page 8, is carried baseplate-to-baseplate using Interconnect Assemblies, I/O Extender Modules, and I/O bus cables. The redundant logic power distribution system is carried using Interconnect Assemblies and I/O Extender modules.

The TriBus, which is local to the MP Baseplate, consists of three independent, serial links operating at 25 megabits per second. The TriBus synchronizes the MPs at the beginning of a scan. Then each MP sends its data to its upstream and downstream neighbors. The TriBus takes the following actions:

- Transfers input, diagnostic, and communication data
- Compares data and flags disagreements with the output of the previous scan and program memory

An important feature of the Trident controller architecture is the use of a single transmitter to send data to both the upstream and downstream MPs. This ensures that the same data is received by the upstream processor and the downstream processor.

I/O Bus and Power Distribution Diagram



Note Each column of modules must have a separate logic power connection.

Field signal distribution is local to each I/O baseplate. Each I/O module transfers signals to or from the field through its associated baseplate assembly. The two I/O module slots on the baseplate tie together as one logical slot. The right or left position holds the active I/O module and the other position holds the hot-spare I/O module. Each field connection on the baseplate extends to both active and hot-spare I/O modules. Consequently, both the active module and the hot-spare module receive the same information from the field termination wiring.

A triplicated I/O bus transfers data at 2 megabits per second between the I/O modules and the MP. The I/O bus is carried baseplate-to-baseplate and can be extended to multiple columns of I/O modules. Each channel of the I/O bus runs between one MP and the corresponding channel on the I/O module. The I/O bus extends between DIN rails using a set of three I/O bus cables.

Logic power for the modules on each DIN rail is distributed using two independent power rails. Each module along the DIN rail draws power from both power rails through redundant DC-DC power converters. Each channel is powered independently from these redundant power sources.

Controller Communications

The controller can communicate directly to TriStation and other devices through the Main Processor Module and the Communication Module.

Main Processor Module

Each MP can provide direct TriStation and Modbus communication. Each MP provides:

- One Tristation (Ethernet) port for downloading an application to the controller and uploading diagnostic information.
- One Modbus RS-232/RS-485 serial port which acts as a slave while an external host computer is the master. Typically, a distributed control system (DCS) monitors—and optionally updates—the controller data directly though an MP.

Communication Module

The Communication Module (CM) provides an optional, three-to-one interface to the MPs that supports various protocols for communication with external hosts. A single controller supports up to two CMs on one CM Baseplate. Each CM operates independently. Two CMs can provide redundant communication connections or independent communication ports.

Each CM provides three RS-232/485 serial ports and two Ethernet ports. These ports support a variety of communication methods, protocols, and physical media types that enable the controller to communicate with:

- External host computers
- Distributed control systems (DCS)
- Open networks
- Network printers
- Other Trident or Tricon V9 controllers

For CM specifications, see Chapter 3, “System Description.” For details about protocols, applications, and other topics concerning Ethernet networks, see the *Trident Communication Guide*.

Physical Communication Interfaces

The following table lists the physical communication interfaces that the MP and CM provide.

Interface	MP	CM
RS-232/RS-485 Modbus Serial Port	✓	✓
10BaseT Ethernet Port	✓	✓
10BaseT/100BaseTX Auto-negotiable Ethernet Port		✓
Attachment unit interface (AUI) for media access unit (MAU)		✓
Media independent interface (MII) for MAU		✓
Debug port	✓	✓

Communication Protocols

The following tables list the communication protocols supported by serial and network ports on the MP and CM.

Protocol for Serial Ports	MP	CM
Modbus Slave	✓	✓
Modbus Master		✓

Protocol for Net1 & Net2 Ports	MP	CM
TriStation	✓	✓
TCP/IP		✓
Triconex System Access Application (TSAA)		✓
Time Synchronization (Time Sync)		✓
Triconex Peer-to-Peer		✓
Hewlett-Packard JetDirect® Network Printer Server Data Link Control (DLC)/Logical Link Control (LLC)		✓

Input/Output Modules

The controller manages the data exchanged between the MP and the following I/O modules:

- Analog Input Module
- Analog Output Module
- Digital Input Module
- Digital Output Module
- Pulse Input Module
- Solid-State Relay Output Module

Analog Input Module

On an AI Module, each channel measures the input signals asynchronously and places the results 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 data is used by the application; in duplex mode, the average is used.

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

Special self-test circuitry is provided to detect and alarm all stuck-at and accuracy fault conditions in less than 500 milliseconds, typically. This safety feature allows unrestricted operation under a variety of multiple-fault scenarios.

Analog Output Modules

AO Module receives three tables of output values, one for each channel from the corresponding Main Processor. Each point on each channel has its own digital-to-analog converter (DAC). One of the three channels is selected to drive the analog outputs. The outputs of the selected channel are continuously verified by I/O loop-back inputs from each point, which are read by all three channels. If a fault occurs in the driving channel, the channel is declared faulty, is disabled, and a new channel is selected to drive the field device. The selection of the driving channel alternates among the channels so that all three channels are periodically tested.

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

Digital Input Module

A Digital Input Module contains 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. Each channel conditions signals independently and provides optical isolation between the field and the controller. A fault on one channel cannot pass to another. In addition, each channel contains a proprietary ASIC which handles communication with its corresponding MP, and supports run-time diagnostics.

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

Special self-test circuitry is provided to detect and alarm all stuck-at and accuracy fault conditions in less than 500 milliseconds, typically. This safety feature allows unrestricted operation under a variety of multiple-fault scenarios.

The input diagnostics are specifically designed to monitor devices which hold points in one state for long periods of time. The diagnostics ensure complete fault coverage of each input circuit even if the actual state of the input points never changes.

Digital Output Module

A DO Module contains the circuitry for three identical, isolated channels. Each channel includes a proprietary ASIC which receives its output table from the I/O communication processor on its corresponding main processor. All DO Modules use special quad output circuitry to vote 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 are voted on. The quad output circuitry provides multiple redundancy for all critical signal paths, guaranteeing safety and maximum availability.

A DO Module periodically executes an output voter diagnostic (OVD) routine on each point. This safety feature allows unrestricted operation under a variety of multiple-fault scenarios.

OVD detects and alarms two different types of faults:

- Points— all stuck-on and stuck-off points are detected in less than 500 milliseconds, typically.
- Switches—all stuck-on or stuck-off switches or their associated drive circuitry are detected.

During OVD execution, the commanded state of each point is momentarily reversed on one of the output drivers, one after another. Loop-back on the module allows each ASIC to read the output value for the point to determine whether a latent fault exists within the output circuit. The output signal transition is guaranteed to be less than 2 milliseconds (500 microseconds is typical) and is transparent to most field devices. For devices that cannot tolerate a signal transition of any length, OVD can be disabled.

OVD is designed specifically to check outputs which typically remain in one state for long periods of time. The OVD strategy for a DO Module ensures full fault coverage of the output circuitry even if the commanded state of the points never changes.

Pulse Input Module

On a PI Module, each channel measures 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 PI Module is guaranteed to remain in calibration for the life of the controller; periodic manual calibration is not required.

Solid-State Relay Output Module

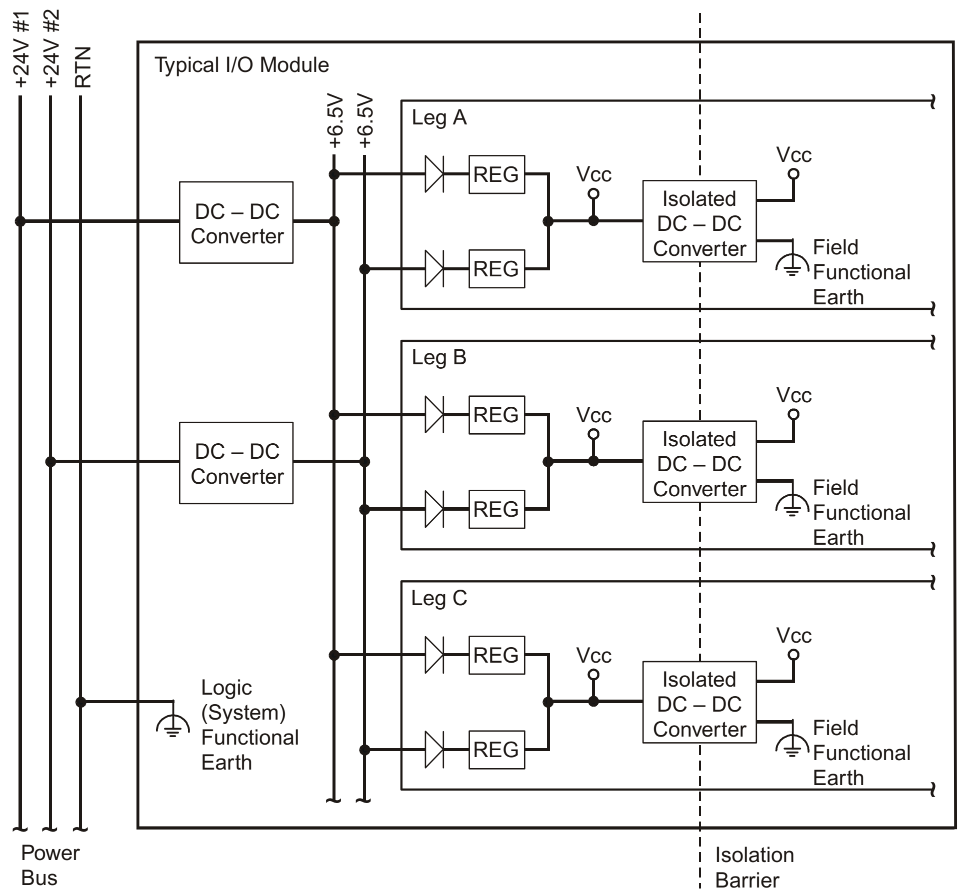
On a Solid-State Relay Output (SRO) Module, output signals are received from the MPs on each of three channels. The three sets of signals are voted and the voted data is used to drive the 32 individual relays. Each output has a loop-back circuit which verifies the operation of each relay switch independently of the presence of a load. Ongoing diagnostics test the operational status of the SRO Module.

The SRO Module is a non-triplicated module for use on non-critical points which are not compatible with high-side, solid-state output switches; for example, interfacing with annunciator panels.

Logic Power

Each module is designed to operate directly from redundant 24 volts DC power sources as shown on page 15. Logic power is carried baseplate-to-baseplate, allowing a single logic power connection per column. The power conditioning circuitry is protected against over-voltage, over-temperature, and over-load conditions. Integral diagnostic circuitry checks for out-of-range voltages and over-temperature conditions. A short on a channel disables the power regulator rather than affecting the power sources.

Logic Power Distribution



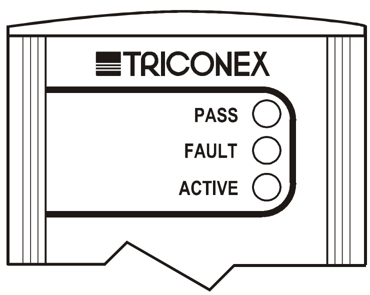
System Diagnostics and Status Indicators

The controller incorporates online diagnostics. These diagnostics and specialized fault monitoring circuitry are able to detect and alarm all single-fault and most multiple-fault conditions. The circuitry includes—but is not limited to—I/O loop-back, watch-dog timers, and loss-of-power sensors. Using the alarm information, the response of the system can be customized to the specific fault sequence and operating priorities of the application.

Each module can activate the system integrity alarm, which consists of normally closed (NC) relay contacts on each MP Module. Any failure condition, including loss or brown-out of system power, activates the alarm to summon plant maintenance personnel.

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

Front Panel Indicators



Normal maintenance consists of replacing plug-in modules. A lighted Fault indicator shows that the module has detected a fault and must be replaced.

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

CHAPTER 2

International Approvals

The Trident controller is evaluated at regular intervals to meet the standards specified by the following agencies:

Canadian Standards Association

CSA/US/C certification verifies the electrical safety of the controller for Canada and the United States.

CSA has certified that the controller fulfills the following standards.

Standard Number	Title
UL 3121-1 1998-07-14	Electrical Equipment for Laboratory Use, Part 1: General Requirements
CSA Standard C22.2 No 0	General Requirements—Canadian Electrical Code, Part II
CSA Standard C22.2 No 0.4	Bonding and Grounding of Electrical Equipment
CAN/CSA C22.2 No 1010.1-92	Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, Part 1: General Requirements

Test Report

A copy of the test report (1200275, dated May 2, 2001) is available upon request.

Factory Mutual

Factory Mutual verifies the controller for use in Class I, Division 2 Temperature T4, Groups A, B, C, and D hazardous indoor locations in compliance with the following standards.

Standard Number	Title
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
3600	Electrical Equipment for Use in Hazardous (Classified) Locations—General Requirements

Test Report

Certification is pending. For test report status, please contact the factory.

European Union CE Mark

The CE Mark ensures electrical safety and the electro-magnetic compatibility (EMC) of the controller with other electrical/electronic equipment. When properly installed, the controller is certified to fulfill the requirements of the *European Union EMC Directive No. 89/336/EEC* and *Low Voltage Equipment Directive No. 72/23/EEC*, as defined by the following documents.

Standard Number	Title
IEC 61131-2:1994/A11:1996	Programmable Controllers Part 2: Equipment Requirements and Test. Overvoltage Category II is assumed.
EN 50081-2:1993	Emission Standards for Industrial Environments
IEC 61010-1	Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Equipment, Part 1: General Requirements

For a copy of the EU Declaration of Conformity, see Appendix G, "EU Declaration of Conformity."

To ensure maximum reliability and trouble-free operation, install all field wiring in accordance with best industry practices. For examples, see the EEE Standard 518-1982*, IEEE Guide for the Installation of Electrical Equipment to Minimize Electrical Noise Inputs to Controllers from External Sources,* which gives particular attention to all low-level analog signals, such as thermocouple or RTD inputs.

Notes To comply with the CE Mark requirement for emissions, the Main Processor Modules and the Communication Modules must be mounted in a metal enclosure.

Field and logic power supplies must be approved for use in safety extra-low-voltage (SELV) circuits according to the requirements of IEC 61010-1.

TÜV Rheinland

TÜV Rheinland certifies controllers for use in safety-critical applications requiring maximum safety and uninterrupted operation, according to applicable DIN and IEC standards. The controller is certified to fulfill the requirements for SIL 3 and AK Classes 5 and 6 applications as defined in the following international standards.

Standard Number	Title
DIN VDE 0116/10.89	Electrical Equipment of Furnaces
DIN V VDE 0801/01.90+A1 10/94	Principles for Computers in Safety-Related Systems
DIN V 19250/05:94	Control Technology: Fundamental Safety Aspects to Be Considered for Measurement and Control Protective Equipment
IEC 61508, Parts 1-7, 2000	Functional Safety of Electrical/Electronic/ Programmable Electronic Safety-Related Systems
IEC 61131, Part 2/92+98	IEC 61131-2:1995, Programmable Controllers Part 2: Equipment Requirements and Test. Overvoltage Category II is assumed.
NFPA 8501/97	Standard for Single Burner Boiler Operation
NFPA 8502/99	Standard for the Prevention of Furnace Explosions/Implosions in Multiple Burner Boilers

Test Report

A copy of the test report (No. 968/EZ 101.00/00, dated 2000-02-17) is available upon request.

Semiconductor Equipment and Materials International (SEMI)

SEMI certifies the controller for use in environmental, health, and safety applications in semiconductor manufacturing facilities as defined by the following standard.

Standard Number	Title
SEMI S2-0200	Environmental, health, and safety guidelines for semiconductor manufacturing equipment

Test Report

A copy of the test report is available upon request.

Installation Guidelines

For semiconductor manufacturing applications, compliance with the following 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
- An application may require a specified environment and warning label
  - For installations with voltages greater than 30 V_{rms}/36 V DC, the controller and associated equipment must be installed in a locked cabinet with a hazardous-voltage warning label attached prominently
  - For installations with ambient temperatures exceeding 35°C (94°F), the controller and associated equipment should be installed in a locked cabinet 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 with a general-hazard warning label attached prominently

For a physical description of labels, see Appendix H, “Warning Labels.”

CHAPTER 3

System Description

This chapter provides descriptions, configuration guidelines, illustrations, specifications, and simplified schematics for system components.

Topics include:

System Overview

Physically, a Trident system consists of field-replaceable modules, the baseplates upon which modules are mounted, field wiring connections, and a TriStation 1131 programmer's workstation. This section briefly describes these major elements and provides general specifications.

Field-Replaceable Modules

Modules are field-replaceable units consisting of an electronic assembly in a protective metal housing.

Field-replaceable modules include:

- Main Processor Module (MP)
- Communication Module (CM)
- Analog Input Module (AI)
- Analog Output Module (AO)
- Digital Input Module (DI)
- Digital Output Module (DO)
- Pulse Input Module (PI)
- Solid-State Relay Output Module (SRO)
- I/O Extender Modules (EM)

Each module is fully enclosed to ensure that no components or circuits are exposed—even when a module is removed from the baseplate. Offset baseplate 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 controller supports:

- Digital input and output points
- Analog input and output points
- Pulse input points
- Solid-state relay output points
- Multiple communication protocols

For a brief description of the modules, see the following tables.

Main Processor Module

Model	Description	Points
3101	14-maximum I/O modules, executes control application and votes on inputs and outputs	Not applicable

Communication Module

Model	Description	Points
3201	Interfaces, Modbus master or slave, selectable RS-232/485 serial ports, TriStation, Triconex Peer-to-Peer, TSAA, and TCP-IP/UDP-IP	Not applicable

Analog Input Module

Model	Description	Points
3351	4–20 mA, commoned, 6% over-range	32

Analog Output Module

Model	Description	Points
3481	4–20 mA, commoned, 6% over-range	4
3482	2 @ 4–20 mA, 2 @ 4–40 mA, commoned, 6% over-range	4

Digital Input Module

Model	Description	Points
3301	24 V DC, commoned	32

Digital Output Module

Model	Description	Points
3401	24 V DC, commoned	16

Pulse Input Module

Model	Description	Points
3381	0.5 Hz to 32 kHz, differential	6

Solid-State Relay Output Module

Model	Description	Points
3451	Non-triplicated, commoned in groups of 2	32

I/O Extender Modules

Model	Description
2281	I/O Extender Module Kit (without termination)
2291	I/O Extender Module Kit for I/O Baseplate (with termination)
2292	I/O Extender Module Kit for MP Baseplate (with termination)

Configuration

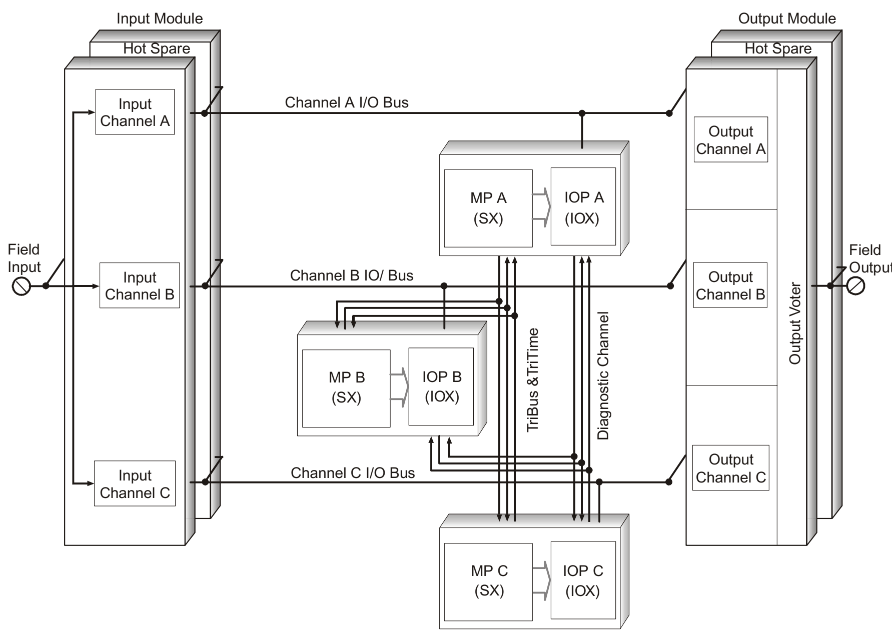
An assembly consists of a module and a baseplate. Three types of assemblies are available:

- Main Processor
- Communication
- I/O

A basic Trident system consists of one MP assembly, an optional CM assembly, and up to 14 I/O assemblies. If AO or PI Modules are included, up to 10 I/O assemblies are allowed.

Assemblies are configured into a system on a mounting plate using interconnect assemblies, extenders, I/O bus cables, and I/O bus terminators. I/O modules communicate with the MPs by means of a triplicated, RS-485, bi-directional communication bus, called the I/O bus.

Typical System Configuration



The I/O bus cable can be used to join I/O columns. Maximum cable length is up to 6 meters (20 feet) without termination or up to 200 meters (650 feet) with termination.

Field Wiring

Terminations for field wiring are integral to each I/O module baseplate.

Programming Workstation

TriStation 1131 is a programmer's workbench for developing, testing, and documenting process-control applications that execute in a controller. TriStation runs on a Windows NT® PC.

After an application is developed, a download operation installs the TriStation 1131 project in a controller and verifies that it is operating correctly. For more information, see the *TriStation 1131 Developer's Guide*.

Programming Languages

TriStation supports the following three programming languages that comply with the *IEC 61131-3 International Standard on Programming Languages for Programmable Controllers* and reflect the guidelines documented in the *IEC 65A Type 3 Report*:

- Function Block Diagram (FBD)
- Ladder Diagram (LD)
- Structured Text (ST)

A fourth language, Cause and Effect Matrix Programming Language Editor (CEMPLE), automates the implementation of CEM methodology.

Environmental Specifications

General environmental specifications are listed in the table below.

Feature	Specification
Operating temperature	0° C to 60° C (40° F to 120° F), ambient[1], per IEC 60068-2-14, tests Na and Nb
Extended operating temperature	–20° C to +70° C (–4° F to +158° F)[1], per IEC 60068-2-14, tests Na and Nb
Storage temperature	–40° C to +85° C (–40° F to +185° F) per IEC 60068-2-2, test Bb, IEC 60068-2-1, test Ab, and IEC 60068-2-30, test Db
Relative humidity	10% to 95%, non-condensing
Sinusoidal vibrations per axis	1 G @ 10 to 150 Hz, per IEC 60068-2-6, test Fc
Shock	15 G for 11 ms, half sine, in each axis, per IEC 60068-2-27, test Ea
Electrostatic discharge	IEC 61000-4-2, Level 3, 8 kV
Conducted susceptibility	IEC 61000-4-4, Class 3, fast transient/burst IEC 61000-4-5, Level 3, Surge Withstand IEC 61000-4-6, Level 3, RFI IEC 61000-4-12, Level 3, damped oscillatory wave
Radiated susceptibility	IEC 61000-4-3, Level 3, RFI, AM, and PM IEC 61000-4-8, Level 4, magnetic field
Radiated emissions	CISPR 11, Class A

1. Ambient refers to the temperature measured at the bottom of each baseplate.

Main Processor Module

The following Main Processor components are available.

Model	Description
3101	MP Module (up to 14 I/O modules)
2101	MP Baseplate

A minimum Trident system has one MP Baseplate housing three MPs. Each MP Module serves as one channel of a Trident system. An MP Module consists of processors that execute the following firmware:

- Application processor and system executive (SX)
- I/O processor and input/output executive (IOX)

System Executive

The system executive performs the following functions:

- Control application execution
- TriBus communication and voting
- System diagnostics
- TriStation and Modbus slave communication

Input/Output Executive

The input/output executive performs the following functions:

- I/O module ASIC communication
- I/O control
- I/O diagnostics

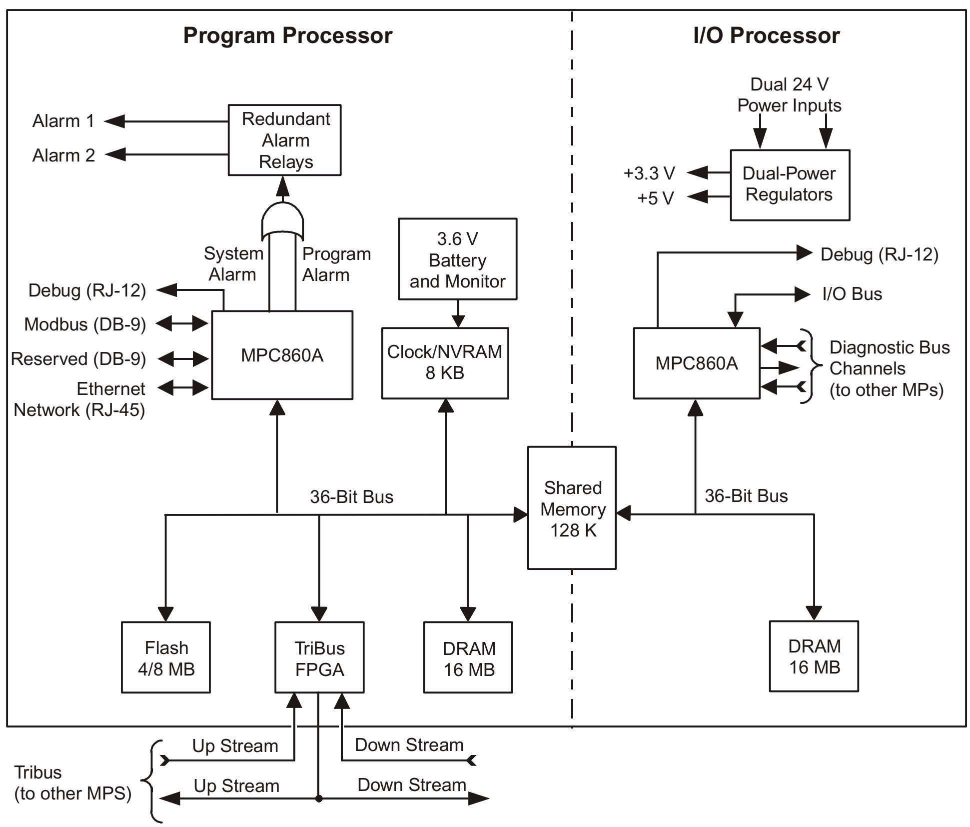
Operation

The three MPs communicate with each other using an inter-processor bus called TriBus. TriBus is a high-speed, fault-tolerant communication path between the MPs that is used primarily for voting and diagnostics. The three MPs communicate with I/O modules over a TMR HDLC I/O bus that operates at 2 megabits per second.

Each MP contains one TriStation 10BaseT Ethernet port and one Modbus RS-232/485 serial port.

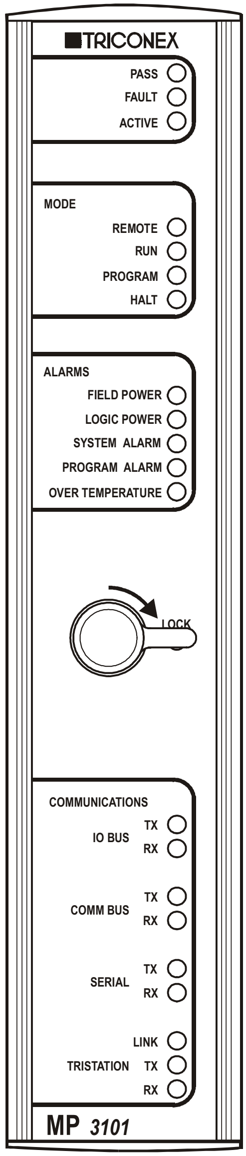
Each MP also contains redundant system alarm contacts. Connectors for the Ethernet ports, Modbus ports, and alarm contacts are located on the MP Baseplate. The MP Baseplate provides redundant, fused logic power connectors for the MP and I/O modules, which are directly connected to the I/O column.

MP Operation



Models 3101 Main Processor Module

MP Module Front Panel



Main Processor Module Specifications

Application Processor

Feature	Specification
SX Processor	Motorola MPC860, 32-bit, 50 MHz
Flash PROM	6 MB used for SX, IOX, and control application storage CRC-protected
DRAM	16 MB used for SX control application execution and program and SOE data Byte parity
NVRAM	8 KB, used for retentive variables CRC-protected
Clock calendar	
Accuracy during power on	1 sec/day typical 2.2 sec/day maximum
Accuracy during power off, with battery backed up	2.2 sec/day typical 9.2 sec/day maximum
Battery	½ AA lithium, 15-year predicted life
TriBus	25 Mbps CRC-protected 32-bit + parity DMA
TriStation port	1 10BaseT Ethernet connector RJ-45 shielded connector on baseplate
Modbus port	1 RS-232/485 DTE DB-9-pin shielded connector on baseplate
Debug port	Used to access diagnostic information RJ-12 connector located on baseplate, shared with IOX debug port
Communication bus	RS-485 2 Mbps HDLC
Alarm contacts	Redundant, normally closed

Input/Output Processor

Feature	Specification
IOX Processor	Motorola MPC860, 32-bit, 50 MHz
DRAM	16 MB, used for IOX execution Byte parity
Shared memory	128 KB, used to communicate with SX Byte parity
Diagnostic bus	2 Mbps HDLC, used to communicate I/O module diagnostic information between MP channels
Debug port	Used to access diagnostic information RJ-12 connector located on baseplate, shared with SX debug port
I/O bus	RS-485 2 Mbps HDLC

Logic Power

Feature	Specification
Nominal input voltage	24 V DC
Operational voltage range	24 V DC –15%/+20% + 5% AC ripple (+19.2 / +30 V DC)
Logic power	8 W maximum
Absolute maximum input voltage	33 V DC
Absolute maximum reverse input voltage	–0.6 V DC
Input power interruption time from nominal Repetition rate	1 ms minimum 1 sec maximum
Reverse current isolation input to input	500 µA maximum
In-rush current per input	2.4 A maximum 1.2 A for 50 ms, typical
Short circuit current limit per input	2.4 A maximum
Functional-earth-to-logic-ground isolation	0 V, no isolation
Protective-to-functional-earth isolation	500 V DC

Communication Ports

Modbus Port

Feature	Specification
Connector	DB-9-pin DTE standard, shielded, located on baseplate
RS-232 maximum cable length	15 m (50 ft)
RS-485 maximum cable length	1.2 km (4,000 ft)
Supported transmission rates (bps)	1200, 2400, 4800, 9600, 19.2 K, 38.4 K, 57.6 K, 115.2 K
Protocols	Slave, RTU mode, optional parity, 1 stop bit
Galvanic isolation	500 V DC

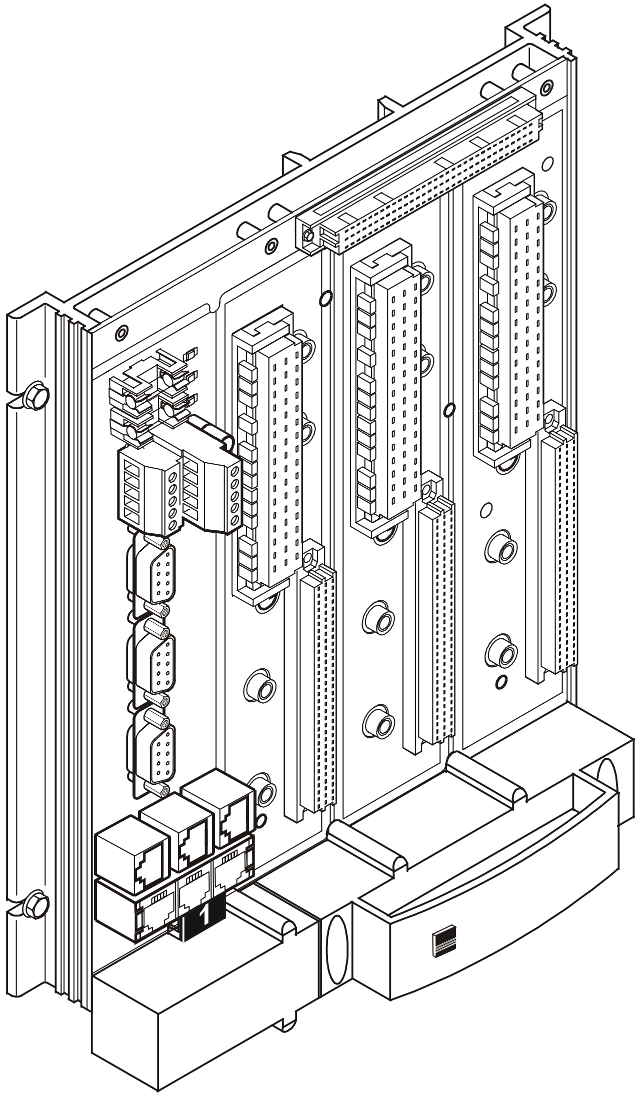
Network Port

Feature	Specification
10BaseT connector	RJ-45 standard, shielded, located on baseplate
10BaseT maximum cable length	100 m (330 ft) using category 5 twisted-pair cable
Protocol	TriStation, TSAA, Triconex Peer-to-Peer
Network address	Derived from baseplate address plug
Galvanic isolation	500 V DC

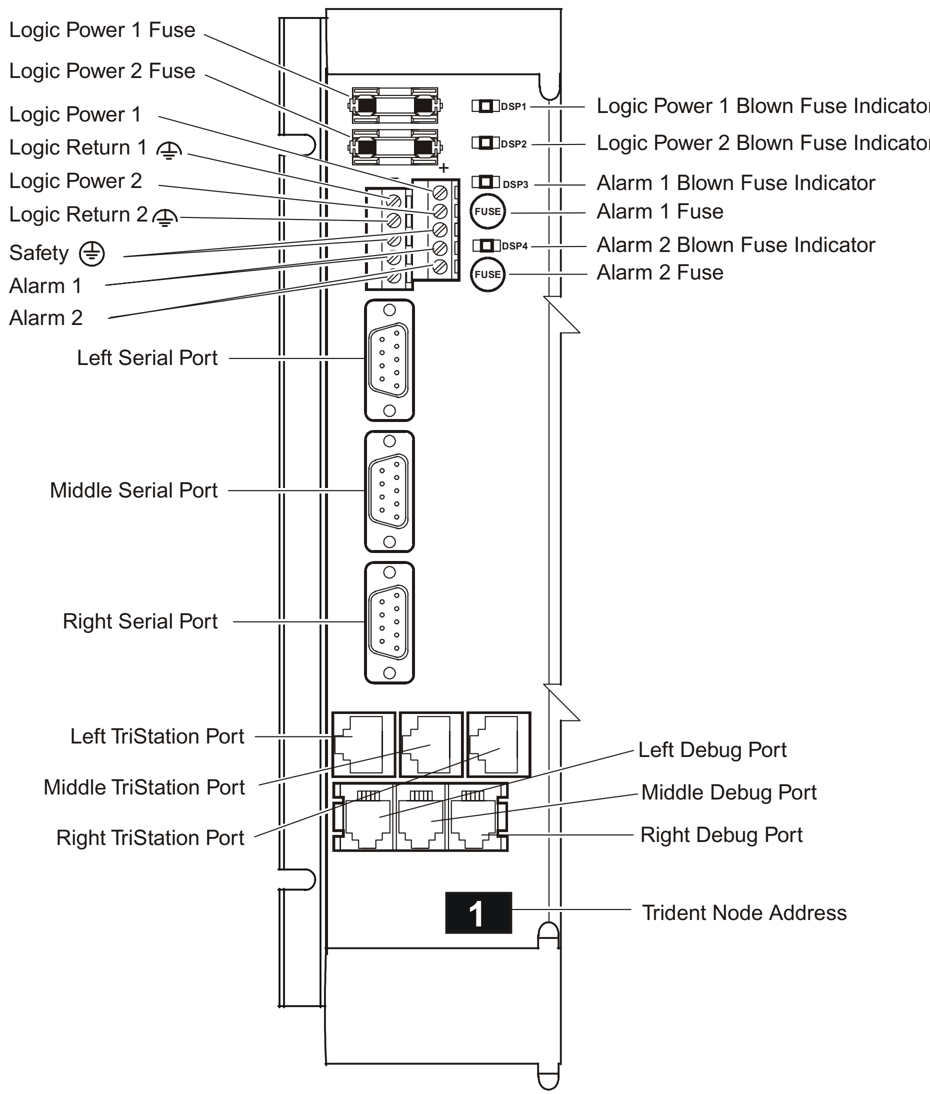
System and IO Executive Debug Ports

Feature	Specification
Connector	RJ-12, Triconex proprietary pin-out
Maximum cable length	8 m (25 ft)
Protocol	RS-232, 9600 bps, ASCII, asynchronous
Galvanic isolation	500 V DC

Model 2101 Main Processor Baseplate



MP Port Connectors



Logic Power Connections

The MP Baseplate provides redundant, fused logic power connectors for the MP and I/O modules, which are directly connected to the MP Baseplate.

Feature	Specification
Logic power	125 W, maximum
Fuse	8 A, slow-acting
Blown fuse indicator	20 mA

Main Processor Alarm Connections

Alarms are asserted when the controller detects either a system alarm or a program alarm. Each MP contains a set of redundant alarm solid-state relays. The relays are normally closed and are connected in series between MPs.

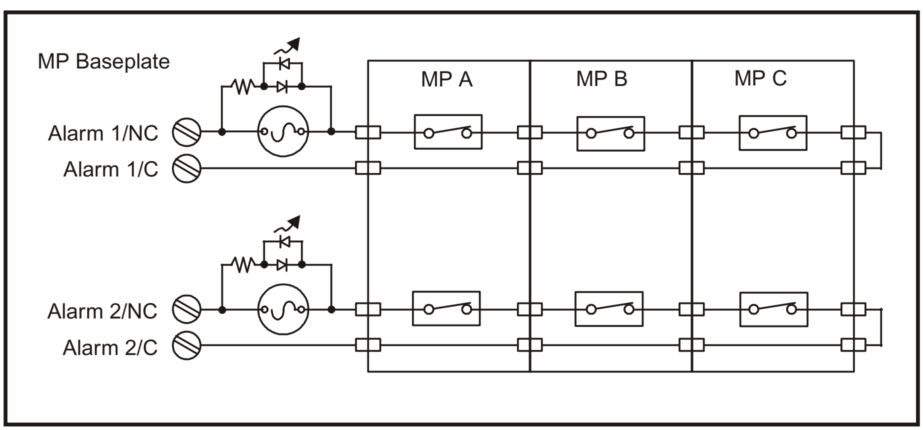
A system alarm indicates a fault in the controller, its power supplies, or field input.

A program alarm indicates a problem detected by the control application. For more information on program alarms, see the *TriStation 1131 Developer's Guide*.

Alarm Contacts

Feature	Specification
Alarm contacts	2, redundant pair, isolated
Rated voltage	±24 V AC/DC
Operational voltage range	0–30 V DC
Maximum switch voltage	33 V
Maximum switching power	15 W resistive
Maximum off-state leakage	<50 µA
Maximum nominal current	0.5 A per contact, continuous 0.7 A per contact for 100 ms
Voltage drop @ baseplate	<0.25 V DC @ 0.5 A
Fuses, mounted on baseplate	1 per contact, 1 A fast-acting
Blown-fuse indicator	On baseplate
Contact-to-protective-earth isolation	500 V DC, minimum
Contact-to-functional-earth (logic) isolation	800 V DC, minimum

Simplified Schematic of MP Redundant Alarm Circuit



Communication Module

The following communication components are available.

Model	Description	Type
3201	Communication Module	Single or redundant Configuration, non-TMR
2201	Communication Baseplate	

The Communication Module (CM) is an optional, three-to-one interface to the MPs. Using a variety of communication methods, protocols, and physical media types, the CM enables communication with:

- External host computers
- Distributed control systems (DCS)
- Open networks
- Network printers
- Other Trident systems
- Tricon V9 systems

A single Trident controller supports up to two CMs on one CM Baseplate. Each CM operates independently and supports three RS-232/485 serial ports and two Ethernet ports. Two CMs can provide redundant communication connections or additional independent communication ports.

The CM Baseplate should be connected directly above or below an MP Baseplate. Two MP Interconnect Assemblies are required to connect the MP Baseplate to the CM Baseplate. For more detailed information, see the *Trident Communication Guide*.

Communication Capabilities

Each CM provides the following communication capabilities:

- Serial ports
- Network ports
- Protocol support

Serial Ports

Each CM provides three optically isolated RS-232/485 serial ports which are user-configurable for Modbus point-to-point or multi-point (network) connections. Transmission rates up to 115 kilobits per second per port can be selected.

Network Ports

Each CM provides two network ports:

- One 10-megabit Ethernet port, with two connectors:
  - 10BaseT
  - Attachment unit interface (AUI) for a 10-megabit media access unit (MAU)
- One 100-megabit Ethernet port, with two connectors:
  - 100BaseTX
  - Media independent interface (MII) for a 100-megabit MAU

MAUs may be used in place of the 10/100 BaseT RJ-45 twisted-pair connections to convert the CM network ports to other Ethernet media types or to extend network distances.

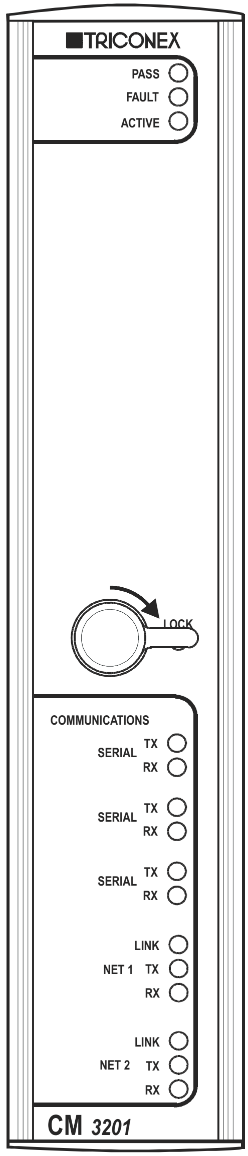
Supported Protocols

Each CM supports the following protocols:

- Modbus master or Modbus slave on the serial ports
- TCP/IP, TSAA, and TriStation network protocols on both network ports for SOE, Wonderware HMI, OPC Server, and other TSAA- or DDE-compatible applications
- JetDirect Network Printer Server DLC/LLC on both network ports
- Triconex Peer-to-Peer communication among multiple Trident systems or a combination of Trident and Tricon systems
- Time synchronization over network ports for multiple Trident systems or a combination of Trident and Tricon systems

Model 3201 Communication Module

CM Front Panel



Specifications

Logic Power

Logic power is supplied by the MP Baseplate.

Feature	Specification
Nominal input voltage	24 V DC
Specified operational voltage range	24 V DC –15% or +20% + 5% AC ripple (19.2 to 30 V DC)
Logic power (without MAUs)	8 W maximum
10 Mb AUI-type MAU	6 W maximum additional per MAU
100 Mb MII-type MAU	3.75 W maximum additional per MAU
Absolute maximum input voltage	33 V DC
Absolute maximum reverse input voltage	–0.6 V DC
Input power interruption time from nominal value	1 ms maximum
Repetition rate	1 sec minimum
Reverse current isolation input to input	500 µA maximum
Inrush current per input	2.4 A maximum, typically 1.2 A for 50 ms
Short circuit current limit per input	2.4 A maximum
Functional-to-logic ground isolation	0 V, no isolation
Protective-to-functional-earth isolation	500 V DC
+12 V AUI output power	12 V ±10%, 6 W maximum, current limited
+5 V MII output power	5 V ±5%, 3.75 W maximum, current limited

Communication Ports

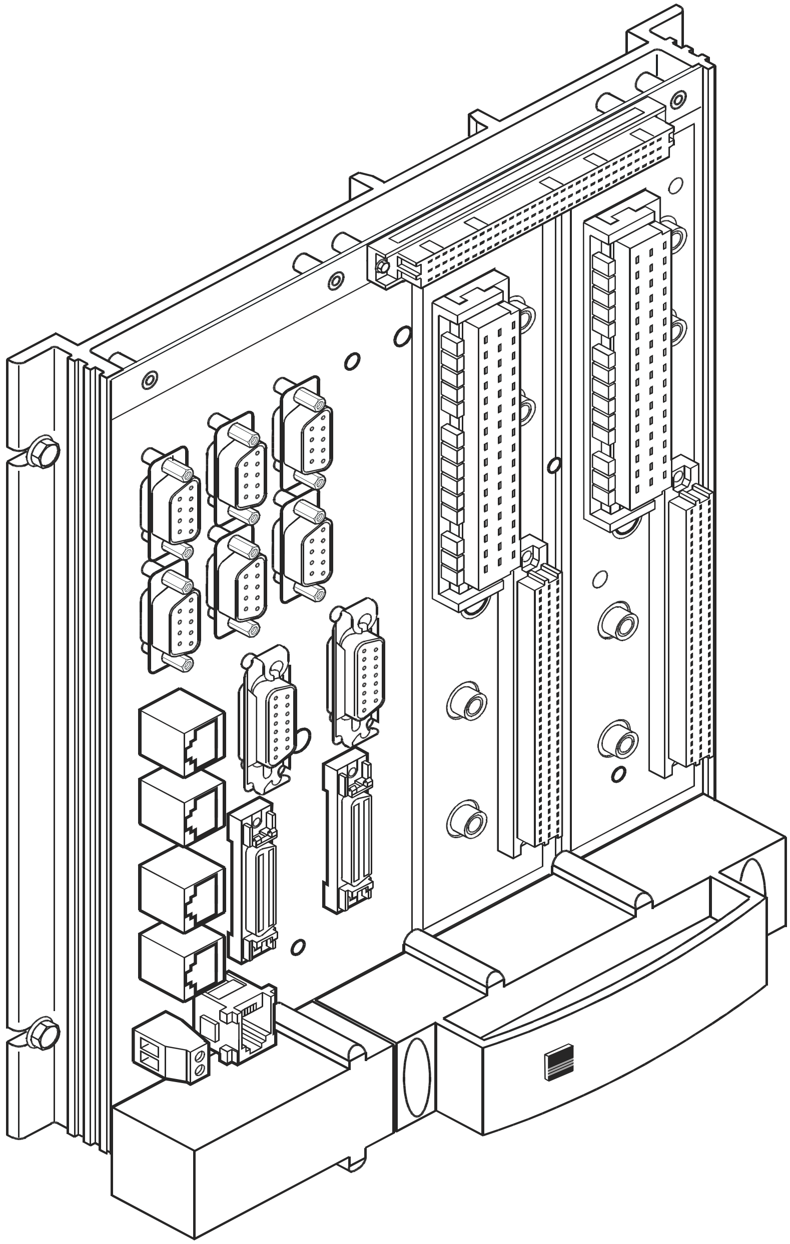
Feature	Specification
Modbus ports	3 optically isolated RS-232/485 ports, configurable from TriStation
Connector	DB-9-pin DTE standard, shielded, located on baseplate
RS-232 maximum cable length	15 m (50 ft)
RS-485 maximum cable length	1.2 km (4,000 ft)
Supported transmission rates (bps)	1200, 2400, 4800, 9600, 19.2 K, 38.4 K, 57.6 K, 115.2 K
Protocols	Master or slave, RTU and ASCII modes, optional parity, 1 stop bit
Serial port Galvanic isolation	500 V DC

Network Ports

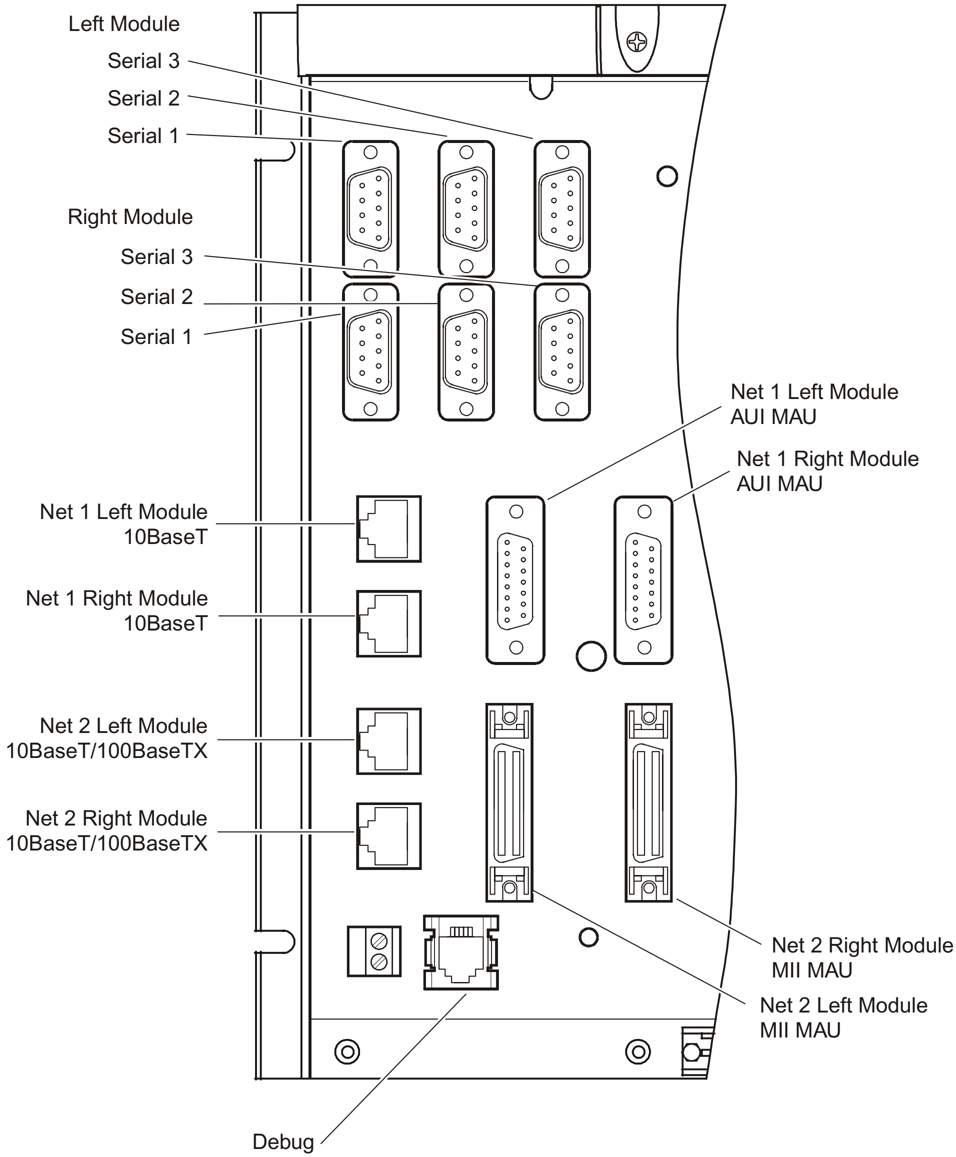
Feature	Specification
10BaseT network port	Ethernet 10 Mbps, protocol-configurable from TriStation
10BaseT connector	RJ-45 standard, shielded, located on baseplate
10BaseT maximum cable length	100 m, using Category 5 twisted-pair cable
10 Mb AUI-type MAU port	Supports AUI MAU located on baseplate Disables 10BaseT RJ-45 connector
100BaseTX Ethernet port	100 or 10 Mbps, speed auto-selected, configurable from TriStation
100BaseTX connector	RJ-45 standard, shielded, located on baseplate
100BaseTX maximum cable length	30 m, using Category 5 twisted-pair cable
100 Mb MII-type MAU port	Supports MII MAU located on baseplate Disables 100BaseTX RJ-45 connector

Feature	Specification
Protocols (both network ports)	JetDirect Network Printer Server DLC/LLC TCP/IP Time synchronization Triconex Peer-to-Peer TriStation TSAA
Network address	Derived from MP Baseplate address plug
Galvanic isolation	500 V DC

Model 2201 Communication Module Baseplate



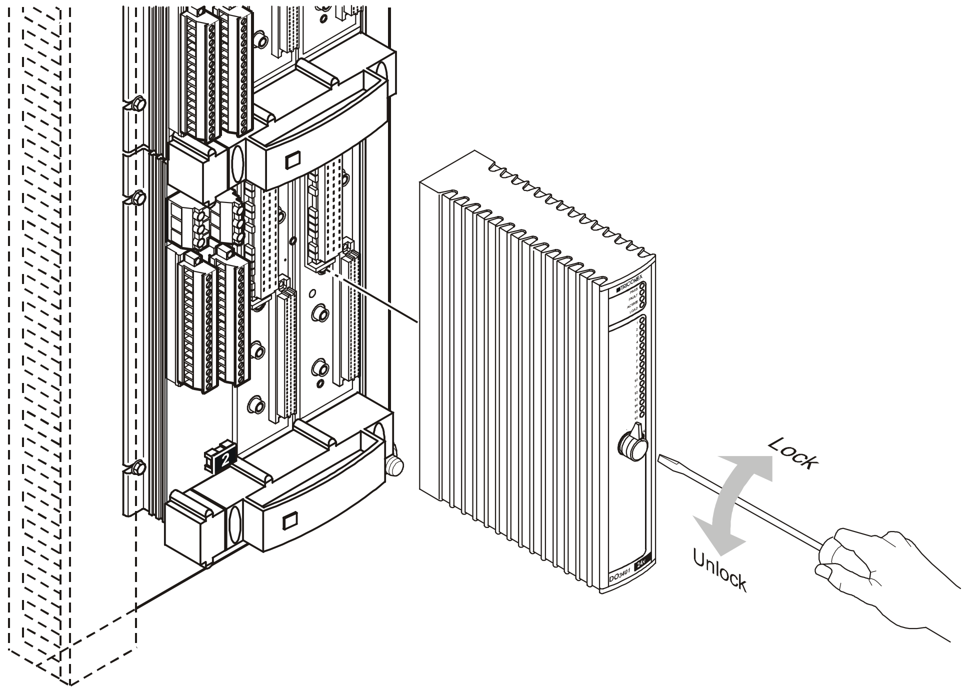
CM Port Connectors



Input/Output Modules

Each I/O module occupies one of two slots that constitute an I/O set. The left module occupies the slot below the “L” label and the right module occupies the slot below the “R” label. At any time, the status of either the left or right module can be active or hot spare (for online replacement or back-up).

I/O Module Placement



Field Terminations

Field devices are terminated directly to the baseplate.

Common Specifications

Wiring Terminals

Feature	Specification
Compression terminals	Compatible with 24 to 12 (0.2 mm^2 to 3.3 mm^2) AWG wiring

Logic Power

Feature	Specification
Nominal input voltage	24 V DC
Voltage range	24 V DC –15% or +20% + 5% AC ripple (19.2 to 30 V DC)
Logic power	<3 W
Absolute maximum input voltage	33 V DC
Absolute maximum reverse input voltage	–0.6 V DC
Input power interruption time from nominal	1 ms maximum
Power interruption interval	1 sec minimum
Reverse current isolation input to input	500 µA maximum
Inrush current per input	2.4 A maximum
Short circuit current limit per input	2.4 A maximum
Functional-earth-to-logic-ground isolation	0 V, no isolation
Protective-to-functional-earth isolation	500 V DC, minimum

Field Power

Feature	Specification
Nominal field voltage	24 V DC
Operational voltage range	24 V DC –15% or +20% + 5% AC ripple (19.2 to 30 V DC)[1]
Power	See module specifications
Absolute maximum input voltage	33 V DC
Absolute maximum reverse input voltage	–0.6 V DC
Input power interruption time from nominal	Not applicable
Power interruption interval	Not applicable
Reverse current isolation	500 µA maximum
Functional- to-protective-earth isolation	500 V DC, minimum
Functional-to-functional-earth (logic) isolation	800 V DC, minimum

1. For the PI Module, the voltage ranges are configurable in TriStation 1131.

Analog Input Module

The following analog input components are available.

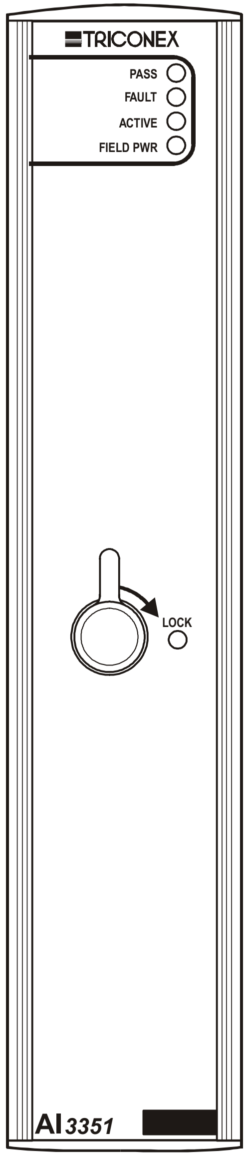
Model	Description	Current	Type
3351	Analog Input Module	4–20 mA	Commoned
2351	Analog Input Baseplate		Direct Termination
2352	Analog Input External Termination Panel Baseplate		External Signal Conditioners

The Analog Input (AI) Module has 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 MPs on demand. One value is then selected using a mid-value selection algorithm to ensure correct data for every scan. Sensing of each input point is performed in a manner that prevents a single failure on one channel from affecting another channel.

The AI Module sustains complete, ongoing diagnostics for each channel. If the diagnostics detect a failure on any channel, the module’s Fault indicator is activated, which in turn activates the system alarm. The Fault indicator points to a channel fault, *not* a complete module failure. The AI Module is guaranteed to operate properly in the presence of a single fault and may continue to operate properly with multiple faults.

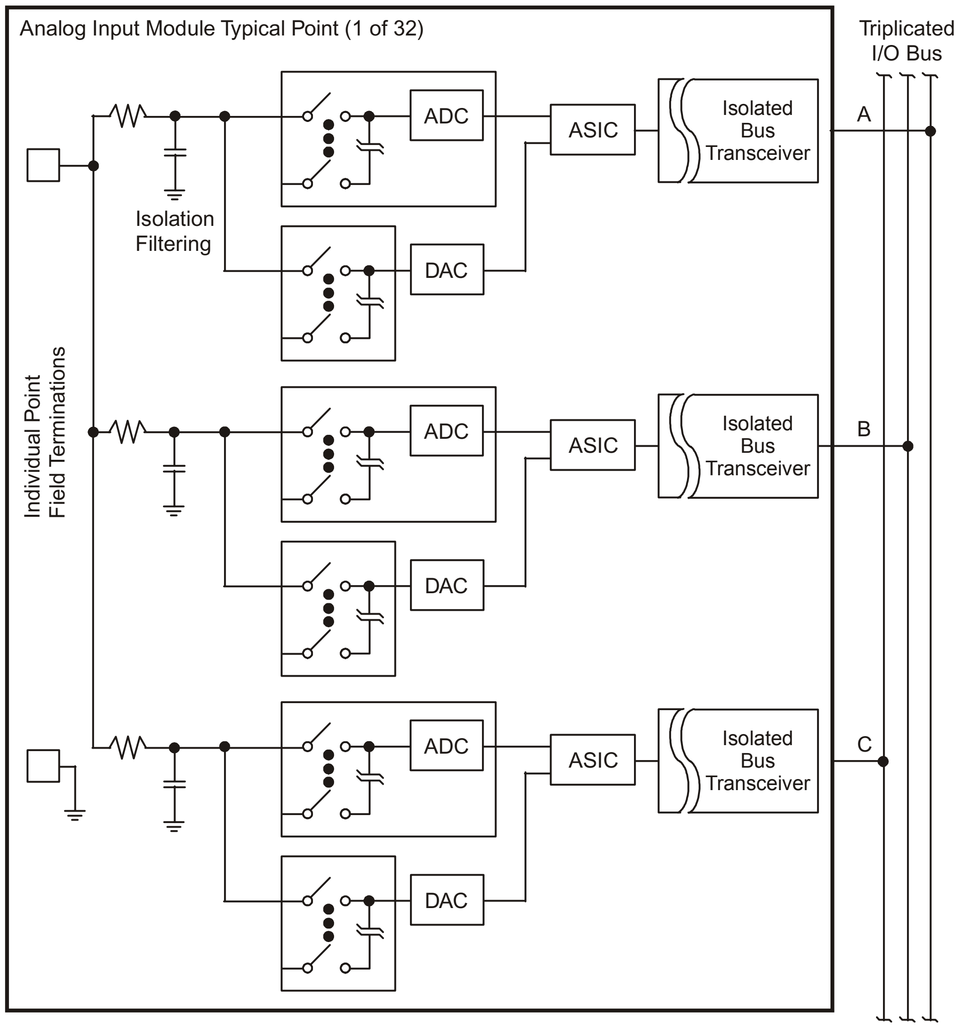
The AI Module supports hot sparing for online replacement of a faulty module or continuous back-up to an active module. The AI Module is mechanically keyed to prevent improper installation in a configured baseplate.

Model 3351 Analog Input Module



AI Module Front Panel

Model 3351 Analog Input Module Simplified Schematic



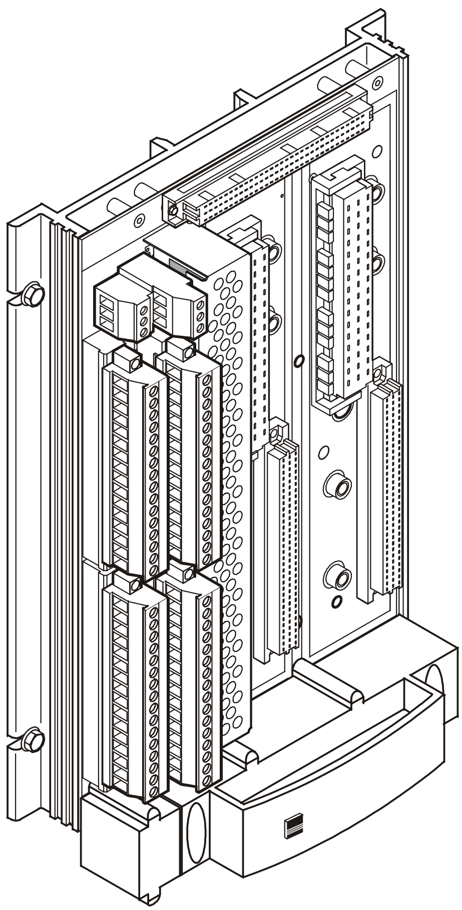
Model 3351 Analog Input Module Specifications

Feature	Specification
Points	32, commoned
Nominal input current	4–20 mA DC
Operational current range	2–22 mA DC
Absolute maximum field voltage	33 V DC
Absolute maximum reverse field voltage	– 0.6 V DC
Absolute maximum input current	50 mA DC
Input bandwidth (3dB)	16 Hz
Source impedance	180 Ω
Input impedance (with baseplate) I to V resistor	250 Ω 100 Ω, ±0.01%
Resolution	12 bits
Absolute error	0.15% of full scale (20 mA)
Diagnostic	Force-to-value diagnostic (FVD)
Scan time	<1 ms for all 32 points
Functional-to-protective-earth isolation	500 V DC, minimum
Functional-to-functional-earth (logic) isolation	800 V DC, minimum

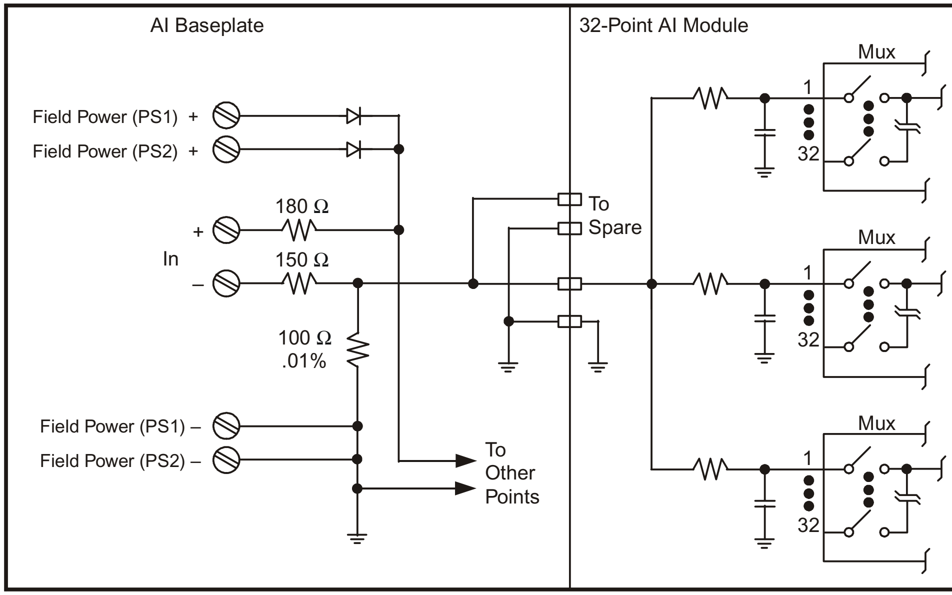
Model 2351 Analog Input Baseplate

The following table lists the short circuit current specifications for field short-to-ground faults.

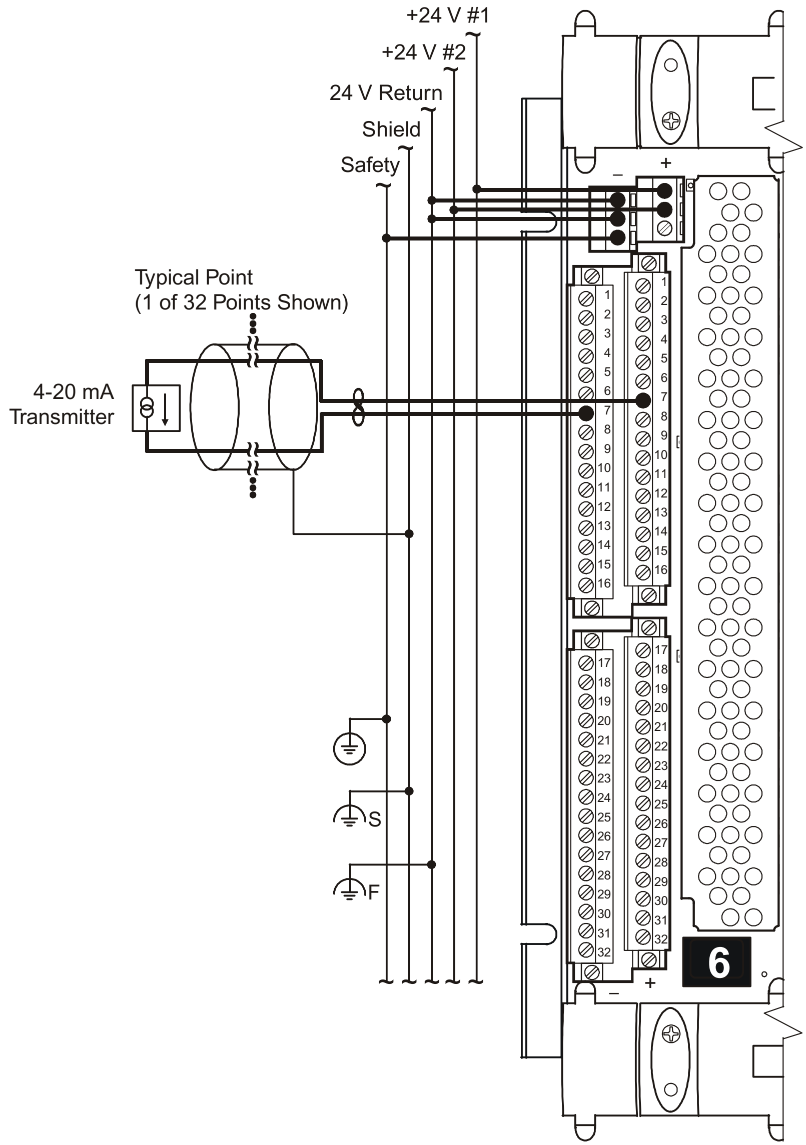
Feature	Specification
Fault current	130 mA, typical 200 mA, maximum



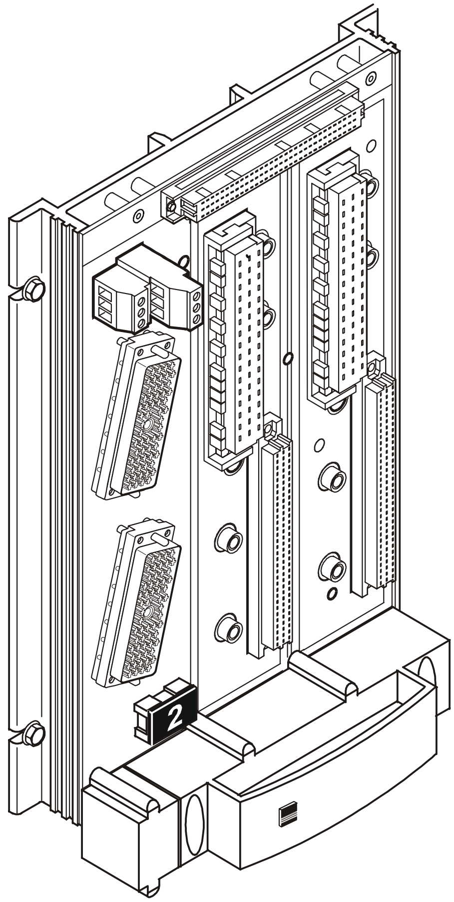
Model 2351 Analog Input Baseplate Simplified Schematic



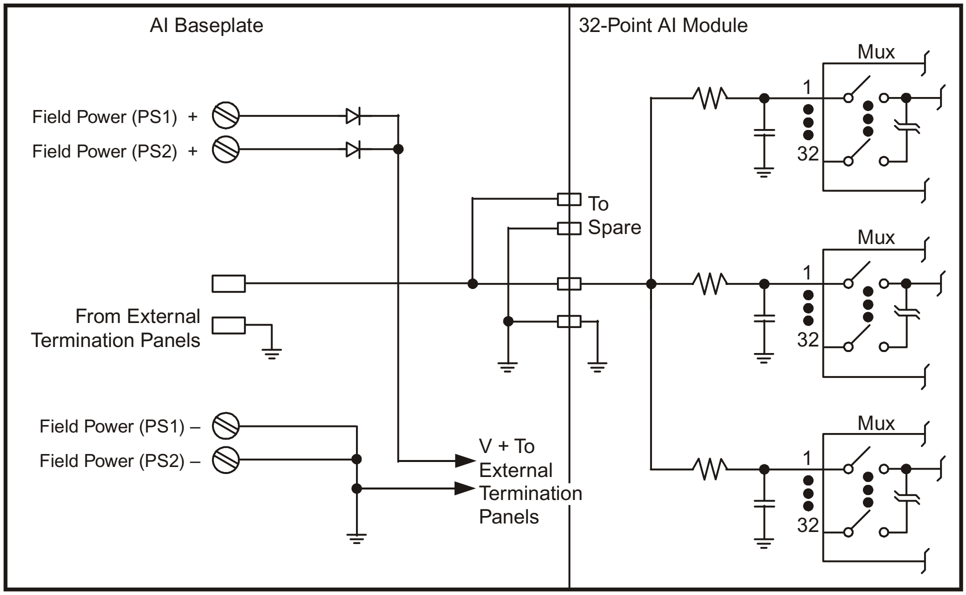
Model 2351 Analog Input Baseplate Field Connections



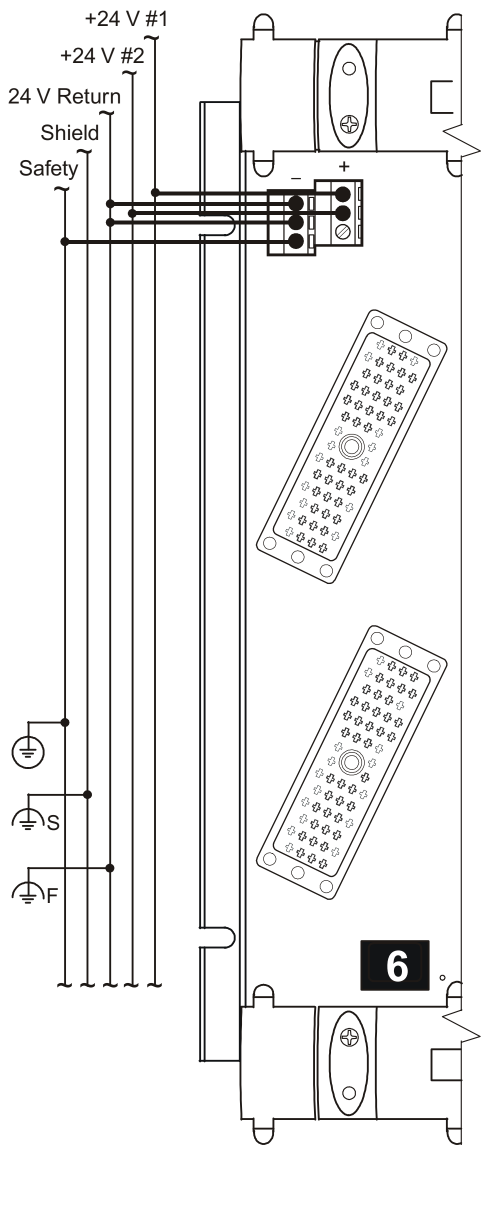
Model 2352 Analog Input External Termination Panel Baseplate



Model 2352 Analog Input External Termination Panel Baseplate Simplified Schematic



Model 2352 Analog Input External Termination Panel Baseplate Field Connections



Model 9764-310 RTD/TC/AI Termination Panel

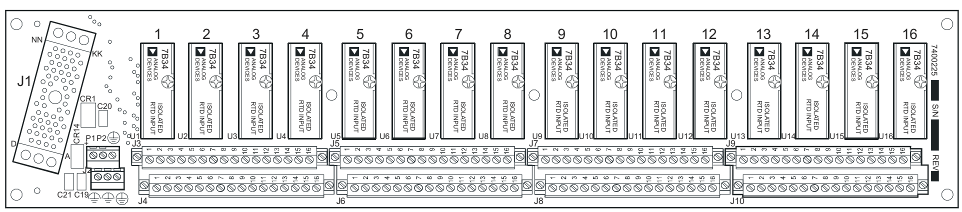
The Model 9764-310 RTD/TC/AI Termination Panel with industry-standard signal-conditioning modules may be cabled to the Model 2352 Analog Input External Termination Panel Baseplate. The RTD/TC/AI Termination Panel supports 16 points and each Analog Input Module can support up to two External Termination Panel. The input-signal conditioners are manufactured by Analog Devices™.

The Model 9764-310 panel comes with a:

- 10-foot cable
- Mounting plate

The Model 9764-310 panel has a barrier strip with four compression screw terminals for connecting an AI Module to 16 analog inputs. The panel accepts power (+24 volts DC) from the AI Baseplate or from direct connection to the panel.

Note Each 24V power source must be able to provide 0.5 amps minimally.



Note Because the Model 9764-310 RTD/TC/AI Termination Panel connects 16 of the available 32 points, you must use two panels.

The following table gives the temperature and output ranges for available signal conditioning modules.

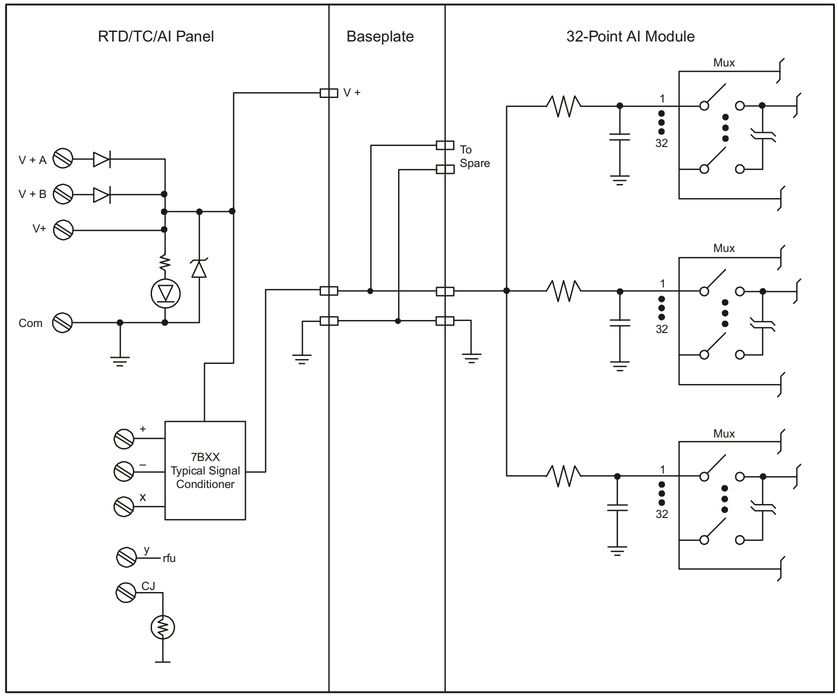
Description[1]	Part Number	Input Range	Output Range
Non-Isolated, Process Current Input Module	1600048-220 (7B32NI)	4 mA to 20 mA	0.4 V to 2 V
Isolated, Linearized, RTD Input,100 Ω Platinum, 2- or 3-Wire, α = 0.00385	1600048-030 (7B34)	0° C to 200° C (32° F to 392° F)	0.4 V to 2 V
	1600048-040 (7B34)	0° C to 600° C (32° F to 1112° F)	0.4 V to 2 V
Isolated, Linearized, Type J, Thermocouple Input Module	1600048-110 (7B47)	0° C to 760° C (32° F to 1400° F)	0.4 V to 2 V
Isolated, Linearized, Type K, Thermocouple Input Module	1600048-120 (7B47)	0° C to 1300° C (32° F to 2372° F)	0.4 V to 2 V
Isolated, Linearized, Type T, Thermocouple Input Module	1600048-130 (7B47)	0° C to 400° C (32° F to 752° F)	0.4 V to 2 V
Isolated, Linearized, Type E, Thermocouple Input Module	1600048-040 (7B47)	0° C to 900° C (32° F to 1652° F)	0.4 V to 2 V
Shorting Plug	1600048-300 (7BDS)	Not applicable	0.0 V

1. For detailed specifications, see the Analog Devices catalog, *Signal Conditioning and Data Acquisition Solution*s.

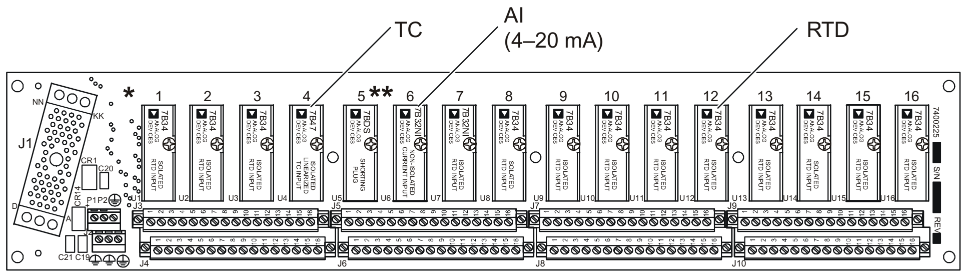
Note Signal conditioners must be ordered separately and are available from Triconex or directly from Analog Devices.

For availability of signal conditioning modules of other types or with different input ranges, contact your regional customer center.

Model 9764-310 RTD/TC/AI Termination Panel Simplified Schematic



Model 9764-310 RTD/TC/AI Termination Panel Field Connections



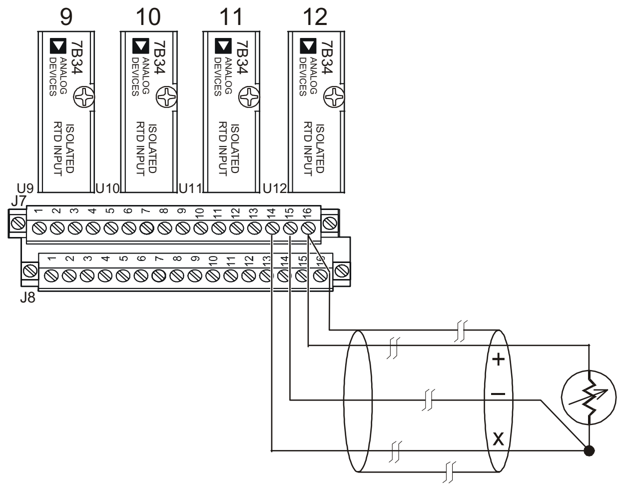
* A signal conditioner must be installed on used and unused points.

** A shorting plug must be installed on unused points. A typical point is shown.

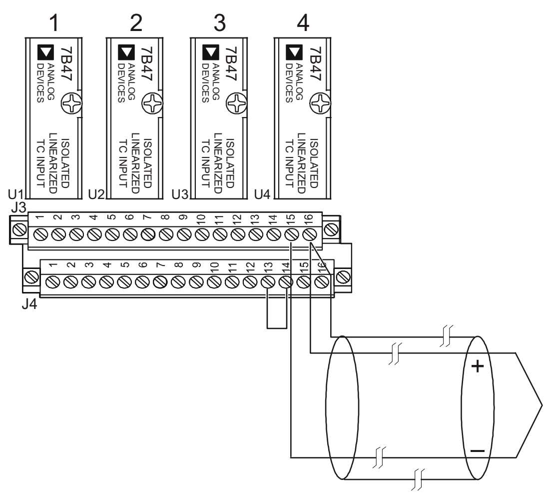
RTD/TC/AI Termination Panel Pin-Outs

Terminal J3	Terminal J4	Point 1	Point 2	Point 3	Point 4
y	CJ	1	5	9	13
x	x	2	6	10	14
–	–	3	7	11	15
+	+	4	8	12	16
Terminal J5	**Terminal J6**	**Point 5**	**Point 6**	**Point 7**	**Point 8**
y	CJ	1	5	9	13
x	x	2	6	10	14
–	–	3	7	11	15
+	+	4	8	12	16
Terminal J7	**Terminal J8**	**Point 9**	**Point 10**	**Point 11**	**Point 12**
y	CJ	1	5	9	13
x	x	2	6	10	14
–	–	3	7	11	15
+	+	4	8	12	16
Terminal J9	**Terminal J10**	**Point 13**	**Point 14**	**Point 15**	**Point 16**
y	CJ	1	5	9	13
x	x	2	6	10	14
–	–	3	7	11	15
+	+	4	8	12	16

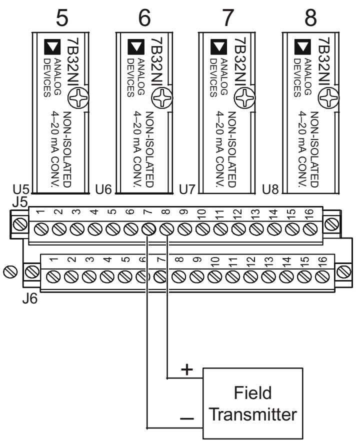
Connecting an RTD to an RTD/TC/AI Termination Panel



Connecting a TC to an RTD/TC/AI Termination Panel



Connecting a Field Device to an RTD/TC/AI Termination Panel



Analog Output Modules

The following analog output components are available.

Model	Description	Current	Type
3481	Analog Output Module	4 @ 4–20 mA	Commoned
3482	High-Current Analog Output Module	2 @ 4–20 mA, 2 @ 4–40 mA	Commoned, High Current
2481	Analog Output Baseplate		Direct Termination

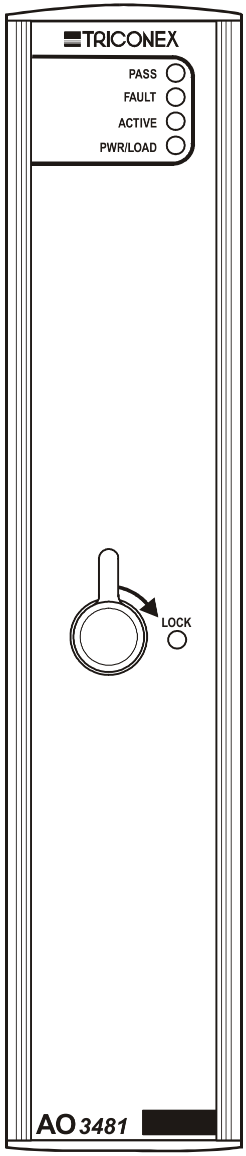
Analog Output (AO) Modules contain the circuitry for three identical, isolated channels. Each channel includes a proprietary ASIC that receives its output table from the I/O communication processor on its corresponding main processor. The AO Modules use special shunt circuitry to vote on the individual output signals before they are applied to the load. This voter circuitry insures only one output, A or B or C, is driving the field load. The shunt output circuitry provides multiple redundancy for all critical signal paths, guaranteeing safety and maximum availability.

The AO Modules continuously execute forced-switch diagnostics (FSD) on each point. By carefully forcing error conditions and observing proper behavior of the voting circuitry, high reliability and safe operation is insured. This safety feature allows unrestricted operation under a variety of multiple-fault scenarios.

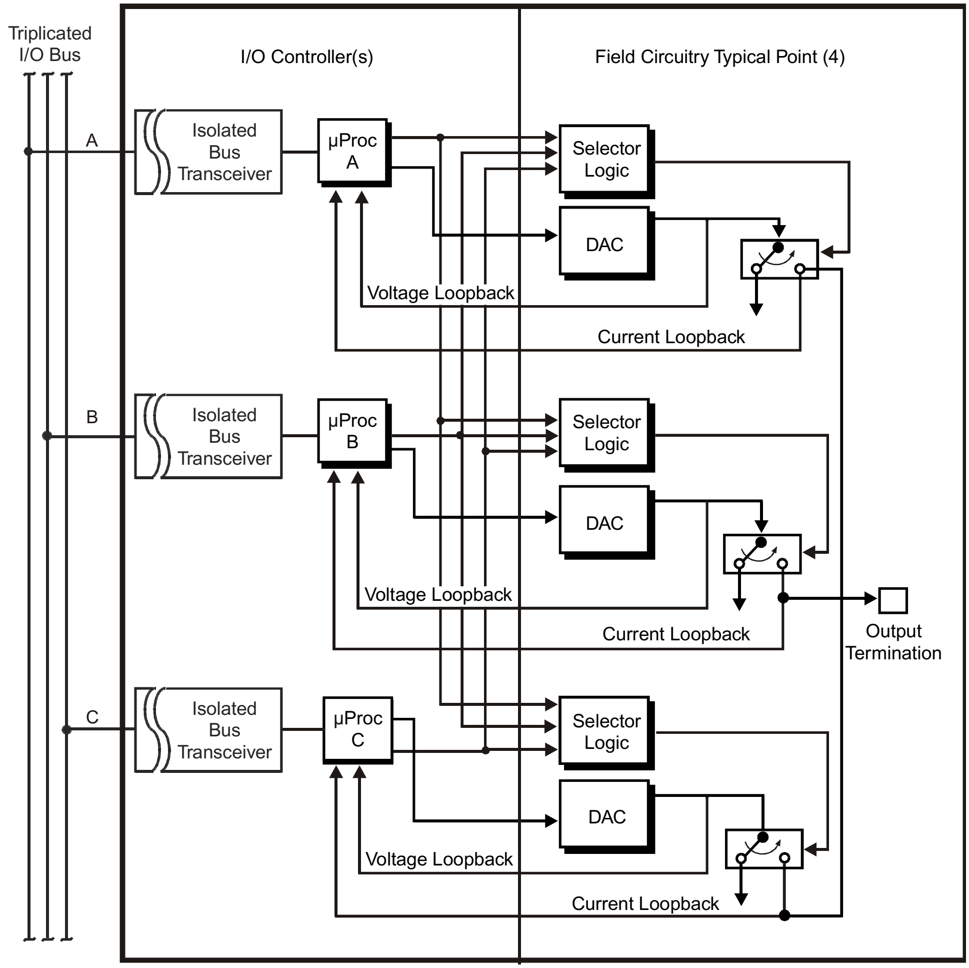
The AO Modules support hot sparing for online replacement of a faulty module or continuous back-up to an active module. The AO Modules are mechanically keyed to prevent improper installation in a configured baseplate.

Model 3481 Analog Output Module

AO Module Front Panel



Model 3481 Analog Output Module Simplified Schematic

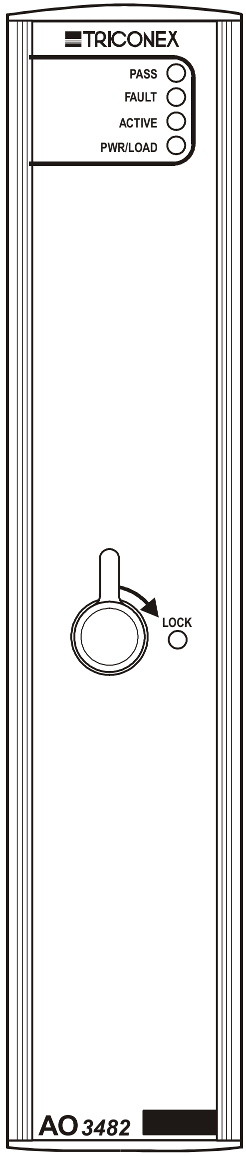


Model 3481 Analog Output Module Specifications

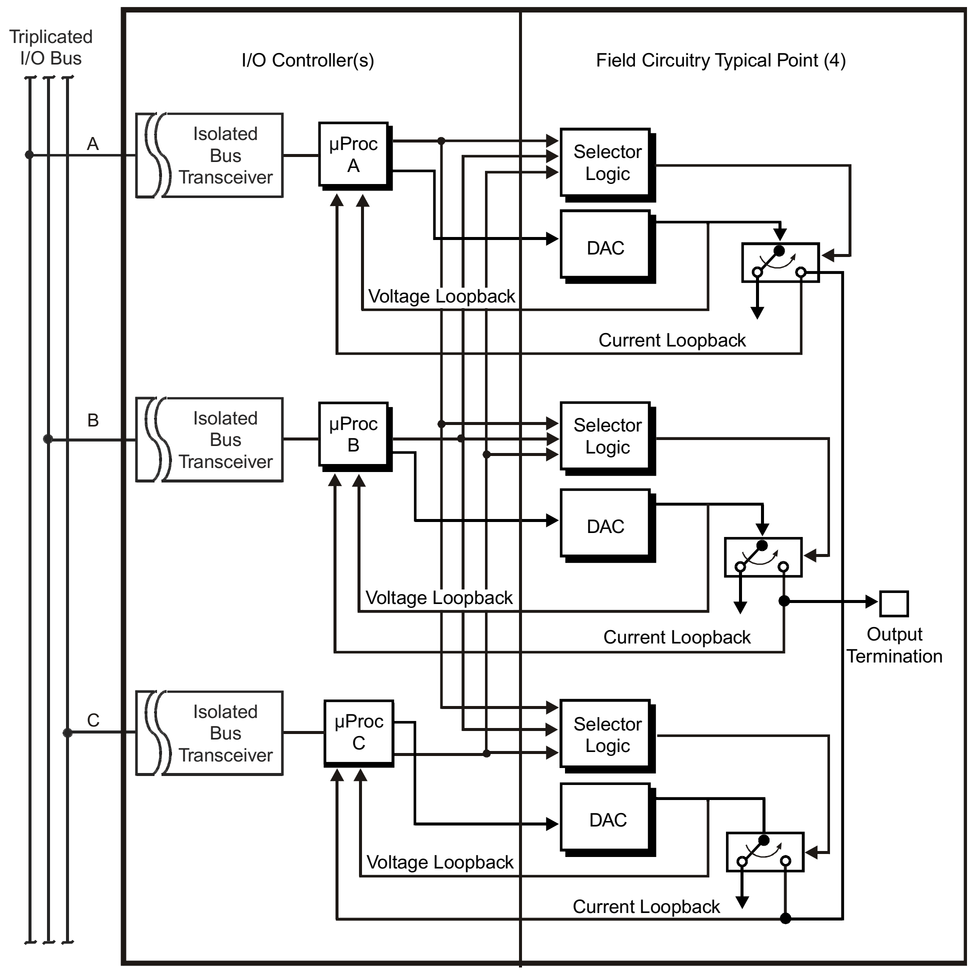
Feature	Specification
Points	4, commoned-return, DC-coupled
Output current range	4–20 mA output, controlled 0–22 mA over-range 0 mA output capability (step function <2 mA)
Output accuracy	<0.25% (in range of 4–20 mA) of FSR (0–22 mA), from 0° C to 70° C (32° F to 158° F)
Type	TMR
Resolution	12 bits
Diagnostic	Forced-switch diagnostic (FSD)
External loop power (reverse voltage-protected)	32 V DC, maximum 24 V DC, nominal
Output loop power requirements for specified load	300 Ω @ >16 V DC (1 A minimum) 500 Ω @ >20 V DC (1 A minimum) 700 Ω @ >24 V DC (1 A minimum) 800 Ω @ >28 V DC (1 A minimum)
Over-range protection	36 V DC, continuous 0 V DC, continuous
Switch time on leg failure	1 ms, typical 3 ms, maximum
Functional-to-protective-earth isolation	500 V DC, minimum
Functional-to-functional-earth (logic) isolation	800 V DC, minimum

Model 3482 High-Current Analog Output Module

AO Module Front Panel



Model 3482 High-Current Analog Output Module Simplified Schematic

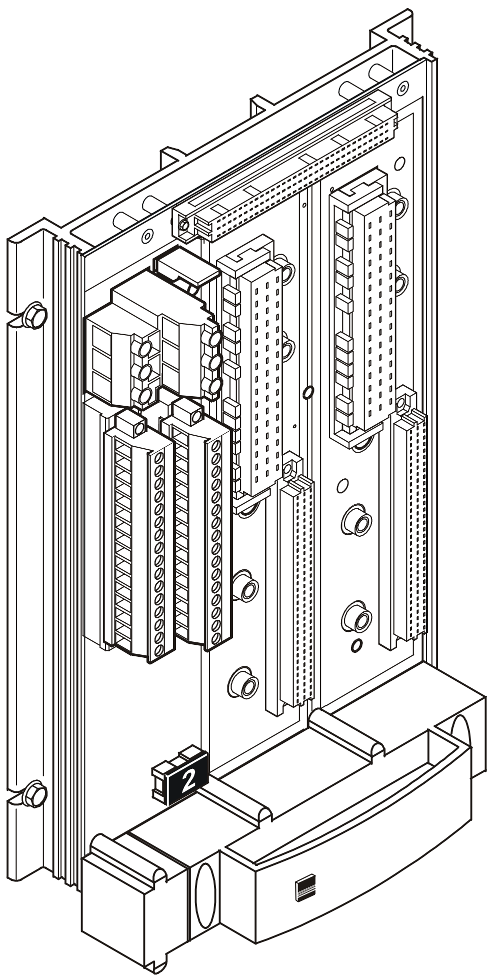


Model 3482 High-Current Analog Output Module Specifications

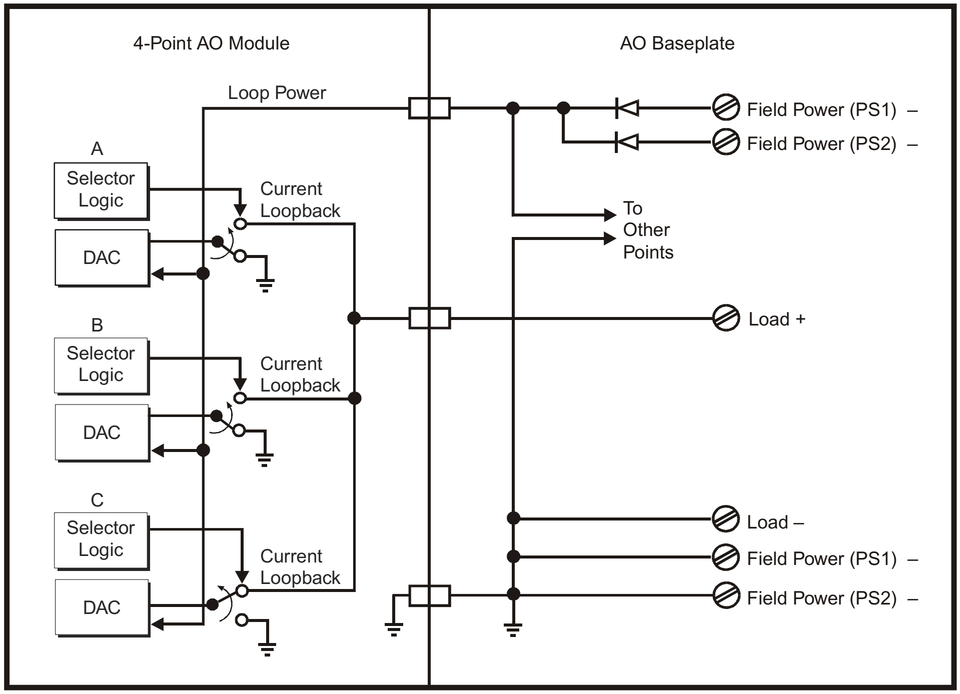
Feature	Specification
Points	4, commoned-return, DC-coupled
Output current range, Points 1–2	4–20 mA output, controlled 0–22 mA over-range 0 mA output capability (step function <2 mA)
Output accuracy, Points 1–2	<0.25% (in range of 4–20 mA) of FSR (0–22 mA), from 0° C to +70°C° (32° F to 158° F)
Output current range, Points 3–4	4–40 mA output, controlled 0–44 mA over-range 0 mA output capability (step function <4 mA)
Output accuracy, Points 3–4	<0.25% (in range of 4–40 mA) of FSR (0–44 mA), from 0° C to 50°C (32° F to 122° F)
Type	TMR
Resolution	12 bits
Diagnostic	Forced-switch diagnostic (FSD)
External loop power (reverse voltage protected)	32 V DC, maximum 24 V DC, nominal
Output loop power requirements for specified load, Points 1–2	300 Ω @ >16 V DC (1 A minimum) 500 Ω @ >20 V DC (1 A minimum) 700 Ω @ >24 V DC (1 A minimum) 800 Ω @ >28 V DC (1 A minimum)
Over-range protection, Points 1–2	36 V DC, continuous 0 V DC, continuous
Output loop power requirements for specified load, Points 3–4	125 Ω @ >16 V DC (1 A minimum) 210 Ω @ >20 V DC (1 A minimum) 295 Ω @ >24 V DC (1 A minimum) 340 Ω @ >28 V DC (1 A minimum)
Over-range protection	36 V DC, continuous with thermal de-rating 0 V DC, continuous
Switch time on leg failure	1 ms, typical 3 ms, maximum

Feature	Specification
Functional-to-protective-earth isolation	500 V DC, minimum
Functional-to-functional-earth (logic) isolation	800 V DC, minimum

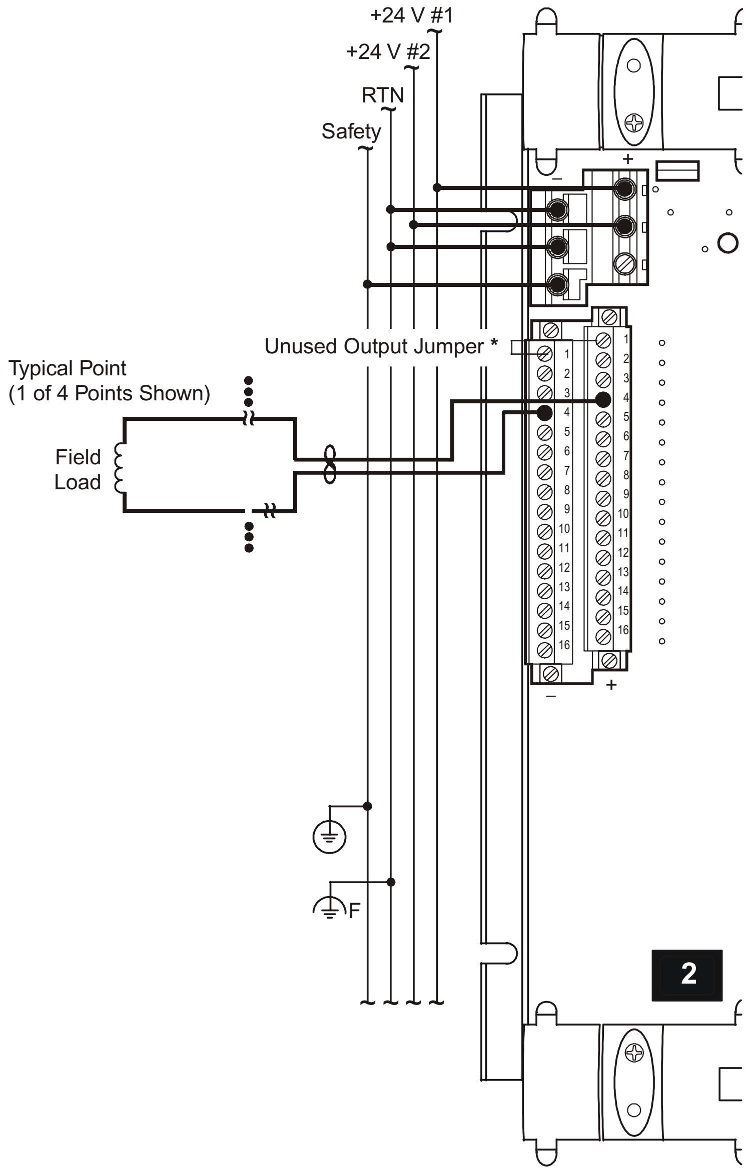
Model 2481 Analog Output Baseplate



Model 2481 Analog Output Baseplate Simplified Schematic



Model 2481 Analog Output Baseplate Field Connections



* Short unused outputs

Digital Input Module

The following digital input components are available.

Model	Description	Voltage	Type
3301	Digital Input Module	24 V DC	Commoned
2301	Digital Input Baseplate		Direct Termination

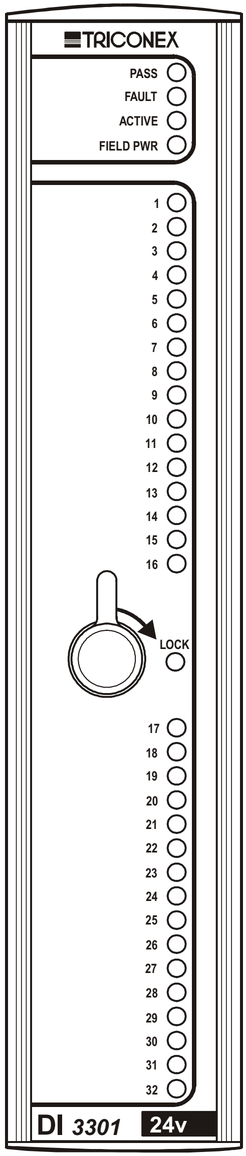
The Digital Input (DI) Module has three independent channels which process all data sent to the module. An ASIC on each channel scans each input point, compiles data, and transmits it to the MPs upon demand. Input data is voted at the MPs before processing to ensure the highest integrity.

The DI Module sustains complete, ongoing diagnostics for each channel. If the diagnostics detect a failure on any channel, the Fault indicator is activated, which in turn activates the system alarm. The Fault indicator points to a channel fault, *not* a complete module failure. The DI Module is guaranteed to operate properly in the presence of a single fault and may continue to operate properly with certain multiple faults.

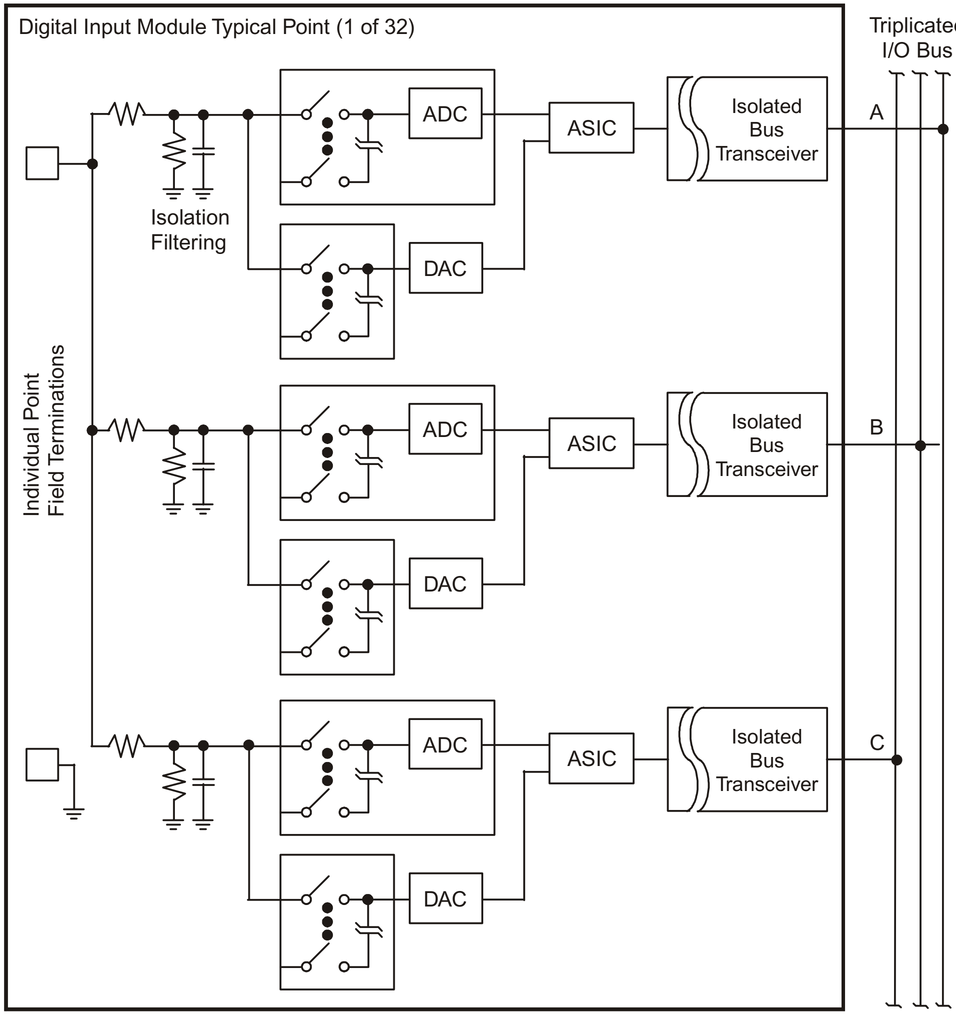
The DI Module continuously verifies the ability of the system to detect transitions to the opposite state. The DI Module supports hot sparing for online replacement of a faulty module or continuous back-up to an active module. The DI Module is mechanically keyed to prevent improper installation in a baseplate.

Model 3301 Digital Input Module

DI Module Front Panel



Model 3301 Digital Input Module Simplified Schematic



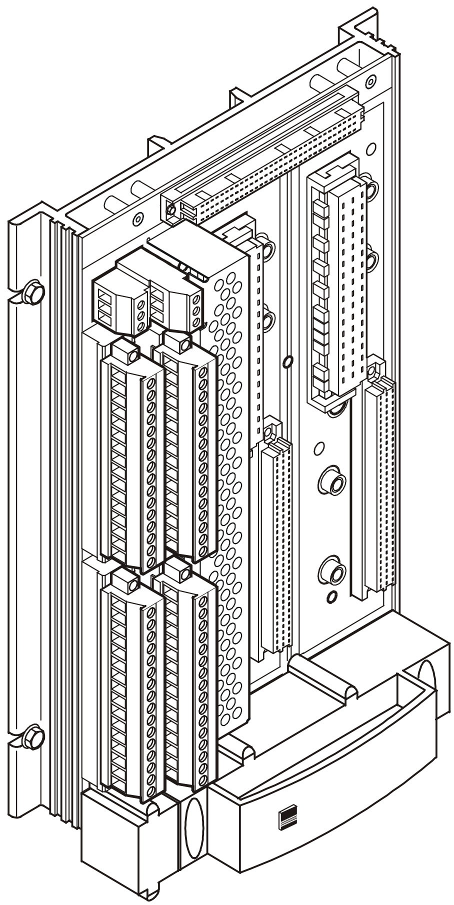
Model 3301 Digital Input Module Specifications

Feature	Specification
Points	32, commoned
Nominal input voltage	24 V DC
Operational voltage range	15–30 V DC
Absolute maximum input voltage	33 V DC
Absolute maximum reverse input voltage	–0.6 V DC
Input delay	<10 ms, On to Off or Off to On TC = 6.4 ms, –3dB @ 25Hz
Input impedance	>30 kΩ without baseplate ≈3 kΩ with baseplate
Input power	0.2 W/pt, @ 24 V DC 0.5 W/pt, @ 33 V DC
Input threshold	0–5 V DC = Off region 6–14 V DC = transition region 15–30 V DC = On region
Diagnostic (loss of view)	Force-to-value diagnostic (FVD), <2 ms/test
Maximum input toggle rate to maintain diagnostic fault coverage	<20/sec
FVD Off-state glitch	
Duration	<2 ms
Magnitude	≈36% test voltage
Output Impedance	0–5 V DC, ≈100 kΩ
ADC scan time	<1 ms for all 32 points
Functional-to-protective-earth isolation	500 V DC, minimum
Functional-to-functional-earth (logic) isolation	800 V DC, minimum

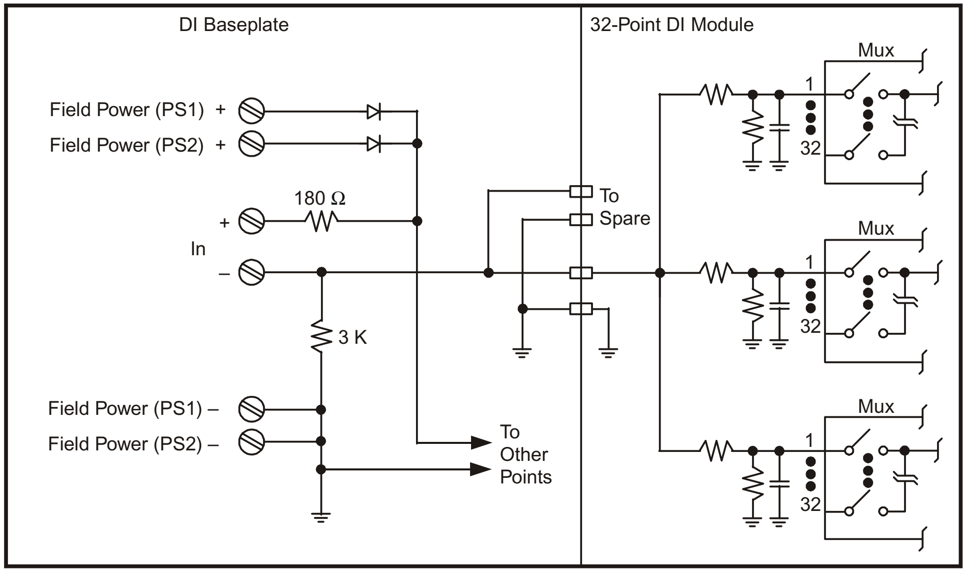
Model 2301 Digital Input Baseplate

The following table lists the short circuit current specifications for field short-to-ground faults.

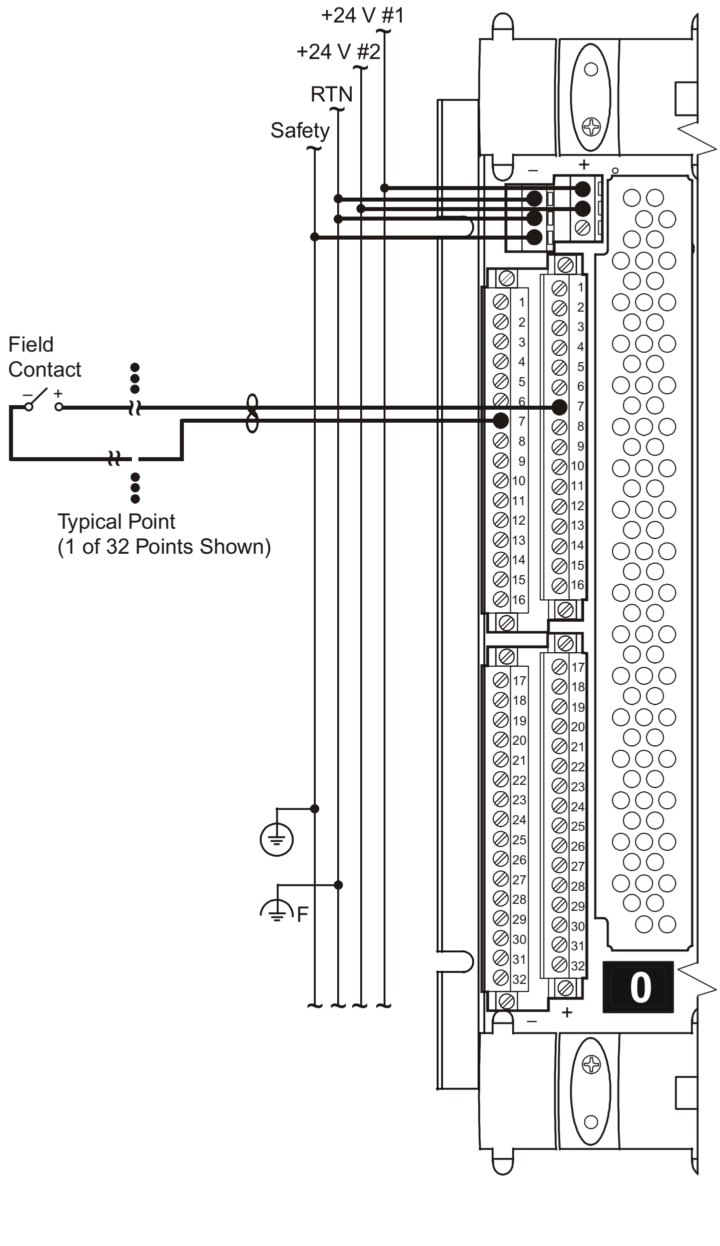
Feature	Specification
Fault current	130 mA, typical 200 mA, maximum



Model 2301 Digital Input Baseplate Simplified Schematic



Model 2301 Digital Input Baseplate Field Connections



Digital Output Module

The following digital output components are available.

Model	Description	Voltage	Type
3401	Digital Output Module	24 V DC	Commoned
2401	Digital Output Baseplate		Direct Termination
2402	Digital Output Baseplate		Current Limited

The Digital Output (DO) Module contains the circuitry for three identical, isolated channels. Each channel includes a proprietary ASIC which receives its output table from the I/O communication processor on its corresponding main processor. DO Modules use special quad output circuitry to vote 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, two out of three drivers are voted on. The quad output circuitry provides multiple redundancy for all critical signal paths, guaranteeing safety and maximum availability.

The DO Module periodically executes an output voter diagnostic (OVD) routine on each point. This safety feature allows unrestricted operation under a variety of multiple-fault scenarios.

OVD detects and provides alarms for the following:

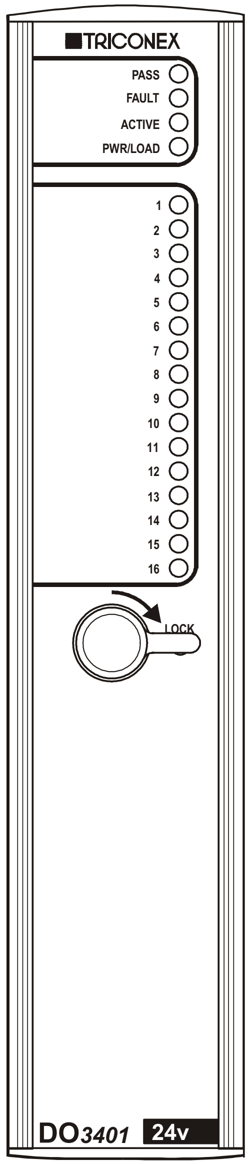
- Points— all stuck-on and stuck-off points are detected in less than 500 milliseconds
- Switches—all stuck-on or stuck-off switches or their associated drive circuitry are detected

During OVD execution, the commanded state of each point is momentarily reversed sequentially on one of the output drivers. Loop-back on the module allows each ASIC to read the output value for the point to determine whether a latent fault exists within the output circuit. The output signal transition is guaranteed to be less than two milliseconds (500 microseconds is typical) and is transparent to most field devices. For devices that cannot tolerate a signal transition of any length, OVD can be disabled.

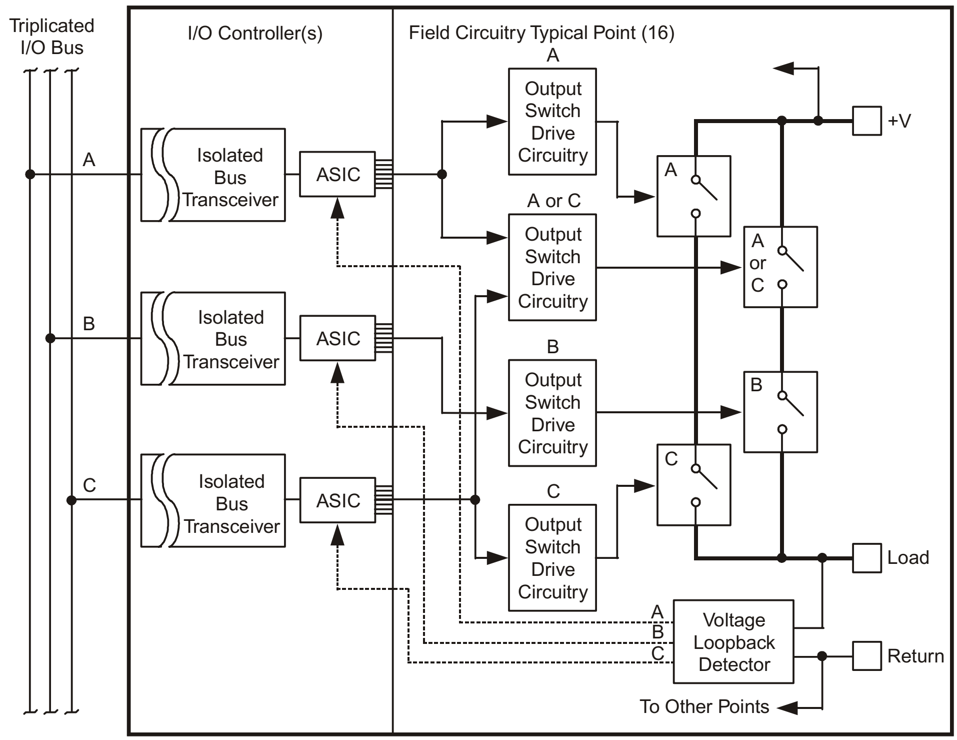
The DO Module supports hot sparing for online replacement of a faulty module or continuous back-up to an active module. The DO Module is mechanically keyed to prevent improper installation in a configured baseplate.

Model 3401 Digital Output Module

DO Module Front Panel



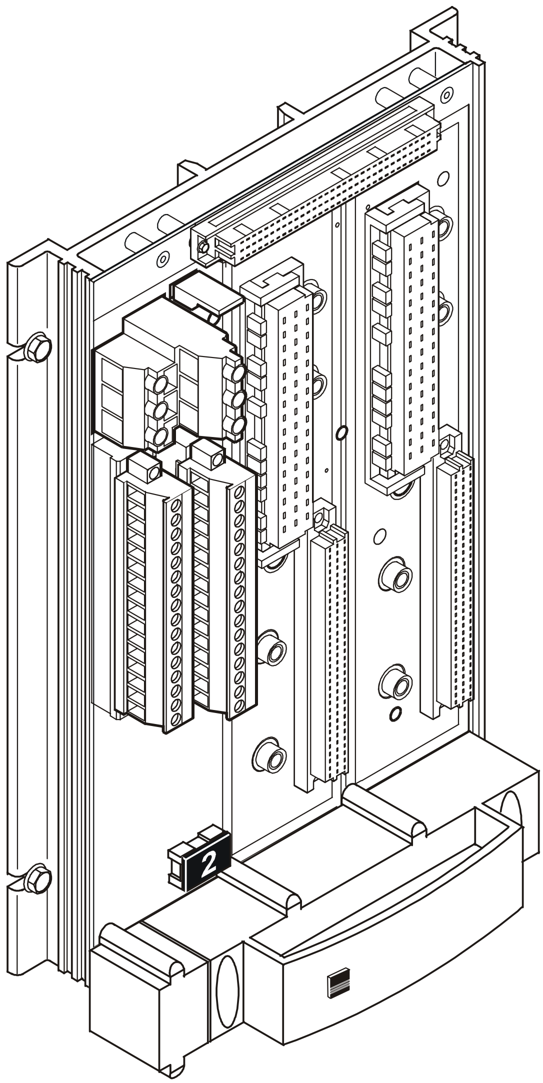
Model 3401 Digital Output Module Simplified Schematic



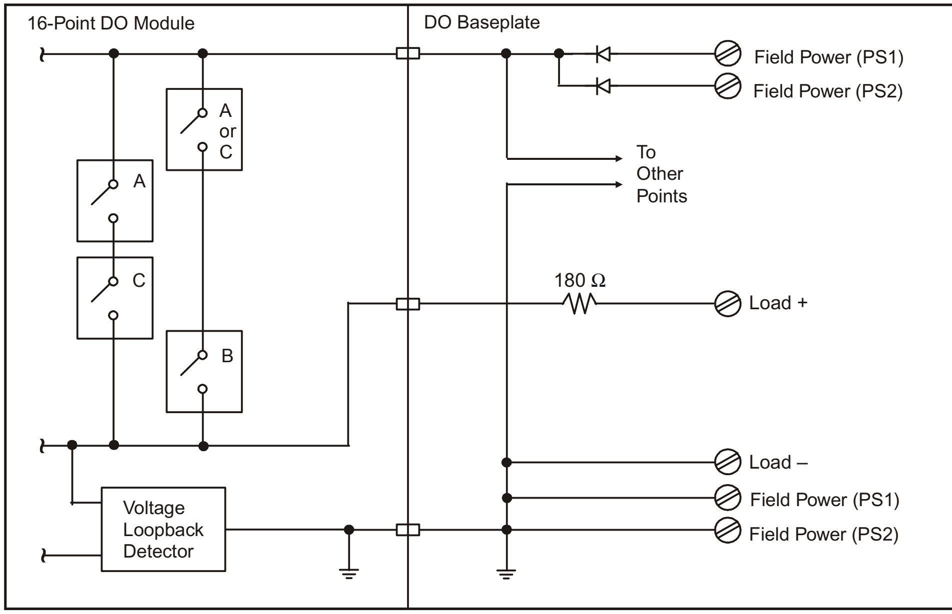
Model 3401 Digital Output Module Specifications

Feature	Specification
Points	16, commoned
Nominal output voltage	24 V DC
Operational voltage range	15–30 V DC
Absolute maximum output voltage	33 V DC
Absolute maximum reverse input voltage	–0.6 V DC
Output current	
Switching	<4.8 A, self-limiting 3 A, typical
Carry	>0.7 A, self-limiting 1.5 A, typical
Field alarms	Loss of field power, output point shorted On or Off
Loop-back thresholds	0–5 V DC = Off region 6–14 V DC = transition region 15–30 V DC = On region
Leakage to load (Off-state)	<1 mA
Diagnostic glitch duration	<2 ms, maximum 500 µs, typical
Diagnostic fault coverage	
Maximum toggle rate	>20 ms
Minimum toggle rate	Not applicable
On-state voltage drop	<1 V DC @ 1.5 A
Loop-back scan time	<1 ms for all 16 points
Functional-to-protective-earth isolation	500 V DC, minimum
Functional-to-functional-earth (logic) isolation	800 V DC, minimum

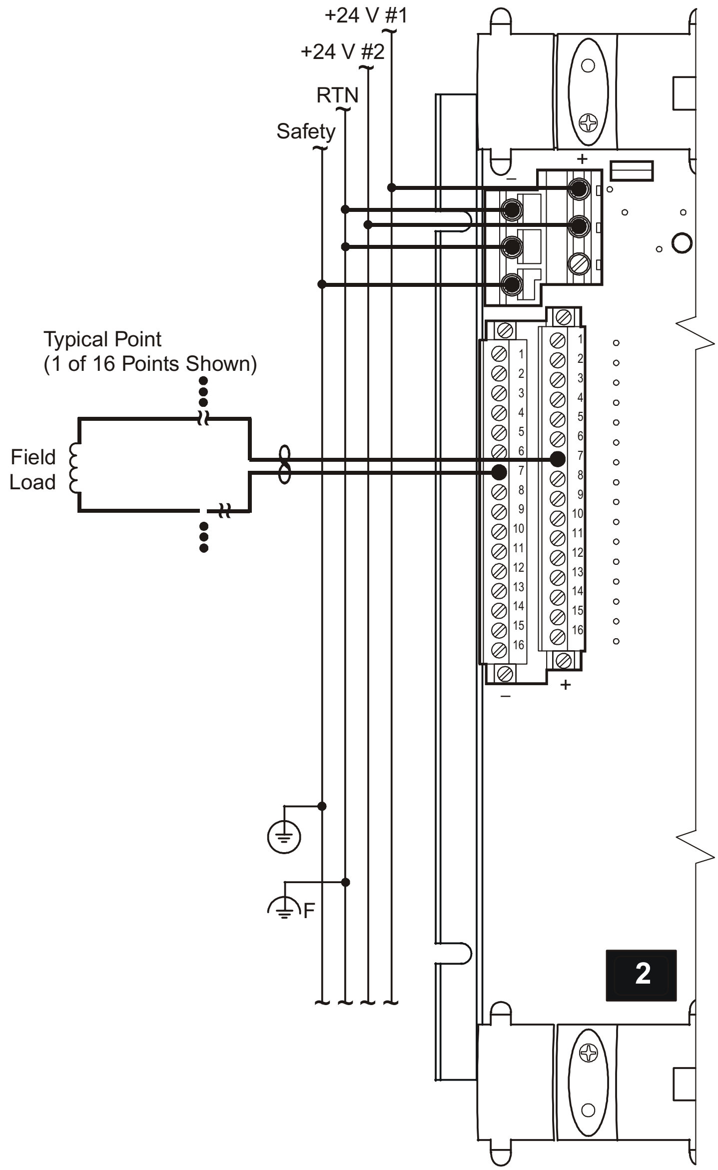
Model 2401 Digital Output Baseplate



Model 2401 Digital Output Baseplate Simplified Schematic

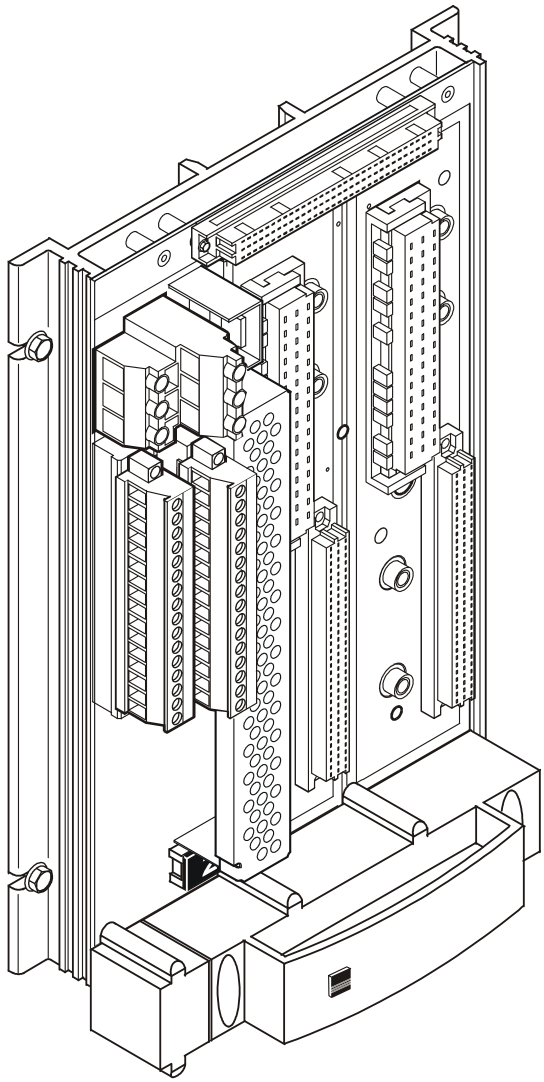


Model 2401 Digital Output Baseplate Field Connections

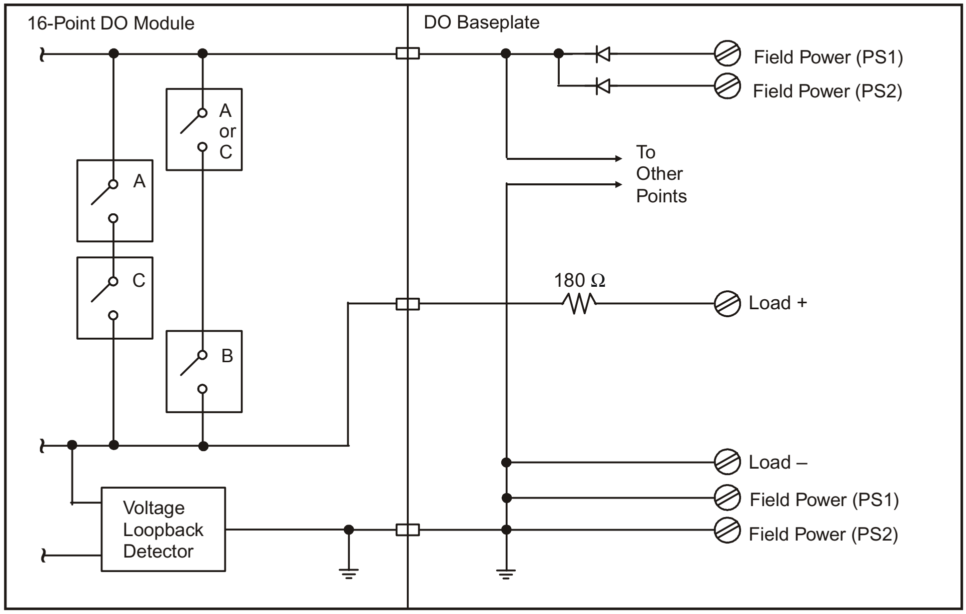


Model 2402 Digital Output Baseplate

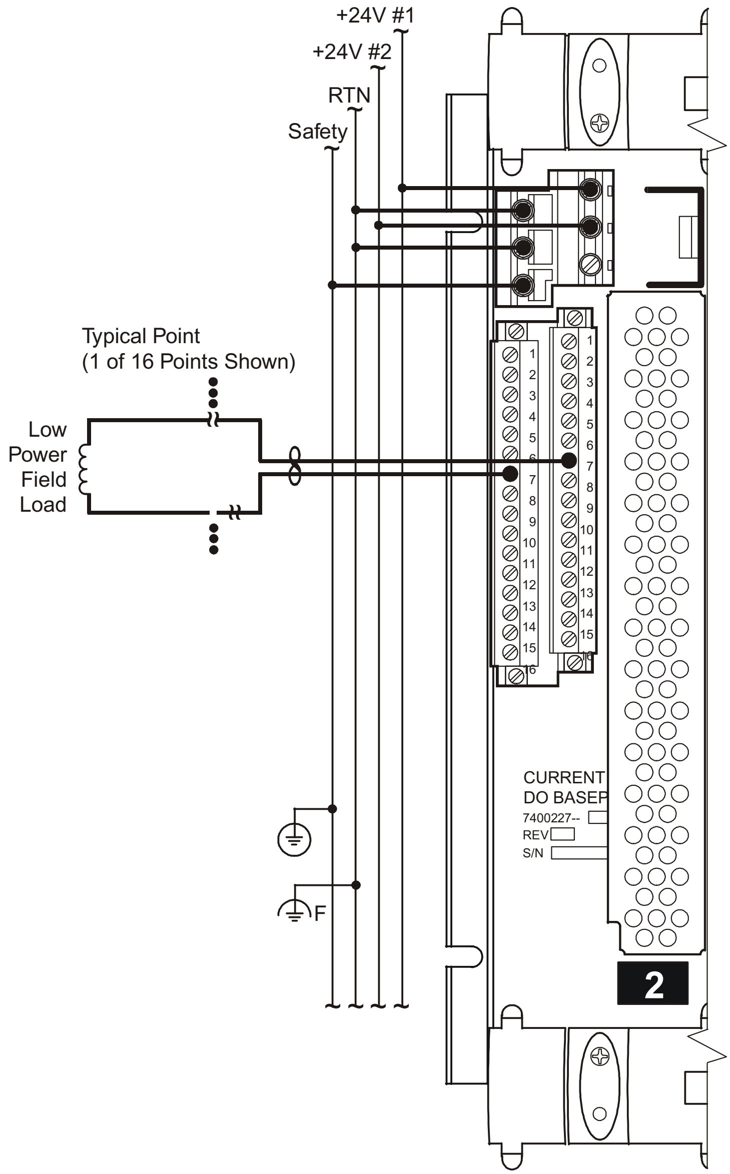
The Model 2402 Digital Output Baseplate is recommended for use with low-power loads only.



Model 2402 Digital Output Baseplate Simplified Schematic



Model 2402 Digital Output Baseplate Field Connections



Pulse Input Module

The following pulse input components are available.

Model	Description	Frequency Range	Type
3381	Pulse Input Module	0.5 Hz–32 kHz	Commoned
2381	Pulse Input Baseplate		Direct Termination

The Pulse Input (PI) Module provides six very sensitive, high-frequency inputs. The inputs can be individually configured for non-amplified and amplified magnetic speed sensors common on rotating equipment, such as turbines or compressors. The PI Module senses voltage transitions from the speed sensors. Every input transition is sampled, and time is measured for an optimized number of input gear pulses. The resulting count and time are used to generate a frequency (revolutions per minute), which is transmitted to the Main Processors.

The type of speed sensor typically used with the PI 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
- 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

A Pulse Input Module uses fully differential, input-signal-conditioning circuitry which is AC-coupled and has high bandwidth. The circuitry is designed for high-frequency operation with de-bounced edge detection, but is still sensitive to any type of waveform distortion that could result in erroneous measurements. The module counts transitions by examining one edge of each pulse. Therefore, ringing on the input signal can result in many additional transitions being counted. The module is capable of counting over 32,000 transitions per second.

The PI Module has three independent input channels. Each input channel:

- Receives pulse input voltages from each point
- Converts the values to frequency (RPM) data
- Transmits the values to the MPs on demand

To ensure correct data for each scan, one value is selected using a mid-value selection algorithm. Sensing of each input point is designed to prevent a single failure on one channel from affecting another channel.

⚠ CAUTION

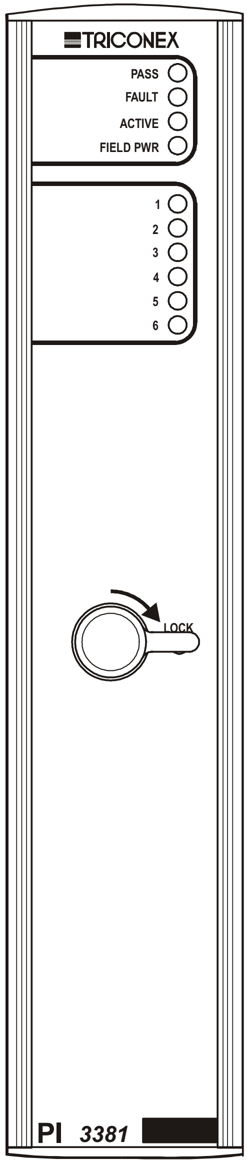
For critical control applications, we recommend using redundant sensors.

The PI Module sustains complete, on-going diagnostics for each channel. If the diagnostics detect a failure on any channel, the Fault indicator is activated, which in turn activates the system alarm. The Fault indicator points to a channel fault, *not* a complete module failure. The PI Module is guaranteed to operate properly in the presence of a single fault and may continue to operate properly with multiple faults.

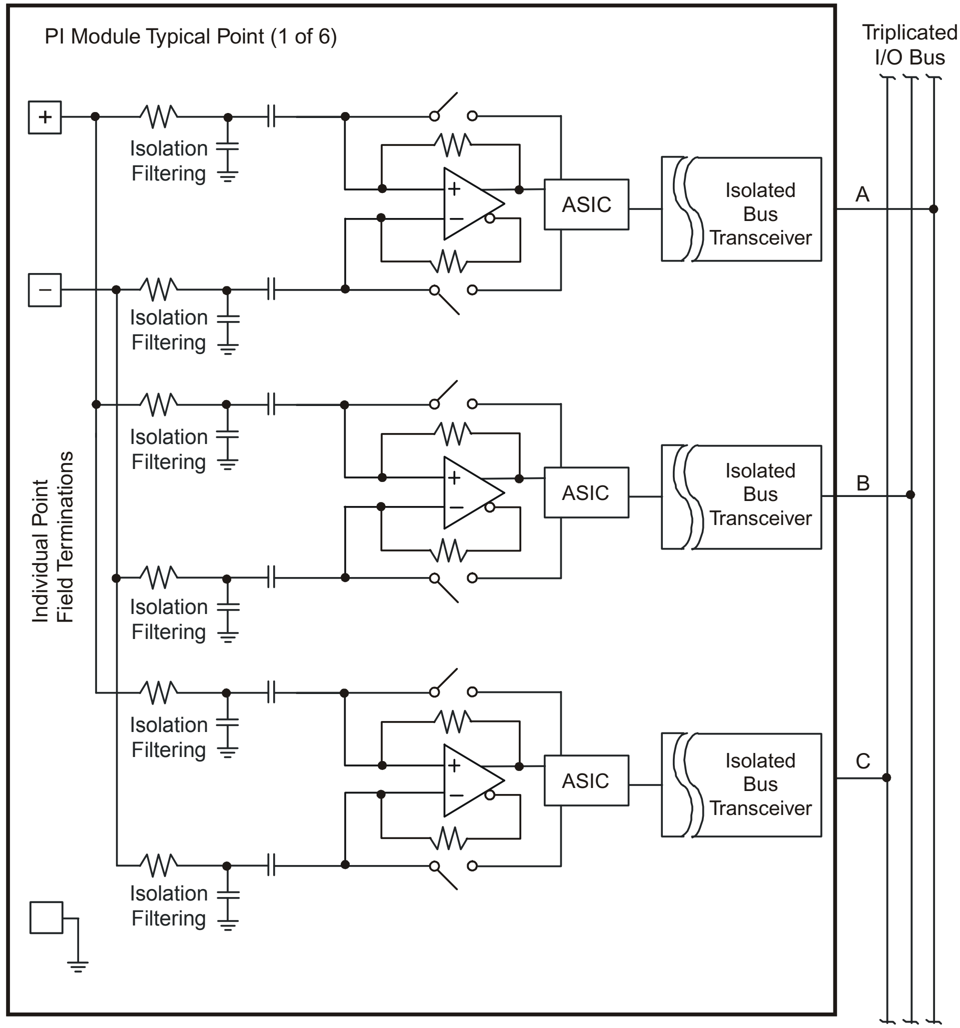
The PI Module supports hot sparing for online replacement of a faulty module or continuous back-up to an active module. The PI Module is mechanically keyed to prevent improper installation in a configured baseplate.

Model 3381 Pulse Input Module

PI Module Front Panel



Model 3381 Pulse Input Module Simplified Schematic



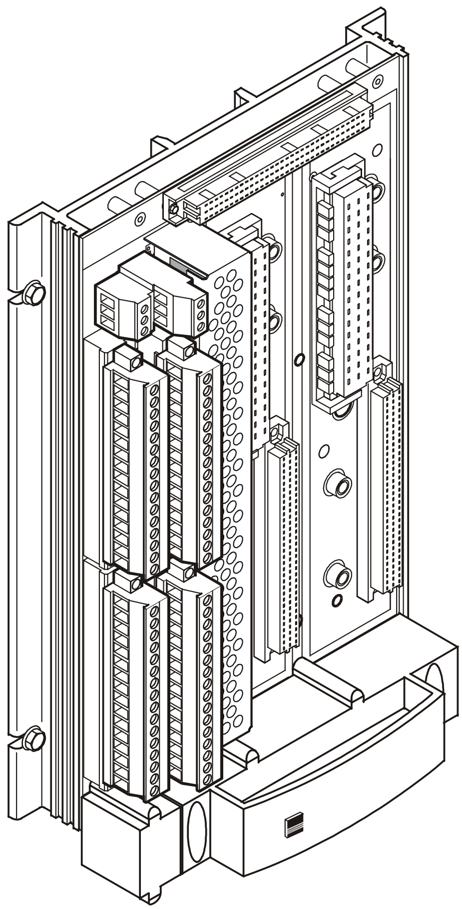
Model 3381 Pulse Input Module Specifications

Feature	Specification
Points	6, channel-isolated, commoned ground
Input type	Differential
Sensor compatibility	Magnetic, active, open collector
Maximum operating voltage	±33 V DC
Minimum operating voltage	
Differential	500 mV P-P, 2 Hz to 32,000 Hz 1 V P-P, 0.5 Hz to 2 Hz
Single-ended	1V P-P, 2 Hz to 32,000 Hz 2V P-P, 0.5 Hz to 2 Hz
Speed range	0 to 32,000 RPM
Input frequency range	0.5 Hz to 32 kHz
Duty cycle	20% to 80%, or 10 µs minimum pulse width
Maximum continuous slew rate	4,000 Hz/sec with 60 gear teeth
Maximum continuous RPM slew rate	4,000 RPM/sec with 60 gear teeth
Number of gear teeth	1–255
Termination resistor	Baseplate configurable
Pull-up resistor	Baseplate configurable
Resolution	24 bits
Absolute error	± 0.01%, 2,000 to 32,000 Hz ± 0.1%, 0.5 to 2,000 Hz
Measurement algorithm	Gear multiple tracking
Diagnostic	Precision reference test
Minimum scan update rate	20 ms
Functional-to-protective-earth isolation	500 V DC, minimum
Functional-to -functional-earth (logic) isolation	800 V DC, minimum

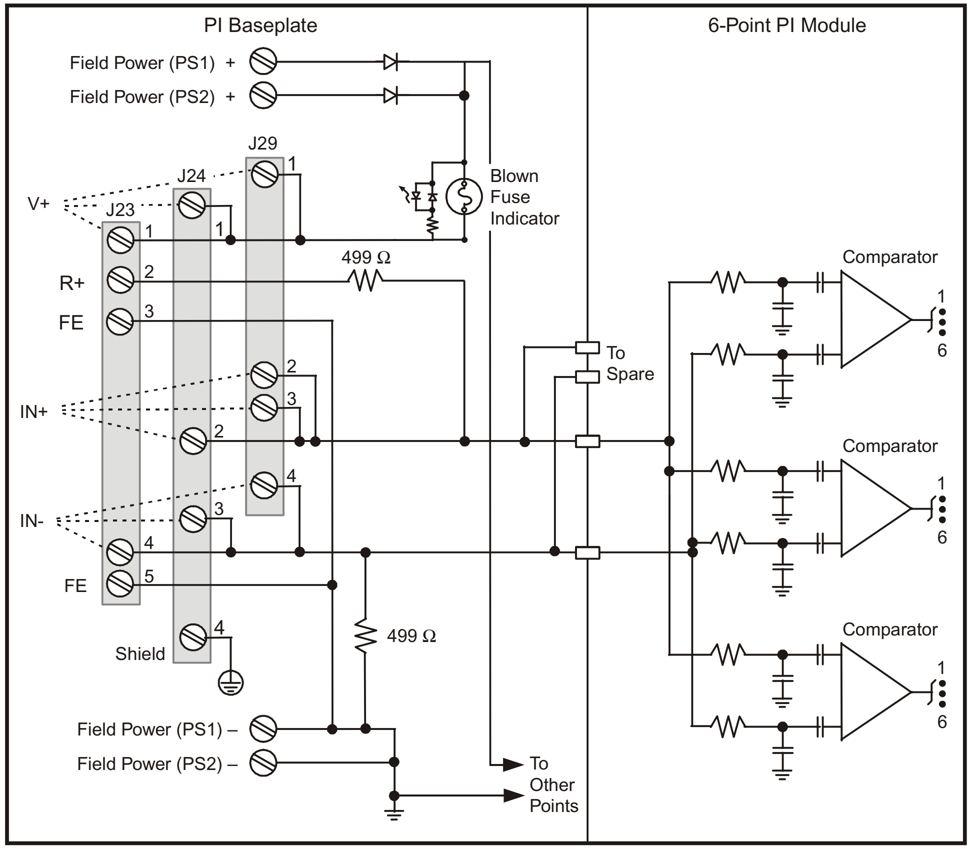
Model 2381 Pulse Input Baseplate

The following table lists the short circuit current specifications for field short-to-ground faults.

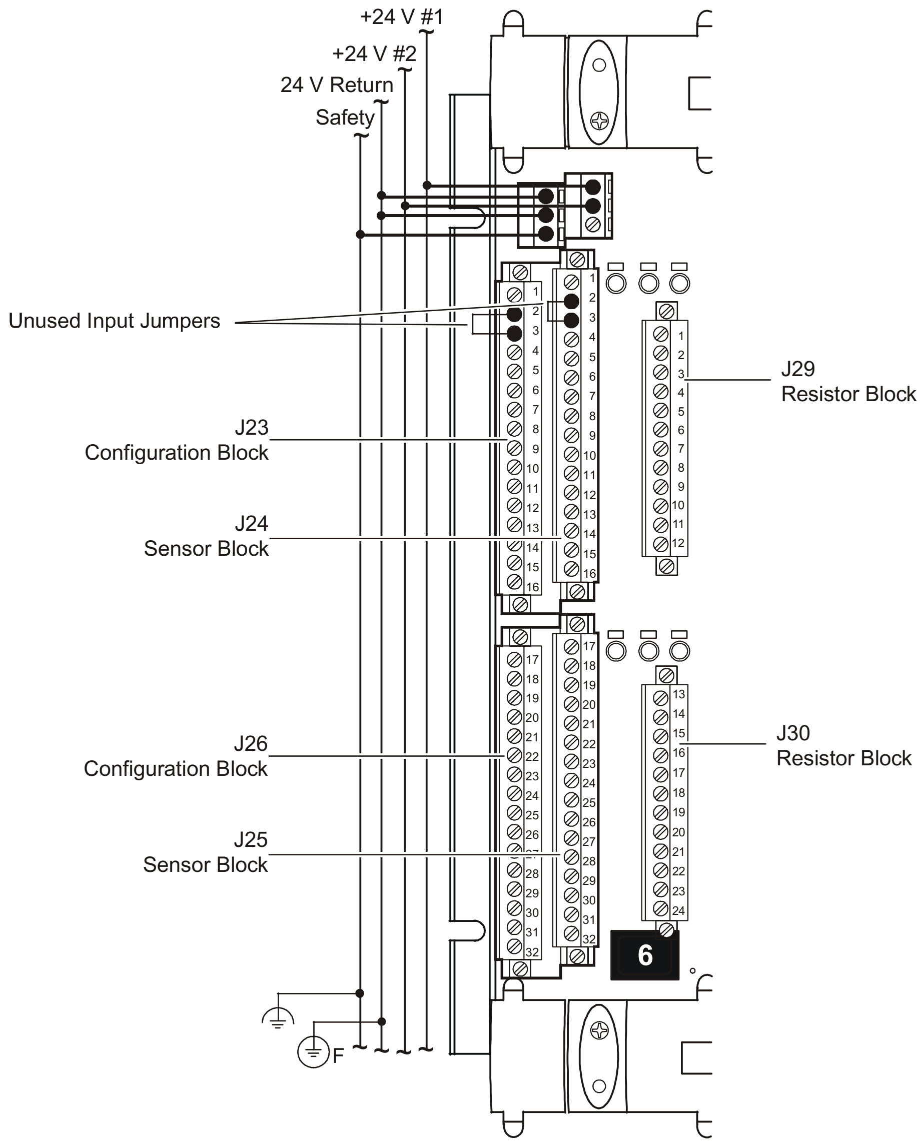
Feature	Specification
Fault current	130 mA, typical 200 mA, maximum



Model 2381 Pulse Input Baseplate Simplified Schematic



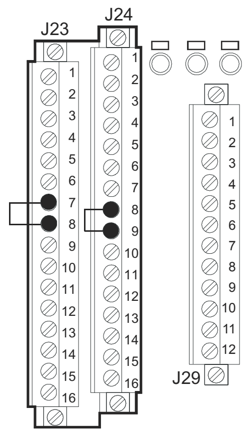
Model 2381 Pulse Input Baseplate Field Connections



Note Unused points must be terminated.

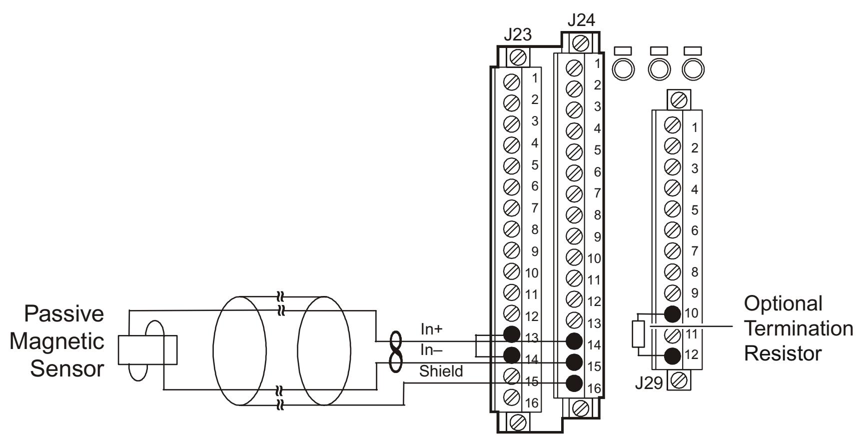
Connecting an Unused Point

The figure below shows a typical connection for point 2.



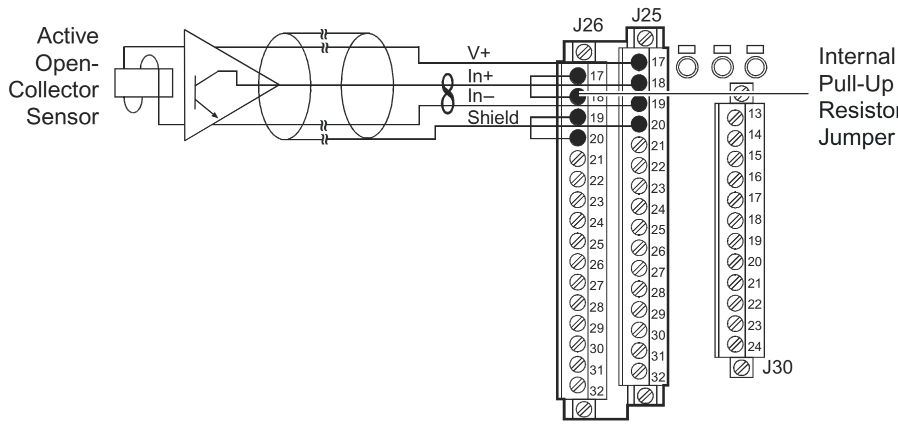
Connecting a Passive Magnetic Sensor

The figure below shows a typical connection for point 3.



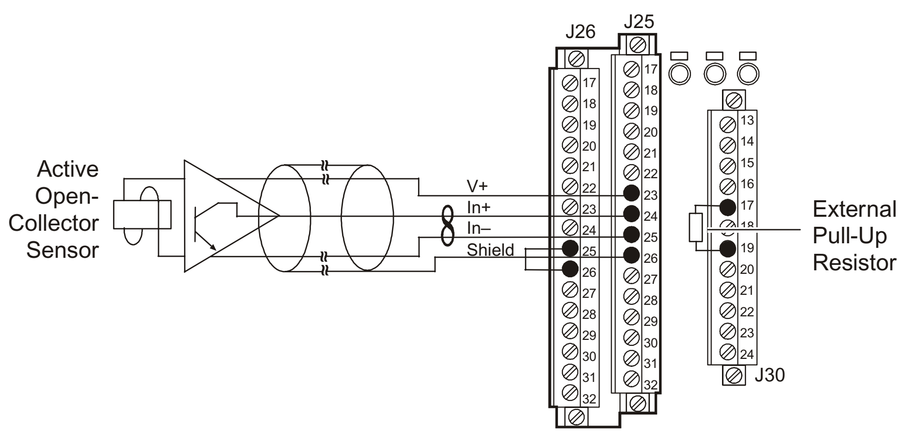
Connecting an Active Open-Collector Sensor with an Internal Resistor

The figure below shows a typical connection for point 4.



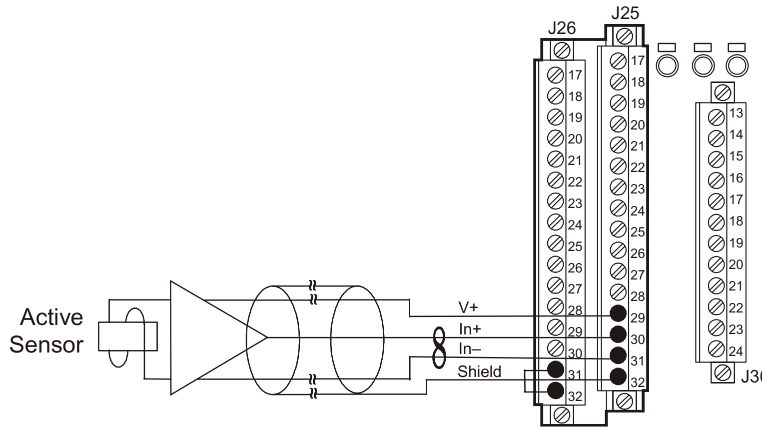
Connecting an Active Open-Collector Sensor with an External Resistor

The figure below shows a typical connection for point 5.



Connecting an Active Sensor

The figure below shows a typical connection for point 6.



Terminal Blocks

The PI Module has three types of terminal blocks: configuration, sensor, and resistor.

The configuration block is used to select passive or active magnetic sensors and to select an internal pull-up resistor when using an active open-collector sensor.

The sensor block is used to connect sensors to the baseplate.

The resistor block is used to attach a user-supplied termination resistor for passive sensors, or a user-supplied pull-up resistor for an active open-collector sensor.

The PI Baseplate is factory-configured with the configuration blocks set to differential mode for each point. The sensory blocks are configured to no points (spare) with the inputs shorted together. When a point is selected for use, the installed jumpers should be moved or removed as appropriate.

PI Baseplate Terminal Block Pin-Outs

Configuration						
J23/J26 Signal	**Point 1**	**Point 2**	**Point 3**	**Point 4**	**Point 5**	**Point 6**
V+	1	6	12	17	22	28
R+	2	7	13	18	23	29
FE	3	8	14	19	24	30
IN1–	4	9	15	20	25	31
FE	5	10	16	21	26	32
Sensor						
J24/J25 Signal	**Point 1**	**Point 2**	**Point 3**	**Point 4**	**Point 5**	**Point 6**
V+	1	7	13	17	23	29
IN+	2	8	14	18	24	30
IN–	3	9	15	19	25	31
Shield	4	10	16	20	26	32
Resistor						
J29/J30 Signal	**Point 1**	**Point 2**	**Point 3**	**Point 4**	**Point 5**	**Point 6**
V+	1	5	9	13	17	22
IN+	2	6	10	14	18	23
IN+	3	7	11	15	19	24
IN–	4	8	12	16	20	25

Solid-State Relay Output Module

The following relay output components are available.

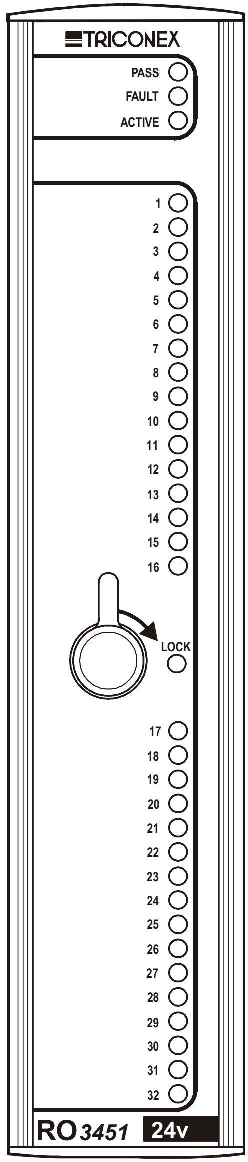
Model	Description	Voltage	Type
3451	Solid-State Relay Output Module	24 V DC	Commoned, in groups of 2
2451	Solid-State Relay Output Baseplate		Direct Termination

The Solid-State Relay Output (SRO) Module is a non-triplicated module for use on non-critical points which are not compatible with high-side, solid-state output switches; for example, interfacing with annunciator panels. The SRO Module receives output signals from the MPs 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 an I/O loop-back circuit which verifies the operation of each relay switch independently of the presence of a load. Ongoing diagnostics test the operational status of the SRO Module.

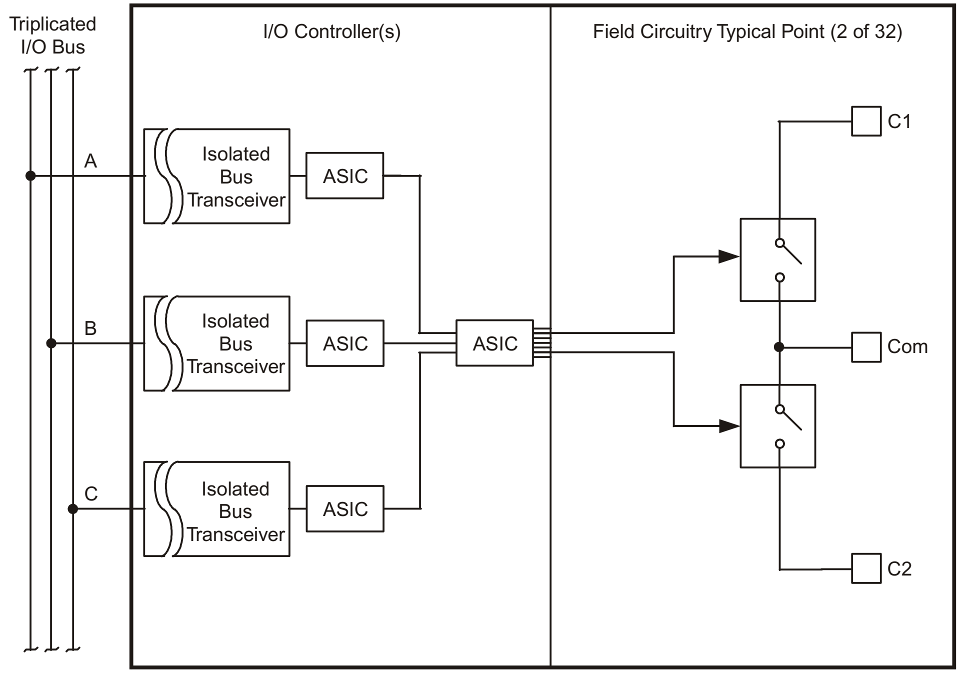
The SRO Module supports hot sparing for online replacement of a faulty module or continuous back-up to an active module. The SRO Module is mechanically keyed to prevent improper installation in a configured baseplate.

Model 3451 Solid-State Relay Output Module

SRO Module Front Panel



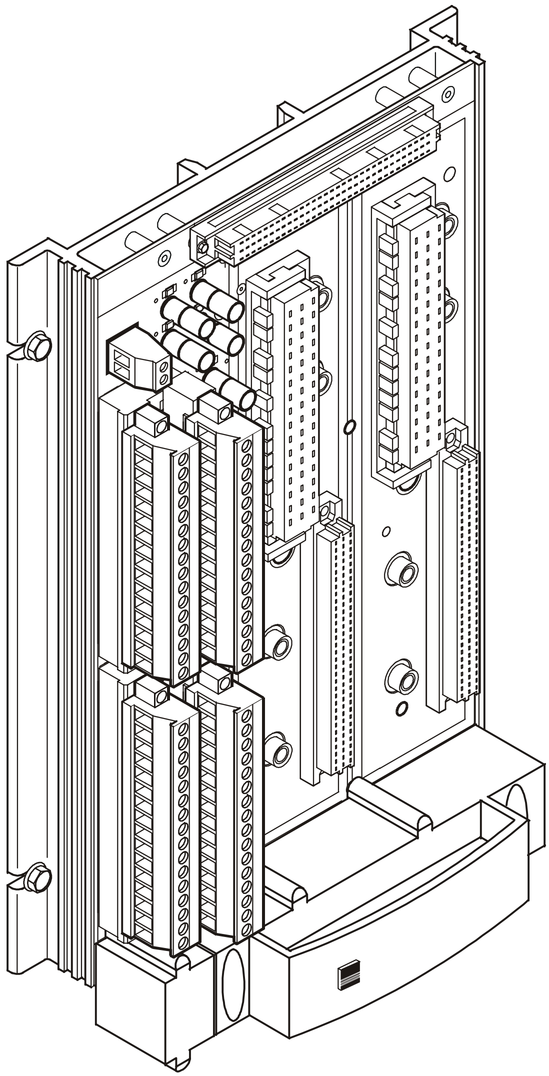
Model 3451 Solid-State Relay Output Module Simplified Schematic



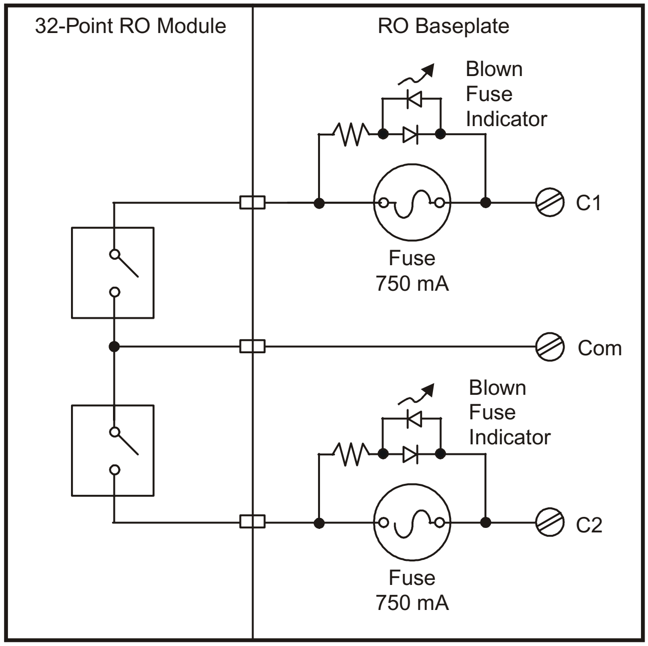
Model 3451 Solid-State Relay Output Module Specifications

Feature	Specification
Points	32, commoned in pairs
Nominal input voltage	± 24 V
Operational voltage range	± 30 V
Maximum switching voltage	± 33 V peak
Maximum switching power	15 W resistive
Maximum off-state leakage	<100 µA
Maximum nominal current	0.5 A per channel
Maximum over current	0.7 A per channel
Voltage drop at baseplate	<0.25 V @ 0.5 A
Fuses, mounted on baseplate	1 per output, 0.75 A, fast-acting
Functional-to-protective-earth isolation	500 V DC, minimum
Functional-to-functional-earth (logic) isolation	800 V DC, minimum

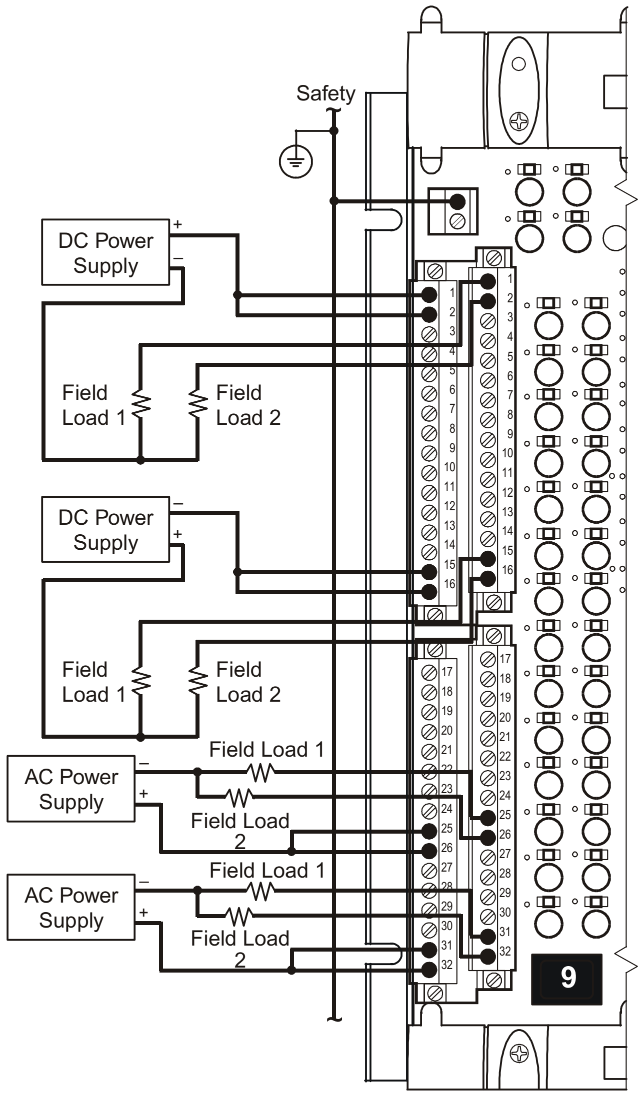
Model 2451 Solid-State Relay Output Baseplate



Model 2451 Solid-State Relay Output Baseplate Simplified Schematic



Model 2451 Solid-State Relay Output Baseplate Field Connections



Note Points on left terminal blocks are commoned together in pairs; for example, 1-2 and 3-4.

I/O Extender Modules

The following I/O Extender Modules Kits are available.

Model	Description
2281	I/O Extender Module Kit (without termination)
2291	I/O Extender Module Kit for I/O Baseplate (with termination)
2292	I/O Extender Module Kit for MP Baseplate (with termination)

The purpose of an I/O Extender Module is to:

- Extend the TMR I/O bus from one I/O column to another I/O column
- Provide TMR I/O bus termination
- Provide additional input terminals for I/O module logic power
- Provide a protective earth (safety ground) connection

An I/O Extender Module contains:

- Three DB-9-pin I/O bus connectors, one per channel
- Two 24-volt logic power input terminal blocks, each with fuse and blown-fuse indicators
- One protective earth terminal block

A maximum of eight baseplates may be stacked end-to-end in a column. To extend a system beyond eight baseplates or to separate the baseplates so that they are not connected end-to-end, a pair of I/O Extender Modules should be used.

Model 2281 I/O Extender Module Kit

A Model 2281 I/O Extender Module Kit contains:

- Two I/O Extender Modules
- Three two-foot cables
- One I/O Interconnect Assembly

Model 2291 I/O Extender Module Kit

A Model 2291 I/O Extender Module Kit contains:

- Two I/O Extender Modules
- Three two-foot cables
- Three DB-9-pin I/O bus terminators, one per channel
- One I/O Interconnect Assembly

Model 2292 I/O Extender Module Kit

A Model 2292 I/O Extender Module Kit contains:

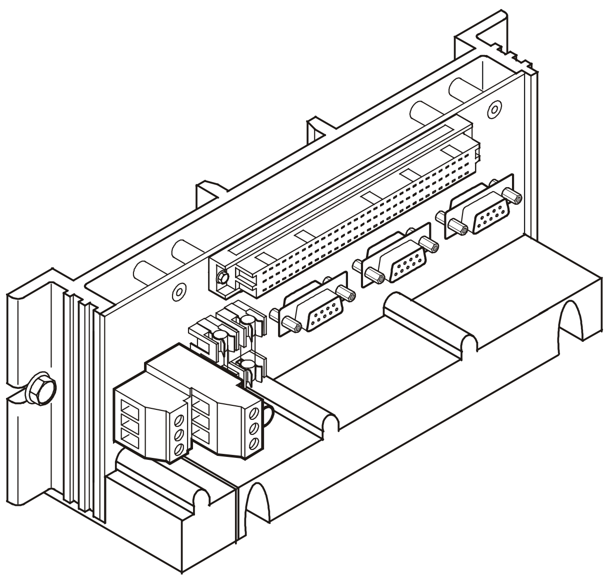
- Two I/O Extender Modules
- Three two-foot cables
- Three DB-9-pin I/O bus terminators, one per channel
- One MP Interconnect Assembly

Connecting I/O Extender Modules

An I/O Extender Module is connected to the top, bottom, or both top and bottom of a column of baseplates. If a column of baseplates contains an MP Baseplate, logic power may be connected to the I/O Extender Module or to the MP Baseplate. If a column of baseplates does not contain an MP Baseplate, logic power can be connected to the I/O Extender Module at the top of the column or to the I/O Extender Module at the bottom of the column.

The I/O bus TMR connections should be daisy-chained through each column of baseplates with an MP Baseplate at the beginning of the column. For long I/O buses, the baseplate furthest from the MP should be connected to an I/O Extender Module with I/O bus termination plugs. Three separate I/O bus cables connect from I/O Extender Module to I/O Extender Module. For the installation procedure, see "I/O Extender Modules" on page 115.

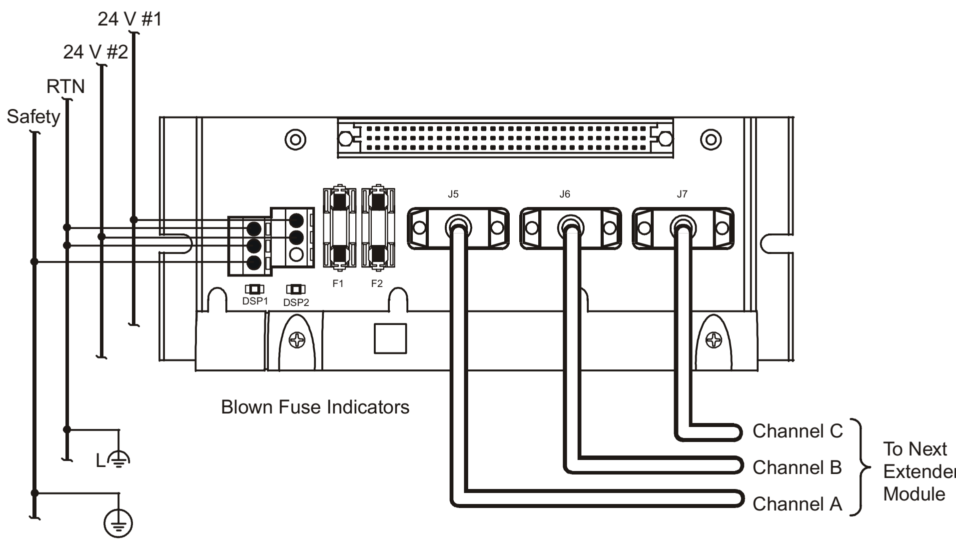
I/O Extender Module



Logic Power

Feature	Specification
Logic power	125 W maximum
Fuse	8 A, slow-acting
Blown fuse indicator	20 mA

Connecting an I/O Extender Module



Note See Chapter 5 for ground connections.

I/O Bus Cables

An I/O bus cable is required for each channel and is terminated at each end by a male 9-pin D connector suitable for rugged industrial applications. Various cable lengths are available.

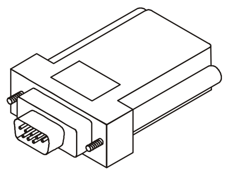
If the I/O bus length is greater than 6 meters (20 feet), the bus should be terminated. The maximum I/O bus length is 200 meters (650 feet) and includes:

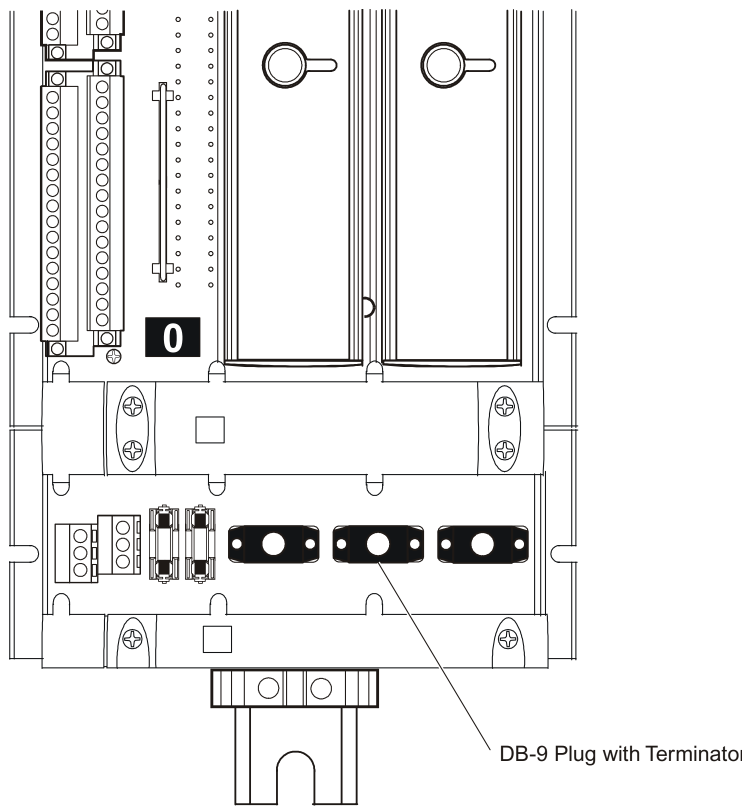
- Length of all baseplates
- I/O Extender Modules
- I/O bus extension cables

Note For distances greater than 200 meters (650 feet) or for applications requiring isolation, fiber-optic transceivers are commercially available. For compatible units and supported distances, contact your regional customer center.

I/O Bus Termination

A terminator consists of a male 9-pin D connector with two 120-ohm resistors mounted in the boot (or shell) of the connector. When the I/O bus length exceeds 6 meters (20 feet), six I/O bus terminators should be installed on the open I/O bus connectors on the I/O Extender modules at each end of the I/O bus.





Interconnect Assemblies

Two interconnect assemblies are available:

Model	Description
2920	MP Interconnect Assembly
2921	I/O Interconnect Assembly

MP Interconnect Assembly

An MP Interconnect Assembly carries the I/O, communication, and system power buses between baseplates. Physically, an MP Interconnect Assembly consists of a small passive PCB in a molded plastic housing with two DIN-C 96-pin male connectors and mounts to the top or bottom of MP Baseplates to bridge adjacent baseplates.

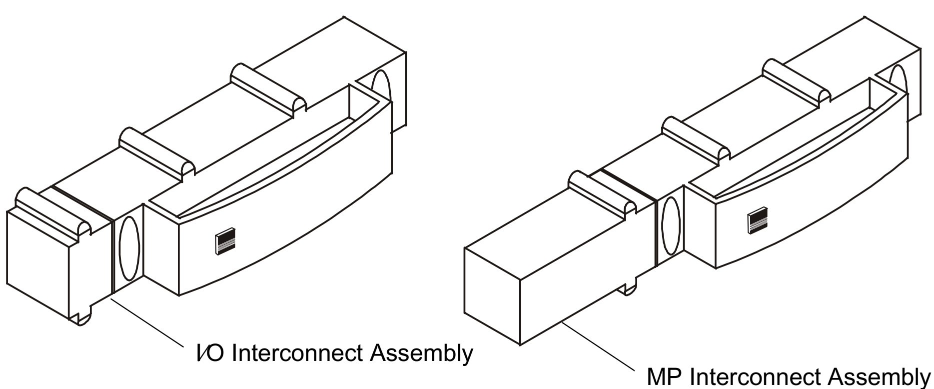
Each MP Baseplate includes one MP Interconnect Assembly.

I/O Interconnect Assembly

An I/O Interconnect Assembly carries the TMR I/O and system power buses between baseplates. An I/O Interconnect Assembly consists of a small passive PCB in a molded plastic housing with two DIN-C 96-pin male connectors and mounts to the top or bottom of I/O baseplates or Extender Assemblies to bridge adjacent baseplates.

Each I/O baseplate includes one I/O Interconnect Assembly.

Interconnect Assemblies



End Caps

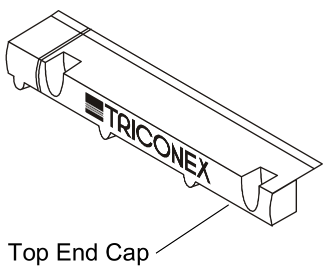
The following types of end caps are available.

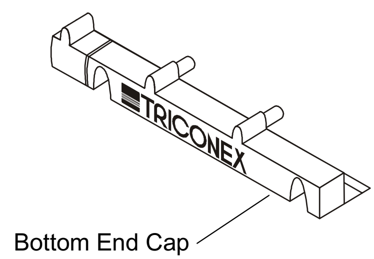
Model	Description
2910	I/O Baseplate/I/O Extender Module Top
2911	I/O Baseplate/I/O Extender Module Bottom
2912	MP Baseplate Top
2913	MP Baseplate Bottom

End Caps:

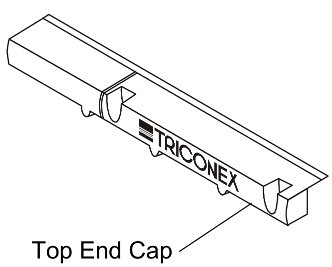
- Protect the top and bottom of each end-of-column baseplate
- Cover the interconnect connector
- Serve as a card guide

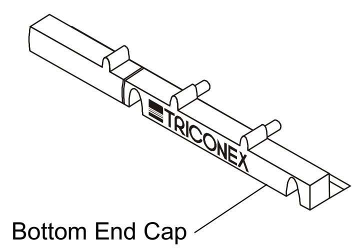
I/O Baseplate/I/O Extender Module End Caps





MP Baseplate End Caps





Covers

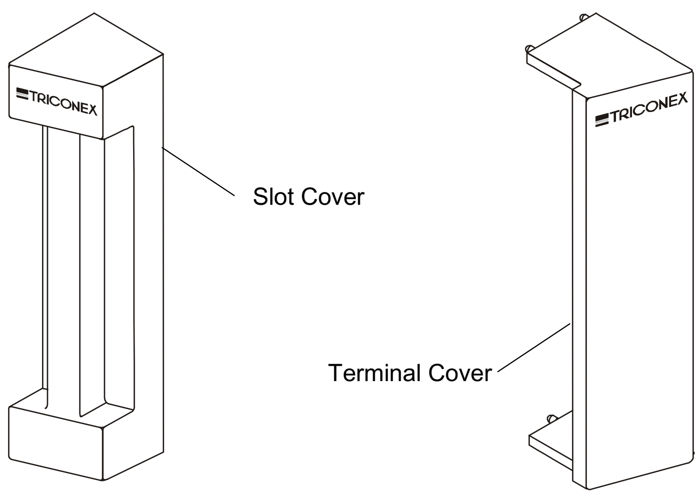
The following types of covers are available.

Model	Description
2900	Slot Cover
2911	Terminal Cover

Covers minimize exposure to:

- Dust
- Dripping/splashing liquids
- Corrosive atmospheres

One Slot Cover and one Terminal Cover are included with each I/O Baseplate.



CHAPTER 4

Installation and Maintenance

This chapter provides guidelines for the person responsible for installing and maintaining a Trident controller.

Topics include:

⚠ CAUTION

The Trident controller can be repaired while operating. However, the integrity of the controller can only be assured if the operator follows maintenance procedures correctly. If the operator is in doubt about the procedures, he or she should take whatever steps are necessary to ensure the safety of the plant and personnel, then call Triconex for assistance in implementing the maintenance procedures.

Guidelines

This section discusses issues to consider when installing and configuring your Trident controller.

⚠ WARNING

During installation of a Trident controller, take special care with all power sources to minimize the hazard of electrical shock.

When unpacking the Trident controller, check the items 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 Triconex.

Configuring Controller Modules

A controller with a Model 3101 MP can include the following components:

- 1 Main Processor (MP) Baseplate assembly with 3 MP Modules
- 1 Communication Baseplate with up to 2 Communication Modules
- Up to 14 baseplates with up to 2 I/O modules per baseplate or up to 10 baseplates if using AO or PI Modules.
- Up to 15 Interconnect Assemblies
- I/O bus extender kits for each I/O column
- End Caps (top and bottom) for each column

System Configuration

When planning your system, the maximum number of I/O modules allowed depends on whether the system includes AO or PI Modules. If the system does not include AO or PI Modules, the maximum allowed I/O modules is 14.

If the system includes AO or PI Modules, the following applies:

- Up to 1 PI Module per system
- Up to 2 AO Modules per system
- Up to 10 total I/O modules per system

Hot-spare modules are not counted as part of the total.

The following table represents possible configurations.

AO Modules	PI Modules	All Other I/O Modules
0	0	14
1	0	9
0	1	9
2	0	8
2	1	7

Maximum Points

The following table lists the maximum number of points you can use for each type of I/O module. You can install any combination of module types within the limit of each point type.

Module Type	Maximum Points
Analog Input Module	448
Analog Output Module	8
Digital Input Module	448
Digital Output Module	224
Pulse Input Module	6
Solid-State Relay Output Module	448

Mechanical Installation

This section provides general guidelines for mounting a panel for controller components.

⚠ **WARNING**

In hazardous locations, a Trident controller must be mounted in a cabinet or rack with a sealed bottom.

Mounting a Panel

The Trident system is mechanically packaged into functional units that are DIN-rail-aligned on a panel mount. Each unit comprises one or more modules connected to a baseplate. Baseplates are concatenated along a DIN rail to form vertical columns. Each rail can support up to eight units, and several rails can be connected with I/O Extender modules. A daisy-chained bus links signals between units mounted in a column. An extension bus links signals between columns. A typical small system may have an MP and several I/O modules.

The vertically rail-aligned MP Baseplate measures approximately 9 inches wide by 9.79 inches long per logical slot. Vertically mounted I/O baseplates measure approximately 7.0 inches wide by 9.79 inches long.

The baseplates support hot-insertion of the I/O modules and provide primary and spare slots. Each baseplate (a logical slot) provides field termination connections for up to 32 points.

All assemblies should be mounted on a 12-gauge (or heavier) steel panel aligned vertically using DIN 50 022-compatible rails. All DIN system and field power supplies should be mounted on horizontal DIN 50 022-compatible rails. DIN rails should be mounted on a 12-gauge (or heavier) steel panel. Clearance should be provided for adequate air flow around system modules. For typical environments, provide at least 5 inches (15 cm) of clearance between active modules and the walls of the enclosure.

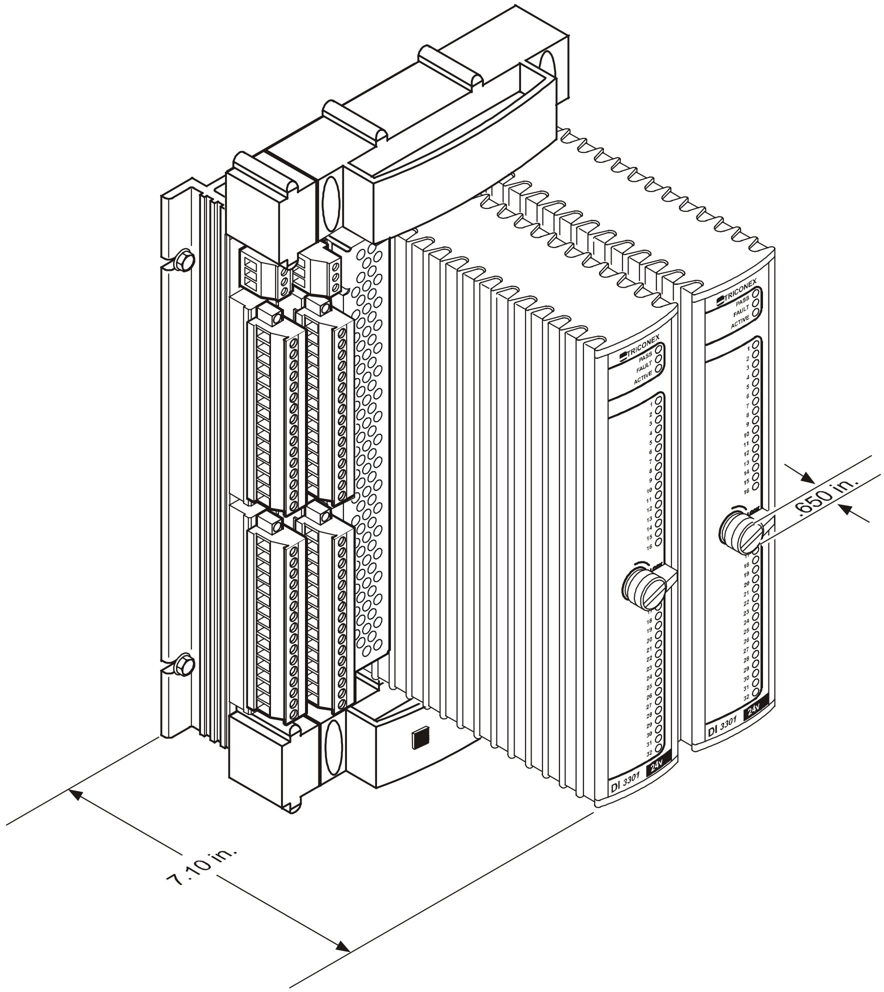
Typically, a panel is mounted in a wall-mounted enclosure (for example, a Hoffman box) or in a floor-mounted enclosure (for example, a Rittal cabinet). The DIN rails and baseplate assemblies should be located on the panel to allow for the installation of wiring channels (for example, Panduit) along the left side of vertical columns and along the bottom of horizontal rails.

For information on dimensions and clearances of baseplates, see:

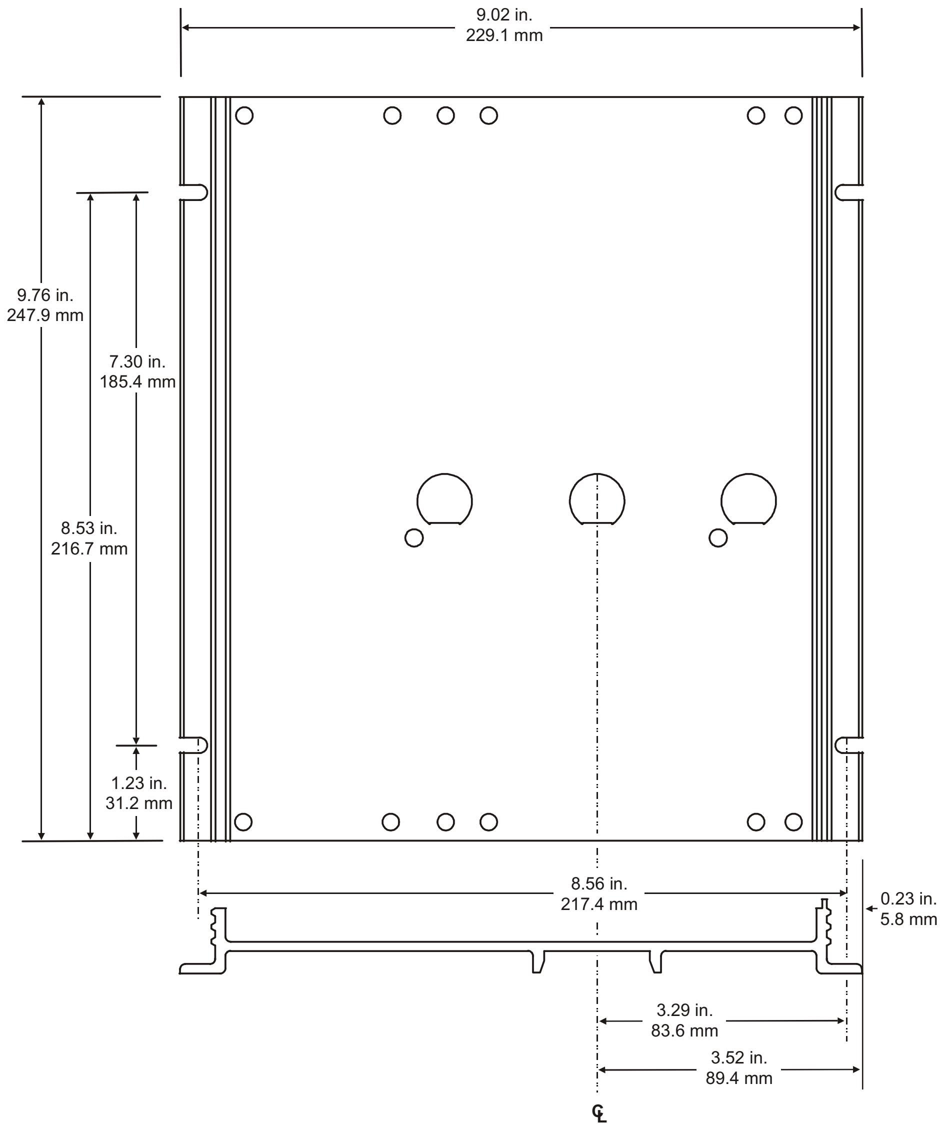
- "Depth Dimensions for Baseplate and Module" on page 129
- "Dimensions and Clearances for Installing MP Baseplates" on page 130
- "Dimensions and Clearances for Installing I/O Baseplates" on page 131
- "Dimension and Clearances for Installation I/O Extender Modules" on page 132

For a separate view of drill holes, see Appendix F, "Mounting Panel Drill Template."

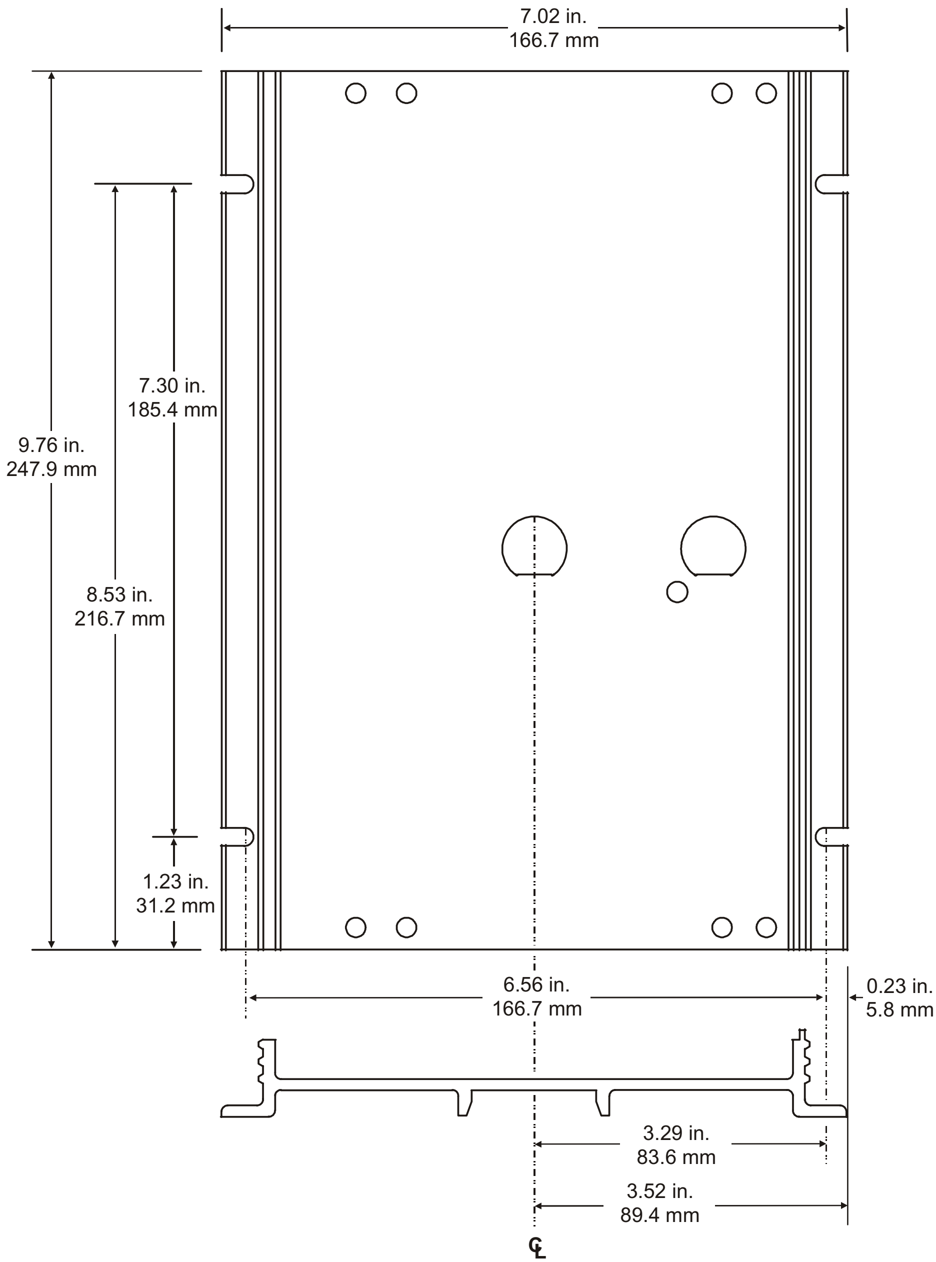
Depth Dimensions for Baseplate and Module



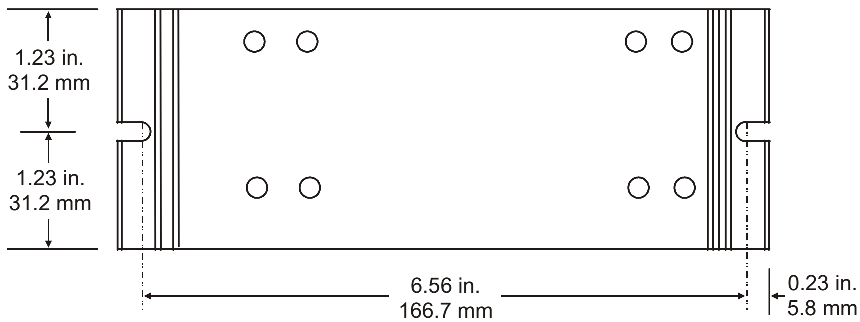
Dimensions and Clearances for Installing MP Baseplates



Dimensions and Clearances for Installing I/O Baseplates



Dimension and Clearances for Installation I/O Extender Modules



Using End Caps

Install End Caps to:

- Protect the top and bottom of each end-of-column baseplate
- Cover the interconnect connector
- Serve as a card guide

Using Slot Covers

Cover unused baseplate slots with a Slot Cover (Model 2900) to minimize exposure to:

- Dust
- Dripping/splashing liquids
- Corrosive atmospheres

Using Terminal Covers

Cover field terminals with a Terminal Cover (Model 2901) to minimize exposure to:

- Dust
- Dripping/splashing liquids
- Corrosive atmospheres

Typical Weights

Component	Weight in Pounds	Weight in Kilograms
Analog Input Module	3.0	1.4
Analog Input Baseplate	2.4	1.1
Analog Output Module	3.1	1.4
Analog Output Baseplate	2.1	1.0
Communication Module	3.3	1.5
Communication Baseplate	2.8	1.3
Digital Input Baseplate	2.4	1.1
Digital Input Module	3.0	1.3
Digital Output Baseplate	2.1	1.0
Digital Output Module	3.2	1.4
Main Processor Baseplate	2.7	1.2
Main Processor Module	3.4	1.5
Pulse Input Module	3.0	1.4
Pulse Input Baseplate	2.8	1.3
Relay Output Baseplate	2.3	1.0
Solid-State Relay Output Module	2.9	1.3
I/O Extender Module	0.4	0.2

Environment

This section provides general guidelines for controlling the controller's environment.

Controlling the Environmental

To minimize the expense and labor associated with system maintenance, observe the following guidelines:

- Do not expose the system to metal chips, conductive particles, or dust (such as that produced by drilling or filing metal-mounting panels). Modules are enclosed for limited protection against these contaminants; nevertheless, short circuits can be caused by particles. Similarly, heat-trapping layers of dust can accumulate on a module and adversely affect its performance.
- Because the temperature in industrial environments is generally not uniform, do not locate the controller's enclosure near units that generate large amounts of heat or operate at high temperatures; for example, large motors.
- For extended operation, the system is designed for a maximum ambient temperature of 70°C (160°F). Lower ambient temperatures increase the life of the individual controller components and decrease the likelihood of module failure, thereby lowering your maintenance costs.

For guidelines on wiring, see Appendix C, "Recommended Wiring Methods."

Allowing for Adequate Cooling

Adequate convection or forced-air cooling should be provided. The following general guidelines can be used for typical environments (50°C maximum ambient temperature with 20°C internal temperature rise):

- In sealed environments, the external surface area of the enclosure should be at least 0.009 m^2/watt.
- In vented environments, the internal air flow should be at least 7 m^3/watt. Air flow should be directed to flow into vents at the bottom of the enclosure (for example, a vent at the bottom of the door) and to exit at the top of the enclosure (for example, a pagoda top).
- For maximum reliability of the system, the average ambient temperature should be below 50°C (120°F). Heat load dissipation should be calculated to include both logic power and field power. Using the following table, sum

the maximum logic and field power for all modules installed on a baseplate. (Field power is the percentage of field circuit power that is dissipated within the controller.) If spares are present, add the same amount of logic power as the primary modules.

Module	Model Number	Maximum Logic Power (Watts)[1]	Maximum Field Power (Watts)	
			Primary	Spare
Analog Input	3351	3	4	Negligible
Analog Output	3481	3	3	Negligible
Analog Output	3482	3	7	Negligible
Communication	3201	8	Not applicable	Not applicable
Digital Input	3301	3	7	Negligible
Digital Output	3401	3	4	Negligible
Main Processor	3101	8[2]	Not applicable	Not applicable
Pulse Input	3381	3	Negligible	Negligible
Solid-State Relay Output	3451	3	4	Negligible

1. To convert watts to British thermal units: BTU = watts x 3.414
2. Without MAUs

For more information about cooling, contact the Triconex Customer Response Center.

Calculating Logic Power

Note Information in this section is based on a fault condition in which only one of the redundant power sources is operational. Under normal operating conditions, both power sources share the load.

To determine the maximum logic power supply needed, use the following table to sum the maximum logic power for all modules, including hot spares, to be installed on a baseplate.

Module	Model Number	Maximum Logic Power (Watts)[1]
Analog Input	3351	3
Analog Output	3481	3
Analog Output	3482	3
Communication	3201	8
Digital Input	3301	3
Digital Output	3401	3
Main Processor	3101	8[2]
Pulse Input	3381	3
Solid-State Relay Output	3451	3

1. To convert watts to British thermal units: BTU = watts x 3.414.
2. Without MAUs

Power Connections

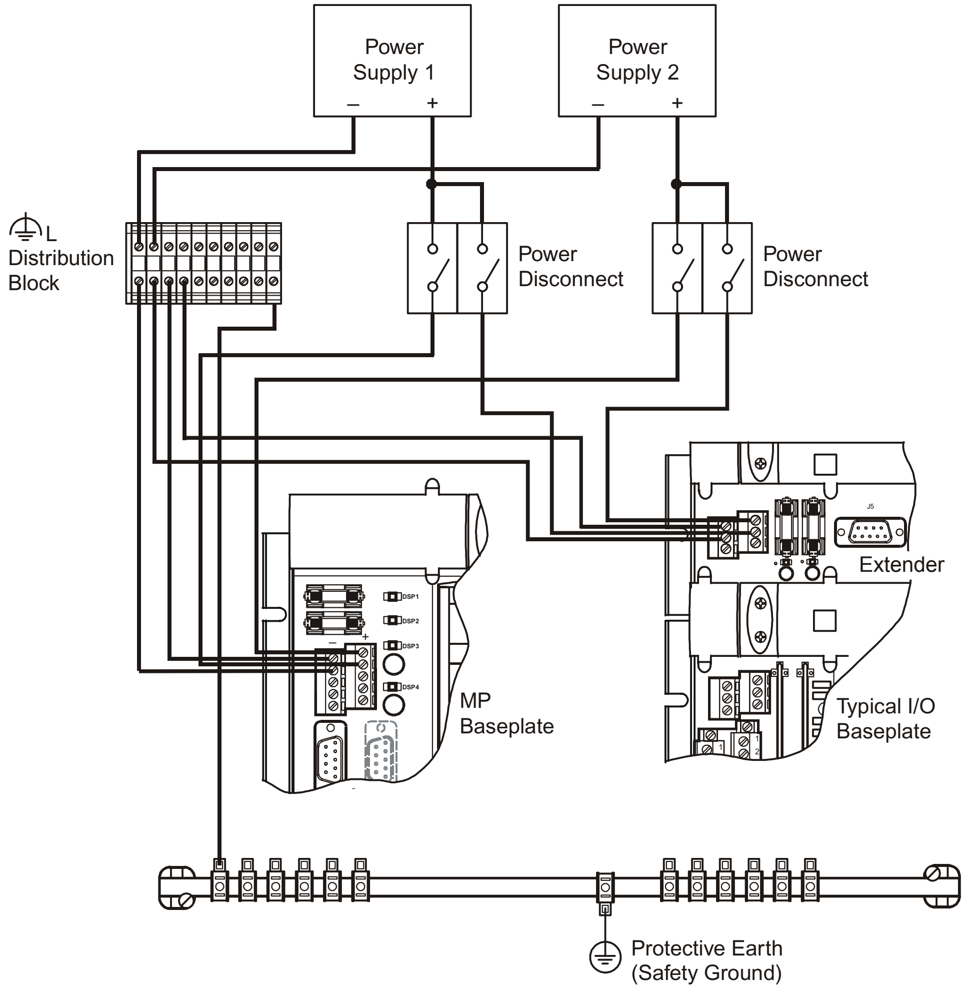
An independent power source, equipped with its own fuse and switch, can be shared by multiple baseplates. You should connect each baseplate to two, independent power sources.

The selection of supply wiring depends on:

- Current ratings
- Temperatures
- Wiring lengths

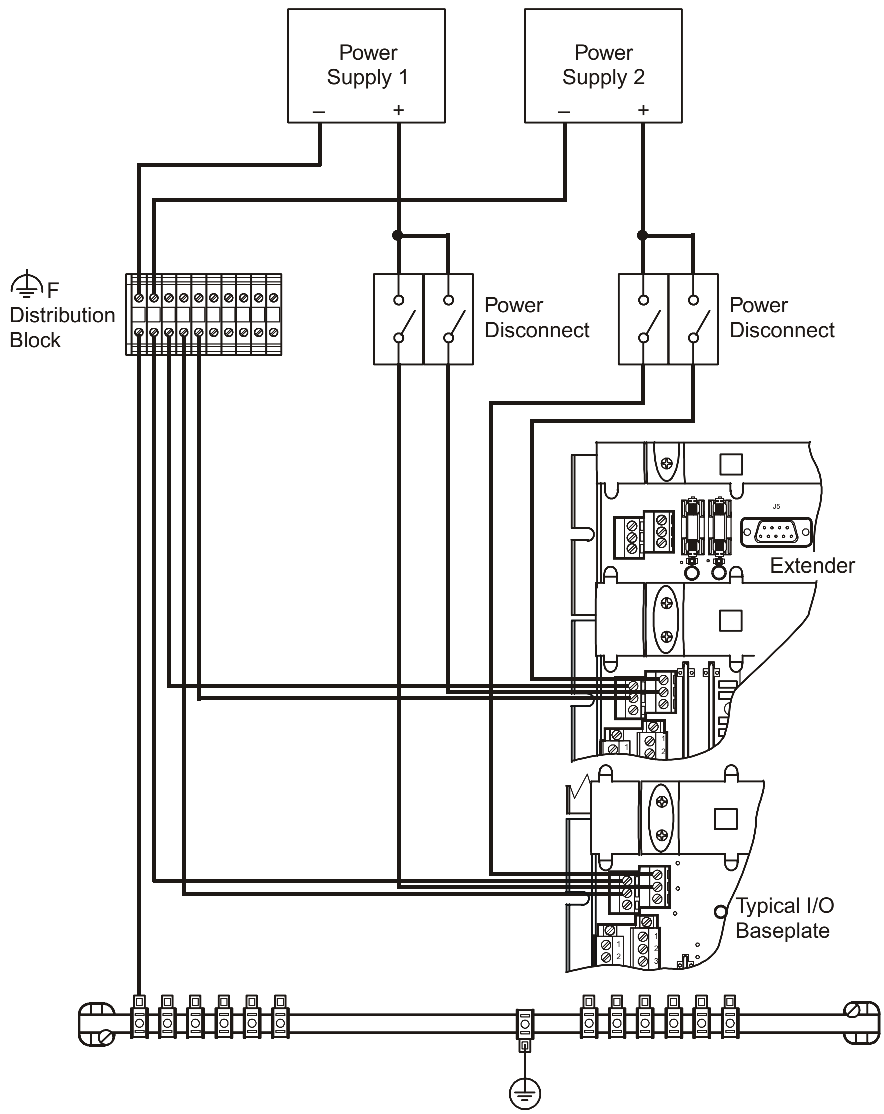
In critical environments, at least one power source should be an uninterruptible power supply (UPS), which can be shared by multiple Trident baseplates. The UPS should be rated for the total number of baseplates to be powered and for the duration of the maximum expected down time.

Typical Connections for Logic Power



Notes L ⏚ should be connected to ⏚ at one and only one place for the entire system, including I/O bus extensions up to 200 meters (650 feet) from the MP. Alternatively,
L ⏚ can be connected to a DCS master reference ground or other quiet earth. In simple environments, logic and field power can be combined and treated as one ground system.

Typical Connections for Field Power



Notes L ⏚ should be connected to ⏚ at one and only one place for the entire system, including I/O bus extensions up to 200 meters (650 feet) from the MP. Alternatively, L ⏚ can be connected to a DCS master reference ground or other quiet earth. In simple environments, logic and field power can be combined and treated as one ground system.

I/O Bus Considerations

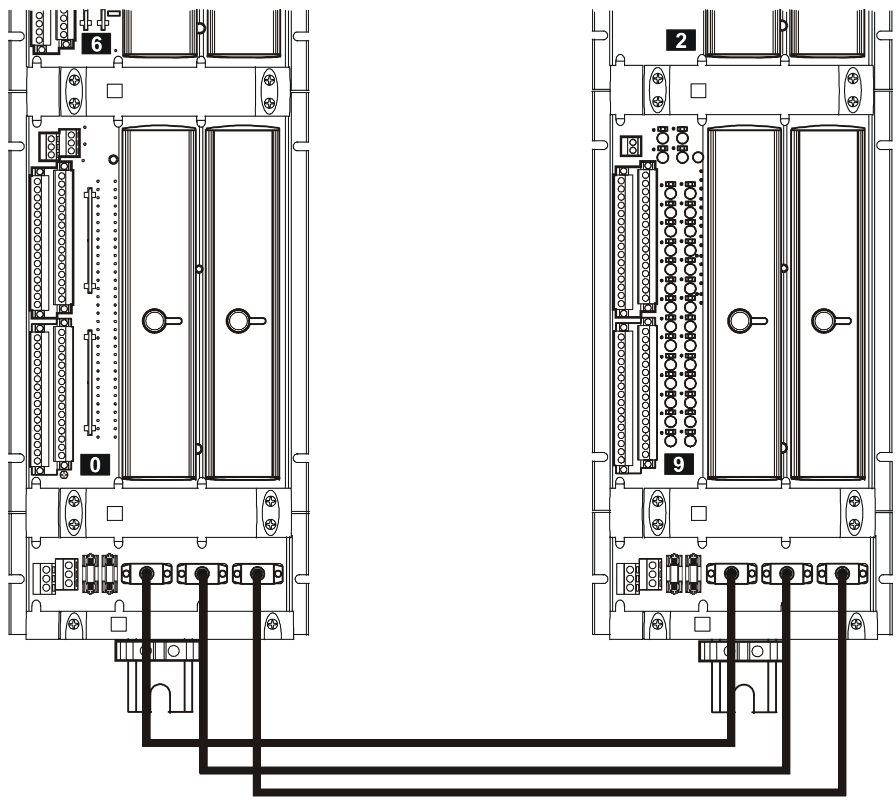
If the total length of the I/O bus is less than 6 meters (20 feet), the I/O bus can be operated without termination.

If the I/O bus length is greater than 6 meters (20 feet), the bus should be terminated. The maximum I/O bus length is 200 meters (650 feet) and includes:

- Length of all baseplates
- I/O Extender modules
- I/O bus extension cables

An I/O bus termination set comprises six terminators. An I/O bus cable set comprises three I/O bus extension cables. The terminators should be installed on the open I/O bus connectors on the I/O Extender Modules at each end of the I/O bus.

I/O Bus Extension Cables

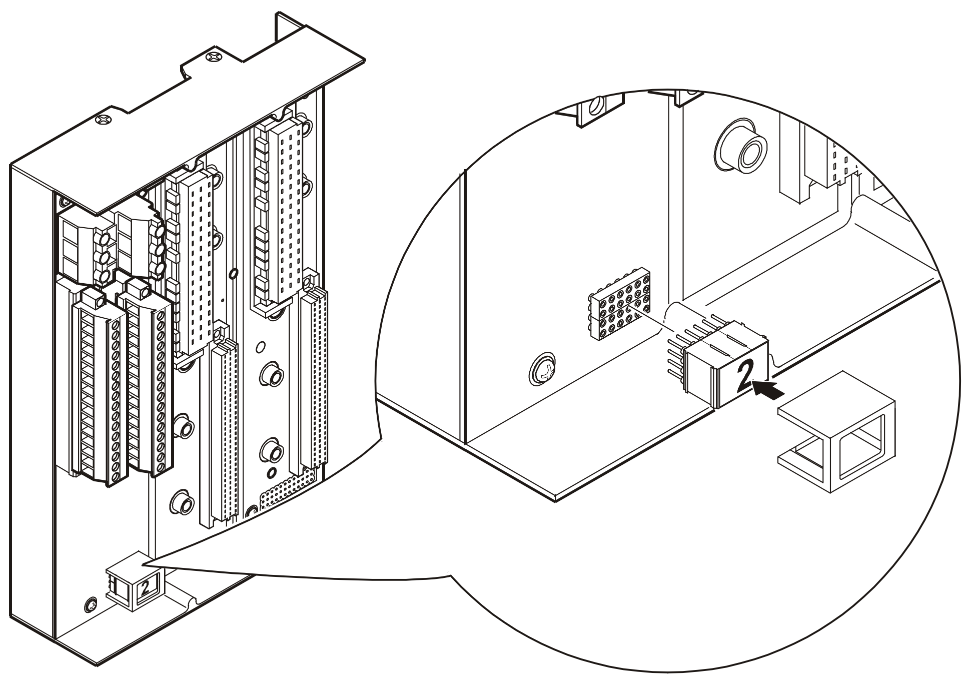


Note For distances greater than 200 meters (650 feet) or for applications requiring isolation, fiber-optic transceivers are commercially available. For compatible units and supported distances, contact your regional customer center.

I/O Bus Addressing

System components are uniquely identified to guarantee operational integrity during installation and routine maintenance. Each I/O baseplate should have a unique I/O bus address. Controllers shipped from the factory have a different address for each baseplate (see figure below). If you add a baseplate to an existing system, verify that the new baseplate has a unique address.

Changing an I/O Bus Address



When configuring a module in a TriStation project, you should identify it according to its baseplate address. Modules are logically added to match the physical DIN rail and baseplate configuration using the Insert Module dialog box in the TriStation Configuration Editor.

If you physically change an I/O bus address, you should:

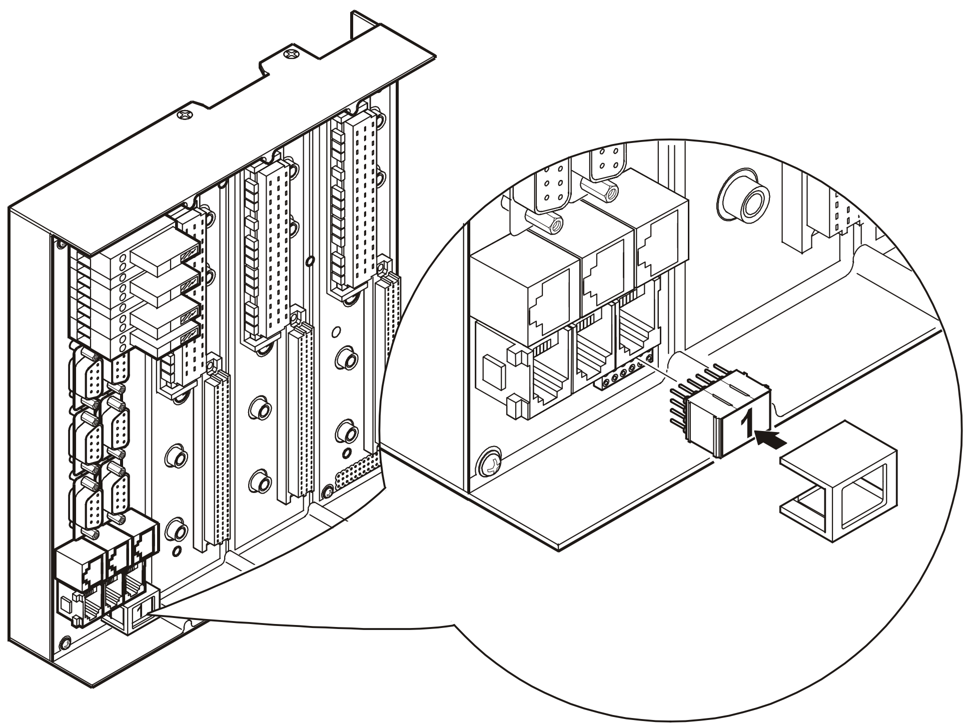
- Cycle power or re-install the module
- Change the TriNode address in the TriStation project

MP Baseplate Addressing

The address plug on the MP Baseplate identifies the TriNode address used by TriStation. The TriNode address specified in TriStation must match the address on the MP Baseplate. Each controller on a network should have a unique address on its MP Baseplate.

If you physically change an MP Baseplate address, you should:

- Cycle power or re-install the module
- Change the TriNode address in the TriStation project



Alarm Wiring

Alarms are asserted when the controller detects a system alarm or a program alarm. Each MP Module supports the following redundant alarm contacts:

Set 1

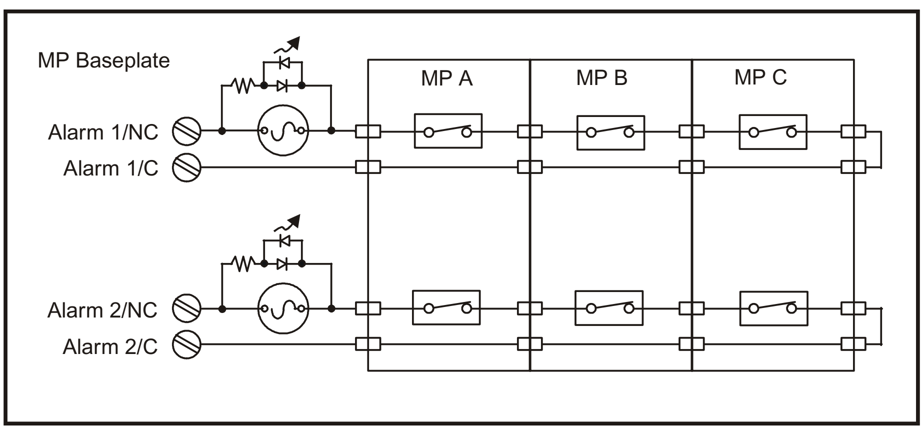
- Normally closed (NC) contact
- Common (C)

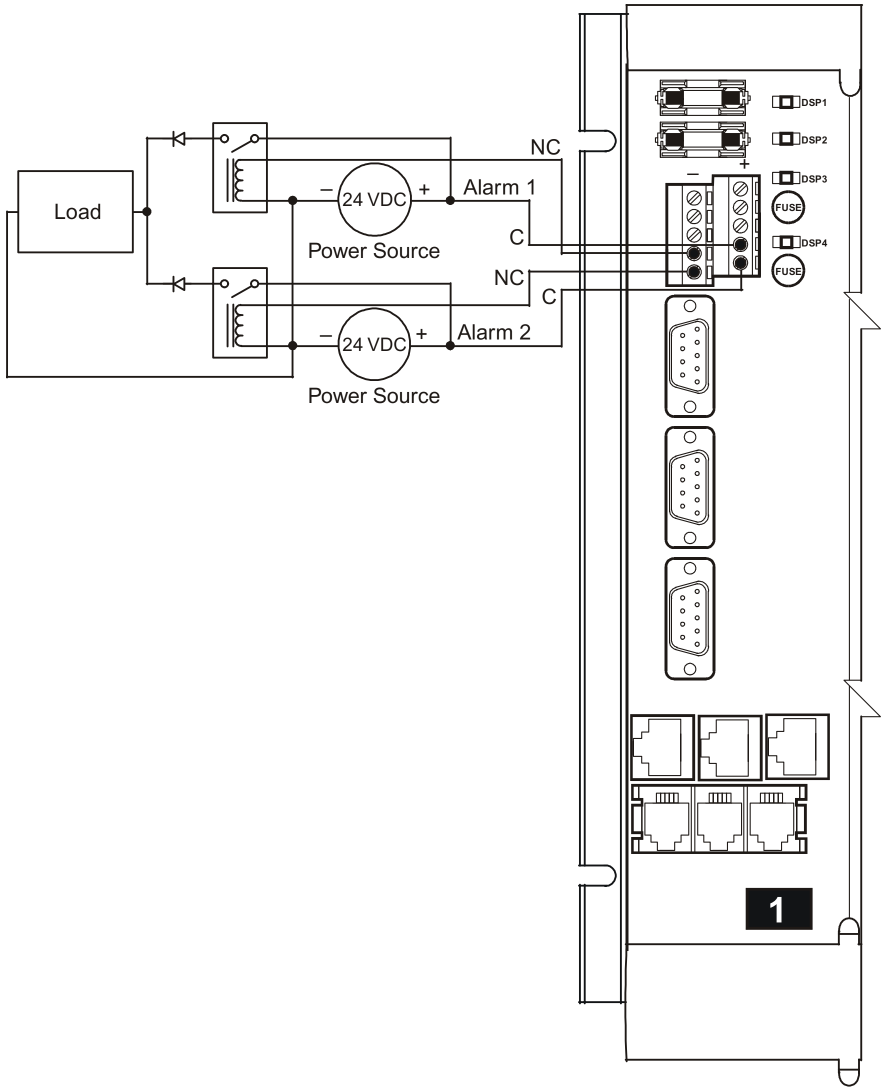
Set 2

- Normally closed (NC) contact
- Common (C)

A control engineer should specify the actual use of these contacts. 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 when either contact signals an alarm condition. For more information on program alarms, see the *TriStation 1131 Developer's Guide.*

Alarm Connections





Typical Alarm Connections

Installation Procedures

Installing the First Baseplate

This section explains how to install the first baseplate on a panel.

▼ **To install a baseplate:**

1. On a mounting panel, locate, drill, and tap mounting holes. For details, see "Mounting Panel Drill Template" on page 233.
2. Install the DIN rail according to the manufacturer's instructions.
3. Install the baseplate using four #10 mounting screws with flat and lock washers and positioning the baseplate along the DIN rail so that the mounting screws are centered in the oblong mounting holes.
4. Tighten the screws to 16 inch-pounds of torque.

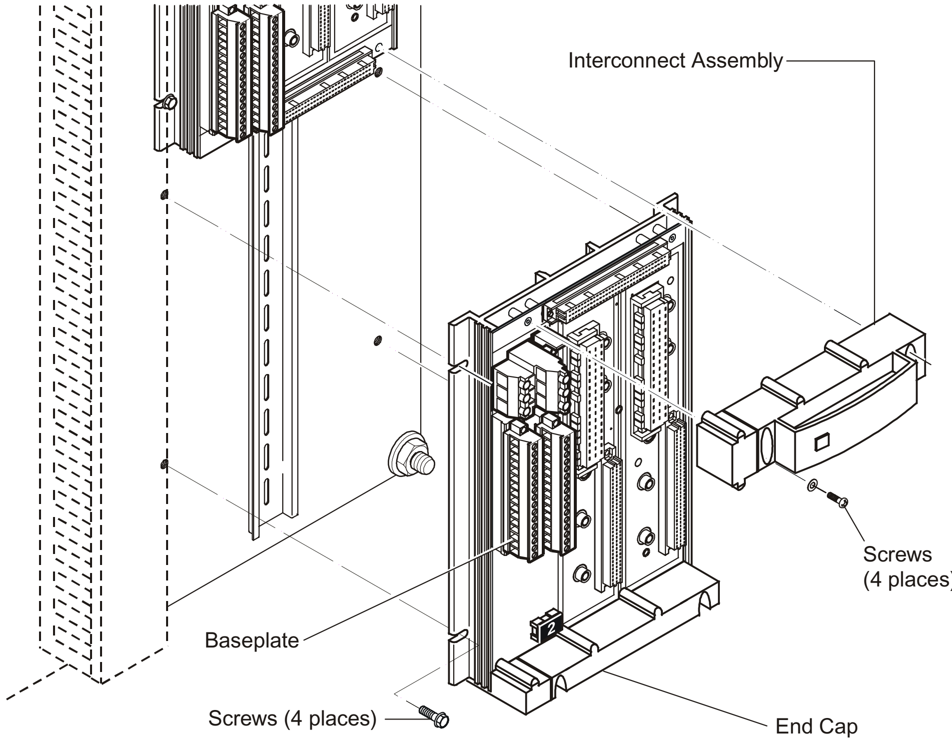
Installing Additional Baseplates on a Column

This section explains how to install additional baseplates on a column.

▼ **To install additional baseplates:**

1. Install additional baseplates as in step 3 above, but *do not* tighten the screws.
2. If installing a baseplate adjacent to an MP Baseplate, attach an MP Interconnect Assembly between the two baseplates, allowing the second baseplate to move until the Interconnect Assembly snaps into place.
3. If installing an I/O baseplate adjacent to another I/O baseplate, install an I/O Interconnect Assembly between the two baseplates, allowing the second baseplate to move until the interconnect assembly snaps into place.
4. Tighten the mounting screws on the second baseplate to 16 inch-pounds of torque.
5. Install additional baseplates, interconnect assemblies, and extenders as needed.

Mounting Components



Installing Additional I/O Columns

This section explains how to install additional I/O columns on a panel.

▼ **To install an I/O baseplate and an I/O Interconnect Assembly:**

1. On a mounting panel, locate, drill, and tap mounting holes. For details, see "Mounting Panel Drill Template" on page 233.
2. Install the DIN rail according to the manufacturer's instructions.
3. Install the first I/O baseplate using four #10 mounting screws with flat and lock washers and positioning the baseplate along the DIN rail so that the mounting screws are centered in the oblong mounting holes.
4. Tighten the screws to 16 inch-pounds of torque.
5. Install the adjacent I/O baseplate as in step 3 above, but *do not* tighten the screws.
6. If installing an I/O baseplate adjacent to an MP Baseplate, attach an MP Interconnect Assembly between the two baseplates, allowing the second baseplate to move until the Interconnect Assembly snaps into place.
7. If installing an I/O baseplate adjacent to another I/O baseplate, install an I/O Interconnect Assembly between the two baseplates, allowing the second baseplate to move until the Interconnect Assembly snaps into place.
8. Tighten the mounting screws on the second baseplate to 16 inch-pounds of torque.
9. Install additional baseplates and extenders as needed.

Installing an I/O Extender Module

This section explains how to install an I/O Extender Module on a panel.

▼ **To install an I/O Extender Module:**

1. Install the I/O Extender Module as in step 3 on page 146, but *do not* tighten the screws.
2. If installing an I/O Extender Module adjacent to an MP Baseplate, attach an MP Interconnect Assembly between the two baseplates, allowing the I/O Extender Module to move until the Interconnect Assembly snaps into place.
3. If installing an I/O Extender Module adjacent to another I/O baseplate, install an I/O Interconnect Assembly between the two baseplates, allowing the I/O Extender Module to move until the Interconnect Assembly snaps into place.
4. Tighten the mounting screws on the I/O Extender Module to 16 inch-pounds of torque.

Installing I/O Bus Extension Cables

This section explains how to install I/O bus extension cables between columns.

▼ **To connect columns of baseplates:**

1. Attach one end of an I/O bus extension cable to the J5 connector on one I/O Extender Module and attach the other end of the cable to the J5 connector on the second I/O Extender Module.
2. Repeat step 1 for the J6 and J7 connectors.

Installing I/O Bus Terminations

Maximum cable length is up to 6 meters (20 feet) without termination or up to 200 meters (650 feet) with termination.

If required, attach terminators to the open I/O bus connectors on the I/O Extender modules at each end of the I/O bus.

Installing Other Components

Interconnect Assemblies

Attach the appropriate interconnect assembly between baseplates.

End Caps

Attach the appropriate end cap to each end-of-column baseplate.

Slot Covers

Attach a Slot Cover in each unused baseplate slot.

Terminal Covers

Attach a Terminal Cover over field terminals.

Installing Modules

This section explains how to install a module on a baseplate.

▼ **To install a module:**

1. Seat a module on its corresponding baseplate.
2. Turn the lock lever manually 90° to 180°.
3. Insert a #2 flat-blade screwdriver into the lock and turn clock-wise to the locked position (360°).

   Typically, 25 in./lbs. of torque are required to rotate the lock lever.

   When the module is installed, the Fault indicator goes on while the diagnostics are running. At the same time, the Point indicators go on briefly, go off, then resume the normal state of blinking. The Pass Indicator should go on within about one minute. If it does not, and the Fault light persists longer than five minutes, check the diagnostic log to determine if there is a problem.

Effective Grounding Methods

You should permanently connect the Trident system to a protective earth in order to:

- Protect operations and maintenance personnel from electrical shock
- Protect the system from damage or malfunction caused by lightning or other electrical noise transients

Ground Systems

The Trident has the following four, separate ground systems:

- Protective earth ⏚—an AC safety ground
- Field ground ⏚ F—a functional earth
- Logic ground ⏚ L—a functional earth
- Shield ground ⏚ S—a functional earth

The logic and field portions of each module use separate, isolated signal return paths. Each is connected to its own functional earth. The metallic portions of the safety ground act as an electrostatic shield for the internal circuitry. Communication cable shields are terminated to the safety ground. The metallic portions of the Trident controller are connected to the protective earth.

Connecting Baseplates to Protective Earth

⚠ WARNING

Do not operate a Trident system without connecting each baseplate to a protective earth (AC safety ground) with a low-impedance cable. Improper grounding creates the potential for dangerous electrical shock—the Trident controller can produce significant leakage currents which must be shunted to earth.

To ensure that your Trident controller and the equipment connected to it operate safely, you should 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 to comply with them. If necessary, contact your local Fire Marshall and Electrical Inspector for assistance.

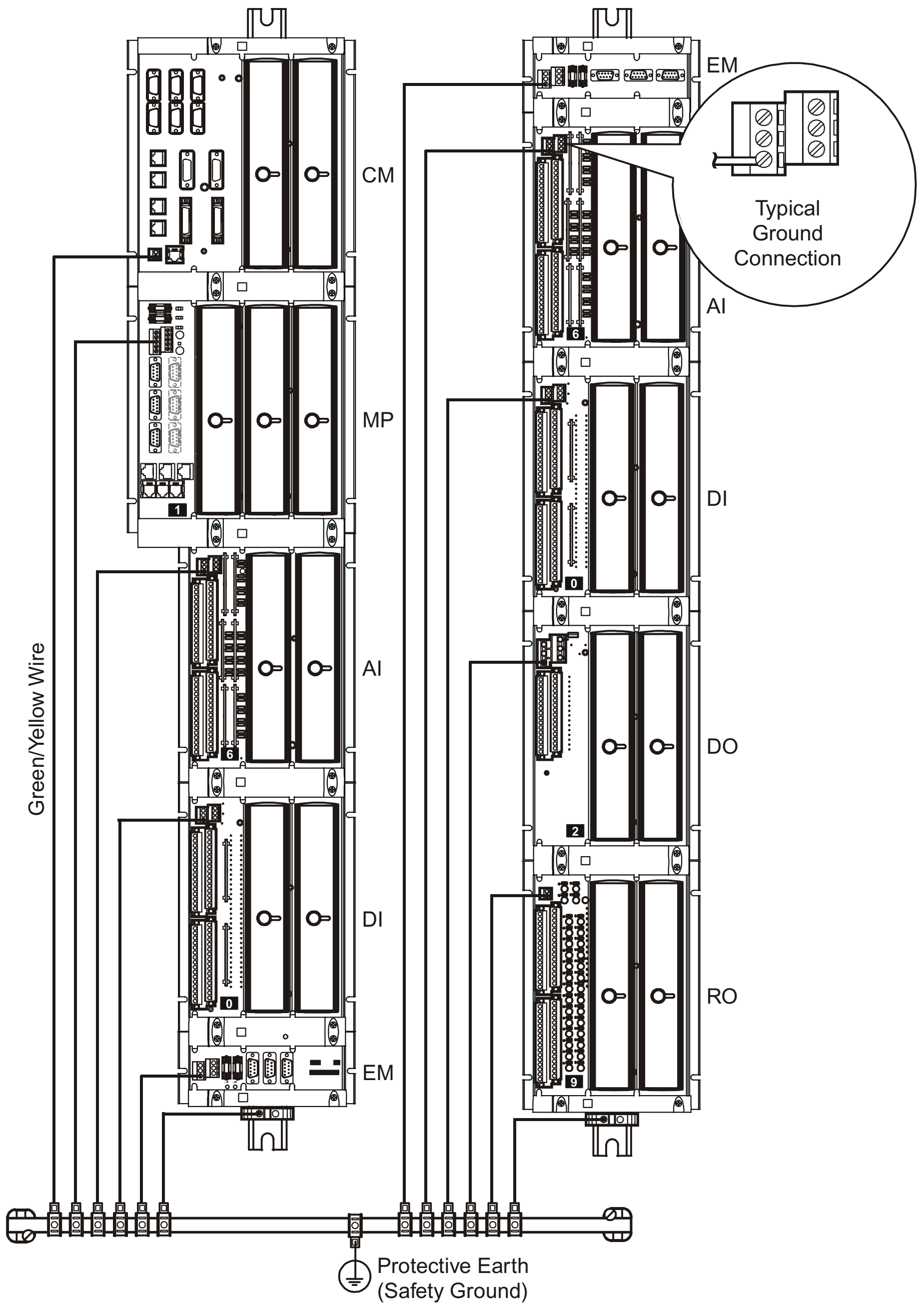
Connect each baseplate in your system to a common tie point, such as a copper bar, according to the applicable electrical codes. You may use the same copper bar to provide a protective earth connection for the Trident controller's field devices and wiring.

The wire should be:

- Heavy
- Solid or stranded
- Bare or insulated

A 12 AWG (3.3 mm^2) wire should be adequate in most environments.

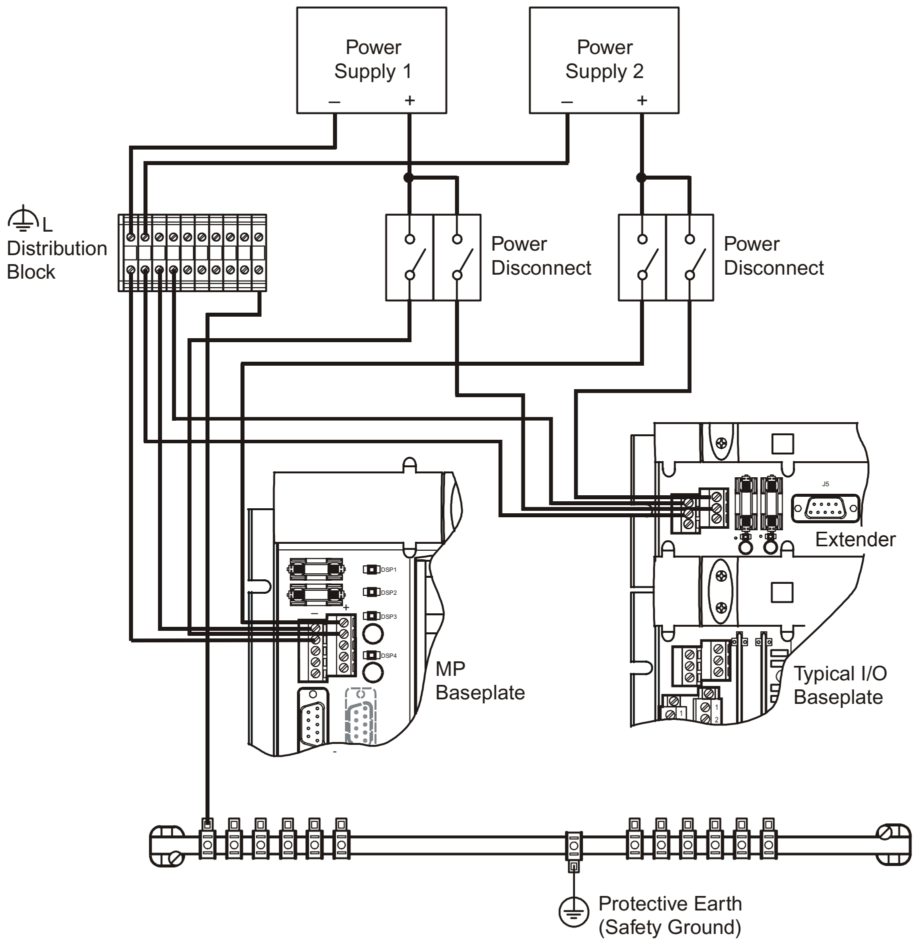
Connecting Baseplates to Protective Earth



Connecting to Signal Ground

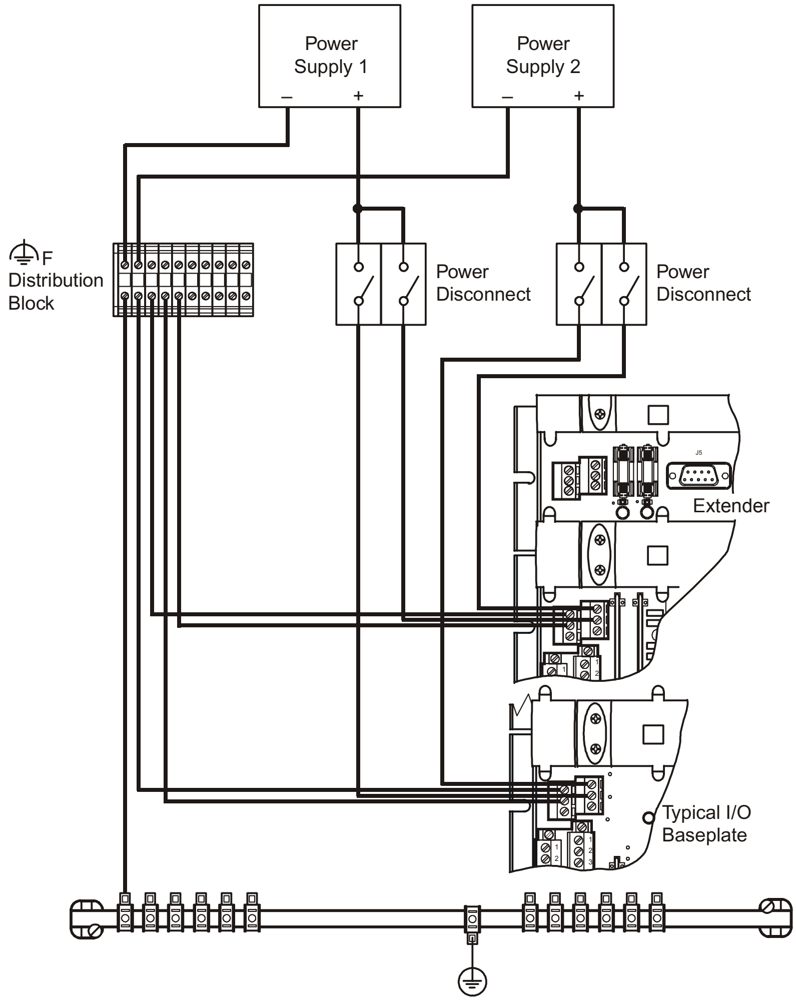
The internal signal grounds (logic and field) are allowed to float with respect to the safety ground. In most installations, it is best to tie the signal ground and safety ground together *at one and only one point.*

Grounding Logic Power



Notes L (logic ground symbol) should be connected to (protective earth symbol) at one and only one place for the entire system, including I/O bus extensions up to 200 meters (650 feet) from the MP. Alternatively, L (logic ground symbol) can be connected to a DCS master reference ground or other quiet earth. In simple environments, logic and field power can be combined and treated as one ground system.

Grounding Field Power

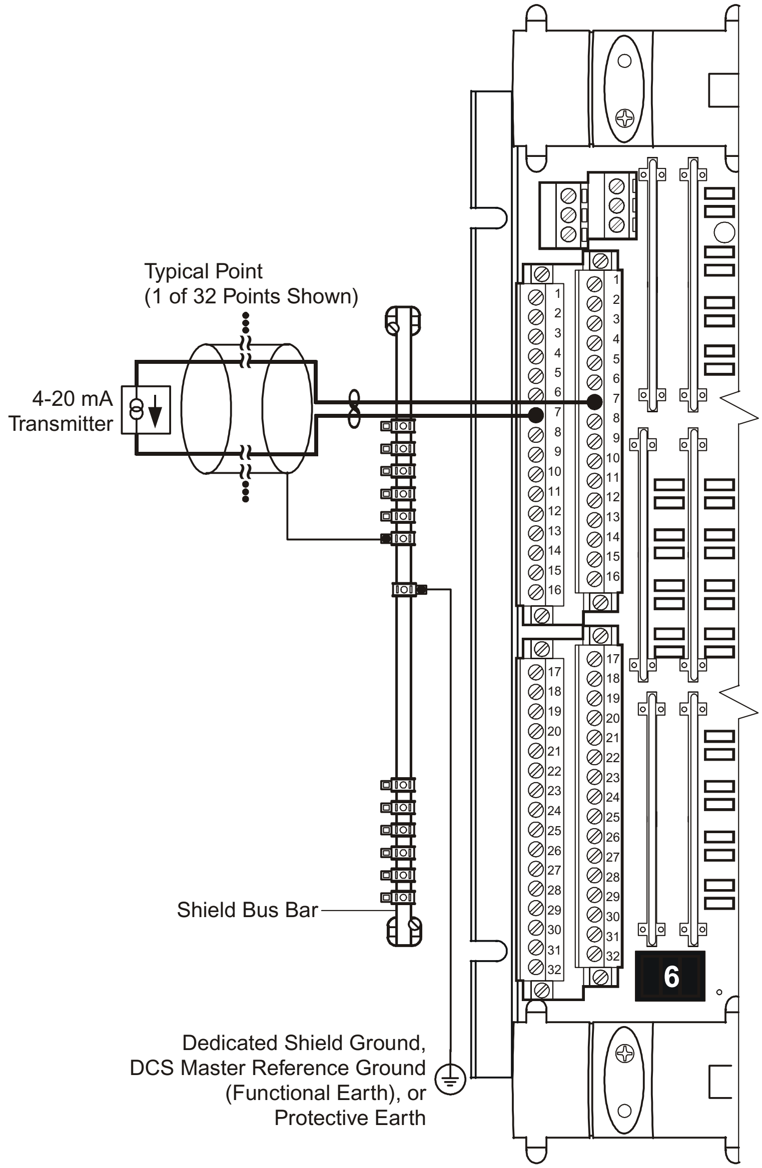


Notes L ⏚ should be connected to ⏚ at one and only one place for each set of redundant field power supplies. Multiple I/O modules can share a single set of power supplies. Or, each I/O module or group of modules can use separate power supplies referenced to alternate grounds. Alternatively, L ⏚ can be connected to a DCS master reference ground or other quiet earth. In simple environments, logic and field power can be combined and treated as one ground system.

Connecting Shields to Earth

Connect a cable shield at one end of the cable, typically at the controller. Also, a connection should be provided near the termination panel using an external shield bus bar. Such bus bars are available from Phoenix Contact or other terminal block suppliers. You should individually connect each shield bus bar to a suitable, quiet ground point, such as a dedicated protective earth or a DCS master reference ground, as shown on page 155.

Connecting a Shield Ground to Earth



Connecting to a TriStation PC

You can connect a Trident controller to a TriStation PC using a 10BaseT cross-over cable or an Ethernet network hub. This section provides instructions for both methods.

An MP uses Ethernet protocol to communicate with a TriStation PC and requires the installation of an Ethernet card, a 10BaseT cross-over cable, and the Data Link Control (DLC) protocol in the PC.

Connecting TriStation to an MP Port

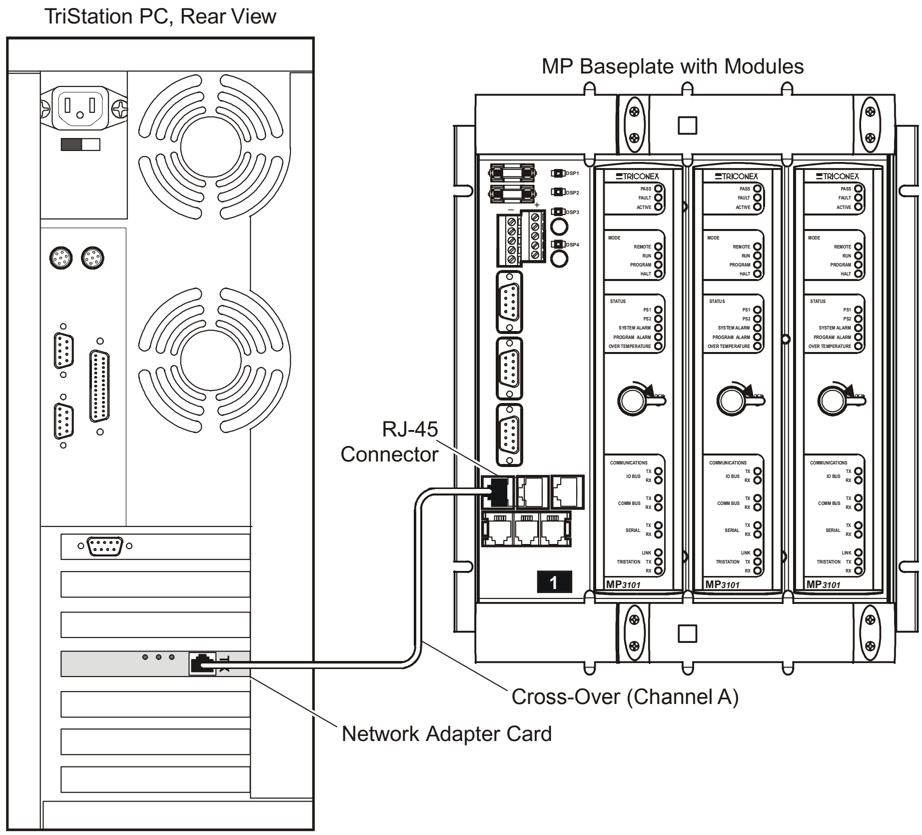
If your controller does not include a Communication Module, you must connect the TriStation PC to one of three TriStation ports on the MP Baseplate. You can make a direct connection using a 10BaseT cross-over cable, or you can connect using a 10BaseT straight-through cable to an Ethernet network or hub.

▼ **To connect a TriStation PC to an MP port using a cross-over cable:**

1. Attach one end of the cross-over cable to one of the RJ-45 connectors on the MP Baseplate. This is normally MP A, as shown in the following illustration.
2. Attach the other end of the cross-over cable to the network adapter card in the PC.

For instructions on logically connecting a controller to a TriStation PC and downloading an application, see the *TriStation 1131 Developer's Guide.*

Connecting an MP Using a Cross-Over Cable



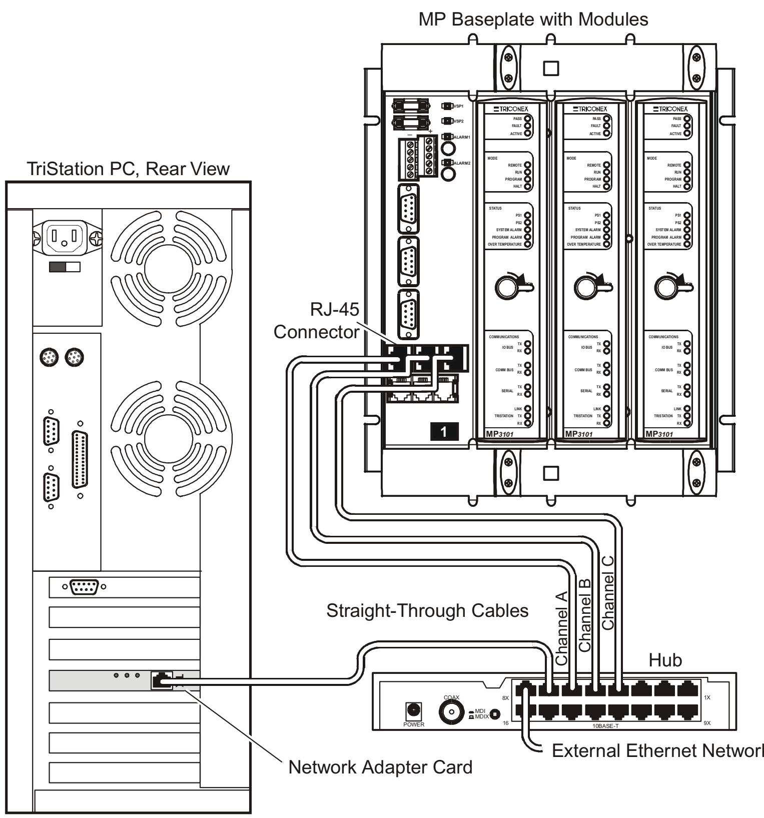
▼ To connect a TriStation PC to an MP port using an Ethernet hub:

1 Attach at least one 10BaseT straight-through cable from an RJ-45 connector on the MP Baseplate to the hub, as shown in the figure below.

Using more than one cable provides redundancy for your TriStation connection. If you use only one cable during live operation, you have to unplug it and move it to another RJ-45 connector if the original connection fails.

2 Attach the network adapter card in the TriStation PC to the hub using another 10BaseT straight-through cable.

Connecting an MP Using a Network Hub



Connecting TriStation to a CM Port

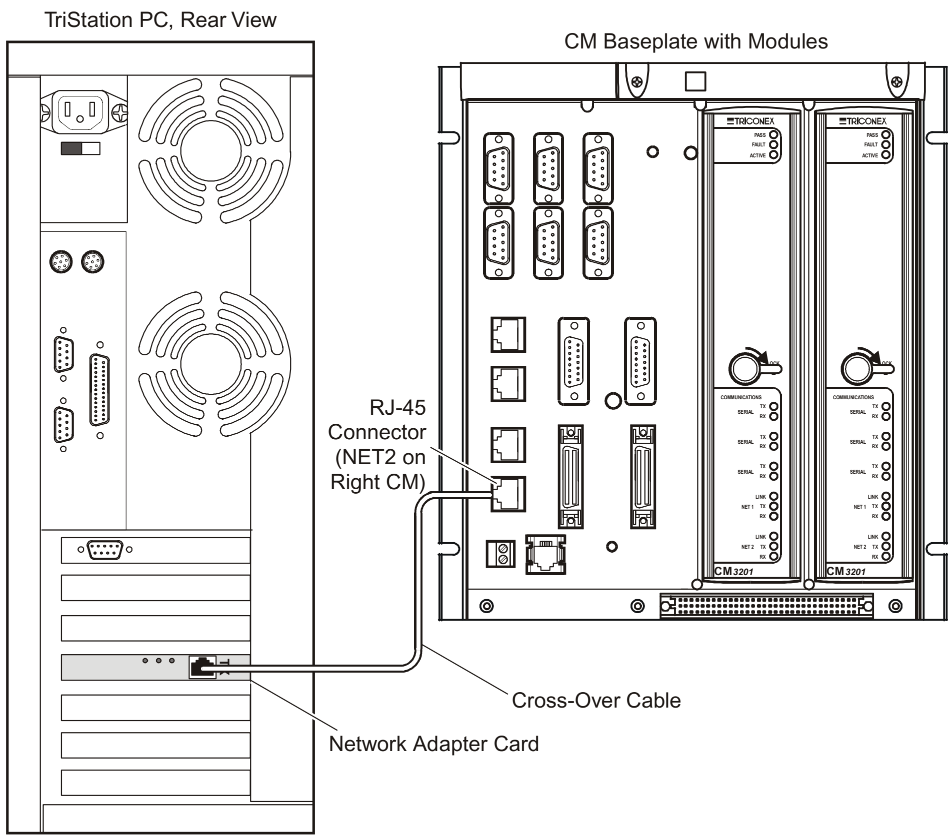
If your Trident system includes a CM and you want to use a TCP/IP connection to the TriStation PC, you can connect the TriStation PC to the NET1 or NET2 port on the CM. A 10BaseT cable must be used for a NET1 connection. A 10BaseT or 100BaseTX cable can be used for a NET2 connection. On the CM Baseplate, you can attach the cable to an RJ-45 connector or to a MAU. For information about the types of MAUs you can use, see the *Trident Communication Guide*.

▼ **To connect a TriStation PC to a CM port using a cross-over cable:**

1 Attach one end of a cross-over cable to a NET1 or NET2 connector on the CM Baseplate, as shown in the example below.

2 Attach the other end of the cross-over cable to the network adapter card in the TriStation PC.

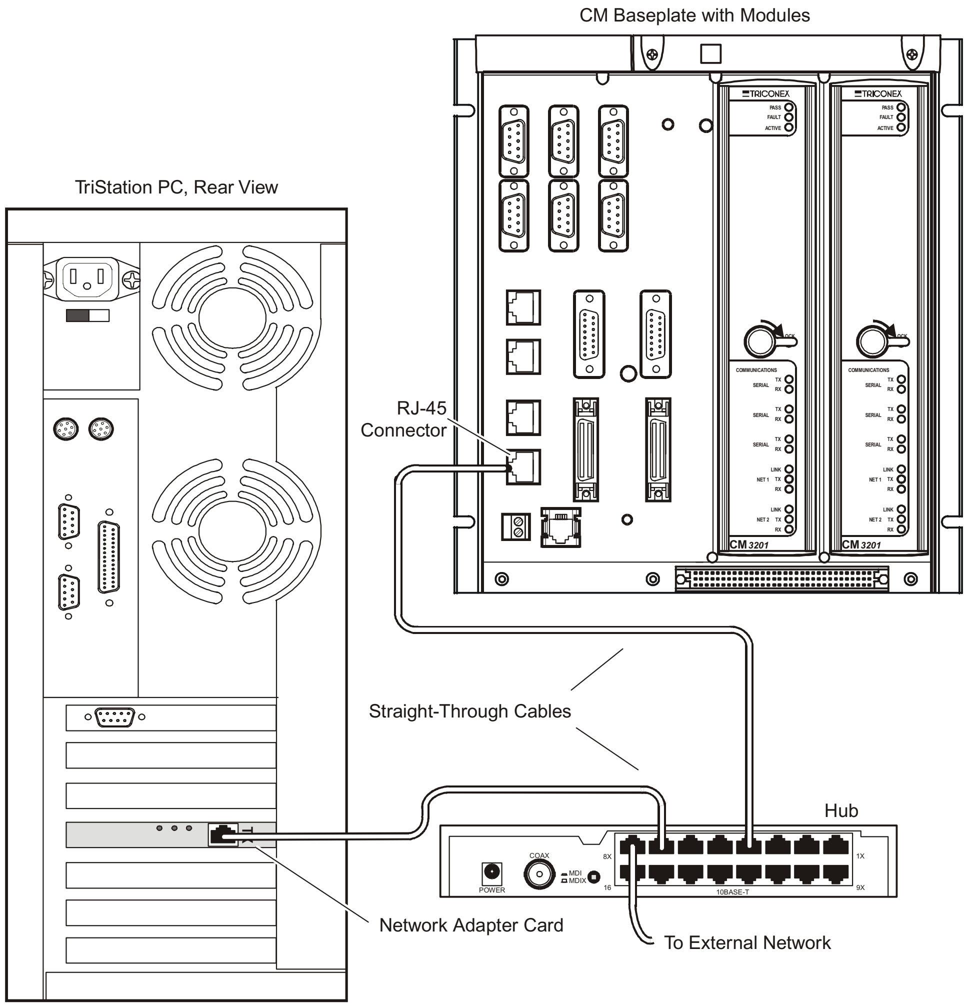
Connecting a CM Using a Cross-Over Cable



▼ To connect a TriStation PC to a CM using an Ethernet hub:

1. Attach one end of a straight-through cable to a NET1 or NET2 connector on the CM base plate.
2. Attach the other end of the straight-through cable to an Ethernet hub, as shown in the example below.
3. Connect the TriStation PC to the hub using another straight-through cable.

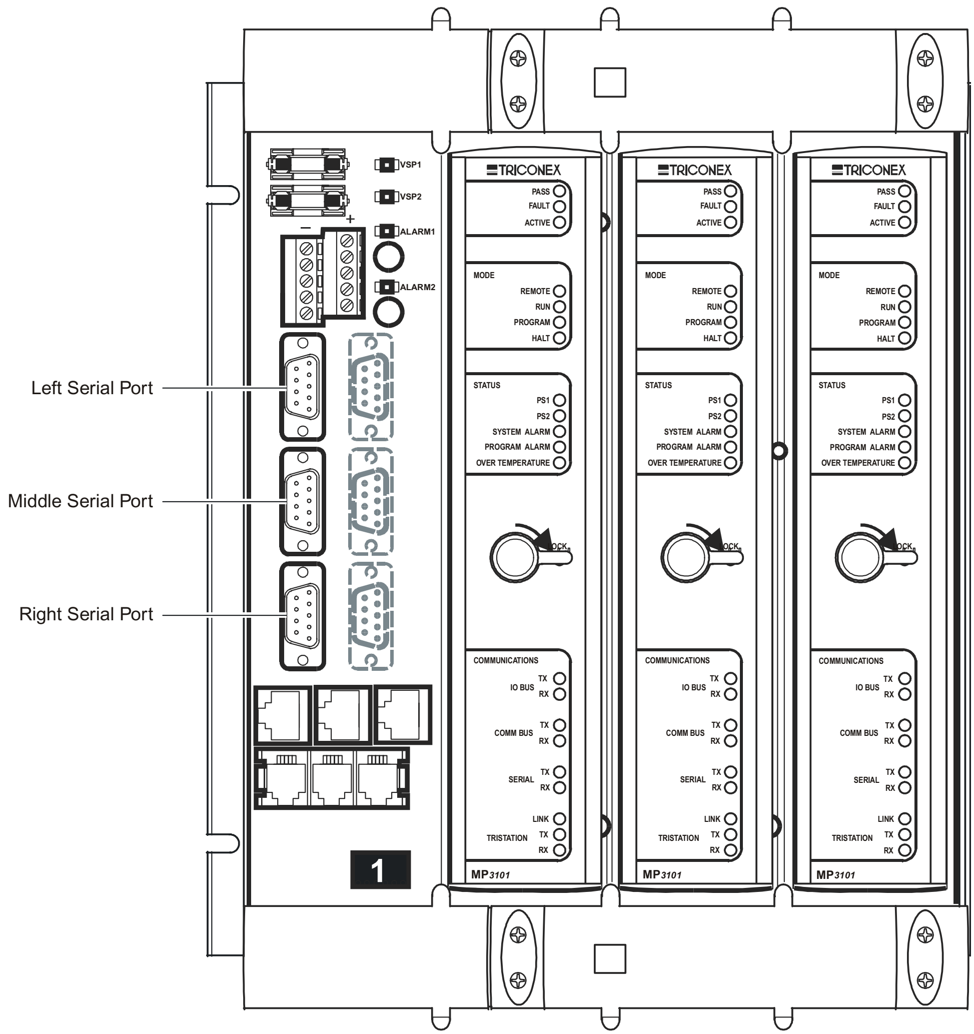
Connecting a CM Using a Network Hub



Connecting to Serial Ports on the MP

Serial ports on the MP can be used for communication as a Modbus slave. The Modbus master can be a DCS or PC. For information on configuring serial ports for Modbus communication, see the *Trident Communication Guide*.

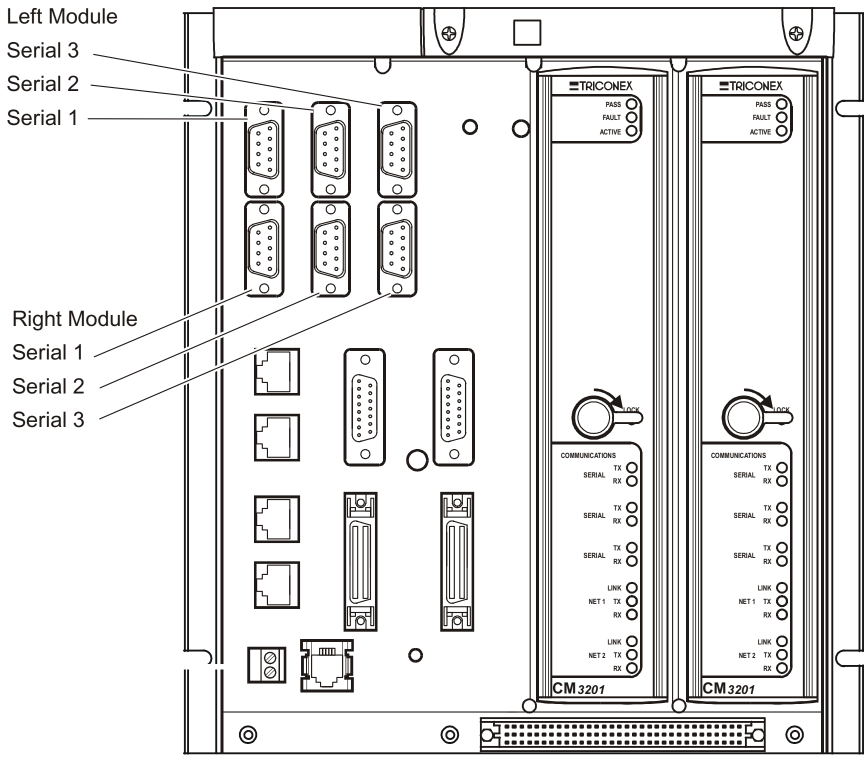
For information on cables, see "RS-232 Modbus Serial Cable" on page 214 or "RS-485 Modbus Serial Cables" on page 215.



Connecting to Serial Ports on the CM

Serial ports on the CM can be used for communication as a Modbus master, slave, or combination master/slave. For information on configuring serial ports for Modbus communication, see the *Trident Communication Guide*.

For information on cables, see “RS-232 Modbus Serial Cable” on page 214 or “RS-485 Modbus Serial Cables” on page 215.



Configuring Output Voter Diagnostics

Output voter diagnostics (OVD) is a set of tests that detects failures in the output voting circuitry of DO Modules only. OVD runs without operator intervention or awareness and enables the Trident controller to continually verify its own integrity.

The diagnostics operate as follows: During execution, the commanded state of each point in the output circuitry is momentarily reversed on each of the output drivers, one after another. I/O loop-back on the module allows each microprocessor to read the output value of the point to determine whether a latent fault exists within the output circuit. If a failure occurs, replace the failed module immediately so that the fault tolerance capability remains in effect.

Triconex guarantees that a glitch to a load lasts less than 2 milliseconds. To ensure safety, you should analyze the sensitivity of each load device attached to the controller for proper operation. The less-than-2-millisecond glitch is tolerated well by electromechanical devices, such as relays, solenoids, and contacts. For assistance with load devices that might be sensitive to such glitches, consult a Triconex Field Service Engineer. If glitches are not tolerable in your controlled process, disable OVD using TriStation.

Disabling OVD on DO Modules

To enable and disable OVD for testing, use the appropriate system attribute in your TriStation project. Leave OVD enabled for several minutes. When testing is done, disable OVD.

If you disable OVD, be sure to schedule regular maintenance periods to ensure the overall integrity of the controller. During maintenance, shut down the controlled process and enable OVD. It is not necessary to cycle the outputs to On and Off states to ensure complete fault coverage.

Controller Verification

After the controller is installed and before running an application, verify that the controller is operational.

▼ **To verify the controller:**

1. Verify that the controller is properly grounded according to directions in "Effective Grounding Methods" on page 149.
2. Remove incoming power, install I/O and extension bus wiring, and perform a static check of the wiring.
3. Before connecting field I/O wiring, apply power to each baseplate.
4. Within five minutes, verify that the green Pass indicators on the MPs and all I/O modules go on.
5. Connect the TriStation PC to the appropriate port on the MP.
6. Connect the field I/O wiring and devices.
7. Verify that all process equipment connected to the controller is disabled to prevent accidental start-up of the equipment during testing.
8. Turn on power to the controller and the TriStation PC.
9. Download the TriStation project.
10. Using the TriStation Control Panel, test all inputs and outputs.
11. To verify the connections of all I/O points to the field wiring, use the TriStation Control Panel.
12. With output devices disabled, use TriStation facilities to verify the application.
13. When satisfied that the application is operating properly, enable the output devices and the process equipment according to the safety requirements for your environment.

You have now made every effort to ensure that your Trident controller is problem-free. However, should problems arise, please call a Triconex Field Service Engineer before starting up your process-control operation.

Performing Routine Maintenance

Routine maintenance consists of the following tasks:

- Checking the integrity of system power sources
- Periodically enabling “disabled” Output Voter Diagnostics (OVD)
- Verifying the integrity of spare modules

You should establish a schedule for routine maintenance and adhere to it to ensure maximum safety and long service.

Checking System Power Sources

Typical installations use redundant power supplies to power the controller and the field circuitry. Under normal operating conditions, the required power is shared between the two power sources. Typically, the sharing is approximately equal with each power supply providing 50 percent of the system power.

Under abnormal conditions, one of the power sources may be required to provide 100 percent of the system power. To verify the integrity of the system power supply, you should periodically test each power source for its ability to provide power for the entire system when the redundant source is disabled.

To verify the stability of the remaining power source under full load, every three to six months, turn off one of the power sources and leave it off for several minutes. After restoring power, repeat the test for the other power supply.

Ideally, this type of testing is performed with the controlled process offline; for example, during a normally scheduled plant maintenance period. Remember to turn on both power sources prior to restarting the controlled process.

Output Voter Diagnostics (OVD)

Output voter diagnostics (OVD) is a set of tests that detects failures in the output voting circuitry of DO Modules only. OVD runs without operator intervention or awareness and enables the Trident controller to continually verify its own integrity.

⚠ CAUTION

OVD may affect a controlled process! For this reason, Triconex provides special instructions for disabling OVD on selected DO points from TriStation. For more information, see the *TriStation 1131 Developer's Guide*.

If OVD is disabled, you should verify that the output voter circuitry is working properly by enabling OVD every three to six months. All DO Modules can be tested simultaneously.

To enable and disable OVD, use the appropriate system attribute in your TriStation project. Leave OVD enabled for several minutes. When testing is done, disable OVD.

Verifying Spare Modules

The 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 spares. The controller automatically tests these modules by shifting control between the active and hot-spare modules as follows:

- Periodically, approximately once an hour
- After a power failure
- After an MP re-education

Spare MPs and I/O modules that cannot be used as hot spares 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 is not allowed to sit on the shelf more that six months.

CHAPTER 5

Fault and Alarm Indicators

This chapter describes indicators that identify the state of each module.

Topics include:

⚠CAUTION

The Trident 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 Triconex for assistance in implementing the repair procedures.

Overview

Indicators are lights on the front panel of each module that identify the state of each module. Each module includes indicators that identify the general state of the module and other indicators related to the function of the module.

The types of indicators include:

- Status indicators which identify the processing state of the module. Each module includes a Pass, Fault, and Active indicator.
- A lock indicator which identifies whether the module is unlocked.
- Mode indicators which identify the current operating state of the controller. (Only on MP Modules.)
- Field power and power load indicators which identify whether a power problem has occurred. (Only on some I/O modules.)
- Communication indicators which identify the type of communication occurring. (Only on MP and CM Modules.)
- Points indicators which identify whether the point is energized.
- Alarm indicators which identify alarm conditions for the controller. (Only on MP Modules.)

Fault and Alarm Indicators

Fault indicators identify potentially serious problems with a module. Alarm conditions identify abnormal field conditions such as loss of power and loss of communication.

If a fault or alarm indicator is on, you should consult the appropriate section of this chapter and take appropriate action. This action may include replacing a faulty module or repairing a faulty circuit or device.

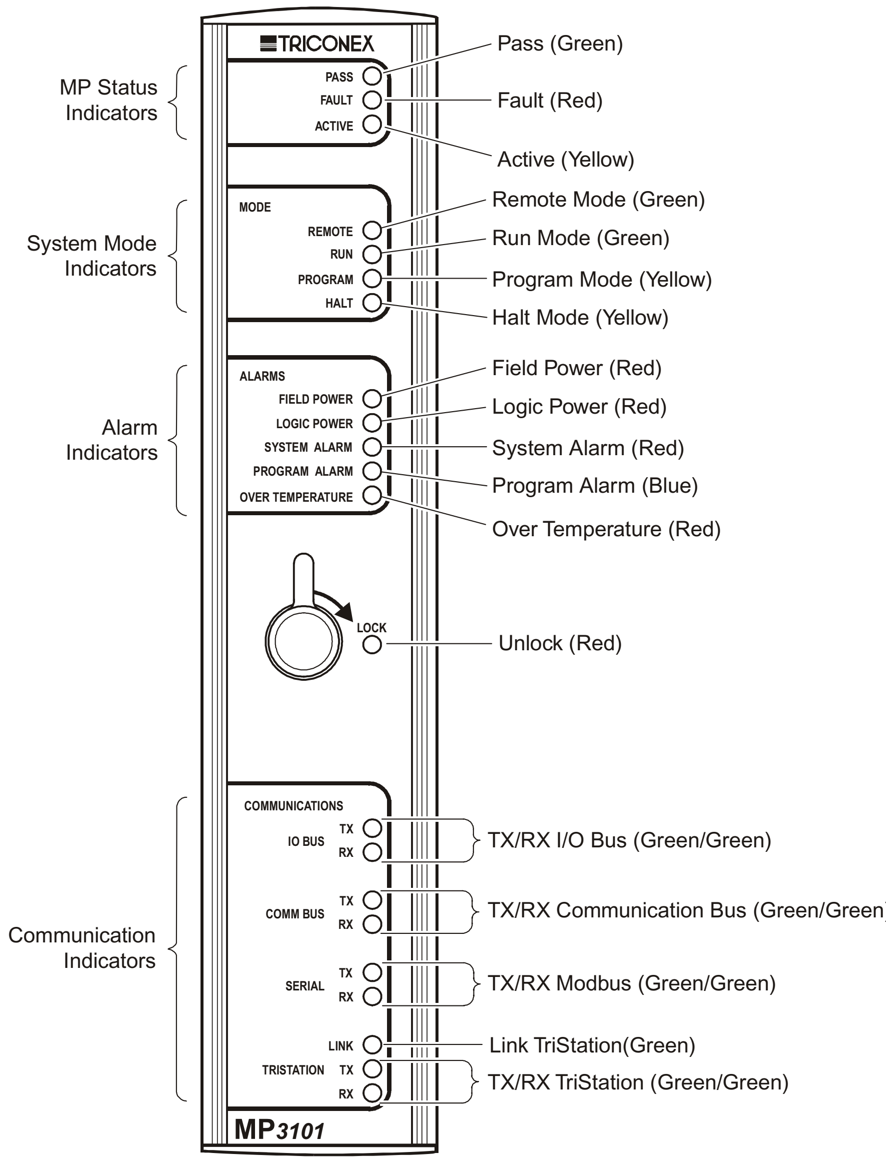
Identifying Fault and Alarm Conditions

You can identify alarm and fault conditions in the following ways:

- By examining the indicators on the front panel of each module and consulting this chapter.
- By using the Diagnostic Panel in the TriStation application. For more information, see the *TriStation 1131 Developer's Guide*.

Main Processor Indicators

This section describes indicators for the MP Module, including the MP status, system mode, alarm, and communications indicators.



MP Status Indicators

The MP status indicators identify the processing state for the MP Module. A fault light indicates that the processor has an internal fault.

Normal States

Pass	Fault	Active	Lock	Description	Action
Green steady	No light	Yellow blinking	No light	Module is operating normally. Active indicator blinks once per scan when executing an application.	Normal status. No action is required.
Green steady	No light	No light	No light	Module is operating normally. Possible conditions include: Application has not been loaded into the MP. Application has been loaded into the MP, but has not been started up. Module has just been installed and is currently being educated by the other MP Modules.	 Load application. Start application. Wait for the module to be educated.

Fault States

Pass	Fault	Active	Lock	Description	Action
No light	Red steady	— [1]	No light	Possible conditions include: Module may have failed. Module may be in the process of power-up self-test. Module has detected a fault.	See mode indicator status for power-up states. If the Pass indicator does not go on within five minutes, replace the module. Module is operational, but should be replaced.
No light	Red steady	—	Red steady	Module is unlocked from the baseplate.	Lock module using a #2 flat-blade screwdriver.
Green steady	Red steady	—	—	Indicators/signal circuitry on the module are malfunctioning.	Replace the module.

1. This symbol (—) means the indicator is not important for this condition.

MP System Mode Indicators

The MP system mode indicators identify the current operating state of the controller. (Operational modes are set in TriStation 1131. For more information, see the *TriStation 1131 Developer's Guide*.)

Remote	Run	Program	Halt	Description
Green steady	Green steady	Yellow steady	No light	Normal operation with write capability. Allows writes to program variables by TriStation, Modbus master, and external hosts. Allows control of the controller from TriStation, including Download All and Download Change.
Green steady	Green steady	No light	No light	Normal operation with read-write capability. Allows writes to program variables by Modbus masters and external hosts. (Download All and Download Change by TriStation are not allowed.)
No light	Green steady	No light	No light	Normal operation with read-only capability. MPs execute the previously loaded application. Attempts to modify program variables by Modbus masters and external hosts are rejected.
No light	No light	Yellow steady	Yellow steady	Application loading and checkout is enabled. Allows control of the controller from the TriStation application, including Download All and Download Change. Application has also been stopped.
Green slow blinking	Green slow blinking	Yellow slow blinking	Yellow slow blinking	Indicators change every few seconds; module is in its power-up state.
Green fast blinking	Green fast blinking	Yellow fast blinking	Yellow fast blinking	Module is ready to download new internal firmware. Condition is caused by removing the MP Baseplate address plug before module power-up.
No light	No light	No light	Yellow steady	Application has stopped.
Green steady	Green steady	Yellow steady	Yellow steady	Module is faulty or has detected a bad address plug.

MP Alarm Indicators

The MP alarm indicators identify alarm conditions for the controller.

Field Power	Logic Power	System Alarm	Program Alarm	Over Temp	Description	Action
—[1]	Red steady	Red steady	—	—	System power supply is missing/bad.	Correct the problem.
Red steady	—	Red steady	—	—	Field power supply is missing/bad.	Correct the problem.
—	—	Red steady	—	—	Possible conditions include: MP or I/O module is malfunctioning. I/O module has detected a field fault. Application has detected an alarm condition.	 Identify the condition by looking at the Pass or Fault indicators of other modules or by using the TriStation Diagnostic Panel. Replace faulty module. Correct field fault. Check application for bypass or overridden points or other abnormal condition.
—	—	—	Blue steady	—	Application has detected an alarm condition. Alarm contacts also indicate an alarm (open contacts).	Identify the fault condition by using the application. Correct the condition.
—	—	Red steady	—	Red steady	Normal operation, but the ambient temperature is too high (greater than 60°C/140°F).	Correct the environmental problem or the controller may fail prematurely.

1. This symbol (—) means the indicator is not important for this condition.

MP Communication Indicators

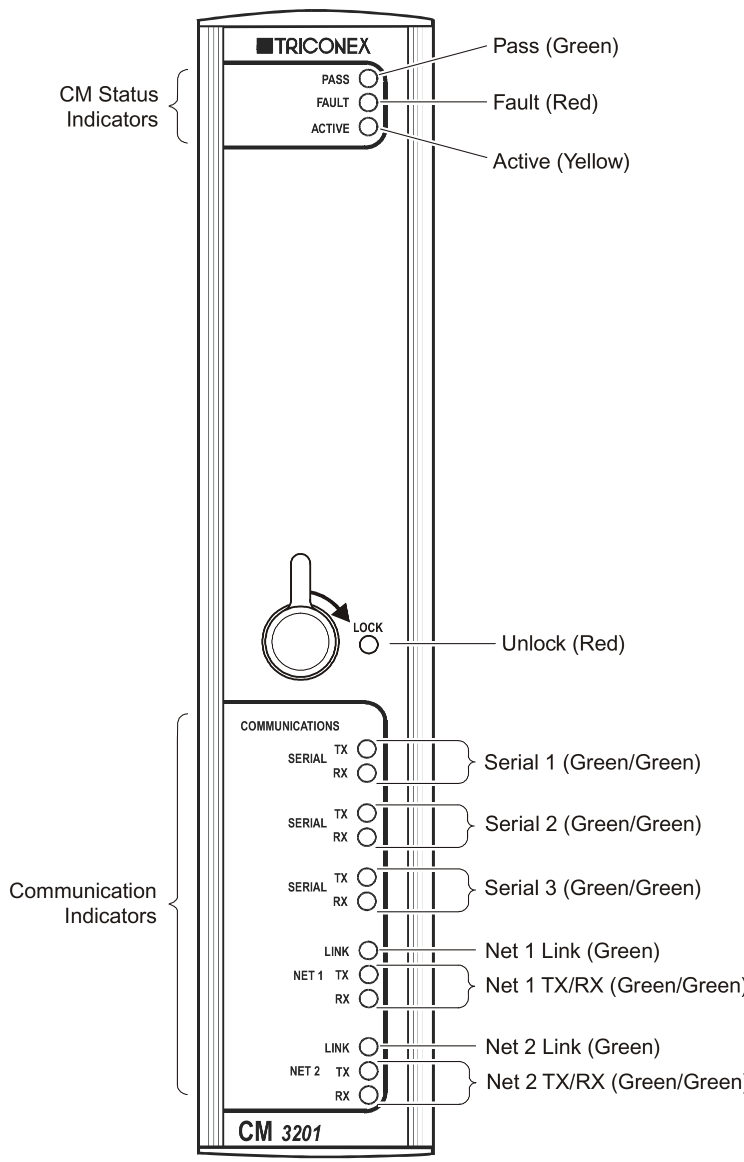
The MP communication indicators identify the type of communication occurring on the controller. The TX light indicates the MP is transmitting a message and the RX light indicates the MP is receiving a message.

I/O Bus	Comm Bus	Serial	TriStation		
RX/TX	RX/TX	RX/TX	Link	RX/TX	Description
Green blinking	—[1]	—	—	—	Normal response. MP is polling and sending responses to the I/O modules.
—	Green blinking	—	—	—	Normal response. MP is polling and sending responses to the CM modules.
—	—	Green blinking	—	—	Normal response. MP is polling and sending responses to the Modbus master.
—	—	—	Green steady	Green blinking	MP is communicating with TriStation.
—	—	—	No light	—	MP is not communicating with TriStation or a network hub. Note: The hub or Ethernet card in the TriStation computer has a link indicator that shows whether a hardware connection has been established with the MP.

1. This symbol (—) means the indicator is not important for this condition.

Communication Module Indicators

This section describes indicators for the CM module, including the CM status and communications indicators.



CM Status Indicators

The CM status indicators identify the processing state for the CM. A fault light indicates that the processor has an internal fault.

Normal States

Pass	Fault	Active	Lock	Description	Action
Green steady	No light	Green steady	No light	Module is operating normally.	Normal status. No action is required.
Green steady	No light	Green blinking	No light	Module is downloading firmware.	Normal status. To cancel, pull module then re-seat module.
Green steady	No light	No light	No light	Module is operating normally. Possible conditions include: Control application has not been loaded into the MP. Control application has been loaded into the MP, but has not been started up. Module has just been installed and is currently being educated by the other MPs.	 Load control application. Start control application. Wait for module to be educated.

Fault States

Pass	Fault	Active	Lock	Description	Action
No light	Red steady	No light	No light	Possible conditions include: Module may have failed. Module may be in the process of power-up self-test.	See mode indicator status for power-up states. If the Pass indicator does not go on within five minutes, replace module.
No light	Red steady	Green steady	No light	Module has detected a minor error.	Module is operational, but should be replaced.
No light	Red steady	—[1]	Red steady	Module is unlocked from the baseplate.	Lock module.
Green steady	Red steady	—	—	Indicators/signal circuitry on the module are malfunctioning.	Replace the module.

1. This symbol (—) means the indicator is not important for this condition.

CM Communication Indicators

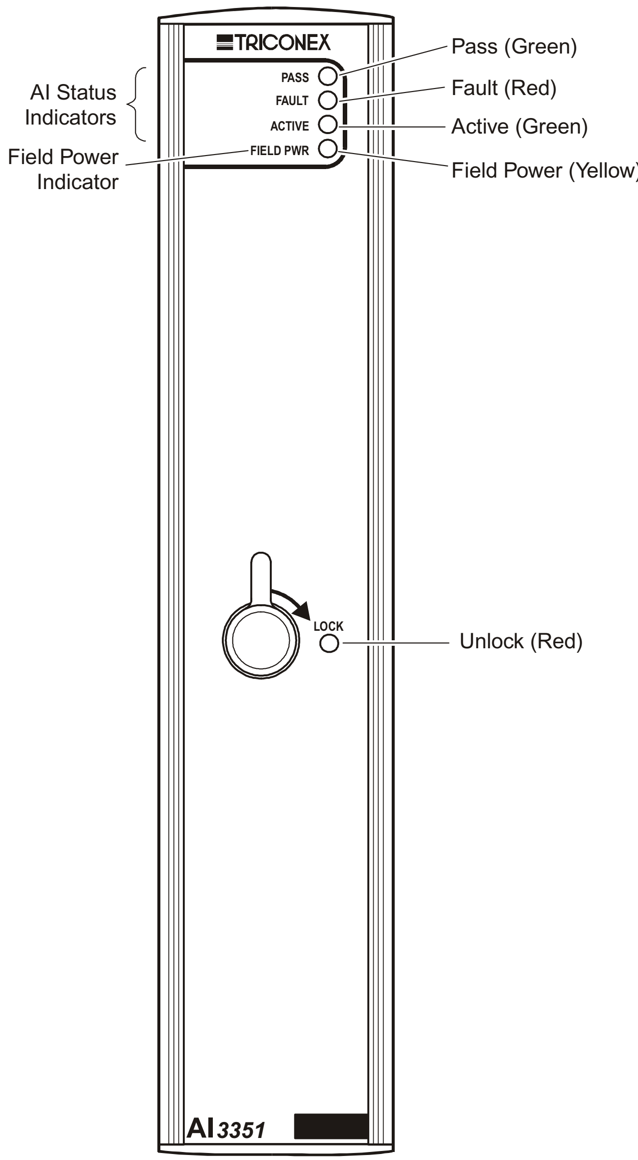
The CM communication indicators identify the type of communication occurring on the controller. The TX light indicates the CM is transmitting a message and the RX light indicates the CM is receiving a message.

Serial 1	**Serial 2**	**Serial 3**	**Net 1**		**Net 2**		
RX/TX	**RX/TX**	**RX/TX**	**Link**	**RX/TX**	**Link**	**RX/TX**	**Description**
Green blinking	—[1]	—	—		—		Normal response. CM is communicating with the attached Modbus master/slave device.
—	Green blinking	—	—		—		Normal response. CM is communicating with the attached Modbus master/slave device.
—	—	Green blinking	—		—		Normal response. CM is communicating with the attached Modbus master/slave device.
—	—	—	Green steady	Green blinking	—	—	CM is communicating with TriStation or with an Ethernet device through the Net 1 port.
—	—	—	—	—	Green steady	Green blinking	CM is communicating with TriStation or with an Ethernet device through the Net 2 port.

1. This symbol (—) means the indicator is not important for this condition.

Analog Input Module Indicators

This section describes the AI Module indicators and recommends actions for fault conditions.



AI Status Indicators

The AI status indicators identify the processing state for the AI Module. A fault light indicates that the module has an internal fault.

Normal State

Pass	Fault	Active	Lock	Description	Action
Green steady	No light	Green steady	No light	Module is operating normally.	No action is required.

Fault States

Pass	Fault	Active	Lock	Description	Action
Green steady	No light	No light	No light	Possible conditions include: Application has not been loaded into the MP. Application has been loaded into the MP, but has not been started up. Module has just been installed and is currently running start-up diagnostics. The other module is active.	If the module is the hot spare, no action is required. If the module is active, replace module.
No light	Red steady	—[1]	No light	Possible conditions include: Module may be in the process of power-up self-test. Module has detected a fault.	If the Pass indicator does not go on within five minutes, replace the module. Module is operational, but should be replaced.
				Module has detected marginal input voltage in a steady-state condition.	Check sensor signal strength. Check sensor positioning.
—	—	—	Red steady	Module is unlocked from the baseplate.	Lock module using a #2 flat-blade screwdriver.
Green steady	Red steady	—	—	Indicators/signal circuitry on the module are malfunctioning.	Replace the module.

1. This symbol (—) means the indicator is not important for this condition.

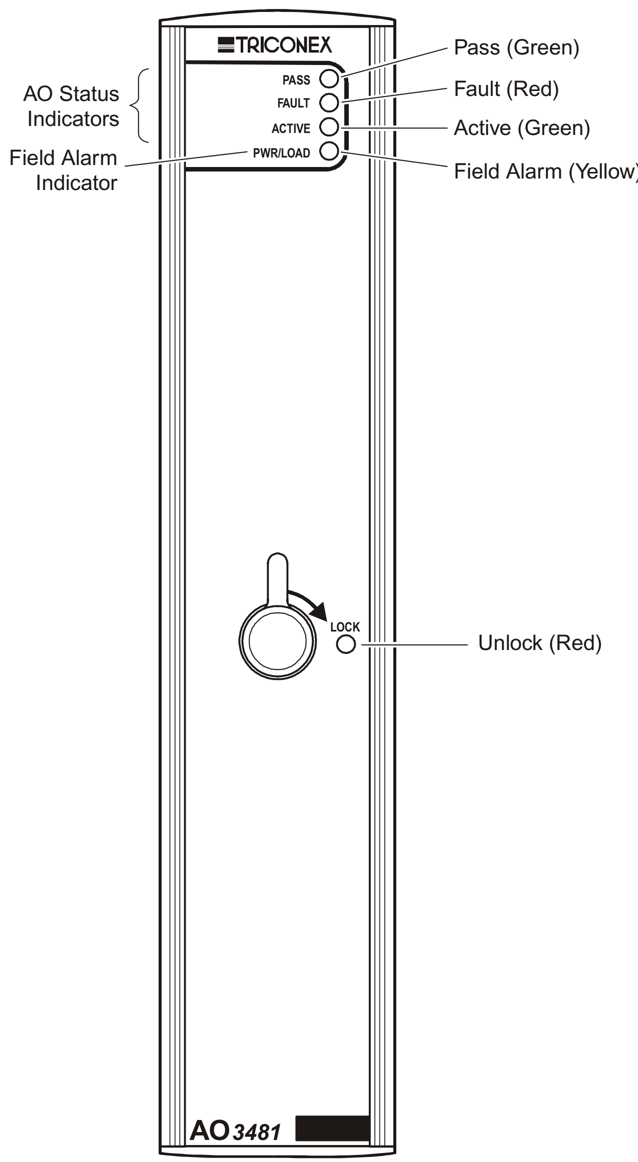
AI Field Power Indicator

The AI field power indicator is lit when a field power problem has occurred.

Field Power	Description	Action
Yellow steady	Field power from one or more of the redundant sources is missing.	To isolate the missing power source, use the TriStation Diagnostic Panel. To determine the actual state, use a voltmeter, then correct the problem in the external circuit. If these steps do not solve the problem, replace the module.

Analog Output Module Indicators

This section describes the AO Module indicators and recommends actions for fault conditions.



AO Status Indicators

The AO status indicators identify the processing state for the AO Modules. A fault light indicates that the module has an internal fault or is missing field power.

Normal State

Pass	Fault	Active	Lock	Description	Action
Green steady	No light	Green steady	No light	Module is operating normally.	No action is required.

Fault States

Pass	Fault	Active	Lock	Description	Action
Green steady	No light	No light	No light	Possible conditions include: Application has not been loaded into the MP. Application has been loaded into the MP, but has not been started up. Module has just been installed and is currently running start-up diagnostics. The other module is active.	If the module is the hot spare, no action is required. If the module is active, replace module.
No light	Red steady	—[1]	No light	Possible conditions include: Module may be in the process of power-up self-test. Field power is missing, if field power light is also on. Module has detected a fault.	If the Pass indicator does not go on within five minutes, replace the module. Restore field power and reseat the module. Module is operational, but should be replaced.
				Module has detected marginal input voltage in a steady-state condition.	Check sensor signal strength. Check sensor positioning.
—	—	—	Red steady	Module is unlocked from the baseplate.	Lock module using a #2 flat-blade screwdriver.
Green steady	Red steady	—	—	Indicators/signal circuitry on the module are malfunctioning.	Replace the module.

1. This symbol (—) means the indicator is not important for this condition.

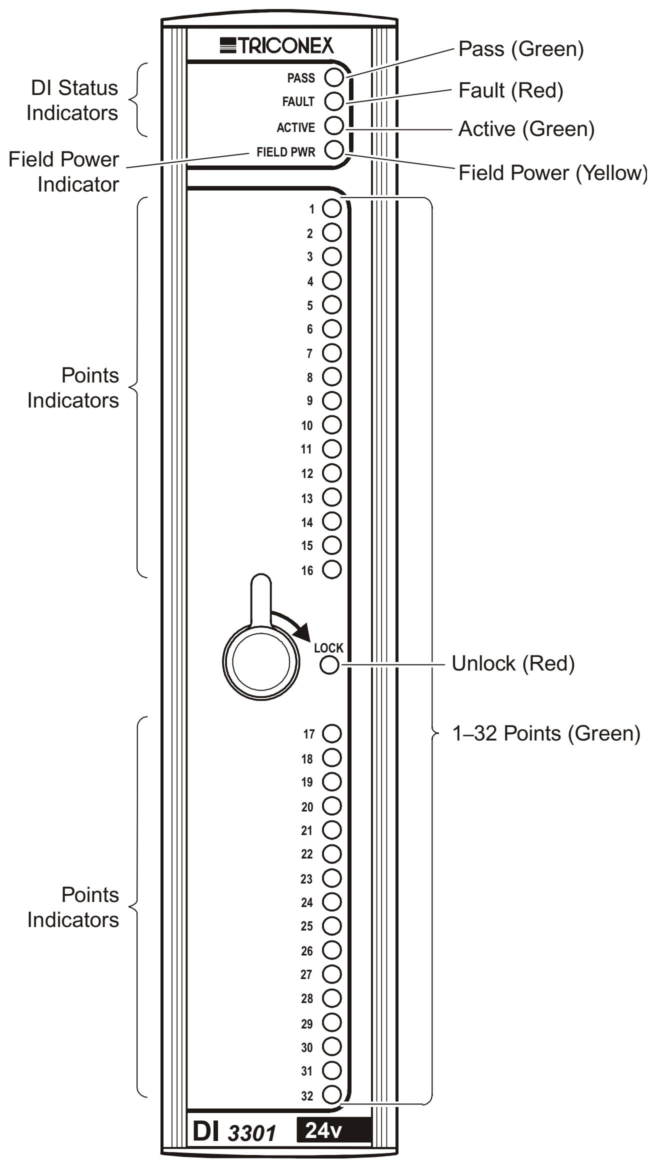
AO Field Alarm Indicator

The AO field fault indicator is lit when a field power problem has occurred.

Field Alarm	Description	Action
Yellow steady	Field power from one or more of the redundant sources is missing or a field error is detected. A field error may be an open load or an out-of-compliance error.	To isolate the missing power source, use the TriStation Diagnostic Panel. To determine the actual state, use a voltmeter, then correct the problem in the external circuit. If these steps do not solve the problem, replace the module.

Digital Input Module Indicators

This section describes the DI Module indicators and recommends actions for fault conditions.



DI Status Indicators

The DI status indicators identify the processing state for the DI Module. A fault light indicates that the module has an internal fault.

Normal State

Pass	Fault	Active	Lock	Description	Action
Green steady	No light	Green steady	No light	Module is operating normally.	No action is required.

Fault States

Pass	Fault	Active	Lock	Description	Action
Green steady	No light	No light	No light	Possible conditions include: Application has not been loaded into the MP. Application has been loaded into the MP, but has not been started up. Module has just been installed and is currently running start-up diagnostics. Other module is active.	If the module is the hot spare, no action is required. If the module is active, replace module.
No light	Red steady	—[1]	No light	Possible conditions include: Module may be in the process of power-up self-test. Module has detected a fault.	If the Pass indicator does not go on within five minutes, replace the module. Module is operational, but should be replaced.
—	—	—	Red steady	Module is unlocked from the baseplate.	Lock the module using a #2 flat-blade screwdriver.
Green steady	Red steady	—	—	Indicators/signal circuitry on the module are malfunctioning.	Replace module.

1. This symbol (—) means the indicator is not important for this condition.

DI Field Power Indicator

The DI field power indicator is lit when a field power problem has occurred.

Field Power	Description	Action
Yellow steady	Field power from one or more of the redundant sources is missing.	To isolate the missing power source, use the TriStation Diagnostic Panel. Correct the problem in the field circuit. If these steps do not solve the problem, replace the module.

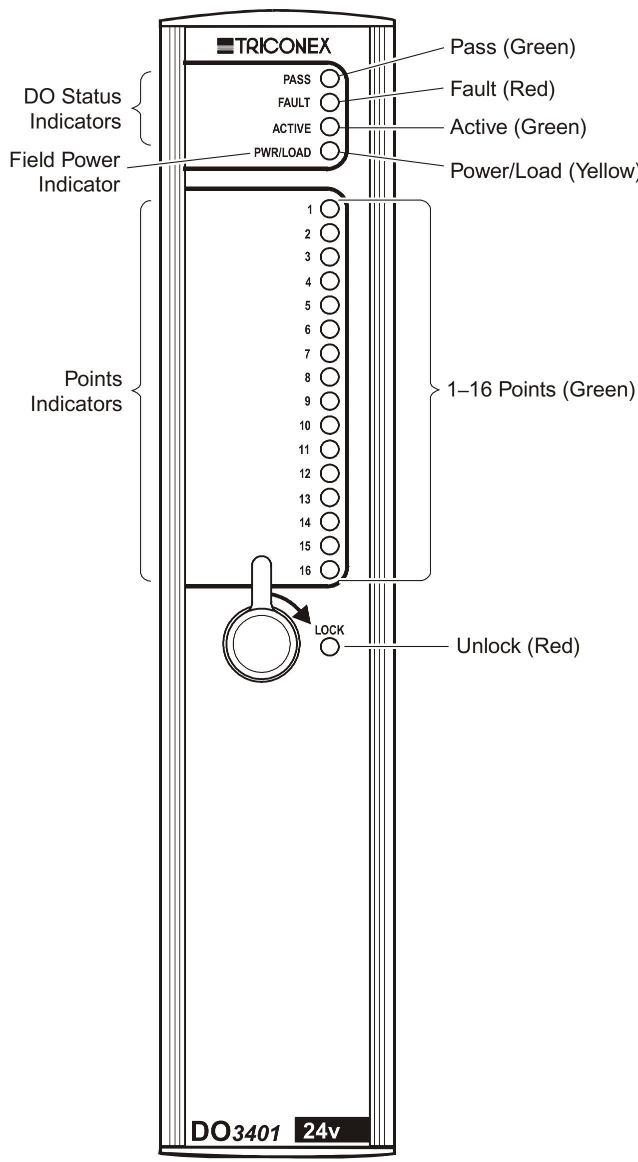
DI Point Indicators

The DI point indicators identify whether the point is energized or not energized.

Point (1-32)	Description
Green steady	Field circuit is energized.
No light	Field circuit is not energized.

Digital Output Module Indicators

This section describes the DO Module indicators and recommends actions for fault conditions.



DO Status Indicators

The DO status indicators identify the processing state for the DO Module. A fault light indicates that the module has an internal fault. If you have a field fault and a module fault, resolve the field fault first.

Normal State

Pass	Fault	Active	Lock	Description	Action
Green steady	No light	Green steady	No light	Module is operating normally.	No action is required.

Fault States

Pass	Fault	Active	Lock	Description	Action
Green steady	No light	No light	No light	Possible conditions include: Application has not been loaded into the MP. Application has been loaded into the MP, but has not been started up. Module has just been installed and is currently running start-up diagnostics. Other module is active.	If the module is the hot spare, no action is required. If the module is active, replace module.
No light	Red steady	—[1]	No light	Possible conditions include: Module may be in the process of power-up self-test. Excessive load current required. Module has detected a fault.	If the Pass indicator does not go on within five minutes, replace the module. Correct field fault condition. Module is operational, but should be replaced.
—	—	—	Red steady	Module is unlocked from the baseplate.	Lock module using a #2 flat-blade screwdriver.
Green steady	Red steady	—	—	Indicators/signal circuitry on the module are malfunctioning.	Replace the module.

1. This symbol (—) means the indicator is not important for this condition.

DO Power/Load Indicator

The DO power/load indicator is lit when a power/load problem has occurred.

Power/ Load	Description	Action
Yellow steady	For at least one point, the commanded state and the measured state do not agree.	To isolate the suspected point, use the TriStation Diagnostic Panel. To determine the commanded state of the output point, use the TriStation Control Panel. To determine the actual state of the output, use a voltmeter, then correct the problem in the external circuit. Verify that load current is within product specification. If these steps do not solve the problem, replace the module.

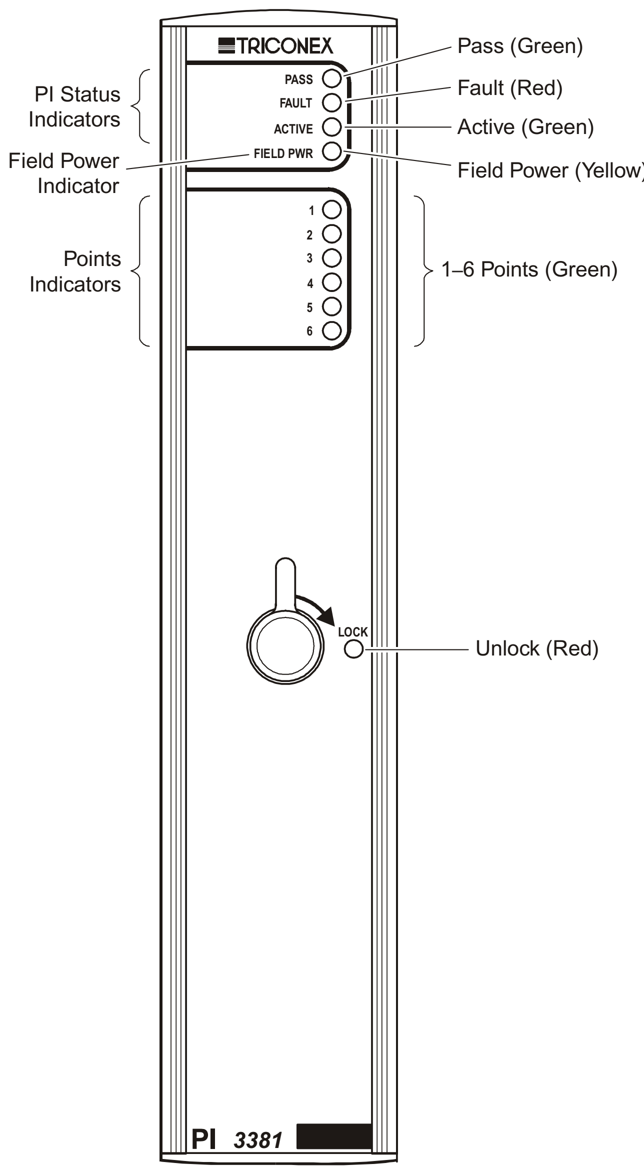
DO Point Indicator

The DO point indicators identify whether the point is energized or not energized.

Point (1-16)	Description
Green steady	Field circuit is energized.
No light	Field circuit is not energized.

Pulse Input Module Indicators

This section describes the PI Module indicators and recommends actions for fault conditions.<<get correct panel graphic>>



PI Status Indicators

The PI status indicators identify the processing state for the PI Module. A fault light indicates that the module has an internal fault.

Normal State

Pass	Fault	Active	Lock	Description	Action
Green steady	No light	Green steady	No light	Module is operating normally.	No action is required.

Fault States

Pass	Fault	Active	Lock	Description	Action
Green steady	No light	No light	No light	Possible conditions include: Application has not been loaded into the MP. Application has been loaded into the MP, but has not been started up. Module has just been installed and is currently running start-up diagnostics. The other module is active.	If the module is the hot spare, no action is required. If the module is active, replace module.
No light	Red steady	— [1]	No light	Possible conditions include: Module may be in the process of power-up self-test. Module has detected a fault.	If the Pass indicator does not go on within five minutes, replace the module. Module is operational, but should be replaced.
				Module has detected marginal input voltage in a steady-state condition.	Check sensor signal strength. Check sensor positioning.
—	—	—	Red steady	Module is unlocked from the baseplate.	Lock module using a #2 flat-blade screwdriver.
Green steady	Red steady	—	—	Indicators/signal circuitry on the module are malfunctioning.	Replace the module.

1. This symbol (—) means the indicator is not important for this condition.

PI Field Fault Indicator

The PI field fault indicator is lit when a field power problem has occurred.

Field	Description	Action
Yellow steady	Field power from one or more of the redundant sources is missing.	To isolate the missing power source, use the TriStation Diagnostic Panel.

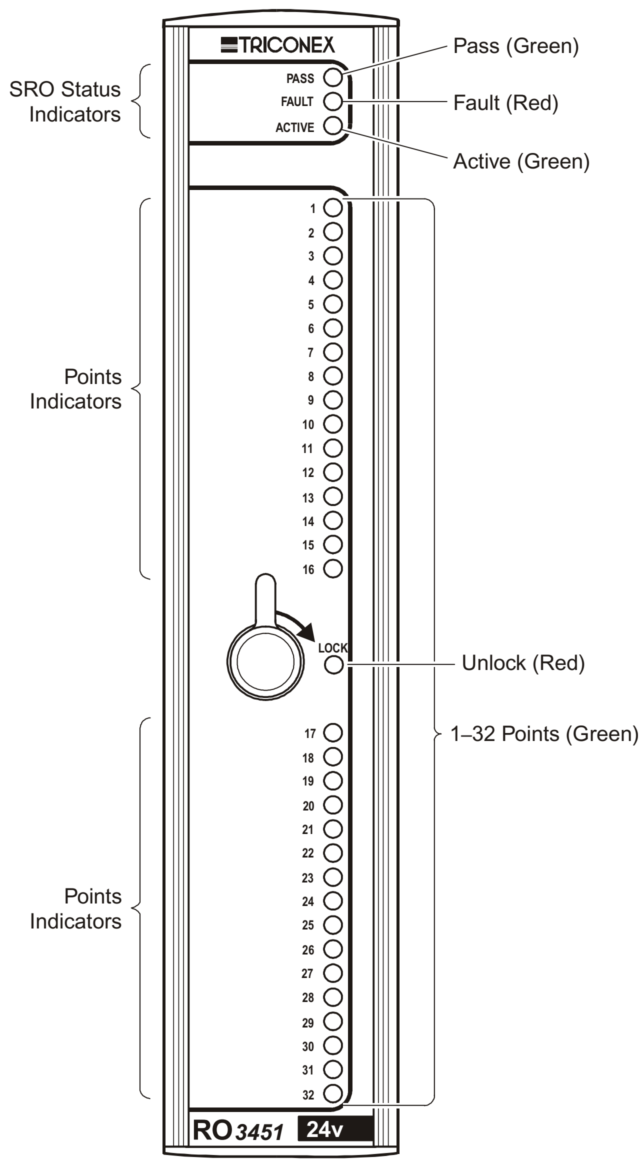
PI Point Indicators

The PI point indicators identify whether the point is greater than or less than 0.5 Hz.

Point (1-6)	Description
Green steady	Input frequency is greater than 0.5 Hz.
No light	Input frequency is less than 0.5 Hz.

Solid-State Relay Output Module Indicators

This section describes the SRO Module indicators and recommends actions for fault conditions.



SRO Status Indicators

The SRO status indicators identify the processing state for the SRO Module. A fault light indicates that the module has an internal fault.

Normal State

Pass	Fault	Active	Lock	Description	Action
Green steady	No light	Green steady	No light	Module is operating normally.	No action is required.

Fault States

Pass	Fault	Active	Lock	Description	Action
Green steady	No light	No light	No light	Possible conditions include: Application has not been loaded into the MP. Application has been loaded into the MP, but has not been started up. Module has just been installed and is currently running start-up diagnostics. The other module is active.	If the module is the hot spare, no action is required. If the module is active, replace module.
No light	Red steady	—[1]	No light	Possible conditions include: Module may be in the process of power-up self-test. Module has detected a fault.	If the Pass indicator does not go on within five minutes, replace the module. Module is operational, but should be replaced.
				Module has detected marginal input voltage in a steady-state condition.	Check sensor signal strength. Check sensor positioning.
—	—	—	Red steady	Module is unlocked from the baseplate.	Lock module using a #2 flat-blade screwdriver.
Green steady	Red steady	—	—	Indicators/signal circuitry on the module are malfunctioning.	Replace the module.

1. This symbol (—) means the indicator is not important for this condition.

SRO Point Indicators

The SRO point indicators identify whether the point is energized or not energized.

Point (1-32)	Description
Green steady	Field circuit is energized.
No light	Field circuit is not energized.

Replacing Modules

This section describes how to replace faulty MP, CM, and I/O modules. The I/O instructions explain how to replace a module when it has a hot spare and when it does not.

The following instructions are included:

- "Replacing a Main Processor Module" on page 196.
- "Replacing a Communication Module" on page 197.
- "Replacing an I/O Module Without a Hot Spare" on page 198.
- "Replacing an I/O Module With a Hot Spare" on page 199.

Guidelines for Replacing Modules

Before replacing any module, you should observe the following guidelines.

⚠WARNING

If a controller has two faults, one in an MP and one in another type of module, **replace the MP first**. Wait until the Active indicator of the replacement module goes on, then replace the second faulty module.

- If an I/O module has a field fault and a module fault, resolve the field fault first. Before replacing the I/O module, then reset the I/O module using the TriStation Diagnostic Panel.

⚠CAUTION

Before inserting any module into the controller, check for damaged pins. **If damaged pins are present, do not insert the module.** Inserting modules with damaged pins may cause the controller to malfunction and may affect the controlled process. If you find a module with damaged pins, please return it to Triconex for repair.

- When replacing a module, you must use a #2 flat-blade screwdriver to lock or unlock the module. See "Installing Modules" on page 148.
- For optimal performance, store spare I/O modules in vacant slots as hot spare/hot replacement modules.
- Store any remaining, unused modules in their original shipping cartons.

Replacing a Main Processor Module

If the fault indicator of an MP Module light is blinking, the diagnostics have detected a module failure.

Before replacing an MP, verify that all I/O modules are locked.

⚠ CAUTION

After replacing an MP, allow the module to fully re-educate before unlocking another MP. Never unlock more than one MP at a time.

▼ **To replace a faulty MP:**

1. If available, make a note of the diagnostic message, model, and serial numbers.
2. Before replacing an MP Module, observe the important instructions provided in the section called "Guidelines for Replacing Modules" on page 195.
3. If the controlled process is online, verify that at least one MP Module has an Active indicator with a blinking yellow light.
4. On the faulty MP Module, rotate the lock lever counter-clockwise until the module ejects from the baseplate.
5. Insert the replacement MP Module and rotate the lock lever clockwise to draw the module into the baseplate.

Note When replacing a module, you must use a #2 flat-blade screwdriver to lock or unlock the module. See the "Installing Modules" procedure on page 148.

   The Pass indicator should go on and stay on within one to six minutes.

   The Active indicator on the replacement MP Module blinks at the same rate as the other MPs within one to six minutes.

   If the module is not properly seated, the Lock indicator stays on. The Active indicator does not go on until the MP Module is properly seated and locked.

6. Contact the Triconex Customer Response Center to obtain a returned material authorization (RMA) number.
7. Return the module to Triconex for repair.

Replacing a Communication Module

If the fault indicator of a Communication Module light is blinking, the diagnostics have detected a module failure.

⚠CAUTION

The CM does not have hot-spare capability.

▼ **To replace a faulty CM:**

1. If available, make a note of the diagnostic message, model, and serial numbers.
2. Before replacing a CM, observe the important instructions provided in the section called "Guidelines for Replacing Modules" on page 195.
3. Detach all communication cables from the faulty module.
4. On the faulty CM, rotate the lock lever counter-clockwise until the module ejects from the baseplate.

Note If communication has not been disrupted by the fault, removing the module disrupts communication until the module is replaced. If you have a redundant CM, replacing the faulty module does not affect communication on the redundant CM.

5. Insert the replacement CM and rotate the lock lever clockwise to draw the module into the baseplate.

   The Pass indicator should go on within one minute.

   The Active indicator should go on within one to two minutes. Then the Active indicator on the faulty module goes off.

   If the module is not properly seated, the Lock indicator stays on. The Active indicator does not go on until the CM is properly seated and locked.
6. Re-attach all communication cables to the CM.
7. Contact the Triconex Customer Response Center to obtain a returned material authorization (RMA) number.
8. Return the module to Triconex for repair.

Replacing an I/O Module Without a Hot Spare

If the fault indicator of an I/O module is on, the diagnostics have detected a module failure.

▼ **To replace an I/O module:**

1. If available, make a note of the diagnostic message, model, and serial numbers.
2. Before replacing an I/O module, observe the important instructions provided in the section called "Guidelines for Replacing Modules" on page 195.
3. Insert the replacement I/O module in the slot adjacent to the faulty module and rotate the lock lever clockwise to draw the module into the baseplate.

Note When replacing a module, you must use a #2 flat-blade screwdriver to lock or unlock the module. See the "Installing Modules" procedure on page 148.

When the module is installed, the Fault indicator goes on while the diagnostics are running. At the same time, the Point indicators go on briefly, go off, then resume the normal state of blinking. The Pass Indicator should go on within about one minute. If it does not, and the Fault light persists longer than five minutes, check the diagnostic log to determine if there is a problem.

If the module is not properly seated, the Lock indicator stays on. The Active indicator does not go on until the I/O module is properly seated and locked.

The Active indicator should go on within one to two minutes. Then the Active indicator on the faulty module goes off. If the Active indicator on the newly inserted module does not go on within five minutes, replace it with another module.

⚠ CAUTION

Never remove the currently active module.

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4. On the faulty I/O module, rotate the lock lever counter-clockwise until the module ejects from the baseplate.
5. Contact the Triconex Customer Response Center to obtain a returned material authorization (RMA) number.
6. Return the module to Triconex for repair.

Replacing an I/O Module With a Hot Spare

If the fault indicator of an I/O module is on, the diagnostics have detected a module failure.

▼ **To replace an I/O Module:**

1. If available, make a note of the diagnostic message, model, and serial numbers.
2. Before replacing an I/O module, observe the important instructions provided in the section called "Guidelines for Replacing Modules" on page 195.
3. On the faulty I/O module, verify that the Fault indicator is on and the Active indicator is off.
4. Verify that at least one I/O module has an Active indicator on.
5. On the faulty I/O module, rotate the lock lever counter-clockwise until the module ejects from the baseplate.
6. Insert the replacement I/O module in the vacant slot and rotate the lock lever clockwise to draw the module into the baseplate.

Note When replacing a module, you must use a #2 flat-blade screwdriver to lock or unlock the module. See the "Installing Modules" procedure on page 148.

   The Pass indicator should go on within one minute.

   The Active indicator should go on within one to two minutes. Then the Active indicator on the faulty module goes off.

   If the module is not properly seated, the Lock indicator stays on. The Active indicator does not go on until the I/O module is properly seated and locked.

7. Contact the Triconex Customer Response Center to obtain a returned material authorization (RMA) number.
8. Return the module to Triconex for repair.

APPENDIX A

Pin-Outs for Cables and Connectors

This appendix provides pin-out information for the following cables and connectors.

Topics include:

MP Baseplate Connectors

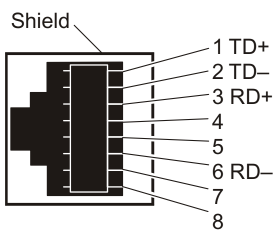
The MP Baseplate provides:

- One Ethernet TriStation connector
- One Modbus RS-232/485 serial connector
- One debug connector

For an illustration of the MP Baseplate, see "Model 2101 Main Processor Baseplate" on page 37.

Ethernet TriStation Connector

Pin-out information for a 10BaseT Ethernet connector is shown below:

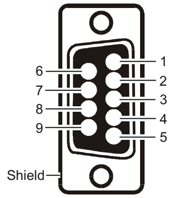


Pin	Signal	Direction	Function
1	TD+	Out	Transmit data +
2	TD-	Out	Transmit data –
3	RD+	In	Receive data +
4	NC	—	
5	NC	—	
6	RD-	In	Receive data –
7	NC	—	
8	NC	—	
Housing	Shield	—	Safety ground

Modbus RS-232/RS-485 Serial Connector

Pin-out information for a Modbus serial connector is shown on page 203. The Modbus port, which is DTE-compatible, is configured using TriStation to operate in either RS-232 or RS-485 mode.

RS-232 Pin-Outs



DB-9 Pin	Signal	Direction	RS-232 Function
1	CD	In	Carrier detect
2	RXD	In	Receive data
3	TXD	Out	Transmit data
4	DTR	Out	Data terminal ready
5	GND	—	Signal ground
6	DSR	—	Not used (data set ready)
7	RTS	Out	Request to send
8	CTS	In	Clear to send
9	RI	—	Not used (ring indicator)
Housing	Shield	—	Safety ground

RS-232 Signal Descriptions

Spacing (on or 0) occurs when RS-232 signals are between +6 and +12 V DC; marking (off or 1) occurs when they are between –6 and –12 V DC. The maximum cable length is 15 meters (50 feet), but can be extended using modems. The following table describes the RS-232 signals.

Signal	Designator	Description
Clear to Send	CTS	MP ignores CTS and transmits data as soon as it is available
Request to Send	RTS	MP turns on RTS unconditionally
Data Carrier Detect	DCD	MP ignores DCD and always accepts data from RXD
Transmit Data	TXD	MP transmits serial data
Receive Data	RXD	MP receives serial data

RS-485 Pin-Outs

DB-9 Pin	Signal	Direction	RS-485 Function
1	—	—	—
2	RD-A	In	Receive data
3	SD-A	Out	Transmit data
4	—	—	—
5	GND	—	Signal ground
6	—	—	—
7	SD-B	Out	Transmit data, invert
8	RD-B	In	Receive data, invert
9	OUT	Term	5 V DC through 1k Ω
Housing	Shield	—	Safety ground

RS-485 Signal Descriptions

RS-485 signals are transmitted over a cable of twisted-pair-wires. The polarity of the 2-to-6-Volt differential between the two wires indicates whether the data is marking or spacing. If terminal A is negative with respect to terminal B, the line is marking. If terminal A is positive with respect to terminal B, the line is spacing. The maximum cable length is dependent on the wire used. For example, using 24-AWG twisted-pair wire, the maximum length is 1.2 kilometers (4000 feet), but can be extended using modems. The following table describes the RS-485 signals.

Signal	Designator	Description
Transmit Data Transmit Data, Inverted	SD-A SD-B	MP transmits serial data
Receive Data Receive Data, Inverted	RD-A RD-B	MP receives serial data
Signal Ground	GND	Signal ground
5 V DC through 1k Ω		Not used

CM Baseplate Connectors

The CM Baseplate provides the following connectors and MAUs:

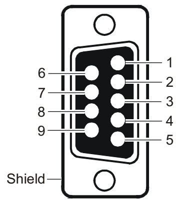
- Modbus RS-232/RS-485 serial connectors
- Ethernet 10BaseT Net1 connectors
- AUI 10-megabit Ethernet MAUs
- Ethernet 100BaseTX Net2 connectors
- MII Ethernet MAUs
- Debug connector

For an illustration of the CM Baseplate, see “Model 2201 Communication Module Baseplate” on page 47.

Modbus RS-232/RS-485 Serial Connector

Pin-out information for a Modbus serial connector is shown on page 206. The Modbus port, which is DTE-compatible, is configured using TriStation to operate in either RS-232 or RS-485 mode.

RS-232 Pin-Outs



DB-9 Pin	Signal	Direction	RS-232 Function
1	CD	In	Carrier detect
2	RXD	In	Receive data
3	TXD	Out	Transmit data
4	DTR	Out	Data terminal ready
5	GND	—	Signal ground
6	DSR	—	Not used (data set ready)
7	RTS	Out	Request to send
8	CTS	In	Clear to send
9	RI	—	Not used (ring indicator)
Housing	Shield	—	Safety ground

RS-232 Signal Descriptions

Spacing (on or 0) occurs when RS-232 signals are between +6 and +12 V DC; marking (off or 1) occurs when they are between –6 and –12 V DC. The maximum cable length is 15 meters (50 feet), but can be extended using modems. The following table describes the RS-232 signals.

Signal	Designator	Description
Clear to Send	CTS	MP ignores CTS and transmits data as soon as it is available
Request to Send	RTS	MP turns on RTS unconditionally
Data Carrier Detect	DCD	MP ignores DCD and always accepts data from RXD
Transmit Data	TXD	MP transmits serial data
Receive Data	RXD	MP receives serial data

RS-485 Pin-Outs

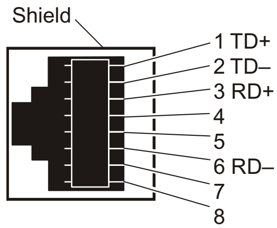
DB-9 Pin	Signal	Direction	RS-485 Function
1	—	—	—
2	RD-A	In	Receive data
3	SD-A	Out	Transmit data
4	—	—	—
5	GND	—	Signal ground
6	—	—	—
7	SD-B	Out	Transmit data, invert
8	RD-B	In	Receive data, invert
9	OUT	Term	5 V DC through 1k Ω
Housing	Shield	—	Safety ground

RS-485 Signal Descriptions

RS-485 signals are transmitted over a cable of twisted-pair-wires. The polarity of the 2-to-6-Volt differential between the two wires indicates whether the data is marking or spacing. If terminal A is negative with respect to terminal B, the line is marking. If terminal A is positive with respect to terminal B, the line is spacing. The maximum cable length is dependent on the wire used. For example, using 24-AWG twisted-pair wire, the maximum length is 1.2 kilometers (4000 feet), but can be extended using modems. The following table describes the RS-485 signals.

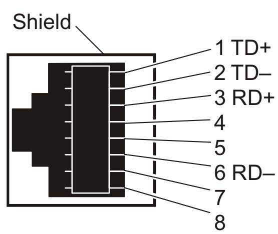
Signal	Designator	Description
Transmit Data Transmit Data, Inverted	SD-A SD-B	MP transmits serial data
Receive Data Receive Data, Inverted	RD-A RD-B	MP receives serial data
Signal Ground	GND	Signal ground
5 V DC through 1 KΩ		Not used

Ethernet 10BaseT Net1 Connectors



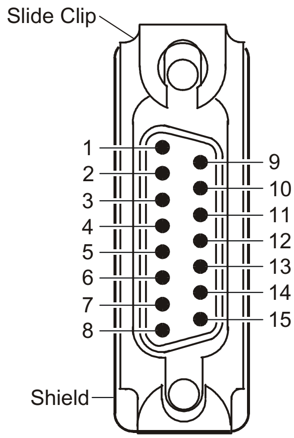
RJ-45 Pin	Signal	Direction	Function
1	TD+	Out	Transmit data +
2	TD-	Out	Transmit data –
3	RD+	In	Receive data +
4	NC	—	
5	NC	—	
6	RD-	In	Receive data –
7	NC	—	
8	NC	—	
Housing	Shield	—	Safety ground

Ethernet 100BaseTX Net2 Connectors



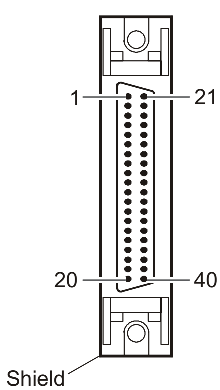
RJ-45 Pin	Signal	Direction	Function
1	TD+	Out	Transmit data +
2	TD-	Out	Transmit data –
3	RD+	In	Receive data +
4	NC	—	
5	NC	—	
6	RD-	In	Receive data –
7	NC	—	
8	NC	—	
Housing	Shield	—	Safety ground

AUI 10 Megabit Ethernet MAU Connectors



DB15 Pin	Signal	Direction	Function
1	Ground	—	
2	CI+	In	Transmit data –
3	DO+	Out	Data output +
4	Ground	—	
5	DI+	In	Data input +
6	Ground	—	Receive data –
7	NC	—	
8	Ground	In	MAU present detect
9	CI–	In	Collision input –
10	DO–	Out	Data output –
11	Ground	—	
12	DI–	In	Data input –
13	+12 V	Out	MAU power –
14	Ground	—	
15	NC	—	

MII Ethernet MAU Connectors



DB40 Pin	Signal	Direction	Function
1	+5 V	Out	MII MAU power
2	MDIO	In/Out	Management data
3	MDC	Out	Management data clock
4	RxD<3>	In	Receive data 3
5	RxD<2>	In	Receive data 2
6	RxD<1>	In	Receive data 1
7	RxD<0>	In	Receive data 0
8	Rx DV	In	Receive data valid

DB40 Pin	Signal	Direction	Function
9	Rx_Clk	In	Receive clock
10	Rx_Er	In	Receive error
11	Tx_Er	Out	Transmit error
12	Tx_Clk	In	Transmit clock
13	Tx_En	Out	Transmit enable
14	TxD<0>	Out	Transmit data 0
15	TxD<1>	Out	Transmit data 1
16	TxD<2>	Out	Transmit data 2
17	TxD<3>	Out	Transmit data 3
18	Col	In	Collision (half-duplex)
19	CRS	In	Carrier receive sense
20	+5 V	Out	MII MAU power
21	+5 V	Out	MII MAU power
22	Logic ground	—	MII MAU logic ground
23	Logic ground	—	MII MAU logic ground
24	Logic ground	—	MII MAU logic ground
25	Logic ground	—	MII MAU logic ground
26	Logic ground	—	MII MAU logic ground
27	Logic ground	—	MII MAU logic ground
28	Logic ground	—	MII MAU logic ground
29	Logic ground	—	MII MAU logic ground
30	Logic ground	—	MII MAU logic ground

DB40 Pin	Signal	Direction	Function
31	Logic ground	—	MII MAU logic ground
32	Logic ground	—	MII MAU logic ground
33	Logic ground	—	MII MAU logic ground
34	Logic ground	—	MII MAU logic ground
35	Logic ground	—	MII MAU logic ground
36	Logic ground	—	MII MAU logic ground
37	Logic ground	—	MII MAU logic ground
38	Logic ground	—	MII MAU logic ground
39	Logic ground	—	MII MAU logic ground
40	+5 V	Out	MII MAU power

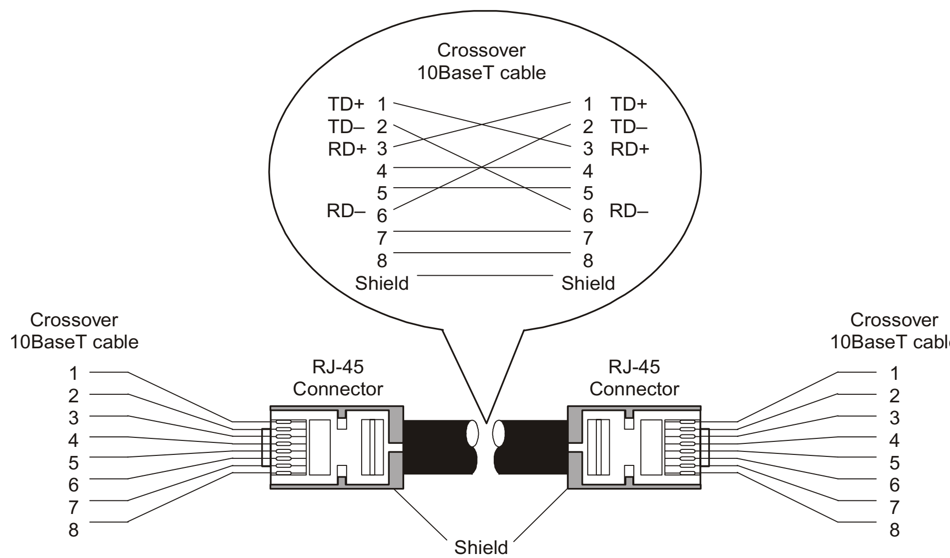
10BaseT Network Cables for TriStation

The following network cables are available for connecting the MPs to a TriStation PC.

Model	Description
1600044-020	10BaseT cross-over cable, 6 m (20 f)
1600045-020	10BaseT straight-through cable, 6 m (20 ft)

10BaseT Cross-Over Cable

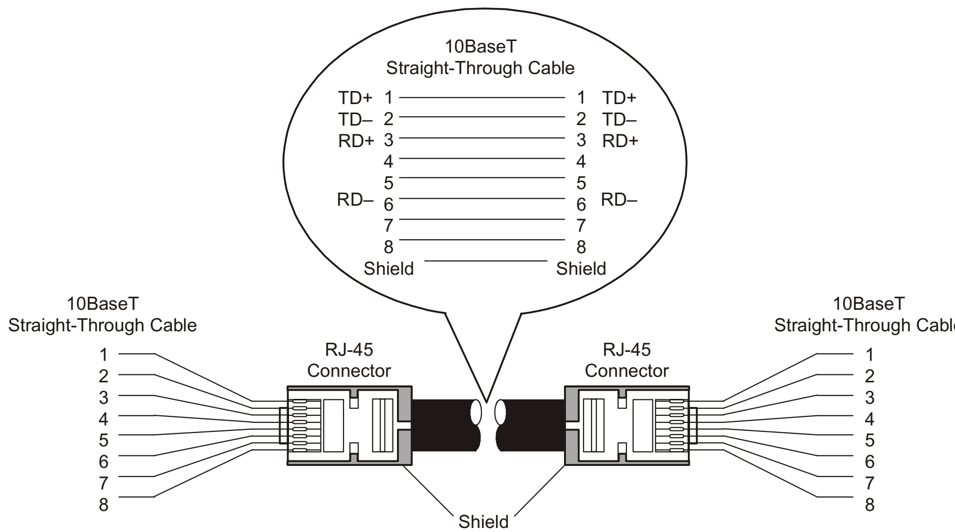
Cross-over cables are used to link the Ethernet card on a PC to the 10BaseT Ethernet connectors on the MP Baseplate.



10BaseT Straight-Through Cable

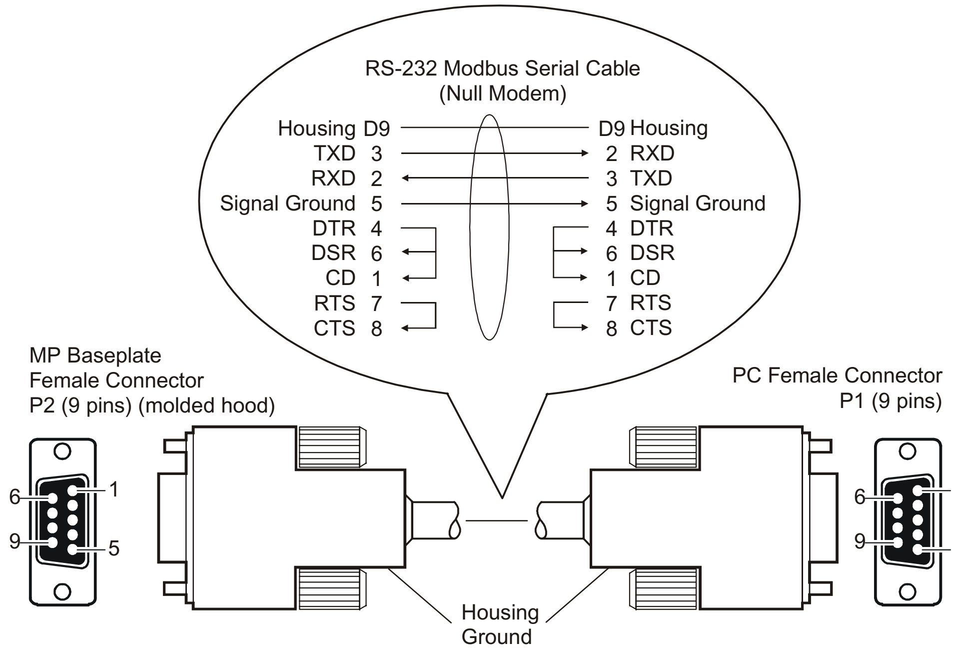
Straight-through cables are used to:

- Link the 10BaseT connector on the MP Baseplate to an Ethernet network hub
- Link the network hub to an Ethernet connector on a PC



RS-232 Modbus Serial Cable

The RS-232 Modbus serial cable is a standard null-modem cable used to link the Modbus connector on the MP Baseplate to a PC acting as the Modbus master. Cable pin-outs are shown below:

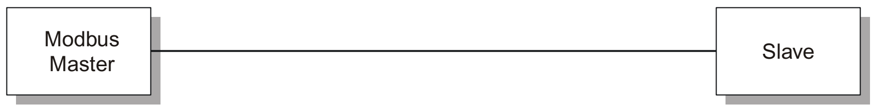


RS-485 Modbus Serial Cables

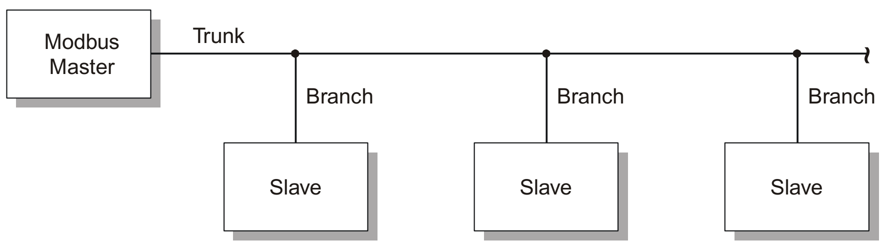
RS-485 Modbus serial cables are used for point-to-point and multi-point connections between an MP or CM and a Modbus master.

The first figure below shows a point-to-point connection between a Modbus master and one slave only. The second figure shows a multi-point connection which includes one Modbus master and 2 to 32 slaves.

Point-to-Point Connection



Multi-Point Connection



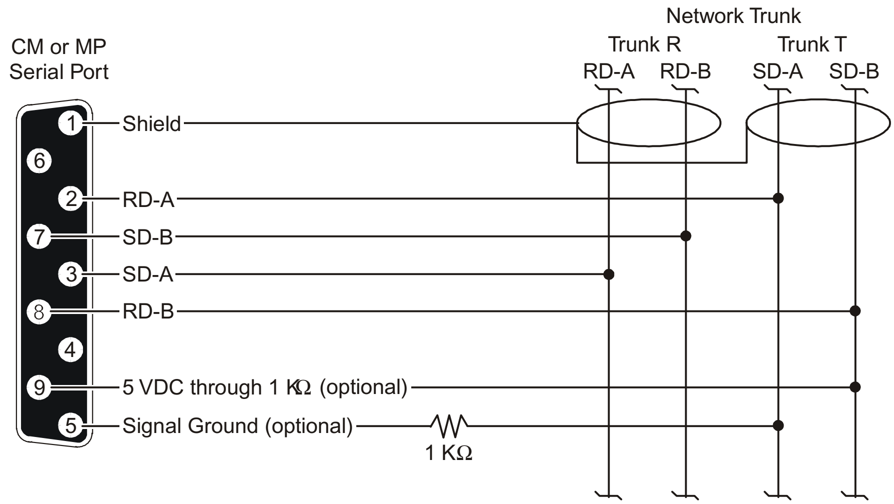
The MP and CM serial ports are configurable for multi-point RS-485 operation without using modems. The following table shows the RS-485 network specifications.

Item	Specification
Nodes	One Modbus master and one slave
Cable length	Cable dependent—1.2 km (4000 ft) maximum using 24-AWG twisted-pair wire (shielding recommended)
Transmission rate (bps)	1200, 2400, 4800, 9600, 19.2 K, 38.4 K, 57.6 K, 115.2 K

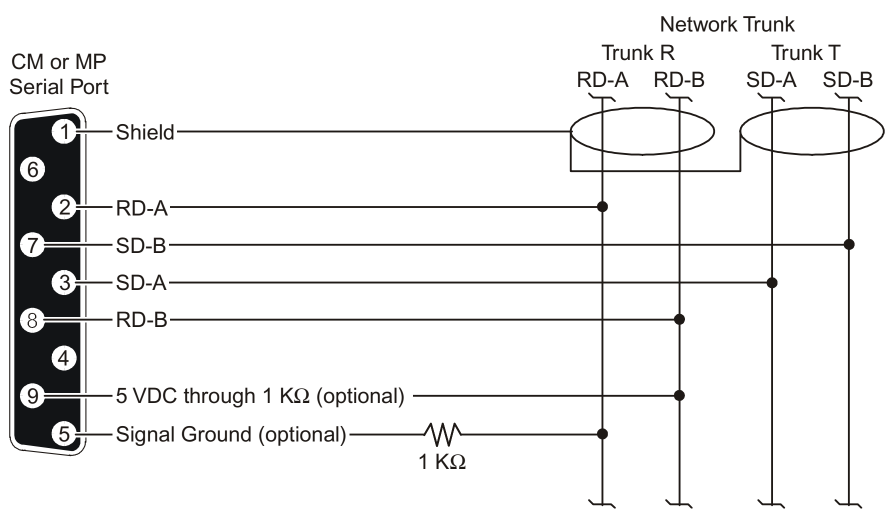
The network trunk should consist of double twisted-pair wires. When the trunk consists of double twisted pairs, one pair serves as the output line for the Modbus master (input line to all slaves). The other pair serves as the input line to the Modbus master (output line from all slaves). When the trunk consists of a single twisted pair, it serves as both the output and input lines to the Modbus master and all slaves. The trunk accommodates up to 32 two-foot branches, without restriction on the distance between branches.The following figures show these connections as they should be made at the MP or CM.

When an MP or CM is a slave in a multi-point network, multiple transmitters connect to the same conductor. One transmitter can be active at any time; otherwise, the signal is distorted. Therefore, each node must be in the tristate (or off) mode. To set the tristate mode for the MP and CM, set the Handshake mode to Hardware using the Setup dialog box in TriStation’s Hardware Allocation screen.

RS-485 Modbus Slave Network



RS-485 Modbus Master Network



Cable Selection

When selecting an RS-485 cable for your Modbus network, you should observe the following guidelines:

- Maintain a cable impedance of greater than or equal to 100 ohms.
- Supply a separate shield for each twisted pair.
- Use double twisted-pair networks to house the pairs in a single sheath or in separate sheaths.
- Use branch cable of the same quality as the trunk cable, but of less rigid construction. For example, use Belden 9182 (150-ohm) for the trunk and Belden 9729 (150-ohm) for the branches.
- Follow all applicable local codes.
- Terminate the cable in the characteristic impedance of the cable.

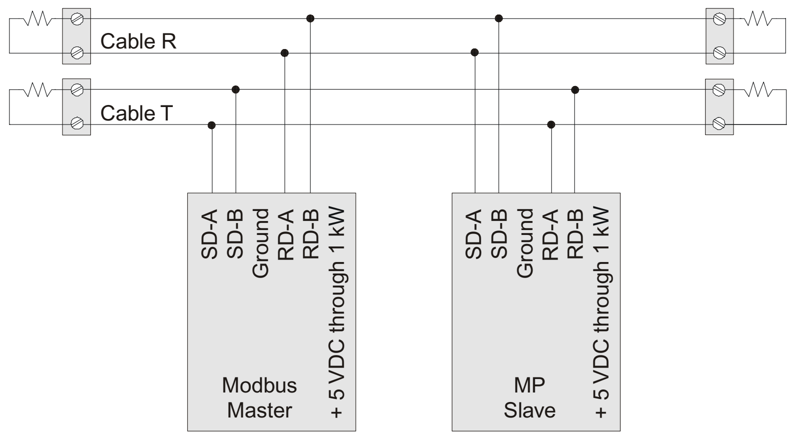
Cable Termination

RS-485 trunk cable termination (point-to-point or multi-point) greater than 200 meters (650 feet) requires termination at each end. Traditionally, resistors are connected to each end of the cable. This technique matches the cable impedance and prevents signal reflections which could cause data errors. However, this technique has the following three undesirable side effects:

- When no driver is active on the pair, the resistors pull the two wires together. Noise—even very low-level noise—can appear to be data when the wires are in this state.
- When a driver is active on the pair but not sending data, the resistors cause 33 mA of DC current to flow in the cable. This is an excessive load on the driver.
- When a driver is transmitting data over the cable, the resistors lower the signal level and consequently lower the immunity to noise.

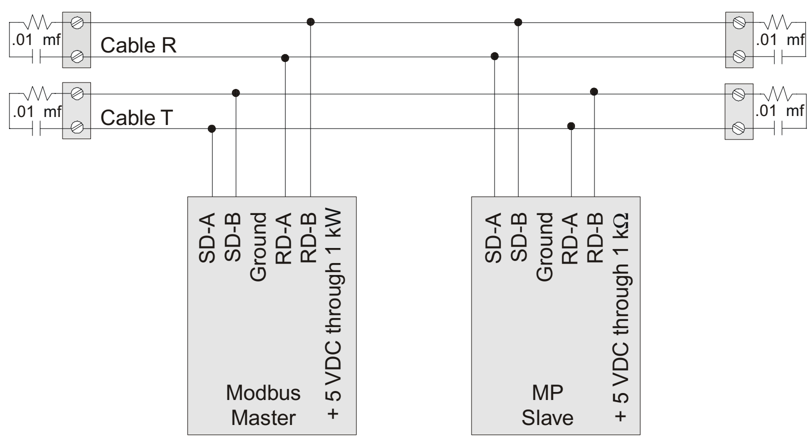
A better technique for terminating the cable pair is to use an RC network and pull-up/pull-down resistors. This reduces power consumption and forces the pair to a valid data state when no driver is active.

Traditional Network Termination



Note Resistor values must match the characteristic impedance of the cable.

Recommended Network Termination Using a Double-Pair Network



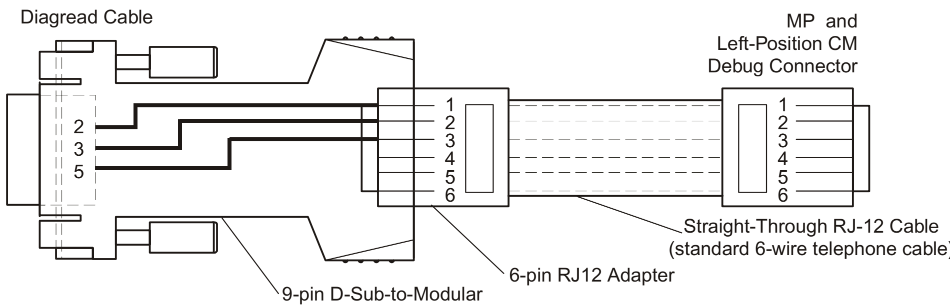
Note Resistor values must match the characteristic impedance of the cable.

Diagread Cables and Debug Connectors

Diagread cables and debug connectors are available for the MP, Communication, and I/O modules. As shown below, different pins on a RJ-12 connector are used for the MP, Communication, and I/O modules.

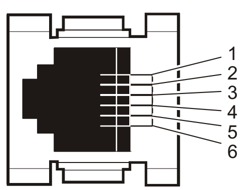
MPs and Left-Position CMs

Diagread Cable



Debug Connector for MPs

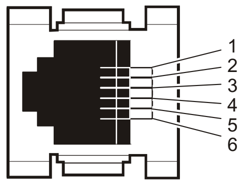
For the MP, the Debug connector uses pins 1, 2 and 3.



RJ-12 Pin	Signal	Direction	Description
1	TXD	Out	MP Diagread Transmit Data
2	RXD	In	MP Diagread Receive Data
3	GND	—	MP Ground

Debug Connector for Left-Position CMs

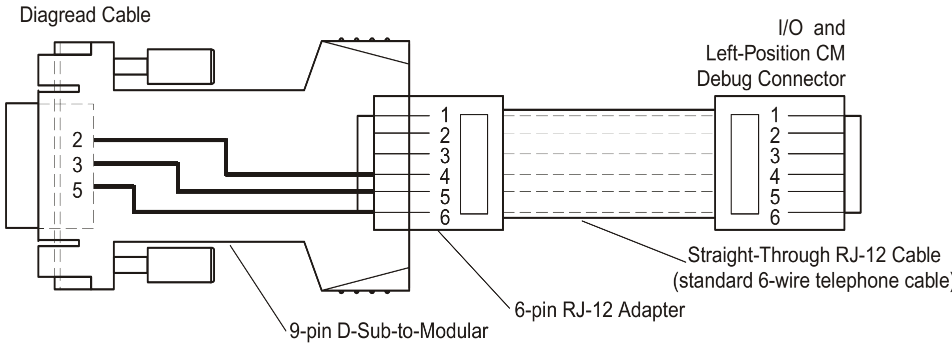
For the left-position CM, the Debug connector uses pins 1, 2. and 3.



RJ-12 Pin	Signal	Direction	Description
1	TXD	Out	CM Diagread Transmit Data
2	RXD	In	CM Diagread Receive Data
3	GND	—	CM Ground

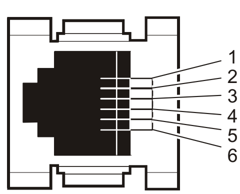
I/O Modules and Right-Position CMs

Diagread Cable



Debug Connector for I/O Modules

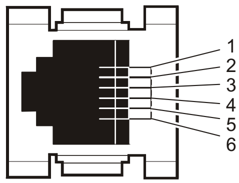
For the I/O modules, the Debug connector uses pins 4, 5 and 6.



RJ-12 Pin	Signal	Direction	Description
4	TXD	Out	IOP Diagread Transmit Data
5	RXD	In	IOP Diagread Receive Data
6	GND	—	IOP Ground

Debug Connector for Right-Position CMs

For the right-position CM, the Debug connector uses pins 4, 5, and 6.



RJ-12 Pin	Signal	Direction	Description
4	TXD	Out	CM Diagread Transmit Data
5	RXD	In	CM Diagread Receive Data
6	GND	—	CM Ground

Recommended Parts for Replacement

The table below lists the parts recommended by Triconex to replace existing parts. The table lists the parts, part numbers, relevant modules, and Triconex-approved manufacturers.

Part Description	Manufacturer	Part Number	Usage
Fuse, ¾ A	Triconex Littlefuse	1410054-001 273.75	SRO Baseplate
Fuse, 5x20 mm, 8 A, slow-acting	Triconex Littlefuse	1410056-001 218008	MP Baseplate and I/O Extender Module
Fuse, 5x20 mm, 1 A, fast-acting	Triconex Littlefuse	1410050-001 217001	MP Baseplate
16-point plug connector	Triconex Phoenix	1420048-001 1901742	I/O Baseplate
Expansion cable, 2-foot	Triconex	4000056-002	I/O Extender Module
Terminator	Triconex	4000138-001	I/O Extender Module
Address plug	Triconex	7400215-0xx (xx = address 01-32)	MP and I/O Baseplates

APPENDIX C

Recommended Wiring Methods

This appendix provides information related to recommended wiring.

Topics include:

- General considerations
- Conduit shielding
- Cable spacing
- Tray considerations
- Grounding

General Considerations

The following general considerations should be observed when installing the Trident system:

- Maintain an ambient air temperature of 60°C (140°F) or less at the bottom of each baseplate.
- Separate all 440 V AC (or higher) electrical supply lines as far away from the components as possible.
- Separate AC and data wiring as much as possible.
- Use best industry practices when installing wiring. For more information, see *IEEE Standard 518-1977.*
- Do not run cables parallel if they carry different types of signals (data versus power); instead, cross the cables at right angles.
- Maintain shield continuity and verify that shield leads are not broken.
- Route cables around, rather than through, high noise areas.
- Route shielded data cable along grounded surfaces such as metal cabinet walls and in conduit or trays. Single-shielded cable is most effective when routed along grounded surfaces.
- Allow the minimum amount of unshielded wire that will accommodate the connection.

Conduit Shielding

Conduit and cable trays route the network trunkline within the plant for short distances or for several miles. Often the same conduit carries both data and power wiring, creating a problem with electromagnetic interference. Your choice of materials and configuration for the cable conduit determines the degree of protection from this interference.

For detailed information on raceway shielding for conduits and trays, refer to *IEEE Standard 518-1982*, *Guide for the Installation of Electrical Equipment to Minimize Electrical Noise Inputs to Controllers from External Sources*.

Cable Spacing

You should separate noise-creating sources (those with time-varying voltage or time-varying current) from data signal cables as much as possible. Group cables with similar levels of noise susceptibility together. Group cables with similar levels of noise generation together in trays and conduit.

IEEE defines four classes of wiring that differ in signal level and noise susceptibility:

IEEE Class	Definition
Data 1	High-noise susceptibility Includes analog signals of less than 50 V and digital signals of less than 15 V
Data 2	Medium-noise susceptibility Includes analog signals greater than 50 V and switching circuits
Data 3	Low-noise susceptibility Includes the following: • Switching signals greater than 50 V • Analog signals greater than 50 V • Regulating signals of 50 V with currents less than 20 A • Feeders less than 20 A
Power	AC and DC buses of 0 – 1000 V with currents of 20 - 800 A

Tray Recommendations

General recommendations for using trays are as follows:

- When separate trays are impractical, place Data 1 and Data 2 cables in the same tray provided the cables are separated by a grounded steel barrier.
- Trays containing Data 1 and Data 2 cabling should have solid bottoms and tray covers to provide complete shielding.
- Ventilation slots or louvers should be used only in trays containing Data 3 cables.

Refer to IEEE Standard 518-1982 for detailed information about tray and conduit spacing.

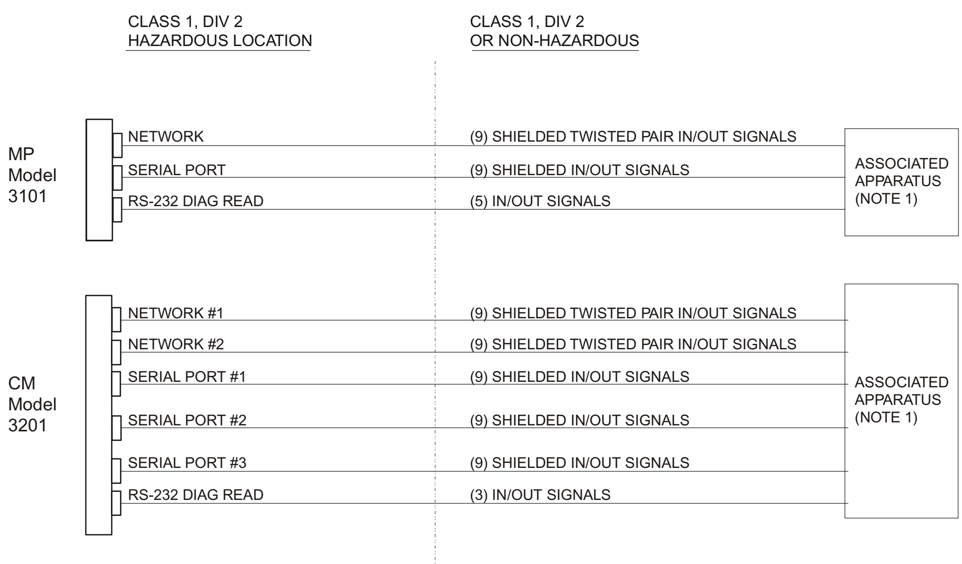
Grounding

For detailed information and instructions about grounding of the Trident system, see "Effective Grounding Methods" on page 149.

Non-Incendive Circuit Parameters

Special parameters apply to Main Processor Modules and Communication Modules for non-incendive communication circuits in the field. These parameters are shown in the following drawing, which are extracted from Triconex Drawing 9110043-001, REV. A.

Schematic of Non-Incendive Communication Circuits



Note 1 FMRC-approved apparatus. The voltage (Vmax) and current (Imax) that the load device can receive must be equal to or greater than the maximum open circuit voltage (Voc) and maximum short circuit current (Isc) that can be delivered by the source device. In addition, the maximum capacitance (Ci) and inductance (Li) of the load, which is not prevented by circuit components from providing a stored energy charge to the field wiring (for example, diode across a winding to clamp an inductive discharge), and the capacitance and inductance of the interconnecting wiring must be equal to or less than the capacitance (Ca) or inductance (La) that can be driven by the source device.

Signal Levels for Non-Incendive Communication Circuits

	MP Model 3101		CM Model 3201	
	NETWORK	SERIAL PORT and RS-232 DIAG READ	NETWORKS 1 and 2	SERIAL PORTS 1, 2, 3 and RS-232 DIAG READ
Voc/Vmax	1V/1V	10V/10V	1V/1V	10V/10V
Isc/Imax	1mA/1mA	30mA/30mA	1mA/1mA	30mA/30mA
Ca/Ci	11nf/11nf	15uF/0	11nf/11nf	15uF/0
La/Li	1.3mH/1.3mH	85mH/0	1.3mH/1.3mH	85mH/0

(NOTE 2)

Note 2 For detailed information on signal data (inputs or outputs), see the manufacturer's documentation.

APPENDIX E

Upgrades and Repairs

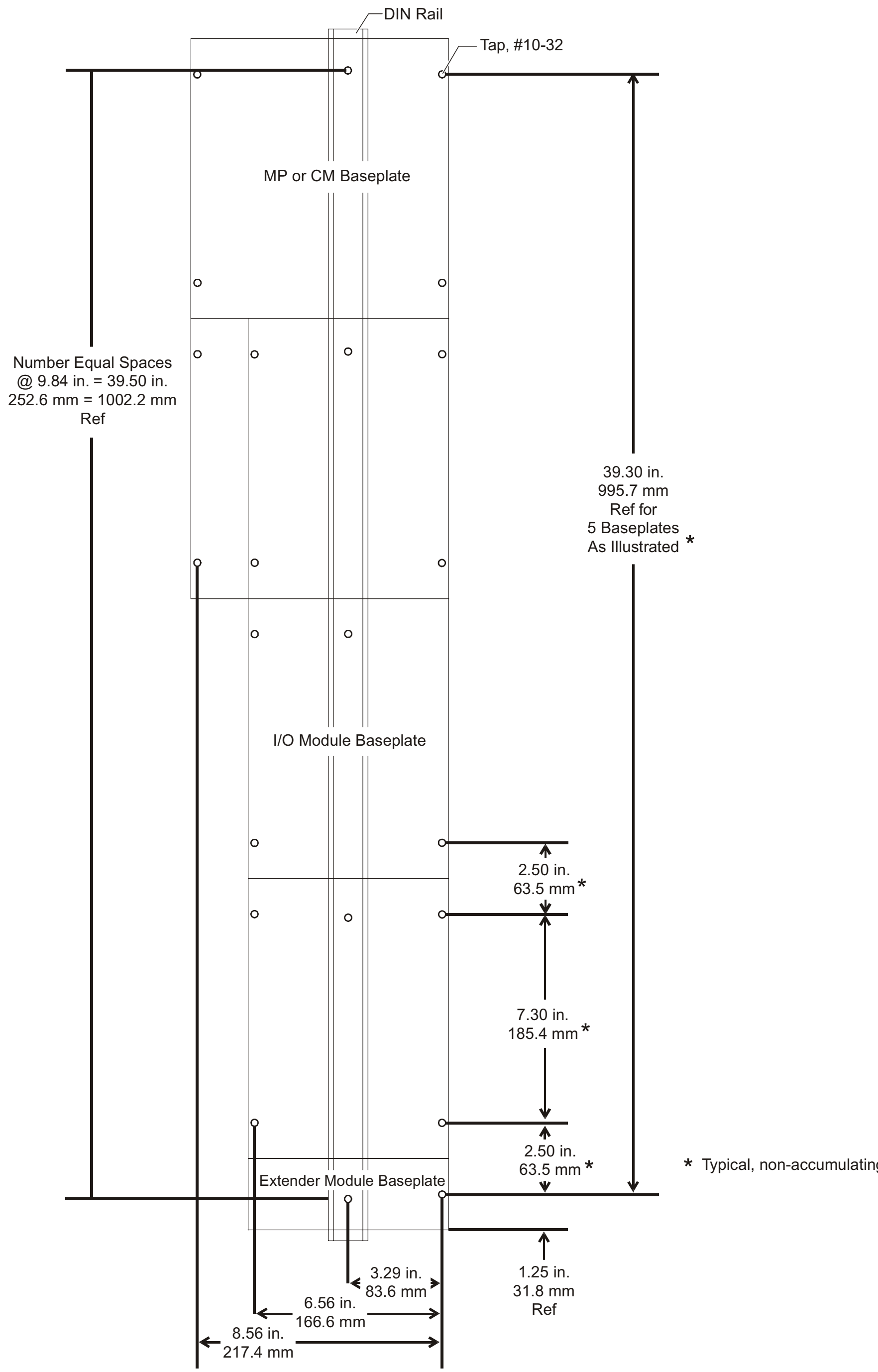
Contact your local customer service representative for firmware updates and the availability of special cables for:

- Adding or replacing the last baseplate in a column without an I/O Extender Module
- Adding or replacing the last baseplate in a column with an I/O Extender Module
- Adding or replacing a baseplate between two baseplates

APPENDIX F

Mounting Panel Drill Template

The following figure shows where the mounting holes should be located.


DIN Rail
Tap, #10-32
MP or CM Baseplate
Number Equal Spaces
@ 9.84 in. = 39.50 in.
252.6 mm = 1002.2 mm
Ref
39.30 in.
995.7 mm
Ref for
5 Baseplates
As Illustrated *
I/O Module Baseplate
2.50 in.
63.5 mm *
7.30 in.
185.4 mm *
2.50 in.
63.5 mm *
* Typical, non-accumulating
Extender Module Baseplate
1.25 in.
31.8 mm
Ref
3.29 in.
83.6 mm
6.56 in.
166.6 mm
8.56 in.
217.4 mm

APPENDIX G

EU Declaration of Conformity

The following declaration of conformity with the European Union directives for electromagnetic compatibility and low-voltage equipment is provided as a convenience. The declaration is the latest available at publication time may have been superseded. For updates, contact the factory.

Invensys Process Systems
15345 Barranca Parkway
Irvine, Ca 92618 USA

EU-Declaration of Conformity

The EU Directives covered by the 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

Trident (Triple Modular Redundant Controller) Version 1.1 – 2101, 2201, 2301, 2351, 2352, 2381, 2401, 2451, 2481, 3101, 3201, 3301, 3351, 3381, 3401, 3451, 3481, 3482, extender modules, and I/O bus cabling

The Basis on which Conformity is being Declared

The product identified above complies with the requirements of the above EU Directives by meeting the following 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
	PrEN 61000-4-12:1994	Ringwave
3.	**EN 61131-2:1994/A11:1996**	**Product Safety**
	EN 61010-1:1993	Overvoltage Category II

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: 2000.

Special Measures and Limitations which must be Observed

The product must be installed and operated as described in the Trident V1.2 Planning & Installation Guide.

The products described above comply with the essential requirements of the directives of the directives specified.

Signed: Scott Miller 6-1-2001

Scott Miller, Vice President Technical Programs, Invensys Process Systems

APPENDIX H

Warning Labels

This appendix provides a physical description of warning labels which must be prominently attached to the controller for systems in which the following hazards apply:

- General Hazard
- Hazardous Voltage
- Hot Surface

Labels must meet the requirements of ANSI Z535, ISO 3864, and IEC 1310-1.

Labels are available from Triconex upon request.

General Hazard

The following figure is an example of a general-hazard label.

†Safety Word

WARNING
Black letters, orange background
Safety orange per ANSI Z535.4
13 parts yellow, 3 parts warm red, ¼ part black

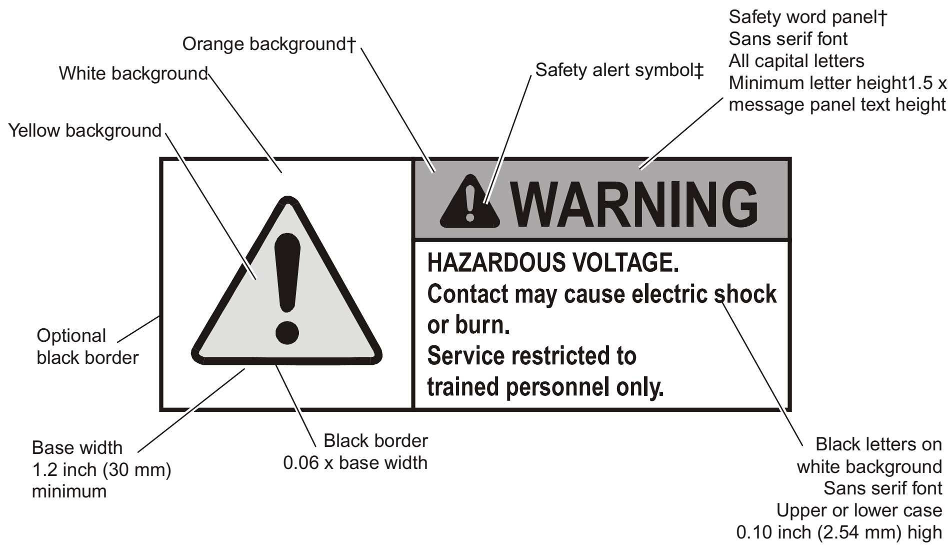
‡Safety Alert Symbol

Black triangle, orange exclamation point

The label must meet the requirements of ANSI Z535, ISO 3864, and IEC 1310-1.
Labels are available from Triconex upon request.

Hazardous Voltage

The following figure is an example of a hazardous-voltage label.



†Safety Word

WARNING
Black letters, orange background
Safety orange per ANSI Z535.4
13 parts yellow, 3 parts warm red, ¼ part black

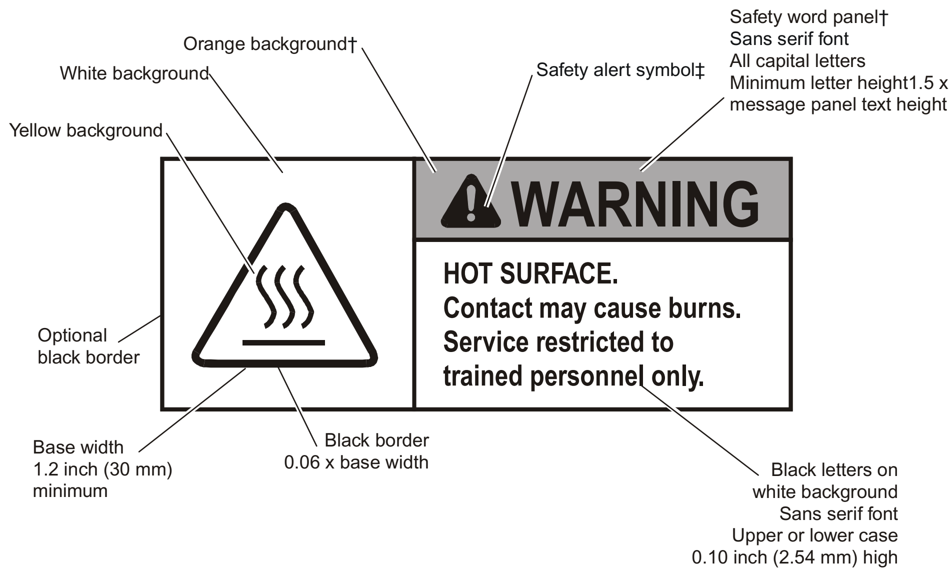
‡Safety Alert Symbol

Black triangle, orange exclamation point

The label must meet the requirements of ANSI Z535, ISO 3864, and IEC 1310-1.
Labels are available from Triconex upon request.

Hot Surface

The following figure is an example of a hot-surface label.



†Safety Word

WARNING
Black letters, orange background
Safety orange per ANSI Z535.4
13 parts yellow, 3 parts warm red, ¼ part black

‡Safety Alert Symbol

Black triangle, orange exclamation point

The label must meet the requirements of ANSI Z535, ISO 3864, and IEC 1310-1.
Labels are available from Triconex upon request.

Glossary

AI Module	Analog Input Module.
alias	Five-digit number that the system uses in place of a variable name when communicating with an external host. The alias is a convention of Modbus, an industry-standard protocol adopted by Triconex for use with its communication modules. Each alias contains a Modbus message type and the address of the variable in the system.
ASIC	Application-specific integrated circuit.
availability	Probability that the controller is operational at some instant of time.
bin	Address range of system aliased variables based on class and type combinations. For example, all Read Only Input Discrete variables are grouped into Bin 2, and all Read/Write Memory Integer variables are grouped into Bin 12.
CE Mark	Certification by the European Union which ensures the electro-magnetic compatibility of the system with other pieces of electrical/electronic equipment.
channel	Data path from input point to output point. Triple modular redundant (TMR) systems have three channels.
CSA	Canadian Standards Association, a not-for-profit membership organization which develops standards and tests in areas ranging from nuclear power, health care, occupational health and safety, housing and construction materials to the electrical, electronic and telecommunications fields. CSA certification of a product generates consumer confidence in many countries.
configuration	Arrangement of the programmable electronics within a system and the combination of programmable and non-programmable equipment within the installation.
control system	Governs the operation of plant, machinery or other equipment by producing appropriate instructions in response to input signals.
coverage	Probability that a particular class of fault is successfully detected before a system failure occurs.

DCS Distributed control system.

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

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

DI Module Digital Input Module.

DO Module Digital Output Module.

dual module Digital Output Module which is optimized for safety-critical environments where low cost is more important than maximum availability. A dual module is equipped with one parallel or series signal path and applies the 2-out-of-3 voting process individually to each switch. While quadruplicated output circuitry provides multiple redundancy for all critical signal paths, dual circuitry provides just enough redundancy to ensure safe operation.

environment Stimuli at an interface (or interfaces) of the system.

error Element of a system resource assumes an undesired state. Such a state is then contrary to the specification of the resource or the expectation (requirement) of the user.

event State change of a discrete aliased variable which has been designated for event logging. An event is said is to occur if such a variable *changes from* the normal state. If the variable later *changes back* to the normal state, another event is said to have occurred.

event logger Program that logs, displays and/or prints critical events in real time, based on state changes of discrete variables in the program. Proper use of an event logger warns users about dangerous conditions and printouts of events can help identify the sequence of events that led to a trip.

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

external host Computer, such as a mainframe, minicomputer, workstation, or PC that communicates with the controller over an Ethernet open network.

fail-safe Characteristic of a device or system to always revert to a safe, predictable state, even when one or more of its internal elements has failed.

failure System resource perceives that a service resource ceases to deliver the expected services. The fault-tolerant system masks most failures. See “fault”.

failure rate Rate at which failures occur over time. Usually expressed in failures per million hours. The inverse of failure rate is MTTF.

fault Cause of a resource failure or an error within the resource.

fault avoidance Result of conservative design techniques using high-reliability components, system burn-in, and careful design. The goal of fault avoidance is to reduce the possibility of a failure by designing a device with performance margins so large that the probability of a detrimental failure is negligible.

fault masking Means of removing failed elements from influencing system operation while enabling properly operating redundant elements to continue the control process.

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

FE Functional earth.

FSR Full-scale range. Specifies an operating range for input or output signals. For example, if 0-5V is the “range,” then 5V is the “full scale”.

host See external host.

hot spare Ability to install spare I/O modules with automatic switchover to the spare if the primary module fails.

input poll time Time required by the controller to collect input data from the controlled process. Input polling is asynchronous and overlaps application execution.

I/A Series DCS Foxboro Industrial Automation (I/A) Series Distributed Control System.

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

ISO International Organization for Standardization (ISO) is a world-wide federation of national standards bodies (ISO member bodies) that promulgates standards affecting international commerce and communications.

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

LED — Light-emitting diode. One of the color-coded signal lights on each controller circuit board that indicates the board's status. Each system component includes at least the Pass, Fail, and Active LEDs.

logical slot — Logical slot comprises a primary module, a hot-spare module, and associated field termination components. A baseplate is a physical representation of a logical slot.

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

MP — Main Processor Module.

module — Active field-replaceable unit consisting of an electronic circuit assembly housed in a metal cover.

MTBF — Mean-time-between-failure. The expected average time between failures of a system, including the time taken to repair the system. Usually expressed in hours.

MTTF — Mean-time-to-failure. The expected average time to a system failure in a population of identical systems. Usually expressed in hours.

MTTR — Mean-time-to-repair. The expected time to repair a failed system or subsystem. Usually expressed in hours.

node — Any of the machines on a network.

node number — Physical address of a node.

non-triplicated module — I/O module with a single set of field-interface circuitry for communication with all three main processor modules. Non-triplicated modules provide a cost-effective alternative to the use of TMR modules for non-critical environments.

open network — Network to which an external host can be connected.

output poll time — Time required by the controller to implement the outputs generated by the application in response to inputs from the controlled process.

PE — Protective earth.

PES — Programmable electronic system.

peer-to-peer Protocol that allow multiple systems on a proprietary network to exchange process and safety information.

permanent fault Failure, fault or error in the system that is continuous and stable.

PHA Process hazard analysis.

process demand Occurrence of a process deviation that results in the SIS initiating a trip of the process unit.

program Basic programming unit within a project. A set of instructions, commands, and/or other directions. In TriStation 1131, programs are written in any of the available languages, and are subsequently placed within a project's hierarchy.

programmable logic controller "Black box" device which accepts analog or digital input signals, acts upon them in a well-defined way, and produces appropriate output signals as a result.

proprietary network Network of controllers.

protocol Set of rules describing the format used for data exchange between two entities.

quad output circuit Provides fault-tolerant outputs. Each output is composed of four identical switching elements in a "quad" arrangement.

reliability Probability that no failure of the system will occur in a given period of time.

scan time Period of the controller's cycle of required control functions. Scan time is composed of three elements:

- Input poll time (asynchronous with program execution)
- Time required to execute the program
- Output poll time

SIL Safety integrity level.

single module Digital Input Module which is optimized for safety-critical environments where low cost is more important than maximum availability. On a single module, only those portions of the signal path which are required to ensure safe operation are triplicated. Special self-test circuitry detects all stuck-on and stuck-off fault conditions in less than half a second.

SIS Safety instrumented system.

SRS Safety requirements specification.

SRO Module Solid-State Relay Output Module.

system Set of components which interact under the control of a design.

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

time sync Triconex Time Synchronization protocol.

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

TMR Triple-Modular-Redundant architecture, which allows the system to achieve fault tolerance. The complete system is triplicated; each of the three identical systems is called a channel. Each channel independently executes the application in parallel with the other channels.

Trident State-of-the-art programmable logic and process controller that provides a high level of fault tolerance.

trip Safety-related shutdown of the controlled process, or a portion of the controlled process.

TriStation 1131 TriStation 1131 is a Windows NT-based developer’s workbench for writing and downloading applications and for performing maintenance and diagnostics on Triconex systems.

TriStation protocol Master/slave protocol used by a TriStation for communication with the system. The TriStation protocol supports a maximum of 10 systems, but each master can communicate with only one slave at a time.

TSAA Triconex System Access Application (TSAA) protocol is a master-slave protocol in which the master (an external host) communicates with one or more slaves over an open network. TSAA supports a maximum of ten controllers.

TÜV Rheinland Technischer Überwachungs-Verein in German or Technical Supervisory Association in English. In Germany, TÜV Rheinland is an authorized technical inspection agency for a wide variety of products, processes, installations, plants, and equipment. In addition, the agency is authorized to carry out statutory inspections and acceptance tests by more than 25 other countries.

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

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

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