ControlLogix SIL 2 Applications

ControlLogix 5570 Controllers with 1756, 1794, or 1715 I/O

Allen-Bradley by ROCKWELL AUTOMATION

Safety Reference Manual

Original Instructions

Important User Information

Read this document and the documents listed in the additional resources section about installation, configuration, and operation of this equipment before you install, configure, operate, or maintain this product. Users are required to familiarize themselves with installation and wiring instructions in addition to requirements of all applicable codes, laws, and standards.

Activities including installation, adjustments, putting into service, use, assembly, disassembly, and maintenance are required to be carried out by suitably trained personnel in accordance with applicable code of practice.

If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

In no event will Rockwell Automation, Inc. be responsible or liable for indirect or consequential damages resulting from the use or application of this equipment.

The examples and diagrams in this manual are included solely for illustrative purposes. Because of the many variables and requirements associated with any particular installation, Rockwell Automation, Inc. cannot assume responsibility or liability for actual use based on the examples and diagrams.

No patent liability is assumed by Rockwell Automation, Inc. with respect to use of information, circuits, equipment, or software described in this manual.

Throughout this manual, when necessary, we use notes to make you aware of safety considerations.

WARNING: Identifies information about practices or circumstances that can cause an explosion in a hazardous environment, which may lead to personal injury or death, property damage, or economic loss.

ATTENTION: Identifies information about practices or circumstances that can lead to personal injury or death, property damage, or economic loss. Attentions help you identify a hazard, avoid a hazard, and recognize the consequence.

IMPORTANT Identifies information that is critical for successful application and understanding of the product.

These labels may also be on or inside the equipment to provide specific precautions.

SHOCK HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that dangerous voltage may be present.

BURN HAZARD: Labels may be on or inside the equipment, for example, a drive or motor, to alert people that surfaces may reach dangerous temperatures.

ARC FLASH HAZARD: Labels may be on or inside the equipment, for example, a motor control center, to alert people to potential Arc Flash. Arc Flash will cause severe injury or death. Wear proper Personal Protective Equipment (PPE). Follow ALL Regulatory requirements for safe work practices and for Personal Protective Equipment (PPE).

The following icon may appear in the text of this document.

Identifies information that is useful and can help to make a process easier to do or easier to understand.

ControlLogix Communication Modules

Chapter 4

1756 ControlLogix I/O Modules

Chapter 5

1794 FLEX I/O Modules

Chapter 6

SIL 2 Add-On Instructions for 1715 Redundant I/O Modules

Chapter 8

Requirements for Application Development

Chapter 9

Faults in the ControlLogix System

Chapter 10

Use of Human-to-Machine Interfaces

Chapter 11

Appendix A
System Reaction Times

Appendix B
SIL 2-certified ControlLogix System Components

Appendix C
PFD and PFH Calculations for 1756 ControlLogix and 1794 FLEX I/O Modules

Appendix D
PFD and PFH Calculations for 1715 Redundant I/O Modules

Appendix E
1756 ControlLogix and 1794 FLEX I/O Modules in SIL 1 Applications

Checklists

About This Publication

This safety reference manual describes the ControlLogix® control system components that are suitable for use in low demand and high demand (no more than 10 demands per year) safety-related control, up to and including SIL 2 applications. The manual also provides safety-related information, such as PFD calculations, system configurations, programming, and implementation.

Rockwell Automation recommends utilizing Logix SIS for a modern solution. Refer to the Logix SIS Safety Reference Manual for more information.

IMPORTANT	This manual describes typical SIL 2 implementations that use ControlLogix equipment. The descriptions in this manual do not preclude other methods of implementing a SIL 2-compliant system by using ControlLogix equipment. Make sure that a certifying body, such as TÜV Rheinland Group, reviews and approves other methods.

Summary of Changes

This publication contains the following new or updated information. This list includes substantive updates only and is not intended to reflect all changes.

Topic	Page
Added link to Logix SIS Safety Reference Manual 1756-RM015	9, 11
Changed requirements in Requirements for 1715 I/O Modules section	81
Changed version number	87
Changed values in Table 4	97
Changed values in Tables 5 and 6	100
Changed values in Table 14	138
Changed value in Communications data	176
Changed screenshots	91, 103, 107, 108, 109, 110, 111, 112, 113, 114

Terminology

This table defines abbreviations that are used in this manual.

Abbreviation	Full Term	Definition
CIP™	Common Industrial Protocol	An industrial communication protocol that Logix 5000-based automation systems on EtherNet/IP™, ControlNet®, and DeviceNet® communication networks uses.
CL	Claim Limit	The maximum level that can be achieved.
DC	Diagnostic Coverage	The ratio of the detected failure rate to the total failure rate.
—	Demand	A safe state safety action that the safety function initiates. A normal control action/function is not a safety demand. A safety demand occurs when safety conditions are met. Typically, a safety demand only occurs when standard control fails to perform its control function.
—	Demand Rate	The expected rate per year that the safety function executes a safe state safety action.
EN	European Norm.	The official European Standard.
GSV	Get System Value	A ladder logic instruction that retrieves specified controller information and places it in a destination tag.
MTBF	Mean time between failures	The predicted elapsed time between inherent failures of a system during operation.
MTTR	Mean Time to Restoration	Average time that is needed to restore normal operation after a failure has occurred.
PADT	Programming and Debugging Tool	RSLogix 5000® and Studio 5000 Logix Designer® application is used to program and debug a SIL 2-certified ControlLogix application.
PFD	Probability of a Dangerous Failure on Demand	The average probability of a system to fail to perform its design function on demand.
PFH	Average Frequency of a Dangerous Failure per Hour	Average frequency of a dangerous failure of an E/E/PE safety-related system to perform the specified safety function over a given period of time.
SIF	Safety Instrumented Function	A function to be implemented by a Safety Instrumented System (SIS) which is intended to achieve and maintain a safe state with respect to a specific hazardous event. It has a specific safety integrity level necessary to meet functional safety.
SIL	Safety Integrity Level	A discrete level for specifying the safety integrity requirements of the safety functions allocated to the electrical/ electronic/ programmable electronic (E/E/PE) part of the safety system.
SIS	Safety Instrumented System	Instrumented system used to implement one or more safety instrumented functions (SIFs). It is composed by any combination of sensors, logic solvers, and final elements.
SFF	Safe Failure Fraction	The ratio of safe failure plus dangerous detected failure to total failures.
STR	Spurious Trip Rate	That part of the overall failure rate that does not lead to a dangerous undetected failure.
T_{CE}	Channel Equivalent Mean Downtime	The sum of downtime contributions from both the dangerous detected failure rate and the dangerous undetected failure rate, on a per channel basis.
T_{GE}	System Equivalent Downtime	The sum of downtimes that result from dangerous detected and dangerous undetected failure rates that are associated with both channels.
—	Useful Life	The useful lifetime is when burn-in failures have been corrected and wear-out failures have not yet begun. It is the flat part of the safety bathtub curve.

Additional Resources

These documents contain additional information concerning related products from Rockwell Automation. You can view or download publications at rok.auto/literature.

Resource	Description
ControlLogix SIL 2 System Configuration Using RSLogix 5000 Subroutines, publication 1756-AT010	Explains how to configure a SIL 2-certified system by using subroutines that are provided by Rockwell Automation.
ControlLogix SIL 2 System Configuration with Add-On Instructions for 1756 I/O Modules, publication 1756-AT012	Explains how to configure a SIL 2-certified system by using the Add-On Instructions that are provided by Rockwell Automation.
Redundancy Systems User Manual, publication 1756-UM015	Describes how to set up, configure, program, monitor, and troubleshoot Logix SIS, ControlLogix 5580, and ControlLogix 5570 redundancy systems.
Logix 5000 Controllers General Instruction Set Reference Manual, publication 1756-RM003	Contains descriptions and use considerations of general instructions available for Logix 5000® controllers.
Logix SIS Safety Reference Manual, publication 1756-RM015	Describes safety considerations for Logix SIS (safety instrumented system) operations.
Logix 5000 Controllers Common Procedures Programming Manual, publication 1756-PM001	Explains various programming-related topics.
High-Resolution Analog I/O Modules User Manual 1756-UM540	Describes how to install, configure, and troubleshoot ControlLogix analog I/O modules.
ControlLogix 5570 and 5560 Controllers User Manual, publication 1756-UM001	Provides design considerations, configuration procedures, and troubleshooting methods for ControlLogix 5570 and 5560 systems.
Redundant I/O System User Manual, publication 1715-UM001	Describes how to install, configure, program, operate, and troubleshoot a Redundant I/O system.
Using ControlLogix SIL 2 with 1715 I/O, publication 1715-RM001	Provides a quick start guide for using a ControlLogix SIL 2 system with 1715 I/O modules.
ControlLogix Digital I/O User Manual, publication 1756-UM058	Provides information about the use of ControlLogix digital I/O modules.
ControlLogix Analog I/O Modules User Manual, publication 1756-UM009	Provides information about the use of ControlLogix analog I/O modules.
EtherNet/IP Device Level Ring Application Technique, publication ENET-AT007	Describes Device Level Ring (DLR) topologies, configuration considerations, and diagnostic methods.
Logix 5000 Controllers Execution Time and Memory Use Reference, publication 1756-RM087	Provides estimated execution times that can be used in worst-case scenario calculations.
EtherNet/IP Network Devices User Manual, publication ENET-UM006	Describes how to configure and use EtherNet/IP devices to communicate on the EtherNet/IP network.
System Security Design Guidelines Reference Manual, publication SECURE-RM001	Provides guidance on how to conduct security assessments, implement Rockwell Automation products in a secure system, harden the control system, manage user access, and dispose of equipment.
Safety Guidelines for the Application, Installation, and Maintenance of Solid-state Control, publication SGI-1.1	Designed to harmonize with NEMA Standards Publication No. ICS 1.1-1987 and provides general guidelines for the application, installation, and maintenance of solid-state control in the form of individual devices or packaged assemblies incorporating solid-state components.
Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1	Provides general guidelines for installing a Rockwell Automation industrial system.
Product Selection and Configuration tools, rok.auto/systemtools	Helps configure complete, valid catalog numbers and build complete quotes based on detailed product information.
Rockwell Automation Global SCCR tool, rok.auto/sccr	Provides coordinated high-fault branch circuit solutions for motor starters, soft starters, and component drives.
Product Certifications website, rok.auto/certifications	Provides declarations of conformity, certificates, and other certification details.

Notes:

SIL Policy

⚠	ATTENTION: Personnel responsible for the application of safety-related programmable electronic systems (PES) shall be aware of the safety requirements in the application of the system and shall be trained in using the system.

Introduction to Safety Integrity Level (SIL)

The TÜV Rheinland Group has approved the ControlLogix® system for use in safety-related applications up to and including SIL 2 according to these standards:

- IEC 61508, edition 2.0
- IEC 61511

Approval requirements are based on the standards current at the time of certification. These requirements consist of detailed design process requirements, test requirements, software analysis, and hardware probability of failure analysis. Further, it is required to have the mean time between failures (MTBF), probability of failure, failure rates, diagnostic coverage, and safe failure fractions that fulfill SIL 2 criteria. The results make the ControlLogix system suitable up to and including SIL 2 for demand rates up to and including ten demands per year.

The TÜV Rheinland Group has approved the ControlLogix system for use in up to, and including, SIL 2 safety-related applications in which the de-energized state is typically considered to be the safe state.

Useful life for the ControlLogix SIL 2 components is 20 years. After that time period, the products must be replaced.

IMPORTANT	Keep in mind that a demand is an event where the safety function is executed. A ControlLogix system can be configured to execute standard control and safety functions. The demand rate is determined by how often the safety function is executed and not how often the control function is executed. When used in accordance with the information in this manual and the relevant safety standards, the ControlLogix system is suitable for applications up to and including SIL 2, where the demand rate is no more than 10 times per year.

For a list of SIL 2 certified catalog numbers, see Appendix B.

Programming and Debugging Tool (PADT)

For support in the creation of programs, the PADT (Programming and Debugging Tool) is required. The PADT for ControlLogix is RSLogix 5000® software or Studio 5000 Logix Designer® application, per IEC 61131-3, and this Safety Reference Manual.

For more information about programming an SIS with 1756 ControlLogix I/O modules by using optional pre-developed Add-On Instructions, see the SIL 2 System Configuration with Add-On Instructions for 1756 ControlLogix I/O Modules, publication 1756-AT012.

For more information about programming an SIS with 1715 I/O modules by using pre-developed Add-On instructions, see Chapter 8.

About the ControlLogix System

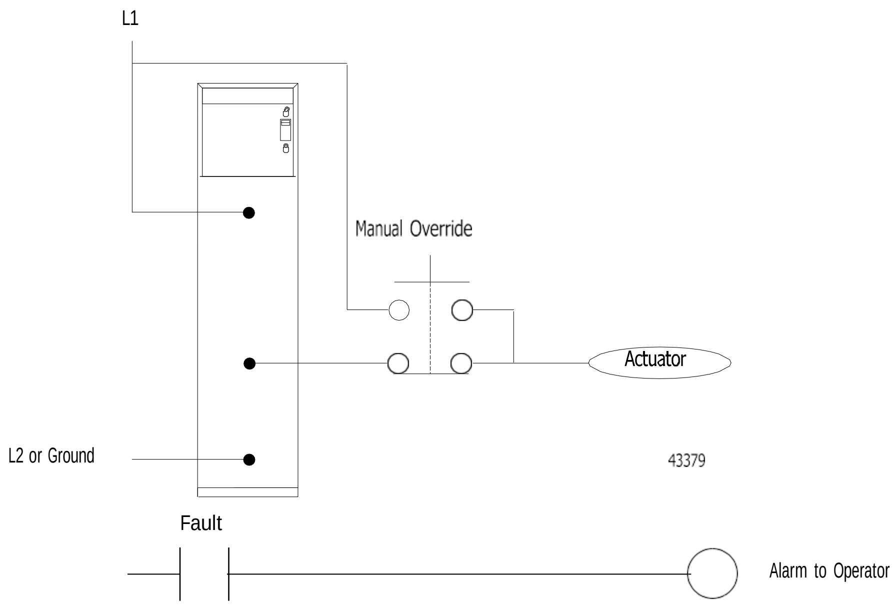
The ControlLogix system is a modular programmable automation system with the ability to pre-configure outputs and other responses to fault conditions. A system can be designed to meet requirements for 'hold last state' if there is a fault. Other requirements for SIL 2, such as inputs from sensors and software, must also be met.

Gas and Fire Considerations

The following measures and modifications are related to the use of the ControlLogix system in Gas and Fire applications:

- The use of a manual override is necessary to make sure that the operator can maintain the desired control if there is a controller failure. This is similar in concept to the function of the external relay or redundant outputs that are required to make sure that a de-energized state is achieved for an ESD system when a failure occurs (for example, a shorted output driver) that helps prevent this from normally occurring. The system knows that it has a failure, but the failure state requires an independent means to maintain control and either remove power or provide an alternate path to maintain power to the end actuator.
- If the application cannot tolerate an output that can fail shorted (energized), then an external means such as a relay or other output must be wired in series to remove power when the fail shorted condition occurs. See Wire 1756 Digital Input Modules on page 44 for more information.
- If the application cannot tolerate an output that fails open (de-energized), then an external means such as a manual override or output must be wired in parallel. See Figure 1. You must supply alternative means and develop the application program to initiate the alternate means to remove or continue to supply power in the event the main output fails.
- This manual override circuit is shown in Figure 1. It is composed of a hard-wired set of contacts from a selector switch or push button. One normally open contact provides for the bypass of power from the controller output directly to the actuator. The other is a normally closed contact to remove or isolate the controller output.
- Generate an application program to monitor the following:
  - Diagnostic output modules for dangerous failures, such as shorted or open-output driver channels
  - Output channel for lost connections to the controller
- A diagnostic alarm must be generated to inform the operator that manual control is required.
- The faulted module must be replaced within the Mean Time to Restoration (MTTR).
- Anytime a fault is detected, the system must annunciate the fault to an operator by some means (for example, an alarm light).

Figure 1 - Manual Override Circuit



Boiler and Combustion Considerations

If your SIL 2-certified ControlLogix system is used in combustion-related applications, you are responsible for meeting appropriate safety standards including National Fire Protection Association (NFPA) standard NFPA 85 and 86. In addition, you must provide a documented lifecycle-system safety analysis that addresses the requirements of NFPA 85 related to Burner Management System Logic.

To comply with the requirements of IEC 61508, the safety demand rate must be no more than 10 demands per year.

You must also consider system reaction capability as explained in Appendix A.

If your system requires compliance with standard EN 50156, then you must also meet the requirements that are identified in the current version of EN 50156. To use FLEX™ I/O or 1756-series I/O modules in SIL 2 EN50156 applications, you must use a GuardLogix® controller. See the GuardLogix Safety Reference Manual, publication 1756-RM093.

IMPORTANT	When using a GuardLogix controller with SIL 2-rated, standard 1756 ControlLogix I/O modules or 1794 FLEX I/O modules, you must also follow the requirements that are defined in this manual.

Typical SIL 2 Configurations

SIL 2-certified ControlLogix systems can be used in standard (simplex or single controller) or high availability (duplex or redundant controller) configurations. For the purposes of documentation, the various levels of availability that can be achieved by using various ControlLogix system configurations are referred to as simplex or duplex. When using a duplex ControlLogix configuration, the ControlLogix controller remains simplex (1oo1) from a safety perspective. This means only the primary controller is solving the safety application code at any given time.

This table lists each system configuration and the hardware that is part of the Safety Instrumented Function (SIF).

System Configuration	SIF Includes
Simplex Configuration on page 16	• Single controller • Single communication module • Dual I/O modules
Duplex Logic-Solver Configurations on page 24	• Dual controllers • Dual communication modules • Dual I/O modules
Duplex System Configuration on page 26	• Dual controllers • Dual communication modules • Dual I/O modules • I/O termination boards

IMPORTANT The system operator is responsible for the following tasks when any of the ControlLogix SIL 2 system configurations are used:
- The setup, SIL rating, and validation of any sensors or actuators that are connected to the ControlLogix control system
- Project management and functional testing
- Programming the application software and the module configuration according to the descriptions in this manual
- Change management process

The design of the SIS maintenance/engineering interface must make sure that any failure of this interface does not adversely affect the ability of the SIS to carry out the required SIFs. This can require that you disconnect maintenance and engineering interfaces, such as programming panels, during normal SIS operation.

Simplex Configuration

In a simplex configuration, the hardware that is used in the SIF is programmed to De-energize to Trip. This state is typically an emergency shutdown (ESD) where outputs are de-energized upon a safety demand.

Figures 2 ...9 show typical simplex SIL loops for limited high demand applications with up to 10 demands per year. The figures show the following:
- Overall SIF
- ControlLogix portion of the overall SIF

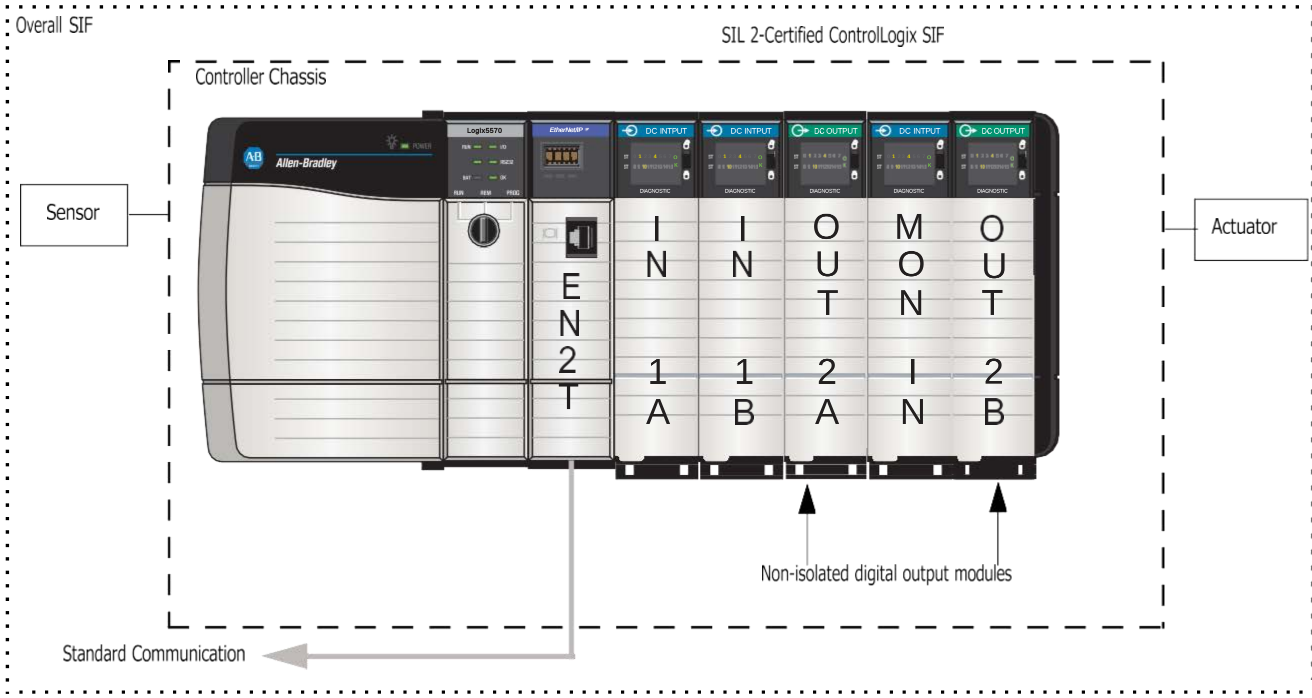
SIL 2 I/O modules in the SIF must meet the requirements that are specified in Chapter 5, Chapter 6, and Chapter 7. Chassis can have modules within a SIL 2 certified ControlLogix SIS that are not participating in any safety functions, if these modules are listed in the SIL 2-certified ControlLogix System Components on page 139.

Table 1 defines the module abbreviations that are used in the graphics in this section.

Table 1 - Legend for the Module Abbreviations

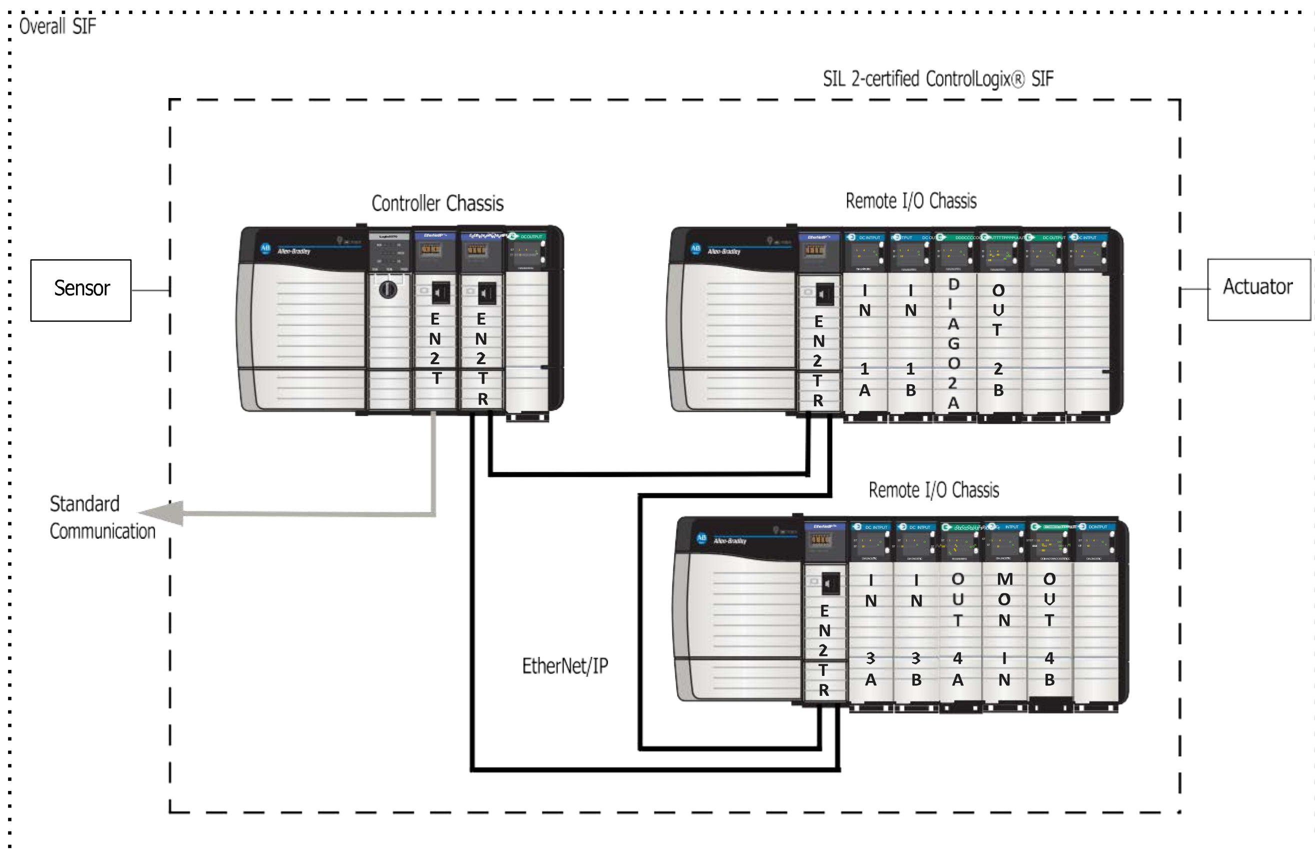
Item	Description
DIAGO	Diagnostic Output Module
IN	Input Module
ISOLO	Isolated Output Module
MONIN	Monitoring Input Module
Out	Non-Diagnostic Output Module
RLY	Relay Module
RM	ControlLogix Redundancy Module

Figure 2 - Single Chassis Configuration



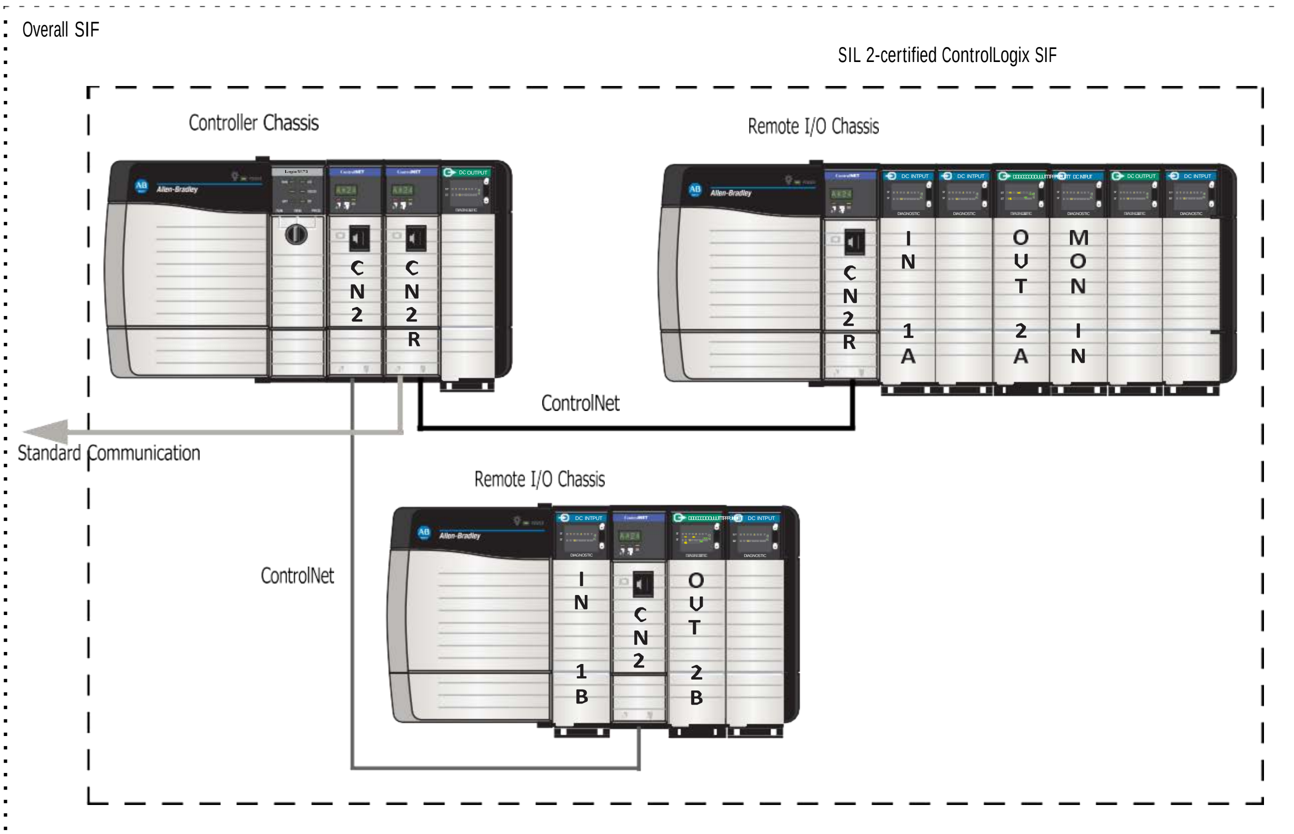
1756 SIL 2 I/O module pairs can be in the same chassis because only SIL 2 capable hardware is within the controller chassis. The number on the label indicates a module pair in a 1oo2 configuration; Module A and Module B. For example, Input 1A and Input 1B are a 1oo2 duplex module pair. For more information on how to wire field devices, see Figure 6 on page 20.

Figure 3 - Fail-safe ControlLogix EtherNet/IP™ Device Level Ring (DLR) Configuration



1756 SIL 2 I/O module pairs can be in the same chassis because non-SIL 2 hardware is on a separate network. For more information on how to wire field devices, see Figure 6 on page 20.

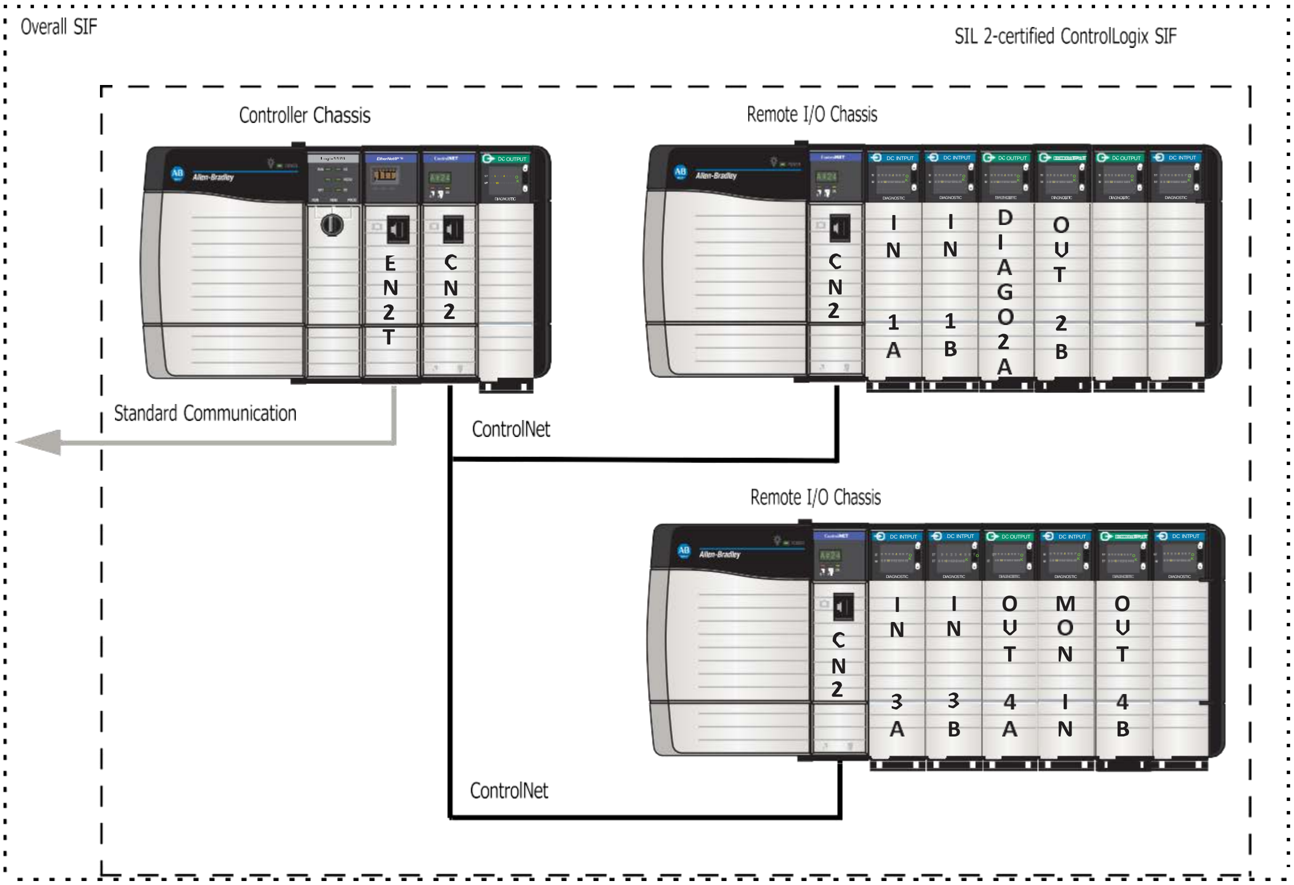
Figure 4 - Fail-safe ControlLogix ControlNet® Configuration (Safety and Standard Connections on the Same Network)



Dual networks are required because one of the two networks includes non-SIL 2 hardware. The 1756 SIL 2 I/O module pairs must be split over two networks. For more information on how to wire field devices, see Figure 6 on page 20.

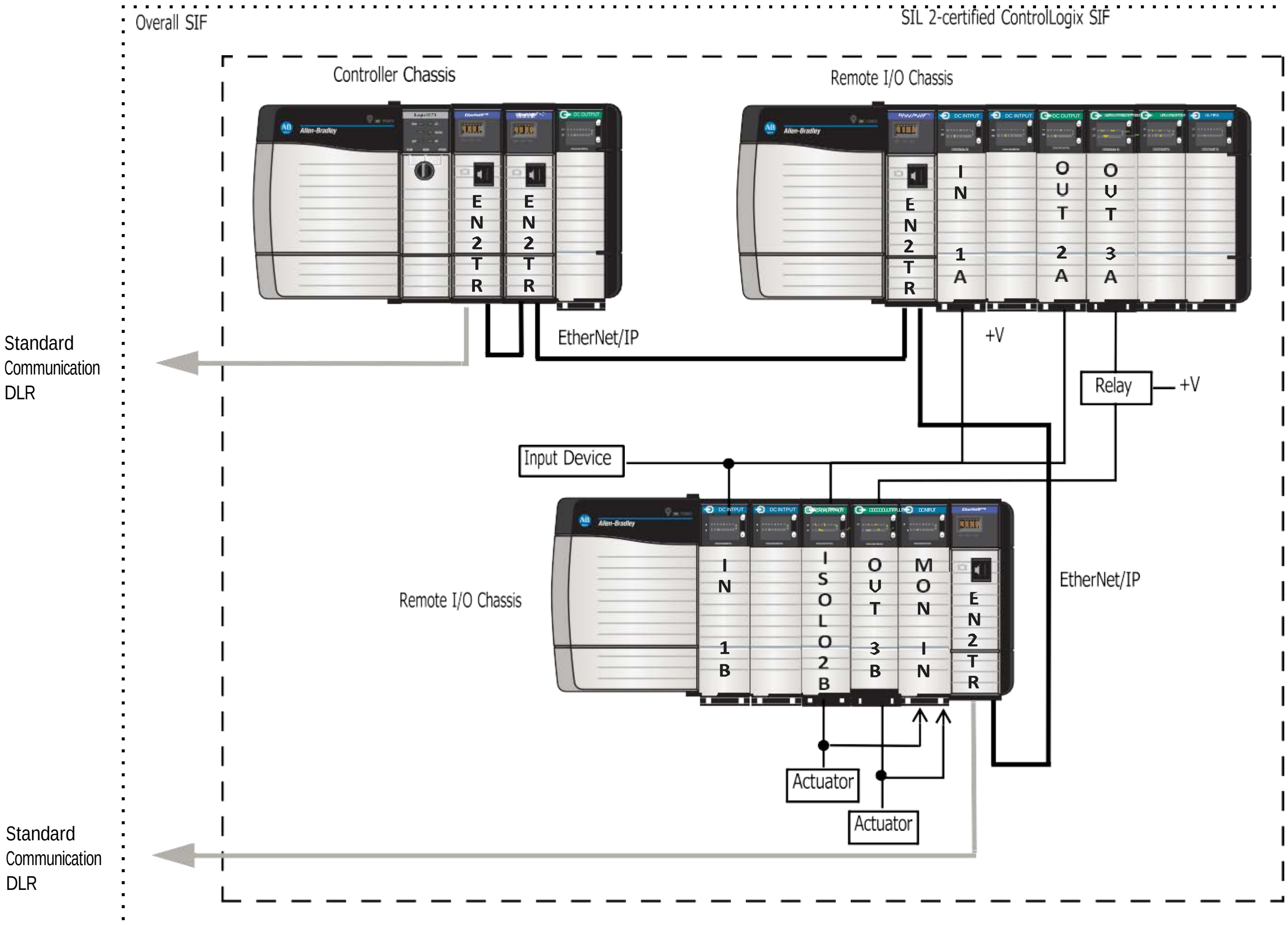
In [Figure 5](#), non-SIL 2 communication on separate subnets lets you place redundant channel I/O in the same rack.

Figure 5 - Fail-safe ControlLogix ControlNet Configuration with Non-SIL 2 Communication (Safety and Standard Connections on Separate Networks)



1756 SIL 2 I/O module pairs can be in the same chassis because the non-SIL 2 hardware is on a separate network. For more information on how to wire field devices, see [Figure 6 on page 20](#).

Figure 6 - Fail-safe ControlLogix EtherNet/IP Configuration: Single DLR Loop for Safety and Standard Communication

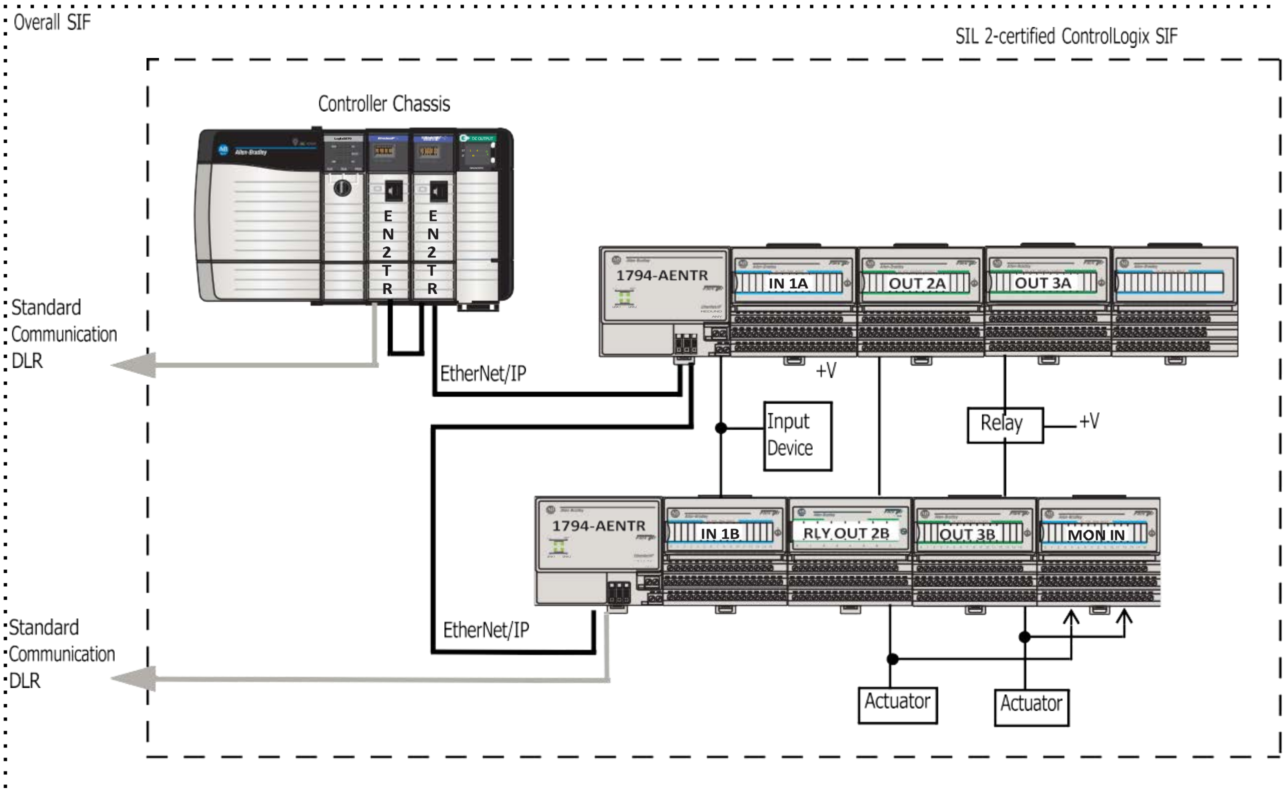


DLR mixes SIL 2 and non-SIL 2 hardware. Independent paths are required to the SIL 2 I/O module pairs. The 1756 adapters and I/O module pairs can be placed into one chassis or split among two. Splitting them over two chassis is shown.

For more information on SIL 2 requirements, see IMPORTANT on page 21.

Unused channels on a SIL 2 input module pair can be used as the monitoring input. There is no need for the monitoring input to be wired to both input modules in a SIL 2 module pair. A separate monitoring input module is not required.

Figure 7 - Fail-safe ControlLogix EtherNet/IP Configuration with FLEX™ I/O Modules: Single DLR Loop for Safety and Standard Communication

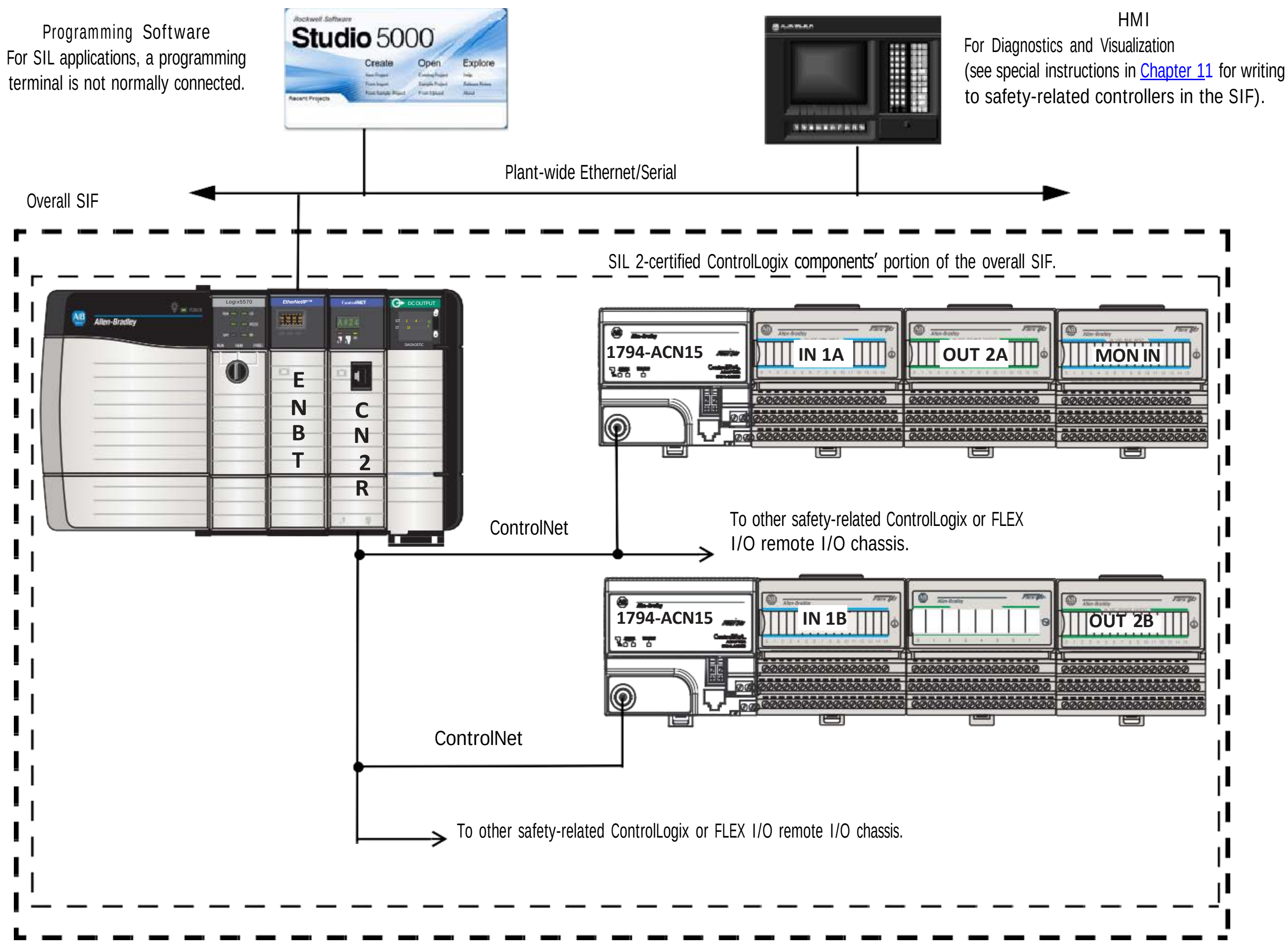


DLR mixes SIL 2 and non-SIL2 hardware. Independent paths are required to the SIL 2 I/O module pairs. FLEX SIL 2 I/O module pairs must always be split over different nodes.

Unused channels on a SIL 2 input module pair can be used as the monitoring input. There is no need for the monitoring input to be wired to both input modules in a SIL 2 module pair. A separate monitoring input module is not required.

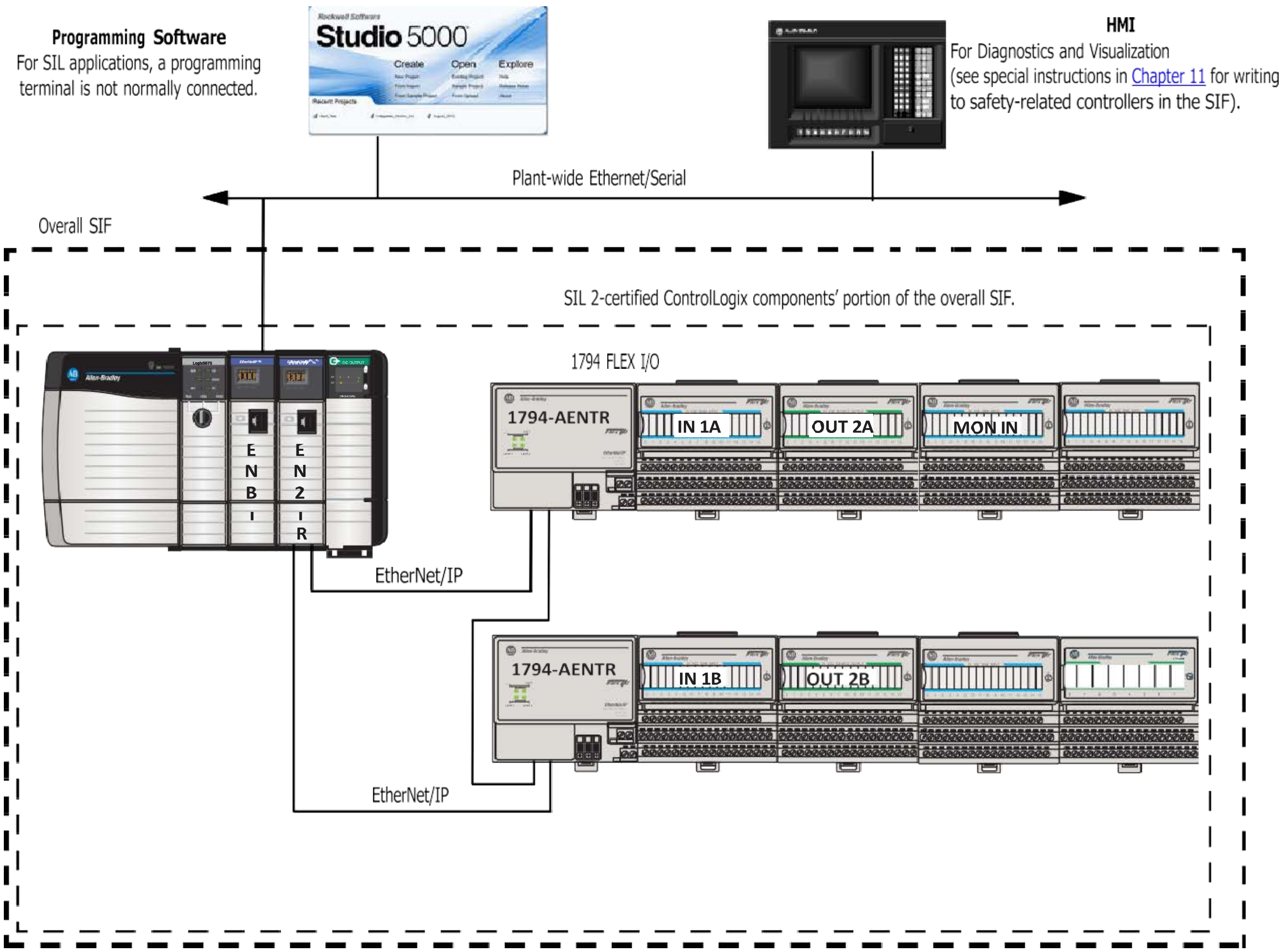
IMPORTANT	As shown in Figure 6 and Figure 7, standard devices can reside within an EtherNet/IP™ SIL 2 subnet if the following requirements are met: • The EtherNet/IP™ subnet topology must be DLR. • The ControlLogix chassis must have two 1756-EN2TR modules. • Independent connection paths must be established for channels A and B I/O through each ControlLogix chassis bridge. • Channel A and Channel B I/O must reside in separate chassis or connected to separate adapters. • Direct Internet connectivity must be limited to EtherNet/IP bridges listed in Appendix B of this manual. Direct Internet connections via other standard devices are not allowed.

Figure 8 - Fail-safe ControlLogix Configuration with FLEX I/O Modules on the ControlNet Network



Non-SIL 2 hardware is on separate networks. FLEX I/O module pairs must always be split over different nodes. For more information on how to wire field devices, see Figure 7 on page 21.

Figure 9 - Fail-safe ControlLogix Configuration with FLEX I/O Modules the EtherNet/IP Network



Non-SIL 2 hardware is on separate networks. FLEX I/O module pairs must always be split over different nodes. For more information on how to wire field devices, see Figure 7 on page 21.

Duplex Logic-Solver Configurations

In duplex configurations, redundant system components are used to increase the availability of the control system. The modules in the redundant controller chassis include the following:

- ControlLogix controllers
- Redundancy modules
- Network communication modules for redundant communication

A ControlLogix redundancy system uses an identical pair of ControlLogix chassis to keep your process running if a problem occurs with one of the chassis. When a failure occurs in the primary chassis, control switches to the secondary controller in the secondary chassis.

IMPORTANT	If there is a redundancy switchover, we recommend that you always investigate the cause of the switchover.

IMPORTANT	When programming your redundant system, program so that your redundancy system status is continuously monitored and displayed on your HMI device. If your redundancy system becomes disqualified or a switchover occurs, the change in status is not automatically annunciated. You must program the system to communicate the change of status via your HMI or other status monitoring device.

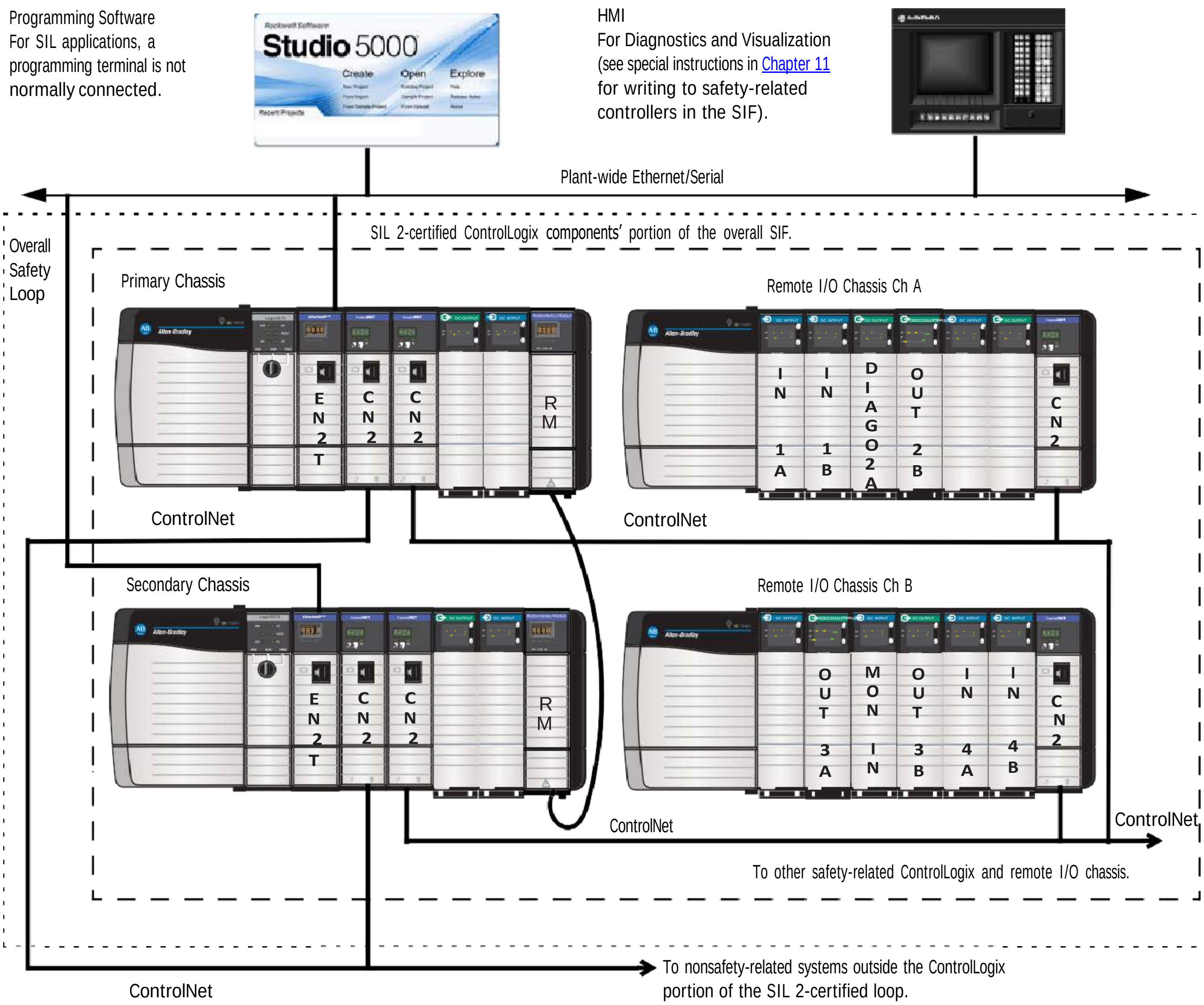
There are different versions for redundant and non-redundant firmware. Only certain versions are certified for use in a SIL 2 system. See the revision release list from these product certifications:

- 1715 Redundant I/O System - Safety Certificate, publication 1715-CT007
- ControlLogix Safety Certificate, publication LOGIX-CT007

Figure 10 shows a typical duplex SIL loop. The figure also shows the following:

- Overall SIF
- ControlLogix portion of the overall SIF
- How other devices, such as HMI, connect to the loop while operating outside of the loop

Figure 10 - Typical SIL Loop with Controller Chassis Redundancy



1756 SIL 2 I/O module pairs can be in the same chassis because non-SIL 2 hardware is on separate networks. SIL 2 I/O modules in the SIF must meet the requirements that are specified in Chapter 5.

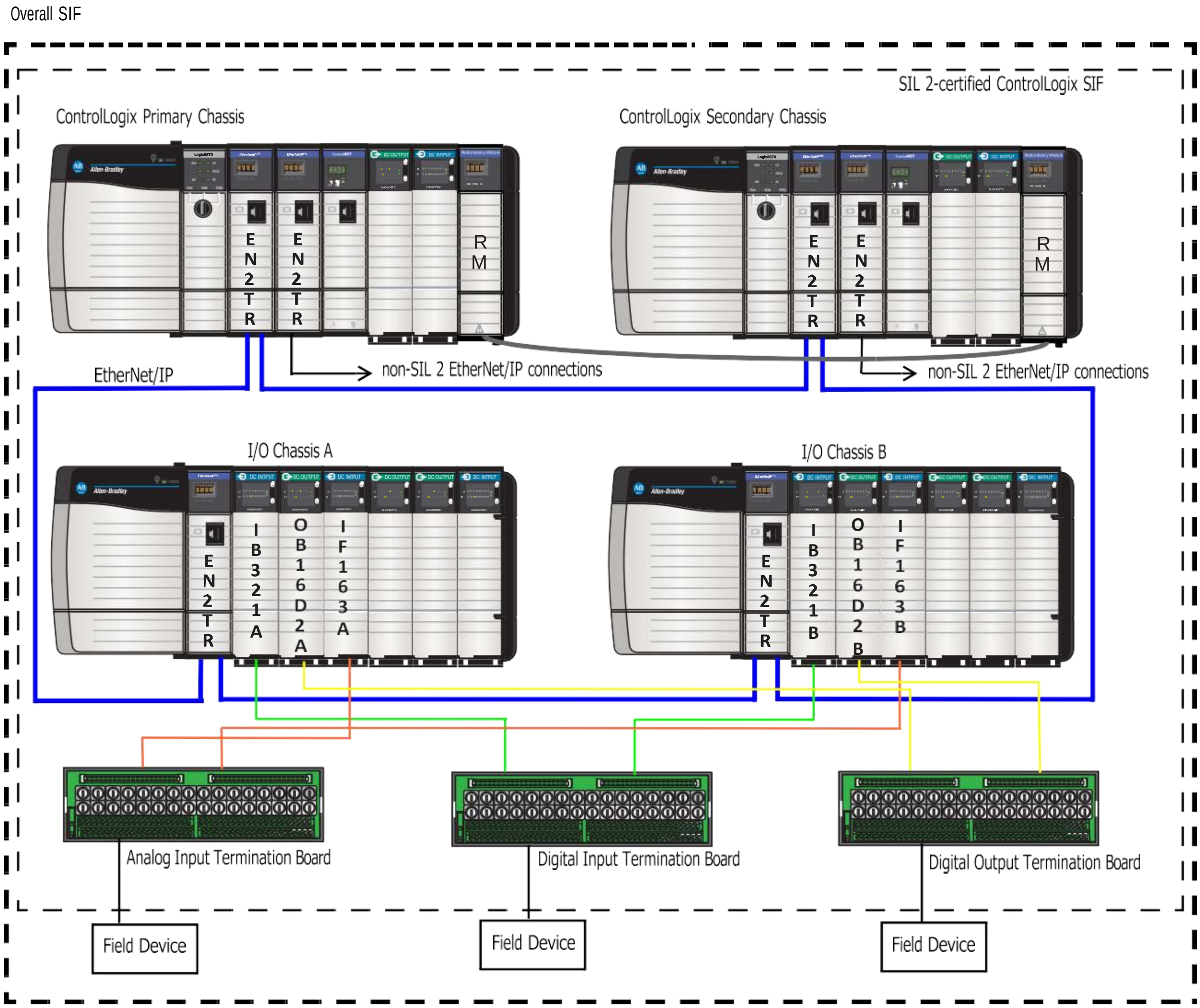
For more information on how to wire field devices, see Figure 6 on page 20.

IMPORTANT	The redundant (duplex) ControlLogix system in Figure 10 provides logic solver fault tolerance. It remains 1oo1 (simplex) from a safety perspective.

Duplex System Configuration

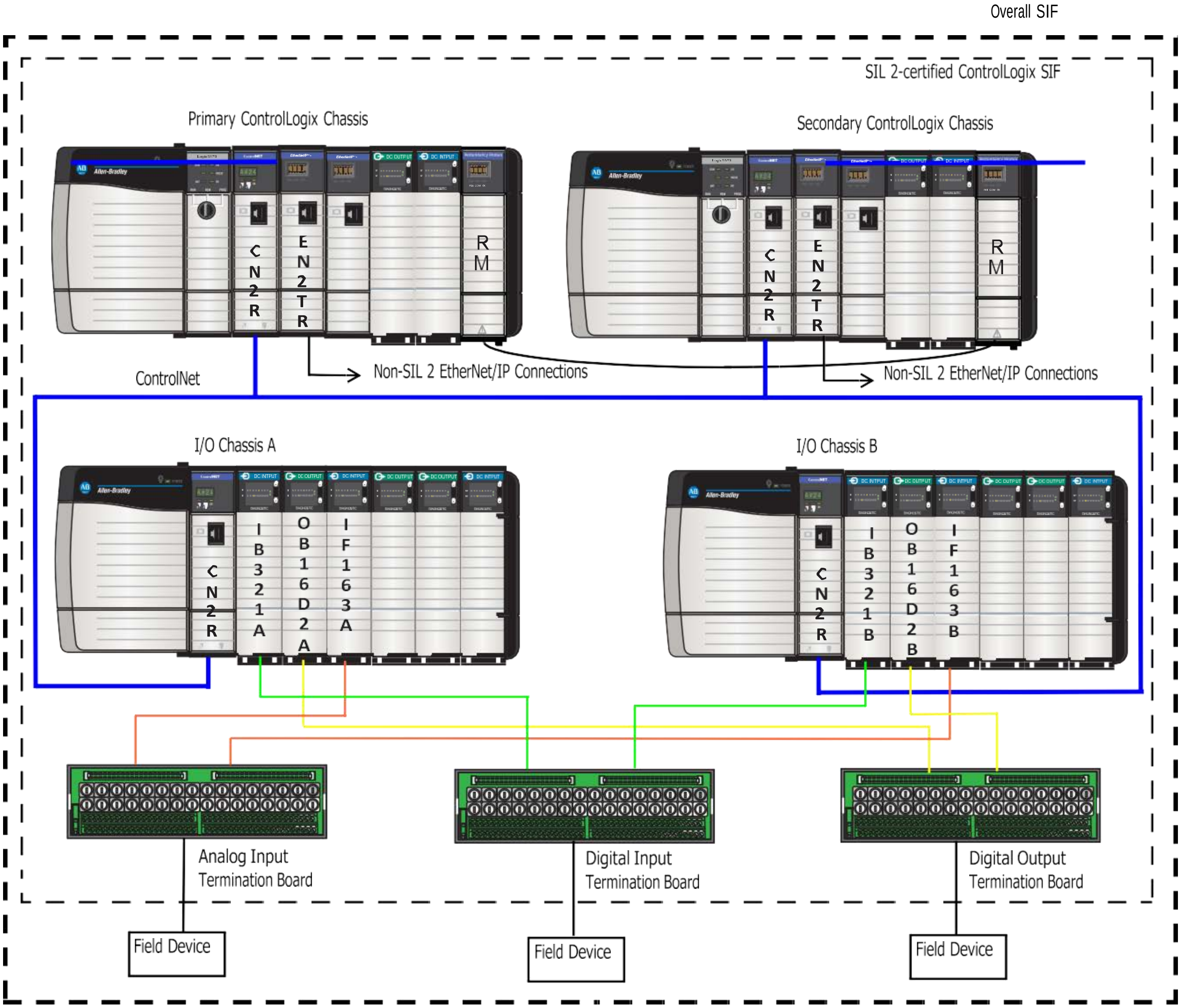
This configuration of the ControlLogix system uses fully redundant controllers, communication modules, and remote I/O devices to achieve enhanced availability.

Figure 11 - Duplex System EtherNet/IP Configuration



For more information about this SIL 2 application solution, see the SIL 2 System Configuration with Add-On Instructions for 1756 ControlLogix I/O Modules, publication 1756-AT012. This publication explains how to configure a SIL 2-certified system by using Add-On Instructions and hardware termination boards with 1756 I/O modules.

Figure 12 - Duplex System ControlNet Configuration



The duplex system configuration uses the safety and programming principles that are described in this manual and the programming and hardware that are described in the application technique manuals.

For more information on the ControlLogix SIL 2-certified system, including termination boards and Add-On Instructions, see the SIL 2 System Configuration with Add-On Instructions for 1756 ControlLogix I/O Modules, publication 1756-AT012.

Proof Tests

IEC 61508 requires that you perform various proof tests of the equipment that is used in the system. Periodic proof tests must be conducted by using a written procedure to reveal undetected faults that prevent the SIS from operating in accordance with the SRS. Proof tests are performed at user-defined times. For example, proof test intervals can be once a year, once every 2 years, or whatever time frame is appropriate based on the SIL verification calculation. Proof tests can include the following:

- Test all safety application-fault routines to verify that process parameters are monitored properly and the system reacts properly when a fault condition arises.
- Test all digital input or output channels to verify that they are not stuck in the ON or OFF state.
  - Manually cycle inputs to make sure that all inputs are operational and not stuck in the ON state.
  - Manually test outputs that do not support runtime pulse testing.
  - You can automatically perform proof tests by switching supply common open on input modules and check to make sure that all input points go to zero (turn OFF.).
- The relays in the redundant power supplies must be tested to make sure that they are not stuck in the closed state.
- Calibrate the analog input and output modules to verify that accurate data is obtained from and used on the modules.

IMPORTANT	Each specific SIF has its own time frame for the proof test interval.

Proof Testing with Redundancy Systems

If you use ControlLogix Redundancy for your SIS, you must perform switchover tests as part of the proof test strategy.

If you are concerned about the availability of the secondary controller if the primary controller fails, it is good engineering practice to implement a switchover periodically (for example, once per proof test interval).

For more information on switchovers and ControlLogix redundancy systems, see the Redundancy Systems User Manual, publication 1756-UM015.

Reaction Times

The response time of the system is the amount of time that it takes for a change in an input condition to be recognized and processed by the controller's logic program, and then to initiate the appropriate output signal to an actuator.

The system response time is the sum of the following:

- Input hardware delays
- Input filtering
- I/O and communication module RPI settings
- Controller program scan times
- Output module propagation delays
- Redundancy system switchover times (applicable in duplex systems)

Each of the times that are listed is variably dependent on factors such as the type of I/O module and instructions that are used in the logic program. For examples of how to perform these calculations, see Appendix A, System Reaction Time

For more information on the available instructions and for a full description of logic operation and execution, see the following publications:

- Logix 5000 Controllers General Instruction Set Reference Manual, publication 1756-RM003
- ControlLogix 5570 and 5560 Controllers User Manual, publication 1756-UM001

Reaction Times in Redundancy Systems

The worst-case reaction time of a duplex system is different than a simplex system. The redundancy system has a longer reaction time.

There are a series of crossloading operations that continuously occur between the primary and secondary controllers. Crossloading fresh data at the end of each program scan increases scan time.

To minimize scan time by reducing crossloading overhead, you can plan your project more efficiently. For example, minimize the use of SINT, INT, and single tags and use arrays and user-defined data structures. Generally, the primary controller in a duplex system has a 20% slower response time than the controller in a simplex system.

For more information about switchover times in redundancy systems, see the Redundancy Systems User Manual, publication 1756-UM015.

IMPORTANT	To avoid spurious trips, you must account for the additional cross-checking time of a duplex system when setting the watchdog time.

Safety Watchdog

Configure the properties of the SIL 2 safety task correctly for your application.

- Priority: must be the highest-priority task in the application (lowest number)
- Watchdog: the value that is entered for the SIL 2 safety task must be large enough for all logic in the task to be scanned

If the task execution time exceeds the watchdog time, a major fault occurs on the controller. You must monitor the watchdog and program the system outputs to transition to the safe state (typically the OFF state) if there is a major fault occurring on the controller. For more information on faults, see Chapter 10.

For more information about setting the watchdog, see the ControlLogix 5570 and 5560 Controllers User Manual, publication 1756-UM001.

Safety Certifications and Compliance

Diagnostic hardware and firmware functions, and how you apply ControlLogix components, enable the system to achieve CL SIL 2 compliance.

IMPORTANT	You must implement these requirements, or at a minimum the intent of the requirements that are defined in this manual, to achieve CL (claim limit) SIL 2.

ControlLogix products that are referenced in this manual can have safety certifications and the SIL certification. If a product has achieved agency certification, the product label is not necessarily marked as certified. To view safety certifications for products, see ControlLogix Safety Certificate, publication LOGIX-CT007.

Notes:

Features of the ControlLogix SIL 2 System

The diagnostic methods and techniques that are used in the ControlLogix® platform let you configure and program ControlLogix controllers to perform checks on the total system. The checks include configuration, wiring, and performance, monitoring input sensors and output devices. Timestamping of I/O and diagnostic data also aid in diagnostics.

Examples of these methods and techniques include the following:

- If an anomaly (other than automatic shutdown) is detected, the system can be programmed to initiate user-defined fault handling routines.
- Output modules can turn OFF selected outputs if there is a failure.
- Diagnostic I/O modules self-test to make sure that field wiring is functioning.
- Output modules use pulse testing to make sure that output switching devices are not shorted.

Module Fault Reporting

Every module in the system is owned by one controller. Multiple controllers can produce consume tag data. Listen Only connections are not supported in the context of this manual. When a controller owns an I/O module, the controller stores the module's configuration data, which you define. This data dictates how the module behaves in the system. Inherent in this configuration and ownership is the establishment of a heartbeat between the controller and module, which is known as the requested packet interval (RPI).

The RPI defines a time interval in which the controller and I/O module must communicate with each other. If communication cannot be established or maintained, for example, the I/O module has failed, the communication path is unavailable, the system can be programmed to run specialized routines. These specialized routines can determine whether the system can continue functioning or whether the fault condition warrants a system shutdown through the application logic. For example, the system can be programmed to retrieve the fault code of the failed module. It can also make a determination, which is based on the type of fault, whether to continue operating.

The controller can monitor the health of I/O modules in the system. The controller can take appropriate action that is based on the severity of a fault condition and gives you complete control of the application. It is your responsibility to establish the course of action appropriate to your safety application.

For more information on Fault Handling, see Chapter 10.

Data Echo Communication Check

IMPORTANT	This section applies to only 1756 and 1794 I/O modules. For 1715 I/O module requirements, see Chapter 7.

Output data echo allows you to verify that the correct output module received the ON/OFF command from the controller was received and that the module attempts to execute the command to the field device.

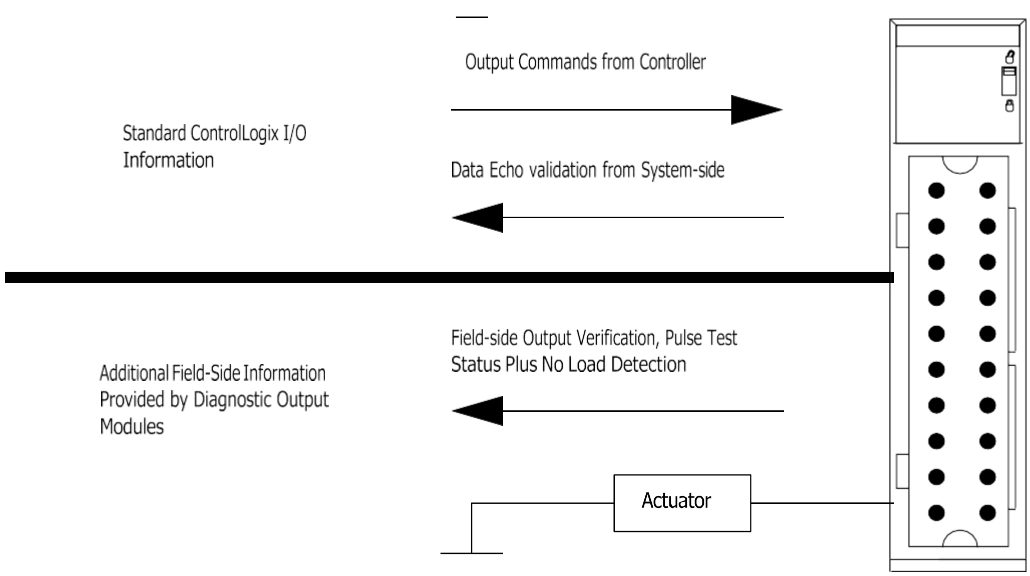
During normal operation, when a controller sends an output command, the output module that receives the command echoes the output command back to the controller upon its receipt. This verifies that the module has received the command and tries to execute it. By comparing the requested state from the controller to the data echo received from the module, you can validate that the signal has reached the correct module. You can also verify that the module attempts to activate the appropriate field-side device. The echo data is technically input data from the output module and is located with the other output module data. For example, an output module at local slot 3 has Local:3:O and Local:3:I, where 3:O are outputs and 3:I are inputs. Again, it is your responsibility to establish the course of action appropriate for your safety application.

When used with standard ControlLogix output modules, the data echo validates the integrity of communication up to the system-side of the module, but not to the field-side. When you use this feature with diagnostic output modules, you can verify the integrity from the controller to the output terminal on the module.

Diagnostic output modules contain circuitry that performs field-side output verification. Field-side output verification informs you that commands that are received by the module are accurately represented on the power side of the module's switching devices. In other words, for each output point, this feature confirms that the output is ON when it is commanded to be ON or OFF when commanded to be OFF.

When using non-diagnostic output modules, you must verify the ON and OFF state. This verification must be accomplished by monitoring the output command from the non-diagnostic output module in an input module or validation by alternative methods. Approve all methods according to IEC 61508. A separate input module is required for a non-diagnostic output module.

Figure 13 - Output Module Behavior in the ControlLogix System



Pulse Test

IMPORTANT	This section applies to only 1756 and 1794 I/O modules. For 1715 I/O module requirements, see Chapter 7.

Discrete diagnostic output modules contain a feature that is called a pulse test. A pulse test can verify the output circuit functionality without actually changing the state of the actuator that is connected to the output. A short-duration pulse is directed to a particular output on the module. The output circuitry momentarily changes its state long enough to verify that it can change state on demand. The test pulse is fast (milliseconds), and typically does not affect actuators. Some actuators can have electronic front ends and can detect these fast pulses. You can disable pulse testing, if necessary.

Software

The location, ownership, and configuration of I/O modules and controllers is performed by using RSLogix 5000® software or the Studio 5000 Logix Designer® application. Use the software to create, test, and debug application logic.

When using the programming software, you must remember these points:

- When SIS is in operation:
  - Disconnect the programming terminal.
  - Set the keyswitch to the RUN position.
  - Remove the controller key from the keyswitch.
- Authorized personnel can change an application program, but only by using one of the processes that are described in Changing Your Application Program on page 125.

Communication

Several communication options are available for connecting with the ControlLogix SIL 2 system and for the exchange of data within the SIL 2 system.

Communication Ports

A built-in serial port is available on 1756-L6*x* controllers for download or visualization purposes only. Do not use the serial port for any exchange of safety-related data.

A built-in USB port is available for program upload and download on 1756-L7*x* controllers.

ATTENTION: The USB port is intended for temporary local-programming purposes only and not intended for permanent connection.

WARNING: Do not use the USB port in hazardous locations.

For information on how to make communication connections, see the ControlLogix 5570 and 5560 Controllers User Manual, publication 1756-UM001.

ControlNet Network

The ControlNet® network can be used to do the following:

- Provide communication between the controller and remote I/O chassis.
- Form the basis for communication in duplex (redundant) configurations.

To schedule the ControlLogix ControlNet network, use RSNetWorx™ for ControlNet software.

IMPORTANT	In SIL 2 applications, all I/O and produce/consume tags that are associated with safety data must use scheduled connections on the ControlNet network.

For more information about ControlNet networks, refer to the ControlNet Network Configuration Guide, publication CNET-UM001.

IMPORTANT	1715 I/O modules support only EtherNet/IP communication.

EtherNet/IP Network

An EtherNet/IP™ connection can be used to do the following:

- Download, monitor, and visualize the controller.
- Connect to remote I/O chassis.

EtherNet/IP networks support messaging, produced/consumed tags, and distributed I/O.

See EtherNet/IP Communication Modules on page 40 for details on how to use EtherNet/IP modules in SIL 2 applications.

Electronic Keying of Modules in SIL 2 Applications

If a module in your SIL 2-certified ControlLogix system is replaced, Exact Match keying is recommended.

Exact Match keying requires all keying attributes of the physical module and the module that is created in the software to match precisely before establishing communication. The keying attributes are Vendor, Product Type, Product Code (catalog number), Major Revision, and Minor Revision.

If any attribute does not match precisely, I/O communication is not permitted with the module or with modules that are connected through it, such as communication modules.

Compatible Keying can be used in a SIL 2 safety function, but you are responsible for reverifying safety functions after replacing SIL 2 modules.

For more information about electronic keying, see the ControlLogix Digital I/O Modules User Manual, publication 1756-UM058.

ControlLogix Controllers, Chassis, and Power Supplies

ControlLogix Controllers

The SIL 2-certified ControlLogix® system is a user-programmed, solid-state control system. Examples of specific functions include the following:

- I/O control
- Logic
- Timing
- Counting
- Report generation
- Communication
- Arithmetic
- Data file manipulation

The ControlLogix controller has a central processor, I/O interface, and memory.

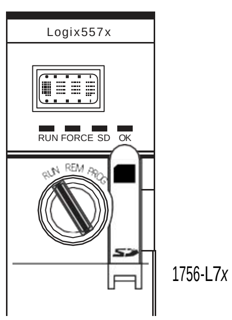
Operating Modes

The controller performs power-up and runtime functional tests. The tests are used with user-supplied application programs to verify proper controller operation.

A three-position keyswitch on the front of the controller governs ControlLogix system operational modes. The following modes are available:

- Run
- Program
- Remote - This software-enabled mode can be Program or Run.

Figure 14 - Keyswitch in Run Mode



When a SIL 2-certified ControlLogix application is operating in the Run mode, the controller keyswitch must be in the RUN position and the key removed.

Requirements for Use

Consider these requirements for a SIL 2-certified ControlLogix controller:

- All components, such as input and output modules, must be owned by a single controller that controls their safety function.
- When installing a ControlLogix controller, refer to the user manual listed in Additional Resources on page 11.
- There are currently separate firmware revisions for standard and redundant controllers and these revisions must not be interchanged. For more information, see Appendix and the Revision Release List available at rok.auto/certifications.

For more information on the ControlLogix controllers, see the publications in Additional Resources on page 11.

ControlLogix Chassis

The ControlLogix 1756-A*xx* chassis provide the physical connections between controllers, communications modules, and/or the I/O modules. The chassis is passive and is not relevant to the safety discussion because any physical failure would be unlikely under normal environmental conditions and would be manifested and detected as a failure within one or more of the active components.

When installing a ControlLogix chassis, see the ControlLogix Chassis Installation Instructions, publication 1756-IN621.

ControlLogix Power Supplies

ControlLogix power supplies are certified for use in SIL 2 applications. No extra configuration or wiring is required for SIL 2 operation of the ControlLogix power supplies. If an anomaly occurs in the supplied voltages, the power supply immediately shuts down. For this reason, the power supply is not part of the safety calculation.

All ControlLogix power supplies are designed to perform these tasks:

- Detect anomalies.
- Provide the controllers with enough stored power to allow for an orderly and deterministic shutdown of the system, including the controller and I/O modules.

IMPORTANT	If you are using any of the 1756-P*x*75 (non-redundant) power supplies with a 1756-L7*x*/B controller, you must use the Series B version of the power supply, which are the 1756-P*x*75/B power supplies.

Redundant Power Supplies

ControlLogix redundant power supplies can be used in SIL 2-certified applications. In a redundant power supply configuration, two power supplies are connected to the same chassis.

The power supplies share the current load that the chassis requires and an internal solid-state relay that can annunciate a fault. Upon detection of a failure in one supply, the other redundant power supply automatically assumes the full current load that the chassis requires without disruption to installed devices.

The 1756-PSCA and 1756-PSCA2 redundant power-supply chassis adapters connect the redundant power supply to the chassis.

Recommendations for Use

When using SIL 2-certified ControlLogix power supplies:

- Follow the information that is provided in the installation instructions.
- Wire the solid-state fault relay on each power supply from an appropriate voltage source to an input point in the ControlLogix system so that the application program can detect faults and react appropriately based on the application requirements.

For more information about how to install ControlLogix chassis and power supplies, see the publications that are listed in Additional Resources on page 11.

Notes:

ControlLogix Communication Modules

The communication modules in a SIL 2-certified ControlLogix® system provide communication from a ControlLogix chassis to other chassis or devices via the ControlNet® and EtherNet/IP™ networks. The following table lists the communication modules that are available.

Network	SIL 2 Modules[1]	
ControlNet	• 1756-CNB • 1756-CNBR • 1756-CN2	• 1756-CN2R • 1756-CN2RXT
EtherNet/IP	• 1756-ENBT, series A[2] • 1756-EN2T, series C • 1756-EN2T, series D[2] • 1756-EN2TXT, series C • 1756-EN2TXT, series D[2]	• 1756-EN2TR, series B • 1756-EN2TR, series C • 1756-EN2TRXT, series C • 1756-EN3TR, series B[2]
DeviceNet®[2]	1756-DNB	
Data Highway Plus™ – Remote I/O[2]	1756-DHRIO	
SynchLink™[2]	1756-SYNCH	

(1) Some catalog numbers have a K suffix. The suffix indicates a version of the product that has conformal coating. These K versions have the same SIL 2 certification as the non-K versions.
(2) Not for use in safety functions.

ControlLogix communication modules can be used in peer-to-peer communication between ControlLogix devices. The communication modules can also be used for expansion of I/O to additional ControlLogix remote I/O chassis.

ControlNet Modules and Components

ControlNet modules provide communication between any nodes that are properly scheduled on the ControlNet network.

IMPORTANT	In SIL 2 applications, all I/O and produce/consume tags that are associated with safety data must use scheduled connections on the ControlNet network.

ControlNet Cabling

For remote racks, one RG6 coax cable is required for ControlNet communication. Although it is not a requirement to use redundant media with the 1756-CNBR or 1756-CN2R modules, it does provide higher system reliability. Redundant media is not required for SIL 2 operation.

ControlNet Repeater

The following ControlNet repeater modules are approved for use in safety applications up to and including SIL 2:

- 1786-RPCD, ControlNet Hub Repeater Module
- 1786-RPFS, Short-distance Fiber Repeater Module
- 1786-RPFM, Medium-distance Fiber Repeater Module
- 1786-RPFRL, Long-distance Fiber Repeater Module
- 1786-RPFRXL, Extra-long-distance Fiber Repeater Module

Use of the 1786-RPA adapter is required with the repeater modules listed.

Table 2 - For More Information about Repeater Modules

Topic	Publication Title	Publication Number
Plan for and install ControlNet repeater modules.	ControlNet Fiber Media Planning and Installation Guide	CNET-IN001
Use of repeaters in safety applications.	TÜV Report 968/EZ	968/EX 135.06.12

ControlNet Module Diagnostic Coverage

All communication over the passive ControlNet media occurs via CIP™. CIP verifies that at least one valid packet is seen during the greater of either 100 ms or 4 times the requested packet interval (RPI). If a valid packet is not seen during this period, data transitions to the safe state.

EtherNet/IP Communication Modules

Use an EtherNet/IP communication module to do the following:

- Connect controller chassis to remote I/O.
- Make connections for visualization purposes.
- Establish connections between the programming terminal and controller.

IMPORTANT	Use of a 1756-EN2TR or 1756-EN2TRXT is required to achieve SIL 2 in your application. See Figure 3 on page 17 for an example.

See the examples in Figure 5 on page 19, Figure 6 on page 20, and Figure 11 on page 26.

DeviceNet Scanner

The 1756-DNB scanner connects the controller to devices on a DeviceNet network. You can use the 1756-DNB module to communicate only nonsafety data to devices outside of the safety loop.

Data Highway Plus - Remote I/O Module (1756-DHRIO)

The 1756-DHRIO module supports both Data Highway Plus and the Remote I/O network of communication. You can use the 1756-DHRIO module to communicate only nonsafety data to devices outside of the safety loop. For example, it can be used to communicate alarms to the Distributed Control System (DCS).

SynchLink Module

The SynchLink™ module (catalog number 1756-SYNCH) is used for CST time propagation between multiple chassis for event recording. The module can be used only outside of the safety loop. It must not be used for any safety-related activity in a SIL 2-certified ControlLogix system.

General Requirements for Communication Networks

Follow these requirements when using SIL 2-certified communication modules:

- When installing ControlLogix communication modules, carefully follow the information that is provided in the installation instructions.
- DH+™ can be used for communication to human machine interfaces (HMI) and for communicating with the nonsafety portion of the system. For more information on how to use HMI, see Chapter 11, Use of Human-to-Machine Interfaces on page 129.
- Only SIL 2 devices or other devices that provide non-interference write to SIL 2 controllers. The only exception is the use of HMI devices. For more information on how to use HMI in the safety loop, see Chapter 11, Use of Human-to-Machine Interfaces on page 129.

Peer-to-peer Communication Requirements

Peer-to-peer communication via a ControlNet or EtherNet/IP network is permitted when these requirements are met:

- Non-SIL 2 controllers can read data from SIL 2 controllers by directly reading the data via a message instruction. The controller can also read data by consuming data from a SIL 2 controller that is configured to produce data.
- Controllers within the safety loop can be configured to:
  - Consume safety data from other safety controllers within the safety loop.

IMPORTANT	Always monitor connection status when consuming safety data from another controller. Use this connection status to take appropriate safety action, if necessary.

  - Consume non-safety data from outside the safety loop, such as a reset signal.
  - Produce data to controllers outside the safety loop by using a write message (MSG) or produced connections.
- Programming that verifies the correct reception of data must be used.
- Use of a Device Level Ring (DLR) is required to produce and consume SIL 2 data on an EtherNet/IP network. If you are not using the ring capability of the 1756-EN2TR when producing or consuming SIL 2 safety data on an EtherNet/IP network, you must use two independent data paths between the SIL 2 devices. For example, to exchange SIL 2 data between two ControlLogix SIL 2 controllers, you could use two produced connections sending data to two consume connections. Each controller produces data to the other.

Additional Resources

This table lists additional resources specific to the ControlLogix communication modules.

Cat. No.	Module Description	User Manual
1756-CNB 1756-CN2	ControlNet communication module	CNET-UM001
1756-CNBR 1756-CN2R	Redundant ControlNet communication module	
1756-DHRIO	Data Highway Plus - Remote I/O communication interface module	1756-UM514
1756-DNB	DeviceNet Scanner	DNET-UM004
1756-ENBT 1756-EN2T 1756-EN2TR 1756-EN3TR 1756-EN2TRXT 1756-EN2TXT	EtherNet/IP communication module	ENET-UM001
1756-RM 1756-RM2 1756-RM3	Redundancy module	1756-UM015
1756-SYNCH	SynchLink module	1756-UM521

Notes:

1756 ControlLogix I/O Modules

IMPORTANT	The programming information and examples in this chapter are provided to illustrate diagnostic and other logic-related principles that must be demonstrated in SIL 2 application programs. • The principles and logic that is shown in this chapter can be encased in Add-On Instructions for easier use. • The wiring diagrams are provided to illustrate SIL 2 concepts. For wiring information, see the I/O module users manual listings in Additional Resources on page 11. • If you are using a duplex configuration and certain I/O termination boards, the programming that is explained in this chapter is available in Add-On Instructions. These Add-On Instructions are certified by TÜV. See the SIL 2 System Configuration with Add-On Instructions for 1756 ControlLogix I/O Modules, publication 1756-AT012.

There are two types of SIL 2-certified ControlLogix® I/O modules:

- Digital I/O modules
- Analog I/O modules

The 1756-IF8I provides the current and voltage input option, the 1756-IRT8I covers the RTD and Thermocouple temperature options while the 1756-OF8I covers current and voltage outputs. The 8-channel modules can emulate the 6-channel modules and are SIL 2, Systematic Capability 2 type certified.

1756 Digital Input Modules

To achieve SIL 2, two digital input modules must be used, with field sensors wired to channels on each module. The software must compare the two channels before reconciling the data.

1756 digital input modules are divided into two categories:

- Diagnostic input modules
- Standard input modules

These modules share many of the same inherent architectural characteristics. However, the diagnostic input modules incorporate features that allow you to diagnose field-side failures. These features include broken-wire detection and, if there are AC Diagnostic modules, loss of line power.

Application Requirements for 1756 Digital Input Modules

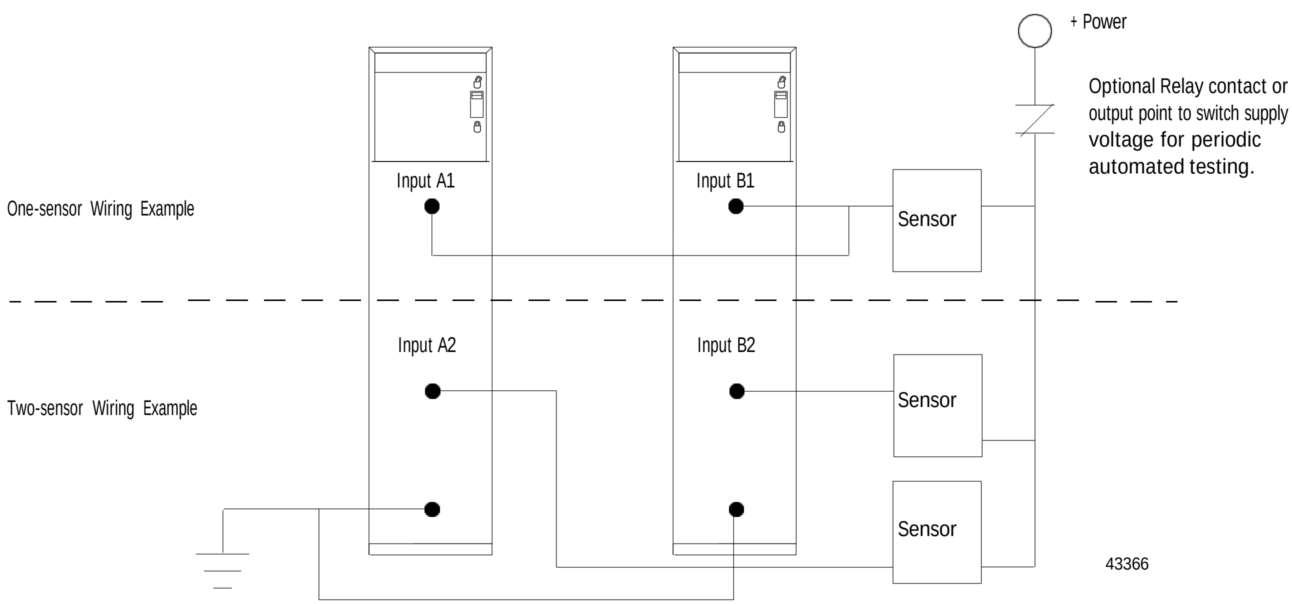
Regardless of the type of 1756 input module, you must follow these general application requirements when applying 1756 digital I/O modules in a SIL 2 application:

- Ownership – The same controller must own both modules.
- Direct connection – Always use a direct connection with any SIL 2 CL modules. You must not use rack-optimized connections in a SIL 2 application.
- Separate input points – Wire sensors to separate input points on two separate modules. The use of two digital input modules is required, regardless of the number of field sensors.
- Field device testing – Test field devices by cycling them. The closer you can get to the device being monitored to perform the test, the more comprehensive the test is.
- Proof tests – Periodically perform a system validation test. Manually or automatically test all inputs to make sure that they are operational and not stuck in the ON or OFF state. Inputs must be cycled from ON to OFF or OFF to ON. For more information, see Proof Tests on page 28.

Wire 1756 Digital Input Modules

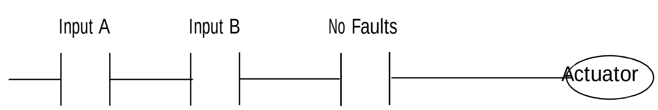
This diagram shows two examples of wiring digital inputs. In either case, the type of sensors being used determines whether the use of one or two sensors is appropriate to fulfill SIL 2 requirements.

Figure 15 - ControlLogix Digital Input Module Wiring Example



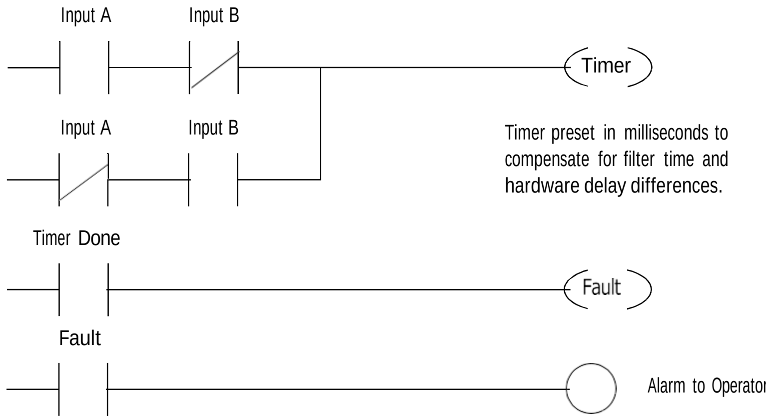
Application logic is used to compare input values for concurrence.

Figure 16 - Logic-comparing Input Values or States



The user program must also contain rungs to annunciate a fault if there is a sustained miscompare between two points.

Figure 17 - Rungs Annunciating a Fault



The control, diagnostics, and alarm functions must be performed in sequence. For more information on faults, see Chapter 10, Faults in the ControlLogix System.

1756 Digital Output Modules

1756 digital output modules are divided into two categories:

- Diagnostic output modules
- Standard output modules

These modules share many of the same inherent architectural characteristics. However, the diagnostic output modules incorporate features that allow you to diagnose field-side failures, such as the following:

- No-Load (loss of load) reporting
- Blown Fuse reporting
- Output verify
- Output pulse test

To achieve SIL 2, a standard output module must be wired back to an input module for monitoring. Diagnostic digital output modules provide their own monitoring.

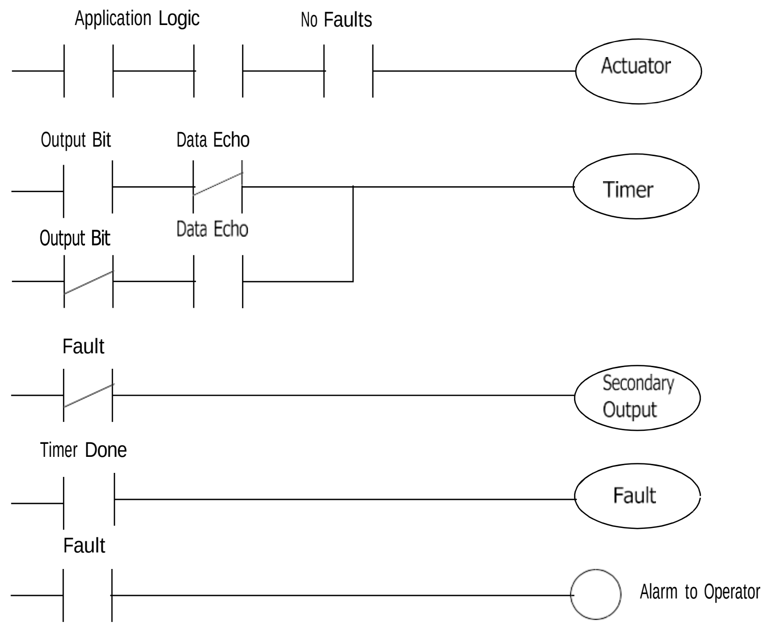
Application Requirements for 1756 Digital Output Modules

Wiring the two types of digital output modules differs, depending on your application requirements. However, regardless of the type of ControlLogix output module, you must follow these general application requirements when applying these modules in a SIL 2 application:

- Proof tests - Periodically perform a system validation test. Manually or automatically test all outputs to make sure that they are operational and not stuck in the ON or OFF state. Outputs must be cycled from ON to OFF or OFF to ON. For more information, see Proof Tests on page 28.
- Examination of output data echoes signal in application logic – The application logic must examine the Data Echo value that is associated with each output point to make sure that the requested ON/OFF command from the controller was received and acted upon by the module.

  In Figure 18, a timer begins to increment for any miscompare between the controller's output and the module's Data Echo feedback. The discrepancy timer must be set to accommodate the delay between the controller output data and the module's Data Echo response. The time value that is chosen must consider various system RPIs and network latency. If a miscompare exists for longer than that time, a fault bit is set.

Figure 18 - Data Echo Discrepancy-Timer Logic



  The control, diagnostics, and alarm functions must be performed in sequence. For more information on faults, see Chapter 10, Faults in the ControlLogix System on page 127.
- Use of external relays to disconnect module power if output de-energized state is critical. To verify that outputs de-energize, you must wire an external relay or other measure that can remove power from the output module if a short or other fault is detected. See Figure 19 on page 47 for an example method of wiring an external relay.
- Test outputs at specific times to make sure that they are operating properly. The method and frequency of testing is determined by the requirements of the safety application. For more information on how to test diagnostic module outputs, see page 47. For more information on how to test standard module outputs, see page 48.
- For typical emergency shutdown (ESD) application outputs must be configured to de-energize: When configuring any ControlLogix output module, each output must be configured to de-energize if there is a fault and if the controller goes into Program mode. For exceptions to the typical ESD applications, see Chapter 1, SIL Policy on page 13.
- When wiring two digital output modules in series so that one can break the source voltage (as shown in Figure 23 on page 49), one controller must own both modules.

Wire 1756 Digital Output Modules

Diagnostic digital output modules and standard output modules have different wiring considerations. Reference the module-type considerations that apply to your system configuration.

Wire Diagnostic Digital Output Modules

Diagnostic output modules have circuitry that is not included in standard output modules. Because of this feature, you are not required to use an input module to monitor output status, as is required with standard output modules.

Diagnostic output modules can be used as-is in a SIL 2 application. No special wiring considerations have to be employed other than the wiring of the external relay or other measures to remove line power from the module if there is a fault to make sure that outputs de-energize if shorted.

For limited high demand applications, see Application Requirements for 1756 Digital Output Modules on page 46. Once every 8 hours, test output modules by turning the outputs ON and OFF to verify proper operation. High demand applications are limited to 10 demands per year for ControlLogix SIL 2 systems.

For more information on pulse tests, see the ControlLogix Digital I/O Modules User Manual, publication 1756-UM058.

Figure 19 - ControlLogix Diagnostic Output Module Wiring

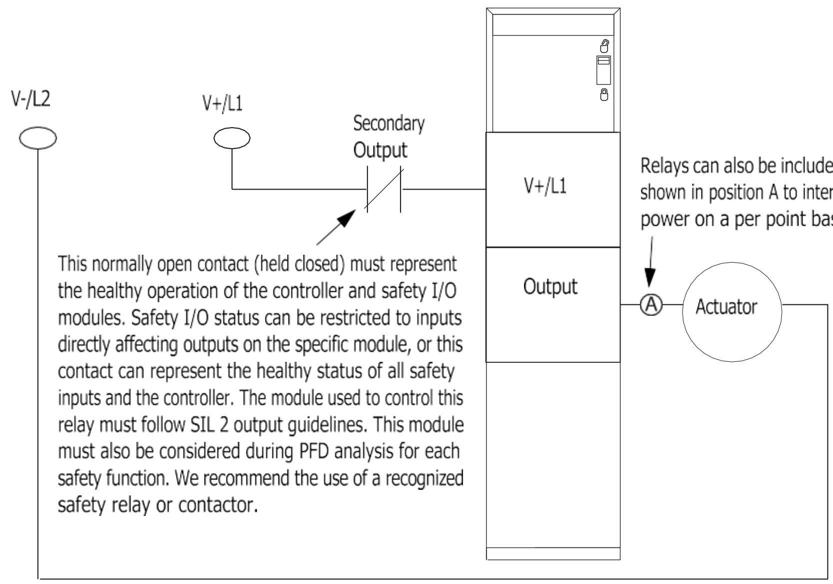
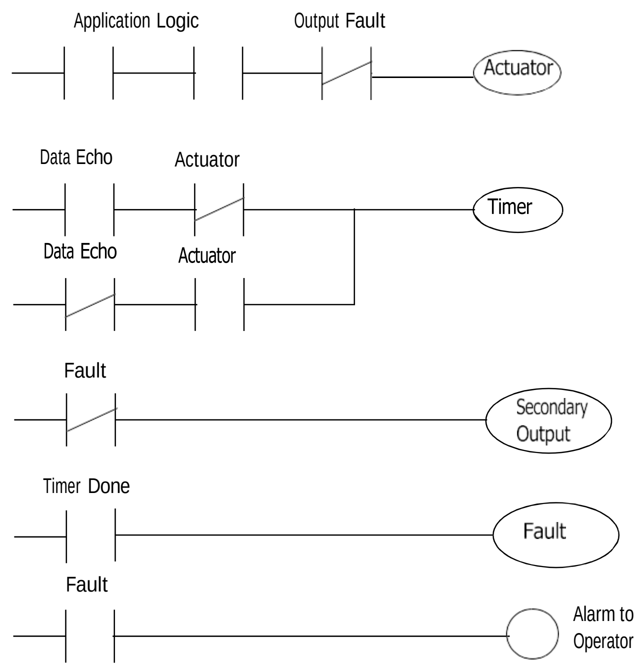


Figure 20 - Diagnostic Output Logic



Output Fault contact must represent module and channel diagnostics.

Wire Standard Digital Output Modules

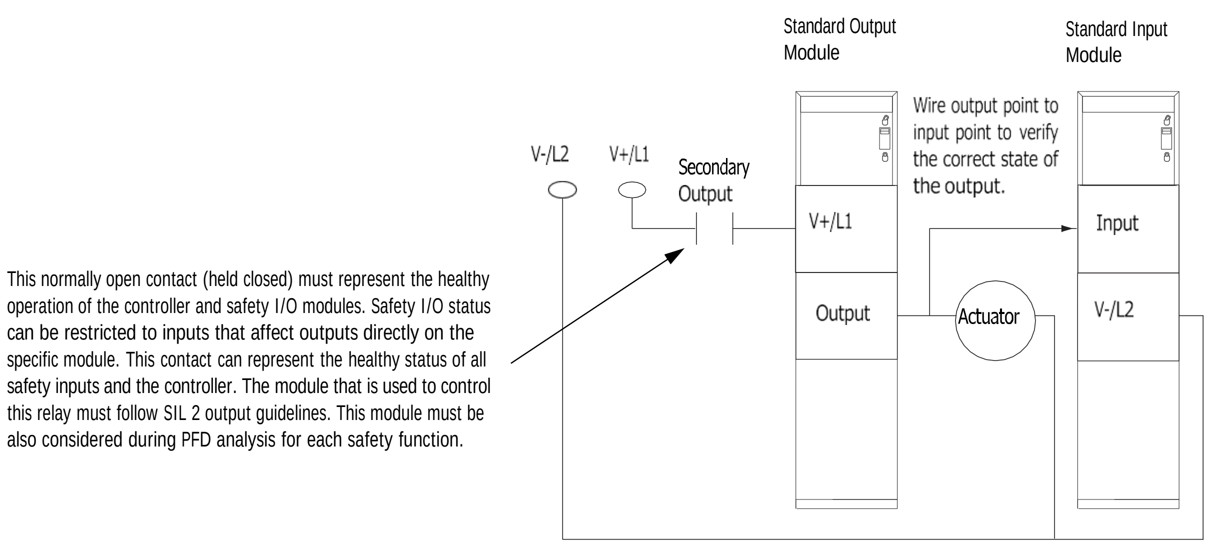
When using standard (non-diagnostic) output modules, you must wire each output to its field device and also to a system input to monitor the performance. To verify output performance, use one of these methods:

- Write logic to test the ability of the output to turn ON and OFF at powerup.
- At the proof test interval, force the output ON and OFF and use a voltmeter to verify output performance.

For limited high demand applications, test the output modules (that is, you turn the outputs ON and OFF to verify proper operation) once every 8 hours. High demand applications are limited to 10 demands per year for ControlLogix SIL 2 systems.

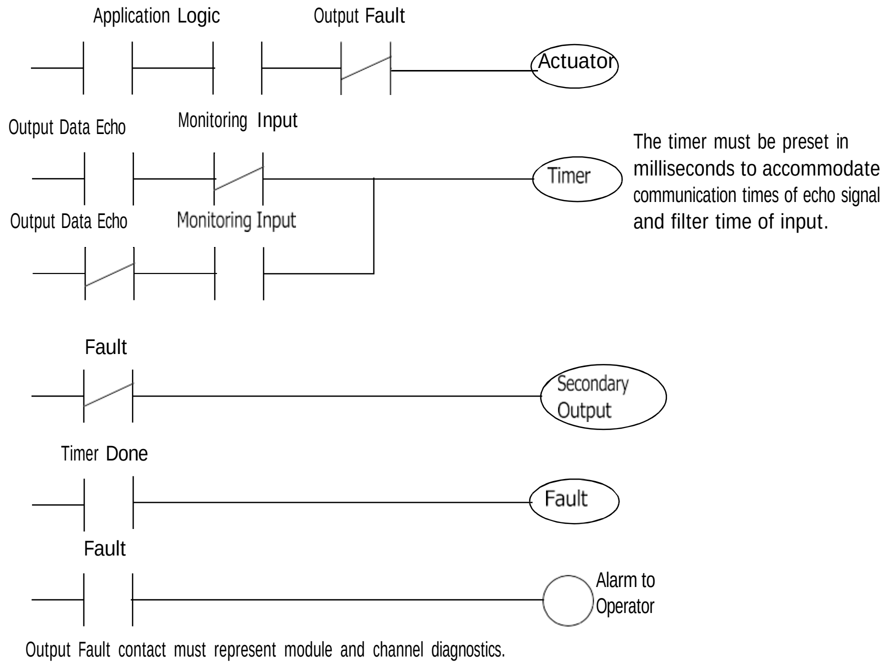
See Application Requirements for 1756 Digital Output Modules on page 46.

Figure 21 - ControlLogix Standard Output Module Wiring



Write the application logic to generate a fault if there is a miscompare between the controller, the actual output state, and the monitored input. The monitoring input module does not have to meet SIL 2 guidelines. The only requirement is that the module is listed in SIL 2-certified ControlLogix System Components on page 139.

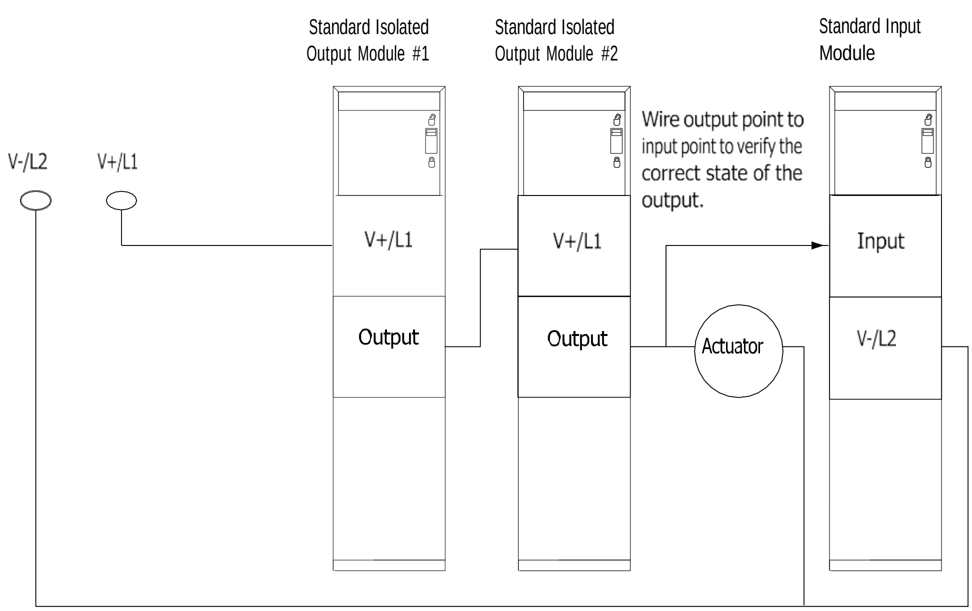
Figure 22 - Comparison Logic for Requested Versus Actual Output



The control, diagnostics, and alarm functions must be performed in sequence. For more information on faults, see Chapter 10, Faults in the ControlLogix System on page 127.

You can also wire two standard outputs in series to critical actuators. If a failure is detected, the outputs from each of the output modules must be set to OFF to make sure that the field devices de-energize. Figure 23 shows how to wire two isolated, standard outputs in series to critical actuators.

Figure 23 - ControlLogix Standard Output Module Wiring with Two Modules



1756 Analog Input Modules

There are a number of general application considerations that you must make when using analog input modules in a SIL 2 application. The following section describes those considerations.

To achieve SIL 2, two analog input modules are required. Field sensors must be wired to channels on each module and compared within a deadband. Whether one or two field sensors are required is dependent on the probability of a dangerous failure on demand (PFD) value of the sensor.

Conduct Proof Tests

Periodically perform a system validation test. Manually or automatically test all inputs to make sure that they are operational. Field signal levels must be varied over the full operating range to make sure that the corresponding channel data varies accordingly. For more information, see Proof Tests on page 28.

Calibrate Inputs

The 6-channel analog input modules must be calibrated periodically, as their use and application requires. The 8-channel modules do not have a periodic calibration requirement. ControlLogix I/O modules ship from the factory with a highly accurate level of calibration. However, because each application is different, you are responsible for making sure your ControlLogix I/O modules are properly calibrated for your specific application.

You can employ tests in application program logic to determine when a module requires recalibration. For example, you can determine a tolerance band of accuracy for a specific application. You can then measure input values on multiple channels and compare those values to acceptable values within the tolerance band. Based on the differences in the comparison, you could then determine whether recalibration is necessary. However, we recommend that you calibrate each analog input at least every 3 years to verify the accuracy of the input signal and avoid nuisance application shutdowns.

Use the Floating Point Data Format

ControlLogix analog input modules perform onboard alarm processing to validate that the input signal is within the proper range. These features are only available in Floating Point mode. To use the Floating Point Data format, select the Floating Point Data format in the Module Properties dialog box.

Program to Respond to Faults Appropriately

When programming the SIL 2 system, verify that your program examines the appropriate module fault, channel fault, and channel status bits and responds by initiating the appropriate fault routine.

Each module communicates the operating status of each channel to the controller during normal operation. Application logic must examine the appropriate bits to initiate a fault routine for a given application. For more information on faults, see Chapter 10, Faults in the ControlLogix System on page 127.

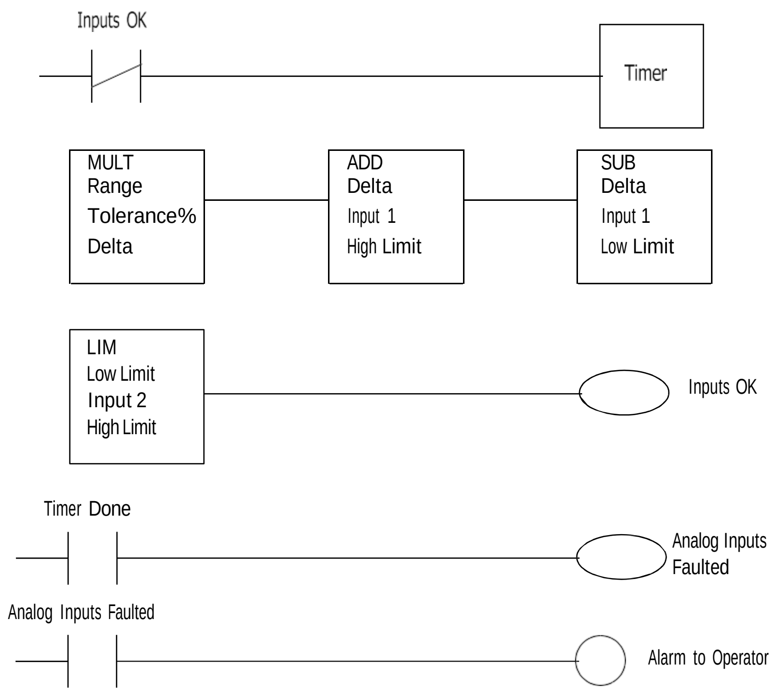
Program to Compare Analog Input Data

When wiring sensors to two input channels on different modules, the values from those channels must be compared to each other within the program for concurrence within an acceptable range for the application, before an output is actuated. Any miscompare between the two inputs outside the programmed acceptable range must be annunciated as a fault.

In Figure 24, a user-defined percentage of acceptable deviation (that is, tolerance) is applied to the configured input range of the analog inputs (that is, range) and the result is stored (that is, delta). This delta value is then added to and subtracted from one of the input channels; the results define an acceptable High and Low limit of deviation. The second input channel is then compared to these limits to determine if the inputs are working properly.

The input's OK bit preconditions a Timer run that is preset to accommodate an acceptable fault response time and any communication filtering lags in the system. If the inputs miscompare for longer than the preset value, a fault is registered with a corresponding alarm.

Figure 24 - Comparison Logic for Two Analog Inputs



The control, diagnostics, and alarm functions must be performed in sequence. For more information on faults, see Chapter 10, Faults in the ControlLogix System on page 127.

Configure Modules

When using identical modules, configure the modules identically, that is, by using the same RPI, filter values, and so on.

When using different modules for improved diversity, make sure the module's scaling of data does not introduce error or fault conditions.

Specify the Same Controller as the Owner

The same controller must own both analog input modules.

You must use Analog Inputs Faulted as a safety status/permissive in respective safety-related outputs.

Wire 1756 Analog Input Modules

The wiring diagrams that are shown in this section apply to applications that require transmitters. The type of transmitter along with the application requirements determine whether one or two transmitters are required.

Good design practice dictates that each of the two transmitters must be wired to input terminals on separate modules such that the channel values can be validated by comparing the two within an acceptable range. Special consideration must be given when you apply this technique, depending on the type of module being used.

Wire the Single-Ended Input Module in Voltage Mode

Make sure you:

- Review the considerations in 1756 Digital Input Modules on page 43.
- Use the correct documentation (see Additional Resources on page 11) to wire the module.
- Tie all (-) leads of the transmitters together when operating in single-ended Voltage mode.

Figure 25 shows how to wire an analog input for use in Voltage mode.

Figure 25 - ControlLogix Analog Input Module Wiring in Voltage Mode

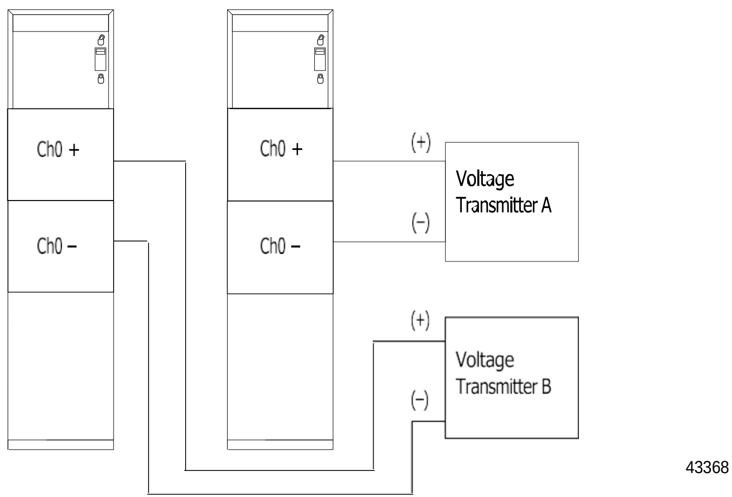
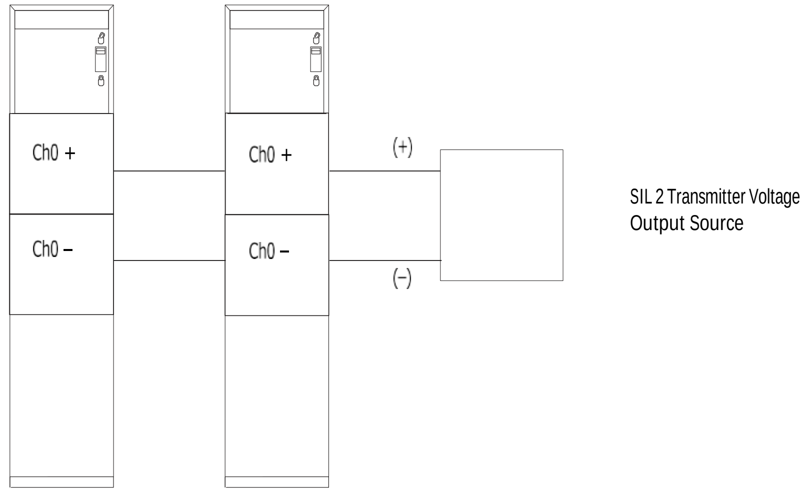


Figure 26 shows how to wire a SIL 2 transmitter to two analog input modules configured for voltage mode.

Figure 26 - ControlLogix Analog Input Module Wiring in Voltage Mode



Wire the Single-ended Input Module in Current Mode

Make sure you:

- Review the considerations in 1756 Analog Input Modules on page 50.
- Use the correct documentation (listed in Additional Resources on page 11) to wire the module.
- Place the devices correctly in the current loop. You can locate other devices in the current loop of an input channel anywhere as long as the current source can provide sufficient voltage to accommodate all voltage drops. Each module input is 250 Ω.

Figure 27 and Figure 28 show how to wire an analog input for use in Current mode.

Figure 27 - ControlLogix Analog Input Module Wiring in Current Mode

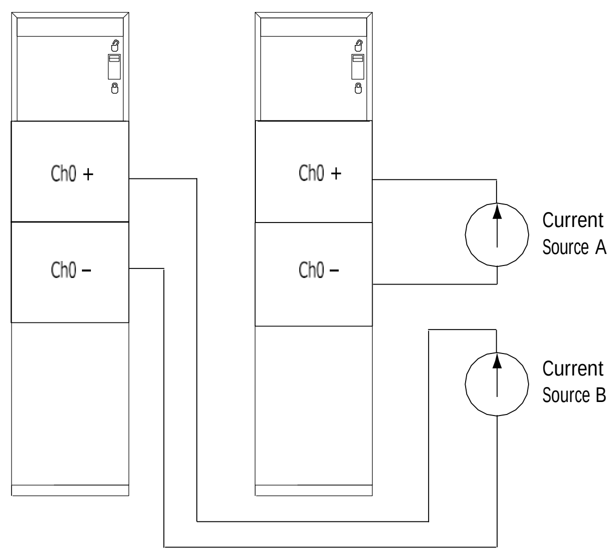
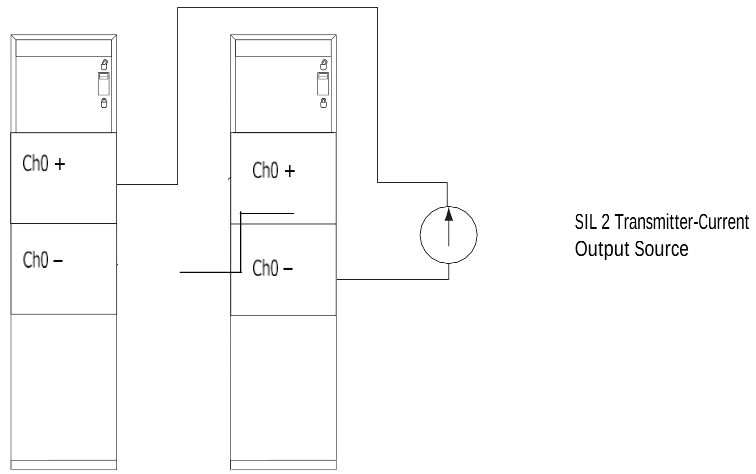
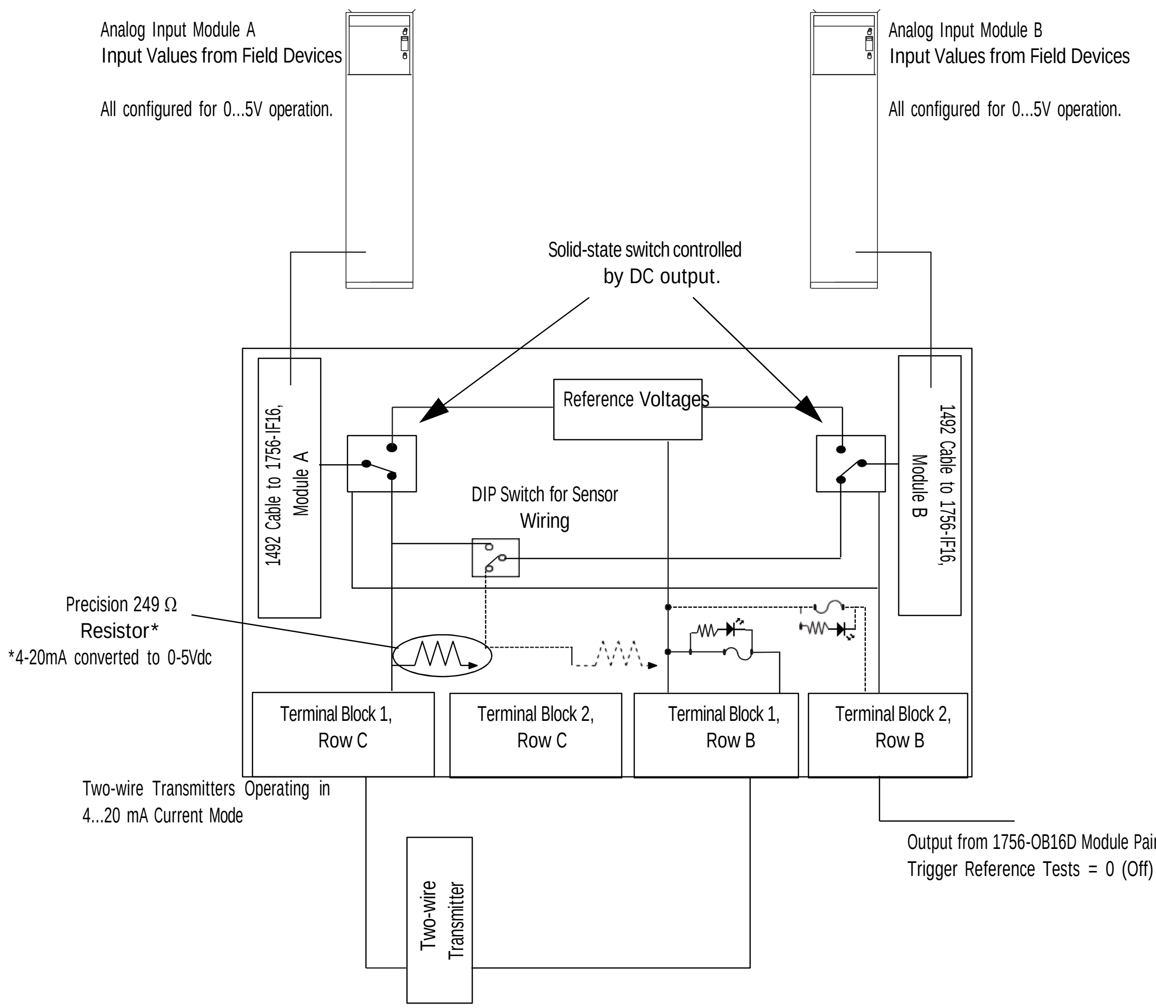


Figure 28 - ControlLogix Analog Input Module Wiring for Isolated Channels in Current Mode



If you use single-ended channels, use a 1492-TAIFM16-F-3 termination board and two 1492-ACABLE010UA cables to split the current sensor into two single-ended channels that are configured for Voltage mode.

Figure 29 - Analog Input Wiring Example with Termination Boards[1]



(1) See ControlLogix SIL 2 System Configuration Using RSLogix 5000® Subroutines, publication 1756-AT012.

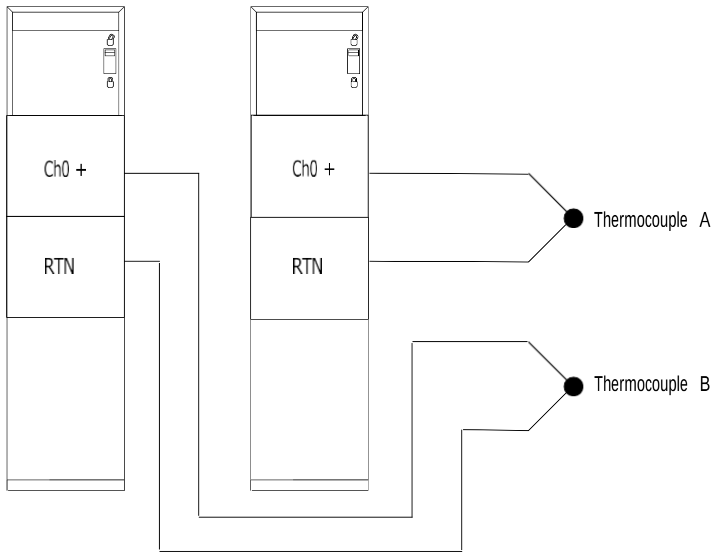
Wire the Thermocouple Input Module

Make sure that you do the following:

- Review the considerations in 1756 Analog Input Modules on page 50.
- Use the correct documentation listed in Additional Resources on page 11 to wire the module.
- Wire to the same input channel on both modules. When you wire thermocouples, wire two in parallel to two modules. Use the same channel on each module to make sure of consistent temperature readings.

Figure 30 on page 55 shows how to wire the 1756-IT6I, 1756-IT6I2, or 1756-IR8TI modules.

Figure 30 - ControlLogix Analog Thermocouple Module Wiring

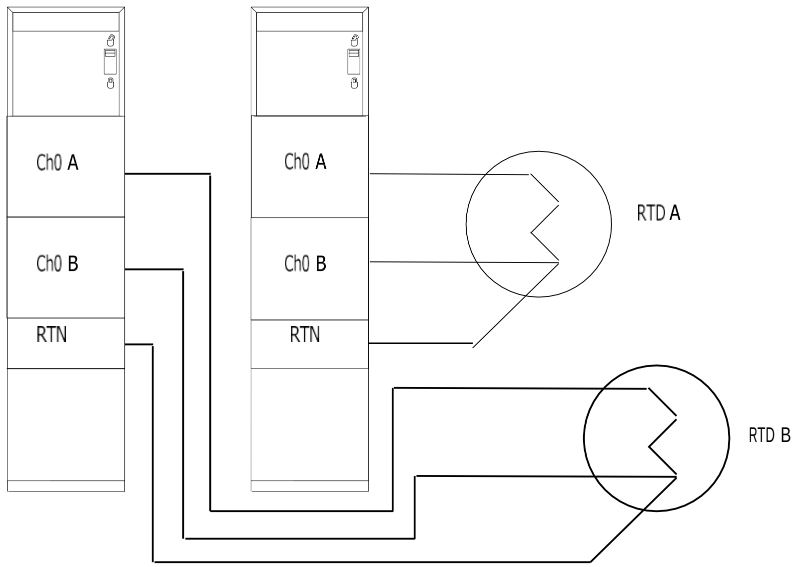


Wire the RTD Input Module

Make sure that you do the following:
- Review the considerations in 1756 Analog Input Modules on page 50.
- Use the correct documentation listed in Additional Resources on page 11 to wire the module.
- Use two sensors. RTDs cannot be wired in parallel without severely affecting their accuracy.

Figure 31 shows how to wire the 1756-IR6I or 1756-IR8TI modules.

Figure 31 - ControlLogix Analog RTD Module Wiring



1756 HART Analog Input Modules

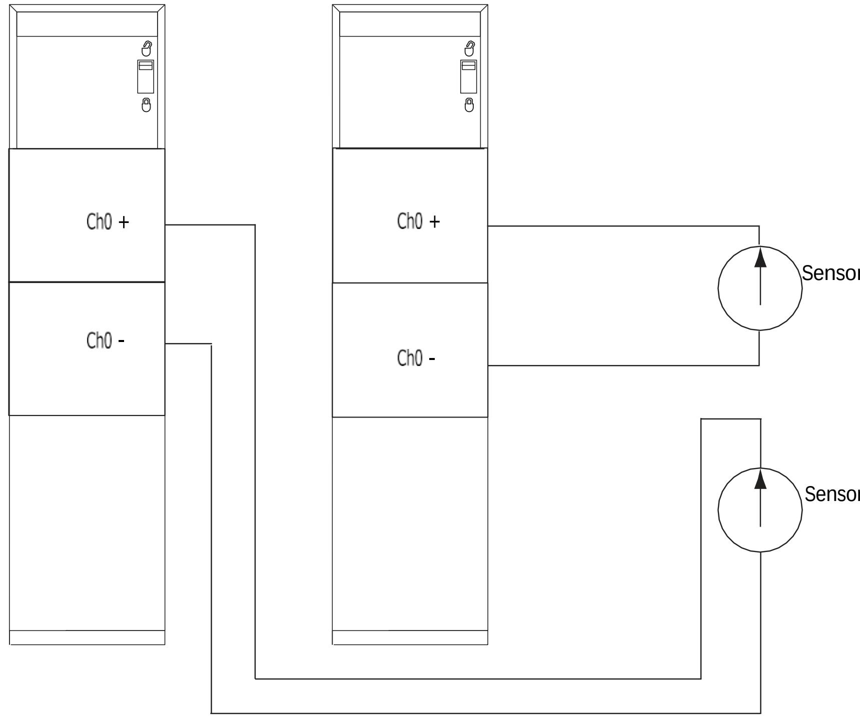
The Highway Addressable Remote Transducer (HART) analog modules must be used according to the same considerations as other analog input modules.

IMPORTANT	HART protocol must not be used for safety-related data.

Wire the HART Analog Input Modules

Make sure that you do the following:
- Review the considerations in 1756 Analog Input Modules on page 50.
- Use the correct documentation listed in Additional Resources on page 11 to wire the module.

Figure 32 - HART Input Analog Module Wiring



1756 Analog Output Modules

There are a number of general application considerations that you must make when using analog output modules in a SIL 2 application. An analog output module, along with an analog input module is required to monitor to achieve SIL 2. The following sections describe those considerations specific to the use of analog output modules.

IMPORTANT	We recommend that you do not use analog outputs to execute the safety function that results in a safe state. Analog output modules are slow to respond to an ESD command and are therefore not recommended for use ESD output modules. The use of digital output modules and actuators to achieve the ESD de-energized state is recommended.

Conduct Proof Tests

Periodically perform a system validation test. Manually or automatically test all outputs to make sure that they are operational. Field signal levels should be varied over the full operating range to make sure that the corresponding channel data varies accordingly. For more information, see Proof Tests on page 28.

Calibrate Outputs

Calibrate the analog output modules periodically, as their use and application requires. ControlLogix I/O modules ship from the factory with a highly accurate level of calibration. However, because each application is different, you are responsible for making sure your ControlLogix I/O modules are properly calibrated for your specific application.

You can employ tests in application program logic to determine when a module requires recalibration. For example, to determine whether you must recalibrate an output module, you can determine a tolerance band of accuracy for a specific application. You can then measure output values on multiple channels and compare those values to acceptable values within the tolerance band. Based on the differences in the comparison, you could then determine whether recalibration is necessary.

Calibration (and subsequent recalibration) is not a safety issue. However, we recommend that you calibrate each analog output module at least every 3 years to verify the accuracy of the signal and avoid nuisance application shutdowns.

Use the Floating Point Data Format

ControlLogix analog output modules perform onboard alarm processing to validate that the input signal is within the proper range. These features are only available in Floating Point mode. To use the Floating Point Data format, select the Floating Point Data format in the Module Properties dialog box. The 1756-OF8I profile only offers a floating point option, which is labeled 'Output Data' as the Connection choice.

Program to Respond to Faults Appropriately

When programming the SIL 2 system, verify that your program examines the appropriate module fault, channel fault, and channel status bits and responds by initiating the appropriate fault routine.

Each module communicates the operating status of each channel to the controller during normal operation. Application logic must examine the appropriate bits to initiate a fault routine for a given application. For more information on faults, see Chapter 10, Faults in the ControlLogix System on page 127.

Configure Outputs to De-energize in ESD Applications

For typical emergency shutdown (ESD) applications, outputs must be configured to de-energize. When configuring any ControlLogix output module, each output must be configured to de-energize if there is a fault and if the controller goes into Program mode. For exceptions to the typical ESD applications, see Chapter 1, SIL Policy on page 13.

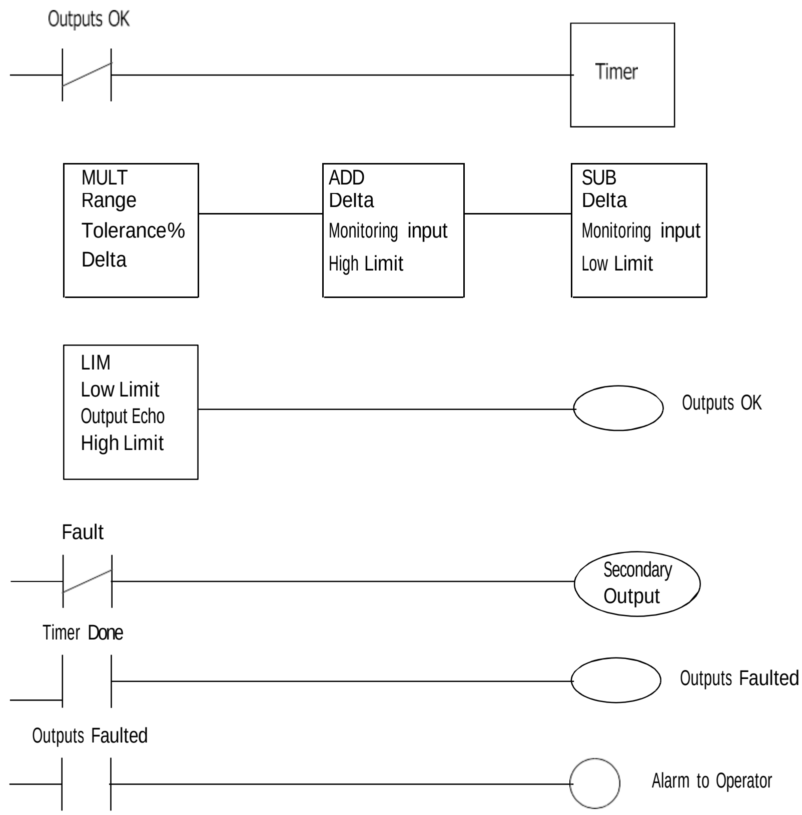
Monitor Channel Status

You must wire each analog output to an actuator and then back to an analog input to monitor the performance of the output, as shown in Figure 34. The application logic must examine the analog input (feedback value) associated with each analog output to make sure that the output from the controller was received correctly at the actuator. The analog output value must be compared to the analog input that is monitoring the output to make sure that the value is within an acceptable range for the application.

In the ladder diagram in Figure 33, a user-defined percentage of acceptable deviation (that is, tolerance) is applied to the configured range of the analog input and output and the result is stored (that is, delta). This delta value is then added to and subtracted from the monitoring analog input channel; the results define an acceptable high and low limit of deviation. The analog Output Echo is then compared to these limits to determine if the output is working properly.

The OK output bit preconditions or the Timer run is preset to accommodate an acceptable fault response time and any communication filtering, or output, lags in the system. If the monitoring input value and the Output Echo miscompare for longer than the preset value, a fault is registered with a corresponding alarm.

Figure 33 - Monitoring an Analog Output with an Analog Input



The control, diagnostics, and alarm functions must be performed in sequence.

Specify the Same Controller as the Owner

The same controller must own both analog modules.

Wire ControlLogix Analog Output Modules

In general, good design practice dictates that each analog output must be wired to a separate input terminal to make sure that the output is functioning properly.

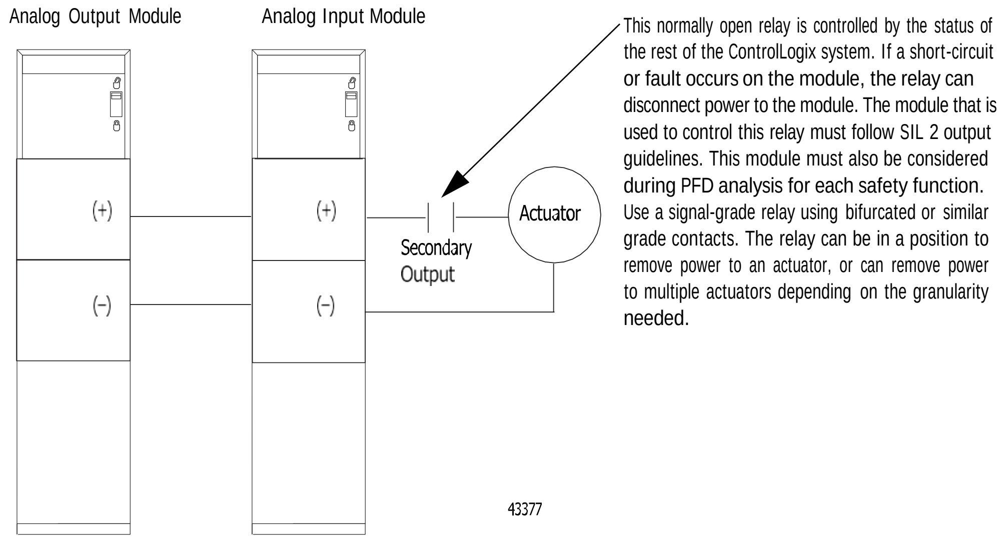
Wire the Analog Output Module in Voltage Mode

Make sure that you do the following:

- Review the considerations in on page 57.
- Use the correct documentation (listed in Additional Resources on page 11) to wire the module.

Figure 34 shows how to wire the 1756-OF8 module for use in Voltage mode.

Figure 34 - ControlLogix Analog Output Module Wiring in Voltage Mode



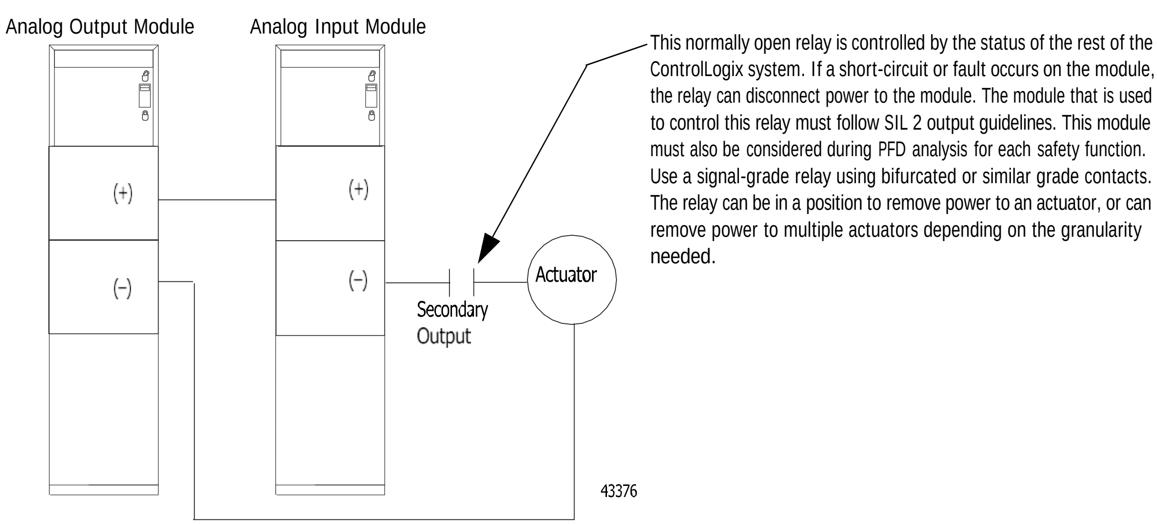
Wire the Analog Output Module in Current Mode

Make sure that you do the following:

- Review the considerations in on page 57.
- Use the correct documentation listed in Additional Resources on page 11 to wire the module.
- Place the devices correctly in the current loop. You can locate other devices in a current loop of the output channel anywhere as long as the current source can provide sufficient voltage to accommodate all voltage drops (each module output is 250 Ω).

Figure 35 shows how to wire the 1756-OF8 module for use in Current mode.

Figure 35 - ControlLogix Analog Output Module Wiring in Current Mode



1756 HART Analog Output Modules

Use the Highway Addressable Remote Transducer (HART) analog modules according to the same considerations as other analog output modules. For an illustration of how to wire the HART analog output modules, see Wire the HART Analog Output Modules on page 61.

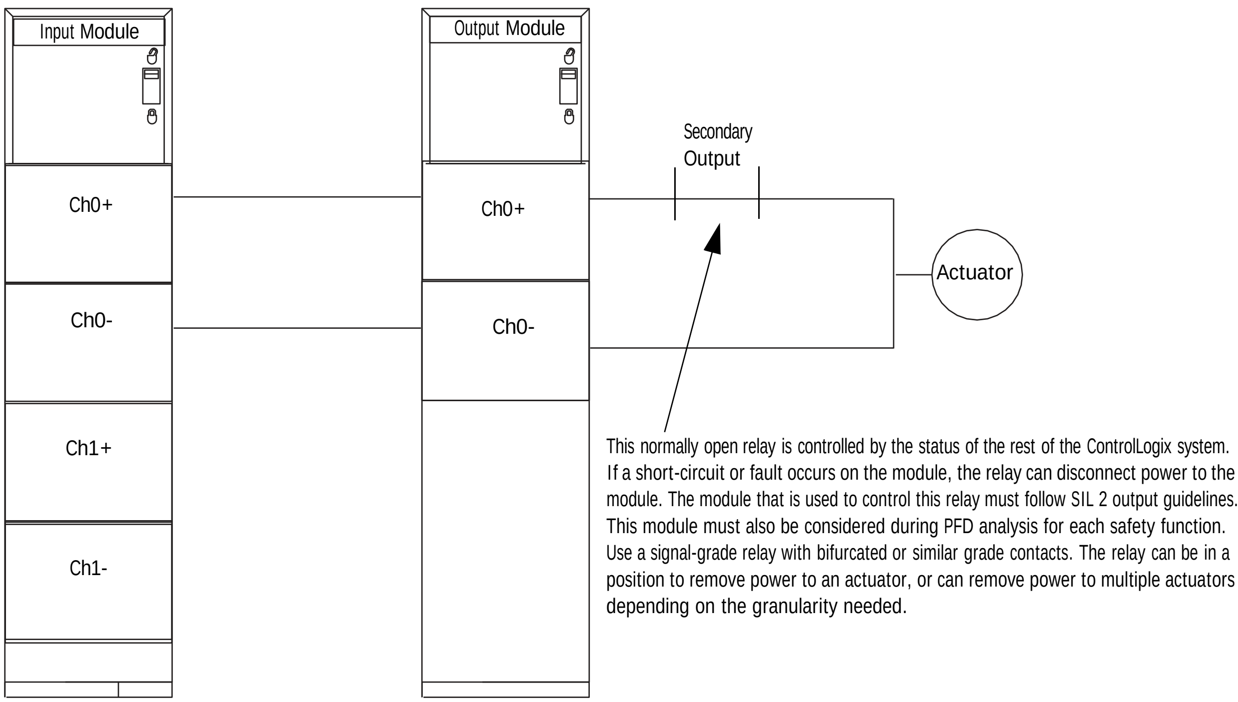
IMPORTANT	HART protocol must not be used for safety-related data.

Wire the HART Analog Output Modules

Make sure that you do the following:

- Review the considerations in Wire ControlLogix Analog Output Modules on page 59.
- Use the correct documentation listed in Appendix B as a reference when wiring the module.

Figure 36 - HART Output Analog Module Wiring



Notes:

1794 FLEX I/O Modules

There are two types of SIL 2-certified 1794 FLEX™ I/O modules:

- Digital I/O modules
- Analog I/O modules

1794 FLEX I/O modules are designed with inherent features that allow them to comply with the requirements of the 61508 Standard. For example, the modules all have a common backplane interface, execute power-up and runtime diagnostics, and offer electronic keying.

1794 Digital Input Modules

To achieve SIL 2, two digital input modules must be used, with field sensors wired to channels on each module. The two digital modules must be on separate 1794 rails. Use the software to compare the two channels before you reconcile the data.

Application Requirements for 1794 FLEX I/O Digital Input Modules

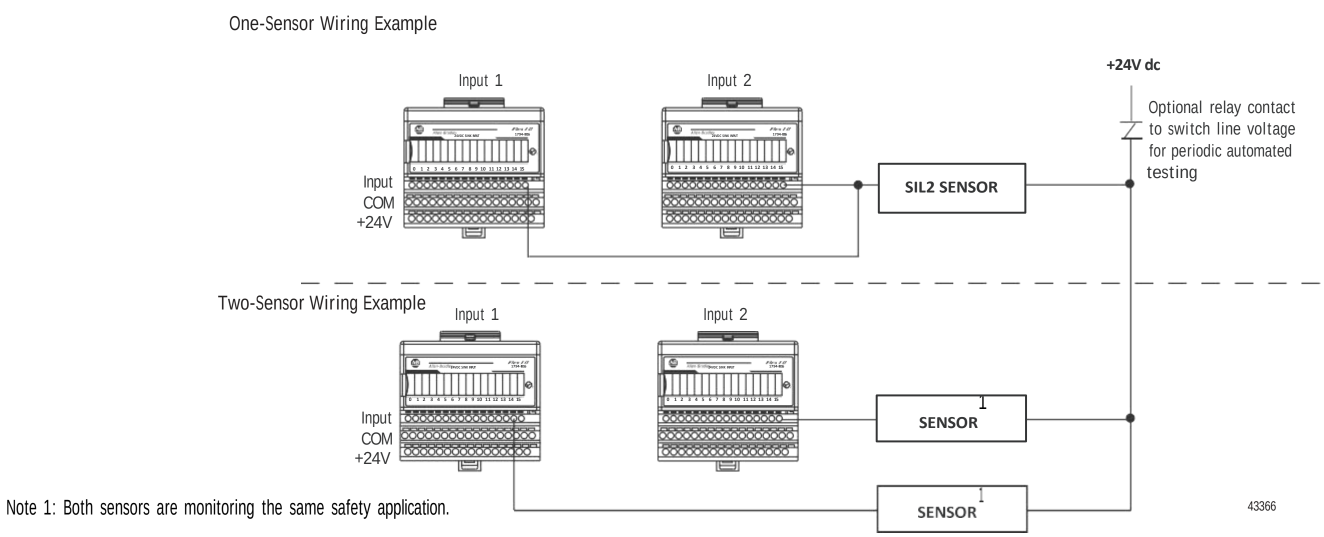
Regardless of the type of 1794 FLEX I/O input module that is used, there are a number of general application considerations that you must follow when applying these modules in a SIL 2 application:

- Proof tests—Periodically a system validation test must be performed. Manually, or automatically, test inputs to make sure that all inputs are operational and not stuck in the ON or OFF state. Inputs must be cycled from ON to OFF or OFF to ON.
- Configuration parameters (for example, RPI, filter values) must be identical between the two modules.
- The same controller must own both modules.
- Monitor the network status bits for the associated module and make sure that appropriate action is invoked via the application logic by these status bits.

Wire 1794 FLEX I/O Digital Input Modules

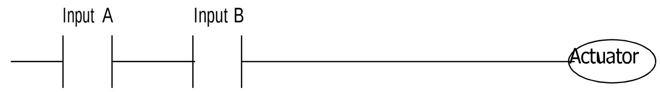
The wiring diagrams in Figure 37 show two methods of wiring the digital input module. In either case, you must determine whether the use of one or two sensors is appropriate to fulfill SIL 2 requirements.

Figure 37 - ControlLogix® Digital Input Module Wiring



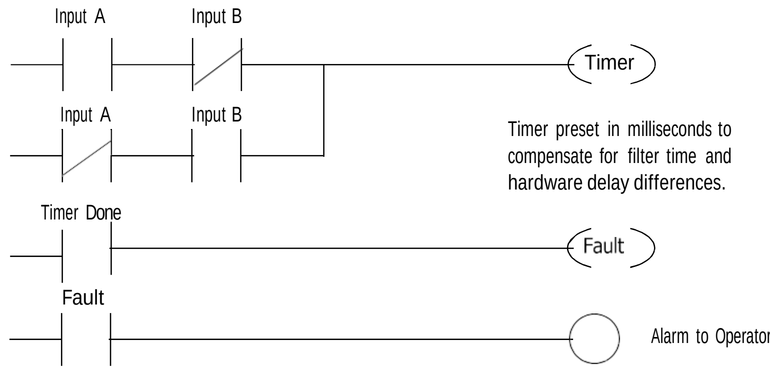
Application logic can compare input values or states for concurrence.

Figure 38 - Compare Input Values



The user program must also contain rungs to annunciate a fault if there is a sustained miscompare between two points.

Figure 39 - Annunciate a Fault



The control, diagnostics, and alarm functions must be performed in sequence.

1794 Digital Output Modules

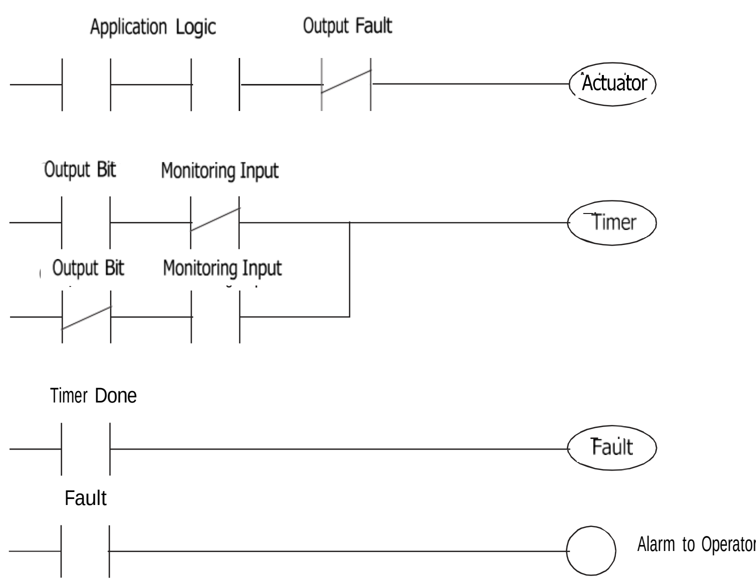
To achieve SIL 2, a 1794 output module must be wired back to an input module for monitoring.

Considerations for 1794 FLEX I/O Digital Output Modules

Regardless of the type of FLEX I/O output module that is used, there are a number of general application considerations that you must follow when applying these modules in a SIL 2 application:

- Proof tests- Periodically a System Validation test must be performed. Manually, or automatically, test outputs to make sure that all outputs are operational and not stuck in the ON or OFF state. Outputs must be cycled from ON to OFF or OFF to ON.

Figure 40 - Testing Outputs



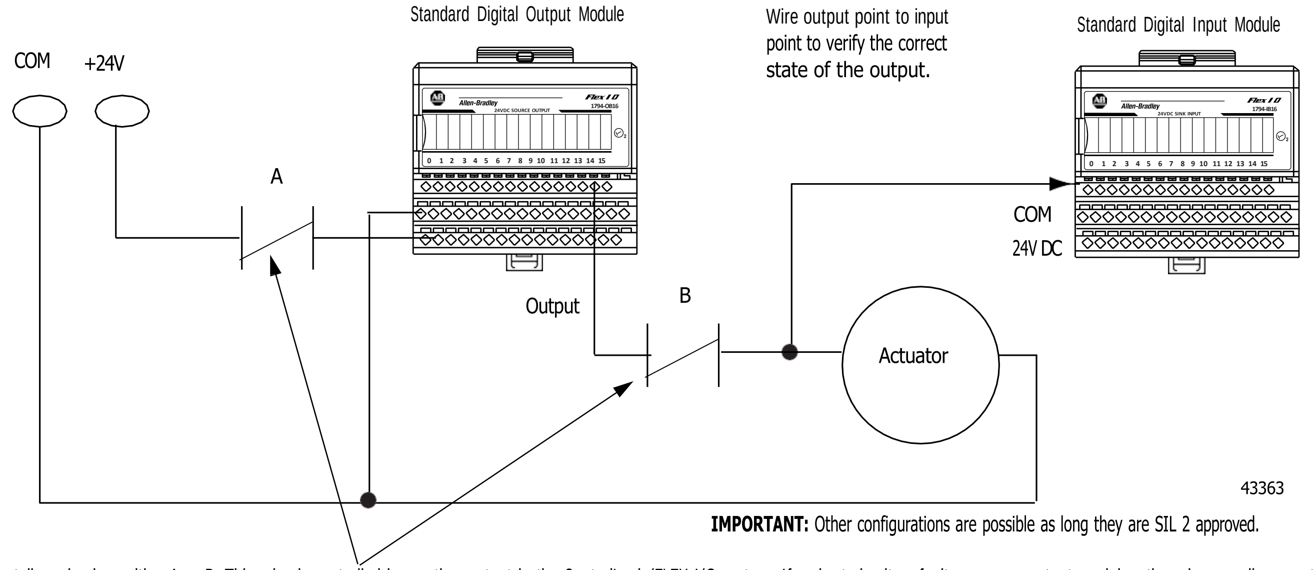
The control, diagnostics, and alarm functions must be performed in sequence.

- Use external relays to disconnect actuator power if output de-energization is critical. To make sure that outputs can de-energize, you must wire an external method that can remove power from the actuator if a short or other fault is detected.
- Test outputs at specific times to make sure that they are operating properly. The type of module determines the test method and frequency.
- Monitor the network status bits for the associated module and make sure that appropriate action is invoked via the application logic by these status bits.

Wire 1794 FLEX I/O Digital Output Modules

When using standard output modules, you must wire an output to an actuator and then back to an input to monitor the performance of the output.

Figure 41 - FLEX I/O Standard Output Module Wiring



Install a relay in position A or B. This relay is controlled by another output in the ControlLogix/FLEX I/O system. If a short circuit or fault occurs on output modules, the relay can disconnect power to the modules. An isolated relay output module (1794-OW8) can be used for this purpose when it is connected to another 1794-ACN15 or 1794-ACNR15 ControlNet® adapter.

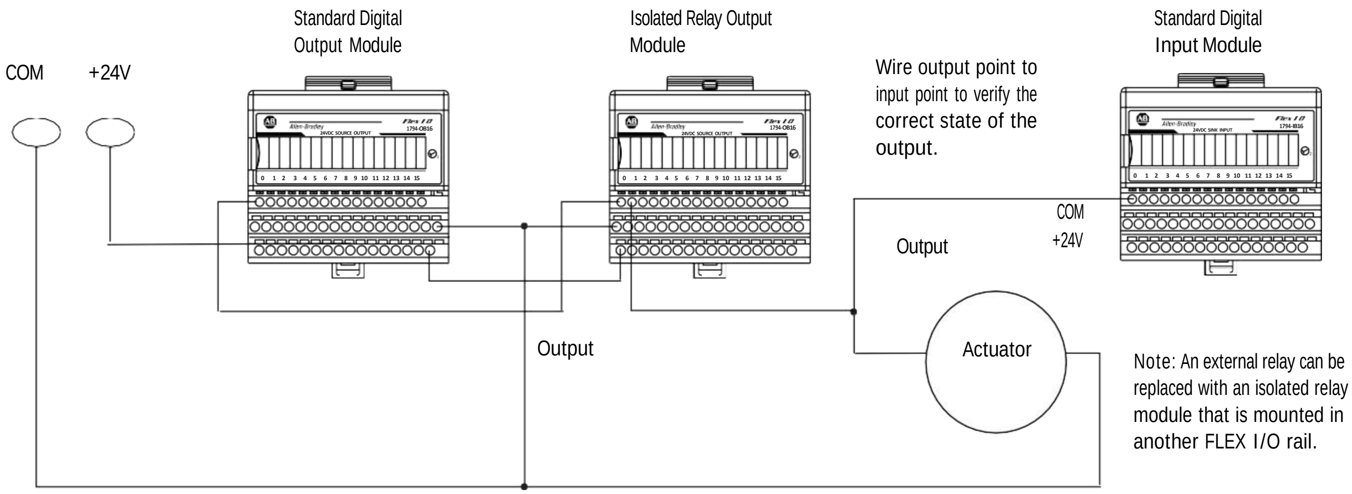
Write application logic so that it generates a fault if there is a miscompare between the requested state of an output (echo) and the actual output state that is monitored by an input channel (see Figure 40 on page 64).

The control, diagnostics, and alarm functions must be performed in sequence.

You can also wire a standard-digital output module in series with an isolated relay output module in series with a critical actuator. If a failure is detected, the output from both output modules must be set to OFF to make sure the Output Loads de-energize.

See Figure 42 on page 66 for detailed information about how to wire an output module with an isolated relay module.

Figure 42 - ControlLogix/FLEX I/O Standard Output Module Wiring with an Isolated Relay Module



1794 Analog Input Modules

To achieve SIL 2, two analog input modules are required. Field sensors must be wired to channels on each module and compared within a deadband. Whether one or two field sensors are required is dependent on the probability of a dangerous failure on demand (PFD) value of the sensor.

Considerations for FLEX I/O Analog Input Modules

You must follow these general application considerations when applying these modules in a SIL 2 application:

- Proof tests. Periodically a System Validation test must be performed. Manually, or automatically, test inputs to make sure that all inputs are operational. Vary the field signal levels over the full operating range to make sure that the corresponding channel data varies accordingly.
- Calibrate inputs periodically, as necessary. FLEX I/O modules ship from the factory with a highly accurate level of calibration. However, because each application is different, you are responsible for making sure their FLEX I/O modules are properly calibrated for their specific application.

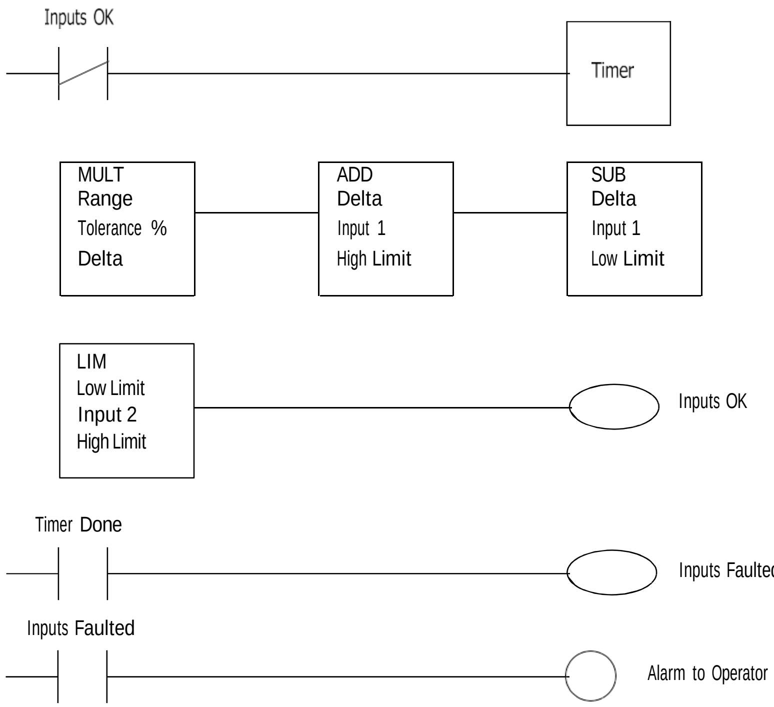
  You can employ tests in application program logic to determine when a module requires recalibration. For example, to determine whether an input module must be recalibrated, you can determine a tolerance band of accuracy for a specific application. You can then measure input values on multiple channels and compare those values to acceptable values within the tolerance band. Based on the differences in the comparison, you could then determine whether recalibration is necessary.

  Calibration (and subsequent recalibration) is not a safety issue. However, we recommend that you calibrate each analog input at least every three years to verify the accuracy of the input signal and avoid nuisance application shutdowns.
- Compare analog input data and annunciate miscompares. When wiring sensors to two input channels, the values from those channels must be compared to each other for concurrence within an acceptable range for the application before actuating an output. Any miscompare between the two inputs outside the programmed acceptable range must be annunciated as a fault.

  In Figure 43 on page 67, a user-defined percentage of acceptable deviation (tolerance) is applied to the configured input range of the analog inputs (range) and the result is stored (delta). This delta value is then added to and subtracted from one of the input channels; the results define an acceptable High and Low limit of deviation. The second input channel is then compared to these limits to determine if the inputs are working properly.

  The OK bit input preconditions a Timer run that is preset to accommodate an acceptable fault response time and any communication filtering lags in the system. If the inputs miscompare for longer than the preset value, a fault is registered with a corresponding alarm.

Figure 43 - Logic for Comparing Analog Input Data



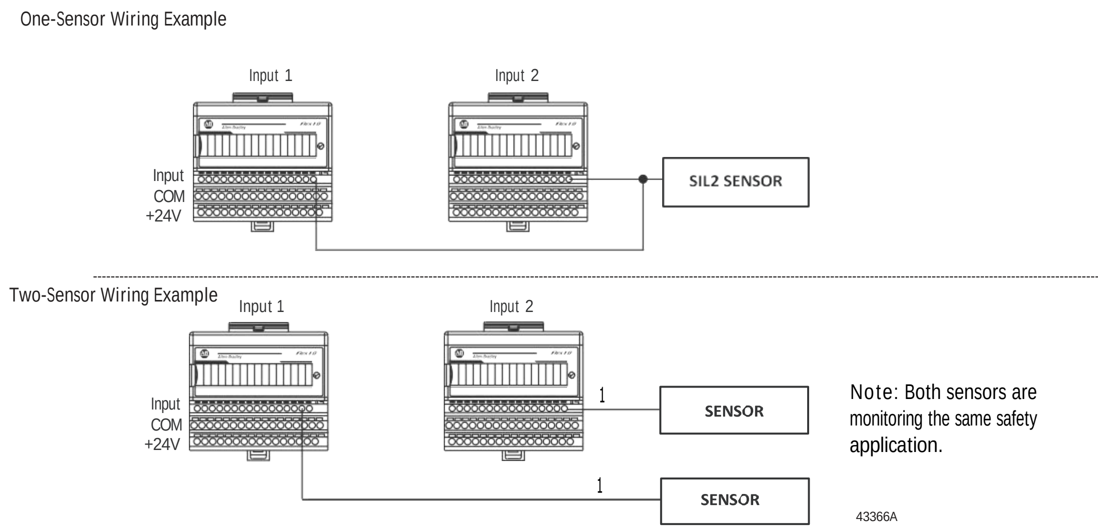
The control, diagnostics, and alarm functions must be performed in sequence.

- Configuration parameters (for example, RPI, filter values) must be identical between the two modules.
- The same controller must own both modules.
- Monitor the network status bits for the associated module and make sure that appropriate action is invoked via the application logic by these status bits.
- Wire sensors to separate input channels on two separate modules that are on different network nodes.

Wire 1794 FLEX I/O Analog Input Modules

The wiring diagrams in this section show two methods of wiring the analog input module. In either case, you must determine whether the use of one or two sensors is appropriate to fulfill SIL 2 requirements.

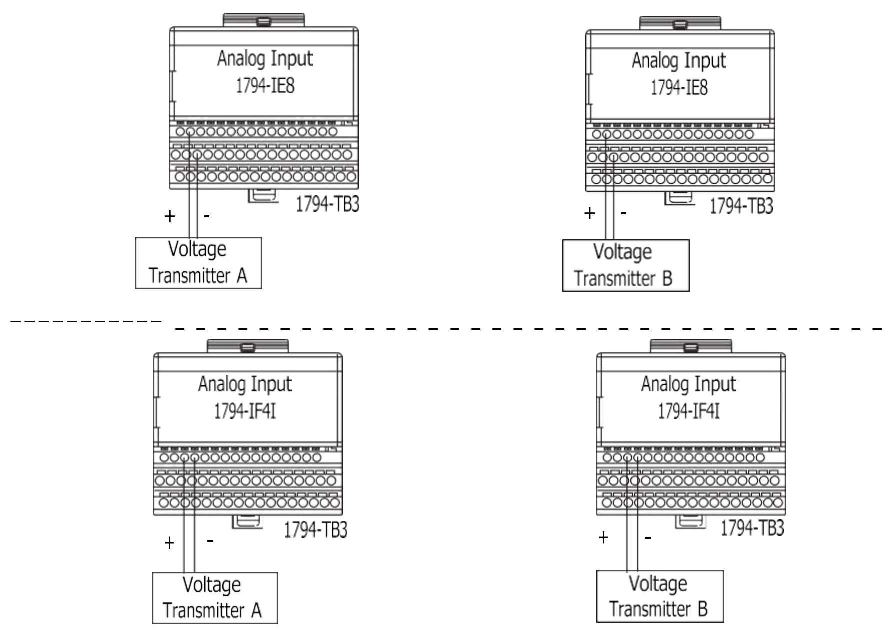
Figure 44 - FLEX I/O Analog Input Module Wiring



Wire the Single-ended Input Module in Voltage Mode

Along with following the Considerations for FLEX I/O Analog Input Modules on page 66, make sure that you use the correct documentation to wire the module.

Figure 45 - FLEX I/O Analog Input Module Wiring in Voltage Mode

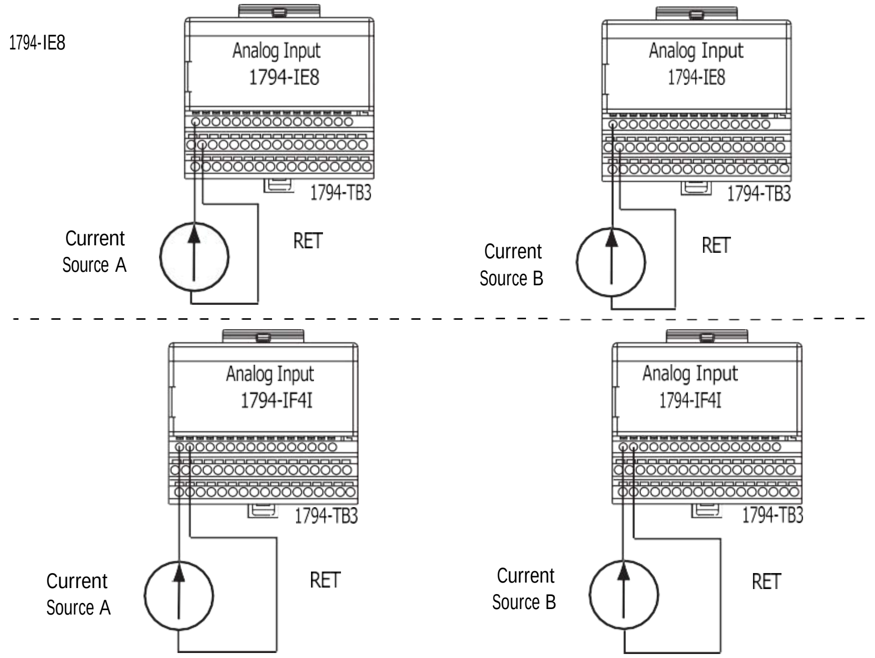


Wire the Single-ended Input Module in Current Mode

Along with following the Considerations for FLEX I/O Analog Input Modules on page 66, before wiring the module, consider the following application guideline:

Place other devices in a current loop. You can locate other devices in a current loop of an input channel anywhere as long as the current source can provide sufficient voltage to accommodate all voltage drops (each module input is 250 Ω).

Figure 46 - FLEX I/O Analog Input Wiring in Current Mode

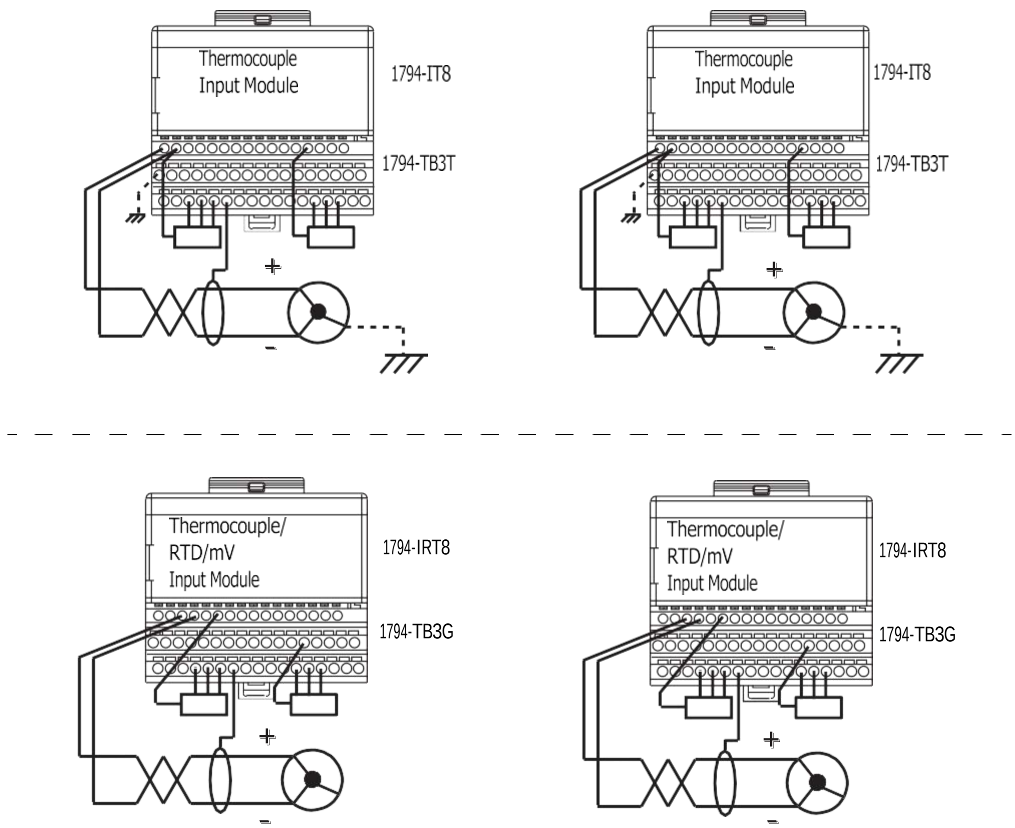


Wire the Thermocouple Input Module

Along with following the Considerations for FLEX I/O Analog Input Modules on page 66 and before wiring the module, consider the following application guideline:

Wire to the same input channel on both modules. When wiring thermocouples, wire two in parallel to two modules. Use the same channel on each module to make sure of consistent temperature readings.

Figure 47 - FLEX I/O Analog Thermocouple Module Wiring

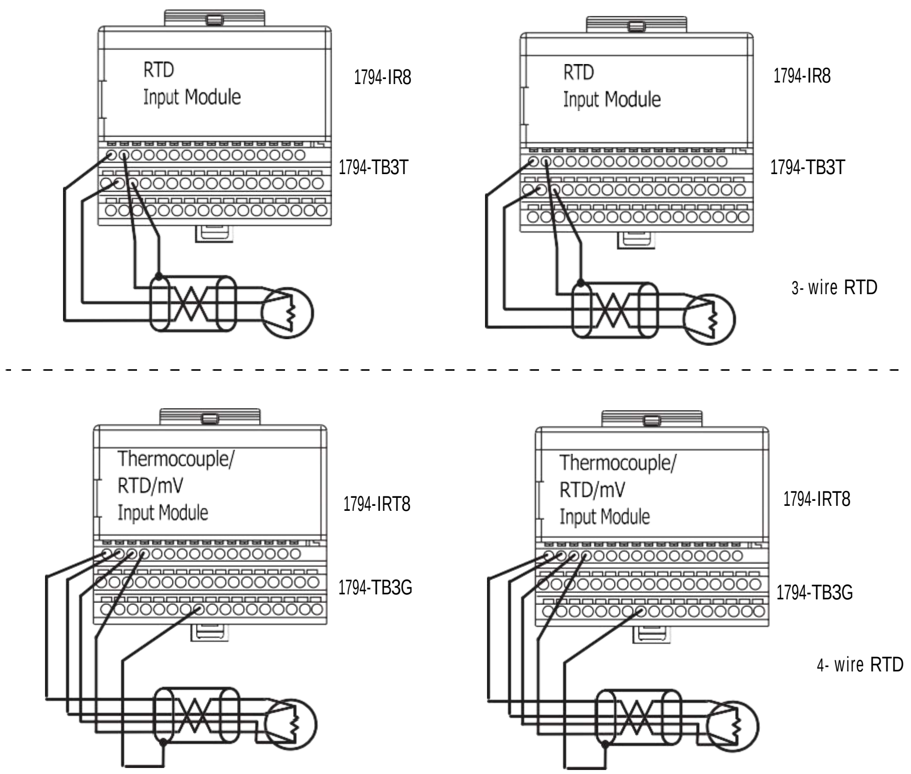


Wire the RTD Input Module

Along with following the Considerations for FLEX I/O Analog Input Modules on page 66 and before wiring the module, consider the following application guideline:

RTDs cannot be wired in parallel without severely affecting their accuracy. Two sensors must be used.

Figure 48 - FLEX I/O Analog RTD Module Wiring



Two-, three-, or four-wire RTDs can be used as applicable to the associated RTD input module.

1794 Analog Output Modules

An analog output module, along with an analog input module for monitoring is required to achieve SIL 2.

IMPORTANT	We strongly recommended that you do not use analog outputs to execute the safety function that results in a safe state. Analog output modules are slow to respond to an ESD command and are therefore not recommended for use ESD output modules. The use of digital output modules and actuators to achieve the ESD de-energized state is recommended.

Requirements for 1794 FLEX I/O Analog Output Modules

Follow these general application considerations when applying the analog output modules in a SIL 2 application:

- Proof tests - Periodically a System Validation test must be performed. Manually, or automatically, test outputs to make sure that all outputs are operational. Vary the channel data over the full operating range to make sure that the corresponding field signal levels vary accordingly.
- Calibrate outputs periodically, as necessary. FLEX I/O modules ship from the factory with a highly accurate level of calibration. However, because each application is different, you are responsible for making sure their FLEX I/O modules are properly calibrated for their specific application.

  You can employ tests in application program logic to determine when a module requires recalibration. For example, you can determine a tolerance band of accuracy for an application to determine if the output module needs recalibrated.

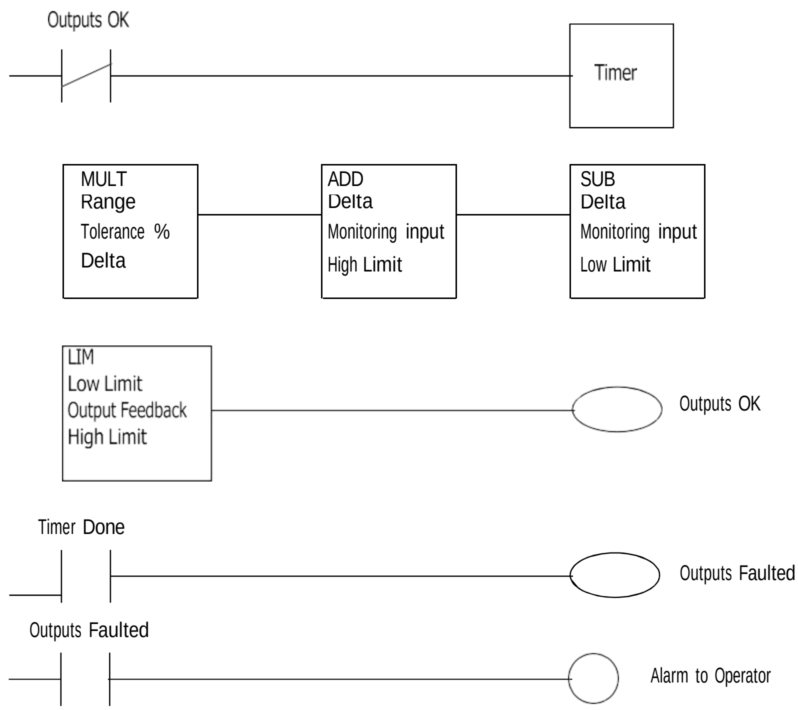
  Then you can measure output values on multiple channels and compare those values to acceptable values within the tolerance band. Based on the differences in the comparison, you could then determine whether recalibration is necessary.

  Calibration (and subsequent recalibration) is not a safety issue. However, we recommend that you calibrate each analog output at least every three years to verify the accuracy of the input signal and avoid nuisance application shutdowns.
- For typical emergency shutdown (ESD) applications, outputs must be configured to de-energize. When configuring any FLEX I/O output module, each output must be configured to de-energize if there is a fault and if the controller goes into Program mode.
- Wire outputs back to inputs and examine output-data feedback signal. You must wire an analog output to an actuator and then back to an analog input to monitor the performance of the output. (The use of feedback transmitters to verify that the performance is acceptable.) The application logic must examine the Data Feedback value that is associated with each output point. This examination makes sure that the requested output command from the controller was sent and the module received it. The value must be compared to the analog input that is monitoring the output to make sure that the value is in an acceptable range for the application.

  The ladder diagram in Figure 49, a user-defined percentage of acceptable deviation (tolerance) is applied to the configured range of the analog input and output (range) and the result is stored (delta). This delta value is then added to and subtracted from the monitoring analog-input channel; the results define an acceptable High and Low limit of deviation. The analog Output Feedback is then compared to these limits to determine if the output is working properly.

  The OK bit precondition for the output is a Timer run that is preset to accommodate an acceptable fault response time, any communication filtering, or output, and lags in the system. If the monitoring input value and the Output Feedback miscompare are longer than the preset value, a fault is registered with a corresponding alarm.

Figure 49 - Monitoring an Analog Output with an Analog Input



The control, diagnostics, and alarm functions must be performed in sequence.

- The same controller owns the AO modules, the DO module that drops power to the AO, and the AI monitoring module
- The AO module and the DO that controls power to it must be on separate FLEX rails. They must not share a FLEX adapter.
- Monitor the network status bits for the associated module and make sure that appropriate action is invoked via the application logic by these status bits.

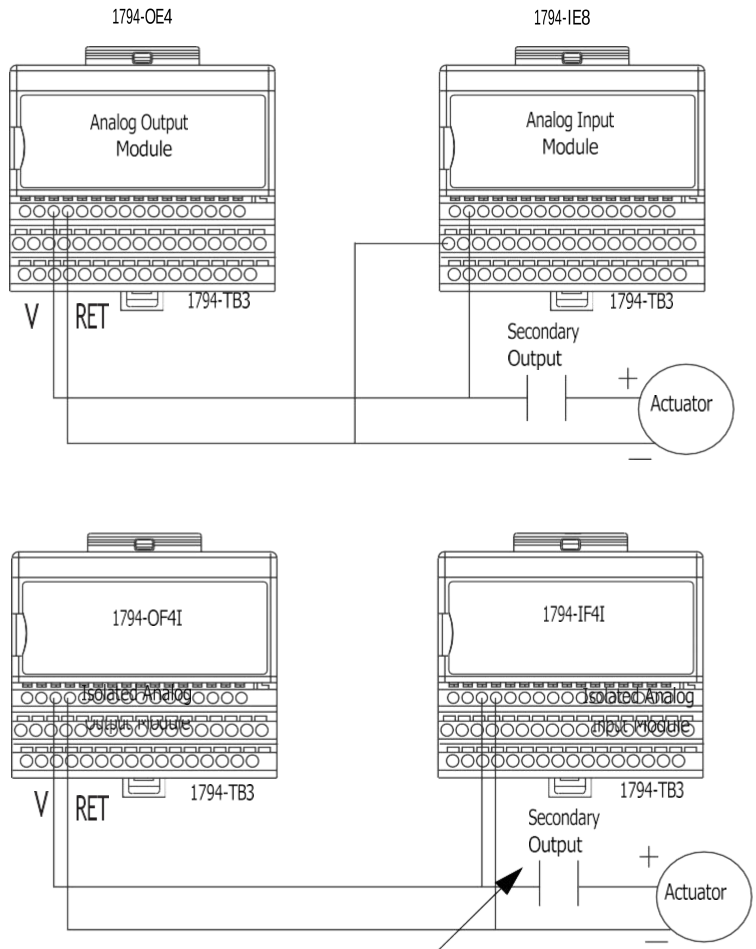
Wire 1794 FLEX I/O Analog Output Modules

In general, good design practice dictates that each analog output must be wired to a separate input terminal to make sure that the output is functioning properly.

Wiring the Analog Output Module in Voltage Mode

You must wire analog outputs to an actuator and then back to an analog input to monitor the output performance.

Figure 50 - Analog Input Module Wiring Example



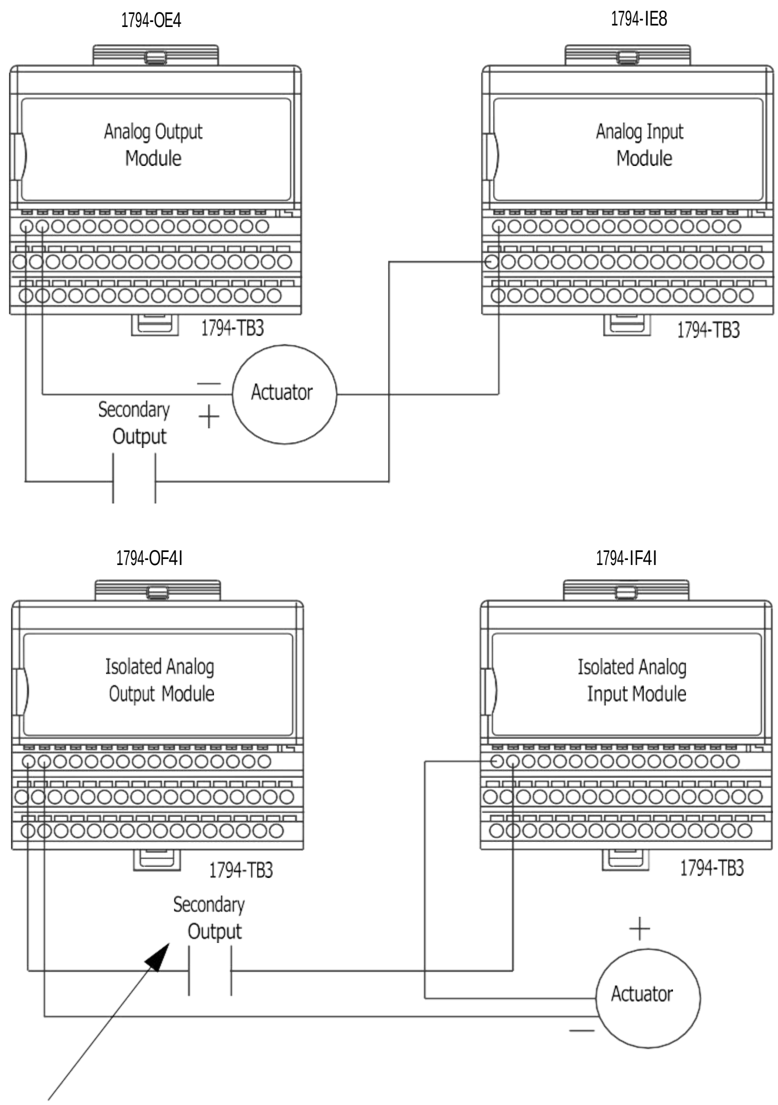
This normally open relay is controlled by the status of the rest of the ControlLogix system. If a short-circuit or fault occurs on the module, the relay can disconnect power to the module. The module that is used to control this relay must follow SIL 2 output guidelines. This module must also be considered during PFD analysis for each safety function.
Use a signal-grade relay with bifurcated or similar grade contacts. The relay can be in a position to remove power to an actuator or can remove power to multiple actuators depending on the granularity needed.

Wire the Analog Output Module in Current Mode

Along with following the Requirements for 1794 FLEX I/O Analog Output Modules on page 72, consider the following application guideline before wiring the module in Current mode:

Place other devices in a current loop. You can locate other devices in a current loop for the output channel anywhere as long as the current source can provide sufficient voltage to accommodate all voltage drops.

Figure 51 - Analog Output Wiring Example



This normally open relay is controlled by the status of the rest of the ControlLogix system. If a short-circuit or fault occurs on the module, the relay can disconnect power to the module. The module that is used to control this relay must follow SIL 2 output guidelines. This module must also be considered during PFD analysis for each safety function.
Use a signal-grade relay with bifurcated or similar grade contacts. The relay can be in a position to remove power to an actuator or can remove power to multiple actuators depending on the granularity needed.

Notes:

1715 Redundant I/O Modules

This chapter provides information about 1715 I/O modules in a SIL CL (Claim Limit) 2 system, such as a ControlLogix®-based SIL 2 system. The system can be low demand or high demand with up to 10 demands per year.

The product complies with the requirements of SC 2 and SIL 2 according to IEC 61508 and can be used in safety-related applications for process control, burner management, fire and gas, emergency shutdown systems where the safe state is the de-energized state, and applications where the demand state is the de-energized or energized state, up to SIL 2.

When used with 1715 I/O, the ControlLogix SIL 2 system supports the following safety configurations. These SIL 2 architectures are for fail-safe low and high demand applications. All SIL 2 architectures can be used for de-energize to trip applications. With special precautions, CLX/1715 SIL 2 can be used in energize-to-trip applications:

- SIL 2 low demand applications
- SIL 2 high demand – up to 10 demands per year
- SIL 2 fail-safe applications
- SIL 2 with fault tolerant inputs
- SIL 2 with fault tolerant outputs
- SIL 2 with fault tolerant inputs/outputs

For general information about 1715 I/O modules, see the Redundant I/O System User Manual, publication 1715-UM001.

SIL 2 Safety Application Requirements

The 1715 I/O system reduces the configuration work for a ControlLogix SIL 2 system. Because 1715 I/O modules are designed to operate in a safety system, there is no requirement for special wiring or IFMs to use ControlLogix in a SIL 2 system. Either or both the I/O system or controller system can be simplex or duplex, which makes the system scalable to fit your application.

To use the 1715 Redundant I/O system in SIL 2 safety applications, you must have revision 4.011 or later, of the adapter firmware, the latest Add-on Profiles (AOPs), and the 1715 SIL 2 Add-On Instructions.

IMPORTANT For SIL 2 safety applications, you must have the following:
- 1715-AENTR adapters, firmware revision 4.011 or later
- 1715 I/O modules, firmware revision 4.011 or later
- Add-on Profile, version 4.04.08 or later for the adapters
- Add-on Profile, version 5.04.13 or later for the I/O modules
- Add-On Instructions, version 4.0 or later if you use a ControlLogix system
- ControlLogix 5570 controllers

ControlLogix 5560 controllers are not supported with 1715 I/O.

ATTENTION: ControlLogix 5570 controllers are certified in RSLogix 5000®, version 20 or later for SIL 2 operations. See the latest certifications for software and firmware at rok.auto/certifications. See the TÜV website at https://www.tuvasi.com/ for SIL 2 certification listings.

IMPORTANT	Listen Only is not supported for SIL 2 operations. Only one ControlLogix 5570 controller can connect to any I/O module within the 1715 chassis for SIL 2 safety functions.

IMPORTANT	Safety functions that are being edited online are not SIL 2 certified from the start of the online edits to the completion of the validation of the changes.

IMPORTANT	1715 I/O modules communicate only via the EtherNet/IP™ network. ControlNet® modules are not supported.

1715 I/O Modules in SIL 2 Safety Applications

1715 I/O modules, firmware revision 4.011 and later[(a)], can be used in safety applications up to and including SIL 2. Your system can be configured with any combination of I/O modules, and in either Simplex or Duplex mode.

You can configure modules for use in SIL 2 Safety applications on these tabs on the Module Properties dialog box:

- SIL 2 Safety tab—Configure the RPI, connection reaction time limit, access diagnostic data, and perform a SIL 2 reset.
- Input States When CRTL Expires tab— Define the safe state for inputs.

For more information on SIL 2 application requirements for 1715 I/O modules, see these resources:

- For information about Add-On Instructions for SIL 2 1715 I/O module applications, see Chapter 8.
- For PFD and PFH calculations, see Appendix C.
- For a SIL 2 application checklist, see Appendix F
- For specifications and certifications related to a 1715 Redundant I/O system, refer to the 1715 Redundant I/O System Technical Specifications, publication 1715-TD001.

See the latest certifications for software and firmware at rok.auto/certifications.

See the TÜV website at https://www.tuvasi.com/ for SIL 2 certification listings.

All I/O modules include line monitoring capability. We recommend that you use line monitoring for safety-related I/O. Safety-related I/O refers to an annunciator being available to an input or output that is attached to a field device. For energize-to-action (normally de-energized) I/O, you must enable line monitoring.

Typical Configurations

The 1715 system supports single (simplex) module configurations where it is acceptable to either stop the system or allow the signals corresponding to that module to change to their default fail-safe state. It also supports fault-tolerant I/O (redundant) configurations where the system is required to continue operating if there is a fault.

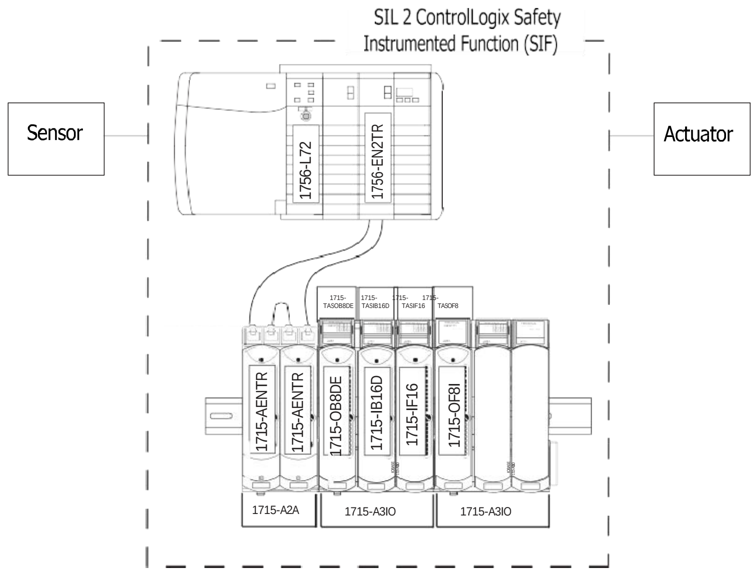
Fault tolerant systems have redundant modules that let the system continue operation in the presence of a fault. The system fails safe (off) if another fault occurs.

All configurations can be used for safety-related applications. Choose the appropriate configurations that are based on the fault tolerance requirements of your application.

(a) See the Module Revision Release List available from the Product Certifications link on at rok.auto/certifications.

DLR Topology

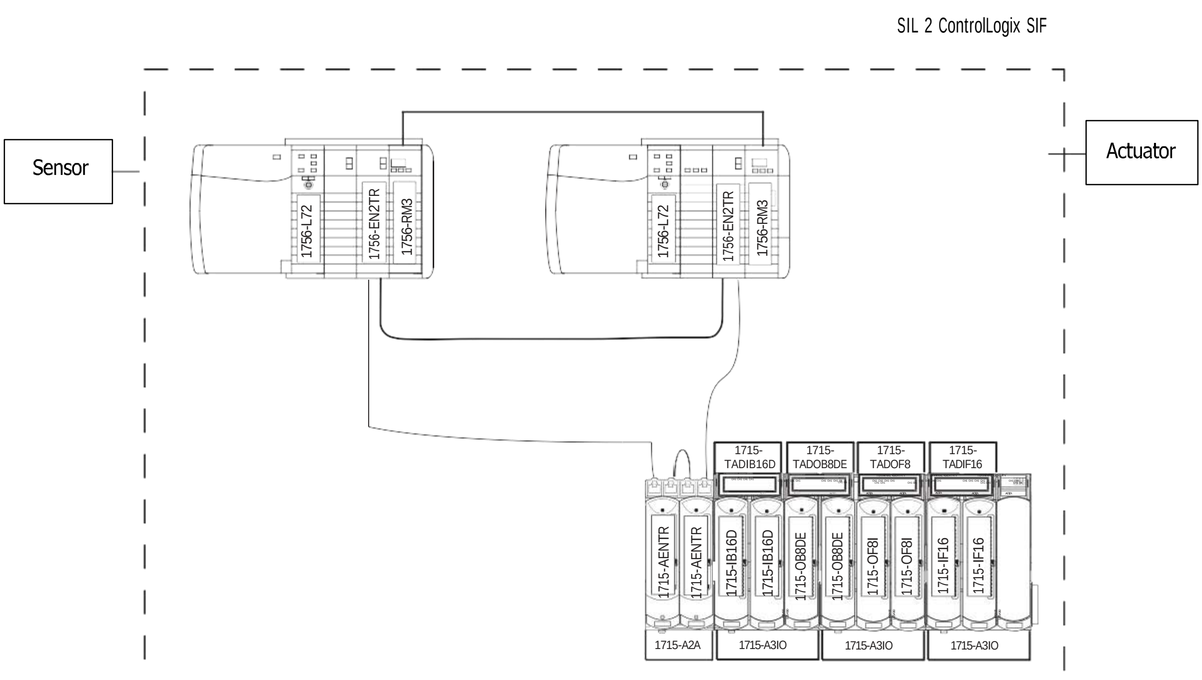
Figure 52 - Simplex DLR with a ControlLogix Controller



For duplex configurations, a SIL 2 fault-tolerant architecture has dual-input, dual adapter, and dual output modules. The input modules operate in 1oo2 (1 out of 2) under no fault conditions and degrade to 1oo1 (1 out of 1) upon detection of the first fault in either module. The modules fail-safe if faults occur on both modules. The adapters operate in 1oo2 under no-fault conditions and degrade to 1oo1 upon detection of the first fault. A duplex system could therefore be 1oo2 reverting to 1oo1 on the first detected fault and reverting to fail-safe when both modules have a fault. Fail-safe is defined as the 'de-energized' or 'off' state.

The Ethernet architecture has no effect on SIL 2 safety functions. You can use either of these example drawings, or any other appropriate Ethernet network. From a safety aspect, if the Ethernet packets are not sent successfully, then the SIL 2 safety functions go to their respective safe states.

Figure 53 - Duplex DLR with a ControlLogix Controller



Star Topology

Figure 54 - Simplex Star with a ControlLogix Controller

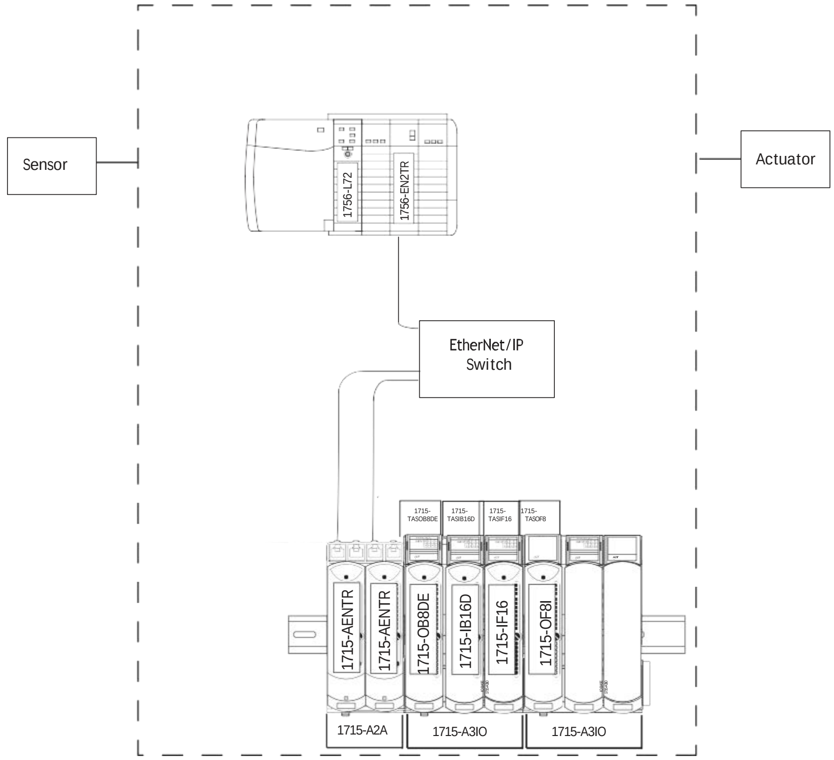
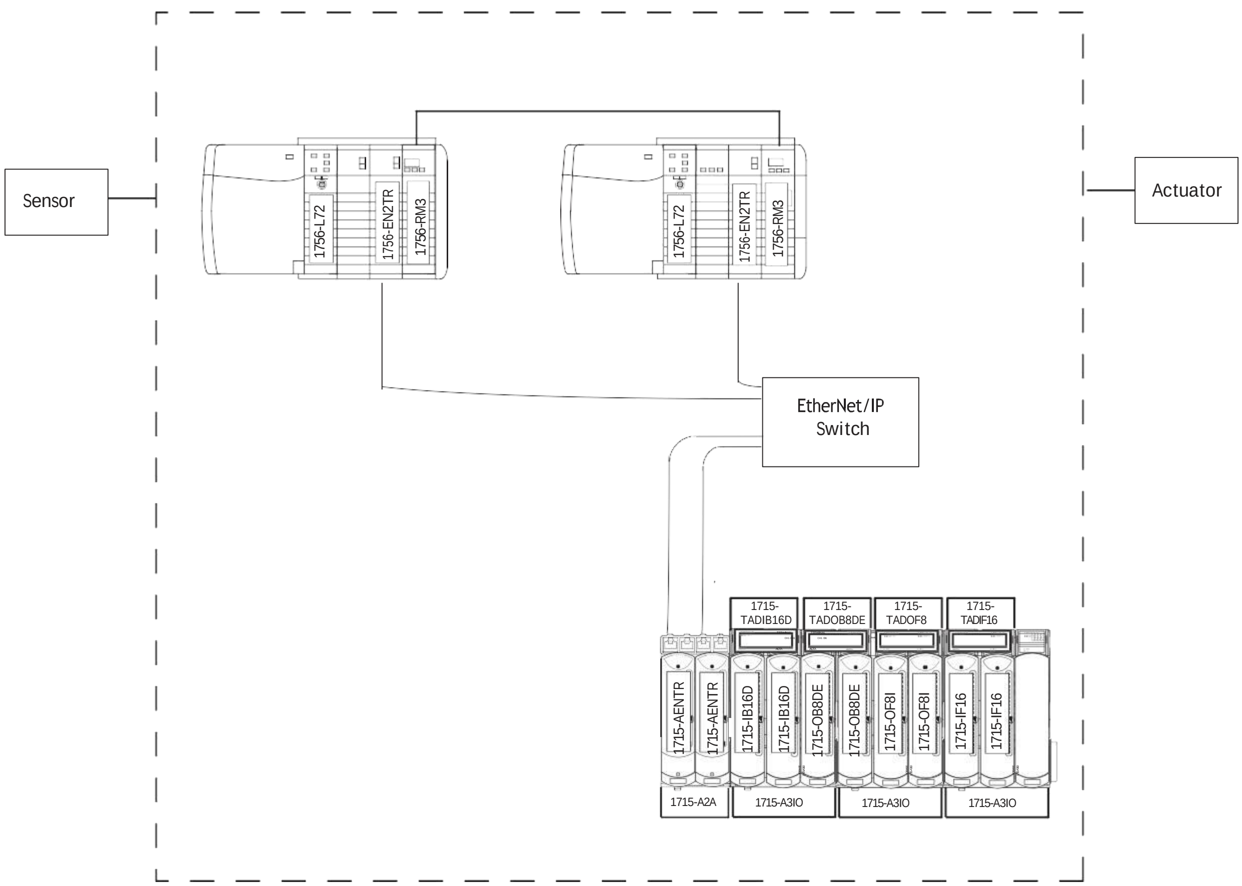


Figure 55 - Duplex Star Topology with a ControlLogix Controller



Internal Diagnostics

The 1715 adapters feature internal diagnostics to identify faults that develop during operation and raise appropriate alarm and status indications. The diagnostic systems run automatically and check for system faults that are associated with the I/O modules and field faults that are associated with field I/O circuits.

The internal diagnostics detect and reveal both safe and dangerous failures. In a duplex configuration, for example, diagnostics can address dangerous failures and therefore the duplex system can be 1oo2 reverting to 1oo1 on the first detected fault and reverting to fail-safe when both modules have a fault.

Power Supplies

On de-energize-to-trip, two power supplies can be used if fault tolerance is required on the power supplies.

If only one power supply is used, both of the power connections must be connected to it (system power can be from another power supply to the I/O modules).

For energize-to-action, dual power supplies are required for both the system and field supplies. The system provides the power supply monitoring, but monitoring needs to be connected in the application.

Requirements for 1715 I/O Modules

You must follow these requirements when using 1715 I/O modules in a SIL 2 application.

IMPORTANT
- In safety applications, channel discrepancy alarms must be monitored by the application program and used to provide an alarm to operations personnel.
- Equipment must be installed and wired in accordance with the product installation and wiring instructions. See the Redundant I/O System User Manual, publication 1715-UM001.
- For energize-to-action systems, you must follow the additional requirements that are described in this section.

The maximum duration for single-channel operation of I/O modules depends on the specific process and must be specified individually for each application. You must use two 1715-AENTR adapters. If one of the modules faults, the adapters can operate in a simplex arrangement up to the duration of the mean time to restoration (MTTR) when used in SIL 2 applications.

Energize-to-action Requirements

Certain applications can require energize-to-action for inputs or outputs or both.

IMPORTANT Energize-to-action configurations can be used only if the following apply:
- At least two independent power sources must be used for both the system and field supplies. The system provides the power supply monitoring, but the monitoring must be connected in the application. These power sources must provide emergency power for a safe process shutdown or a time span that is required by the application.
- Each power source must feature power integrity monitoring with safety-critical input readback into the system controller or implicit power monitoring that is provided by the I/O modules. Any power failure must trigger an alarm.
- Unless provided implicitly in the I/O modules, all safety-critical inputs and outputs must be fitted with external line and load integrity monitoring and safety-critical readback of the line-status signals. Any line or load failure must trigger an alarm.
- The application program must be designed to shut down energize-to-action SIL 2 safety instrumented functions if a faulty simplex adapter or output module has not been replaced within the mean time to restoration (MTTR).
- For SIL 2 high demand, energize-to-action applications, you must use two output modules.

In cases where one or more outputs is used in an energize-to-action configuration, all specific requirements that are listed previously must be implemented for all associated inputs.

IMPORTANT SIL 1 applications must use the wiring and measures that are defined for SIL 2 applications. Energize-to-action requires line monitoring for any SIL application.

Requirements for ControlLogix SIL 2 Applications

Add-On Instructions

The Add-On Instructions provide a mechanism to verify the validity of data that is transferred between the ControlLogix controller and the 1715 adapter. When you use the Add-On Instructions, the sender of the data adds check data to the produced data. The receiver of the data uses the check data to verify the integrity of the consumed data.

IMPORTANT	To meet SIL 2 application requirements in a ControlLogix system that uses 1715 I/O, you must use the 1715 Add-On Instructions that are described in Chapter 8.

Connection Reaction Time Limit

The Connection Reaction Time Limit (CRTL) setting defines the maximum time that the connection can operate with old data, before substituting the configured safe state values. If the CRTL expires, the receiver requires a SIL 2 Reset before valid data is provided again.

For an input module, if the CRTL expires before the Add-On Instruction detects valid data, the value of the affected input assembly transitions to the configured safe state value. A SIL 2 reset is required before inputs transition from the safe state to field values.

For an output module, if the CRTL expires before the 1715 firmware detects that valid output data is received from the Logix controller the output data transitions to the configured safe state values. In this case, a SIL 2 Reset is required before outputs can be re-energized.

1715 Adapter in SIL 2 Applications

The 1715-AENTR adapter performs the following functions:

- External communication with the controller via an Ethernet network
- Communication with I/O modules, such as receiving input values, sending output values, and coordinating diagnostics
- Enforcement of the output CRTL on data that is received from a ControlLogix controller

Use two 1715-AENTR adapters in simplex and duplex SIL 2 applications.

Reaction to Faults

The 1715-AENTR adapter reports faults via status indicators that turn red when a fault is detected in the adapter. Fault indications are also sent to the user application. These variables provide the following information:

- Module presence
- Module health and status
- Channel health and status
- An echo of the front panel indications

1715 I/O Modules in SIL 2 Applications

I/O modules can be replaced or installed online without an effect on controller operation, provided at least one module is installed and is fully operational. However, each module must be installed one at a time and allowed to startup before the next module is installed.

Input Modules

The simplex and duplex termination assemblies are safety critical, that is, an input or output that is attached to a field device, and provide termination for 16 channels. They connect the field signals to the input modules. Both digital and analog input termination assembly circuits have fuse protection.

Input modules support high availability when they are configured for duplex operation and they use the appropriate termination assembly.

Input modules can be configured to operate in SIL 2 energize-to-action or de-energize-to-trip applications.

Reactions to Faults

If an input channel is not capable of reporting a voltage within a safety accuracy specification of 1% of the full-scale measurement range, then the module returns safe values to the processor. Signals transition to a safe state if the module scan time exceeds the connection reaction time limit (CRTL).

All I/O modules feature status indicators and can also report faults via application variables. All modules provide the following status information:

- Module presence
- Module health and status
- Channel health and status
- Field faults
- An echo of the front panel indicators for each module

Safety Accuracy

The I/O input modules determine the channel state and the line fault state by comparing the reported input values with user-programmed threshold values. For each channel of a module, two independent measurements are made. The discrepancy between these measurements is monitored to determine if it is within the safety accuracy limit.

The channel is in fault and the last valid value is held until after the CRTL period if the values are outside these limits:

- Digital input module = 4%
- Analog input module = 1%

After the CRTL period, the value changes to 0.

When using dual modules that are both reporting valid channel data, the lowest value is used. If one module of a pair reports a fault on a channel, the value of the operational module is used.

ATTENTION: In safety critical applications, the discrepancy alarms must be monitored by the application program and used to provide an alarm to operations personnel.

Digital Output Modules

The digital output module is rated at SIL 2 as a fail-safe module. Each module provides the following safety functions:

- Output channel signals are based on commands from the controller.
- Redundant voltage and current measurements are sent to the controller for monitoring and diagnostics.
- Modules feature overcurrent and overvoltage channel protection.
- Diagnostic tests are executed on command from the adapter and results are reported back to the adapter.
- On power-up or module insertion, all output channels are set to the de-energized (fail-safe) state until command states are received from the controller. Each channel is driven individually according to the command state values.
- The module enters a shutdown mode when the time between controller communication exceeds the CRTL.
- If a module fails, then all of its channels are set to the de-energized state.

The digital output termination assembly is safety critical and comes in two sizes - simplex or duplex. Termination assemblies have fuses for field output power and eight field termination connections for the output signals.

Output modules support high availability when they are configured for duplex operation and they use the appropriate termination assembly.

Reaction to Faults

If an output module faults, the following status information is reported:

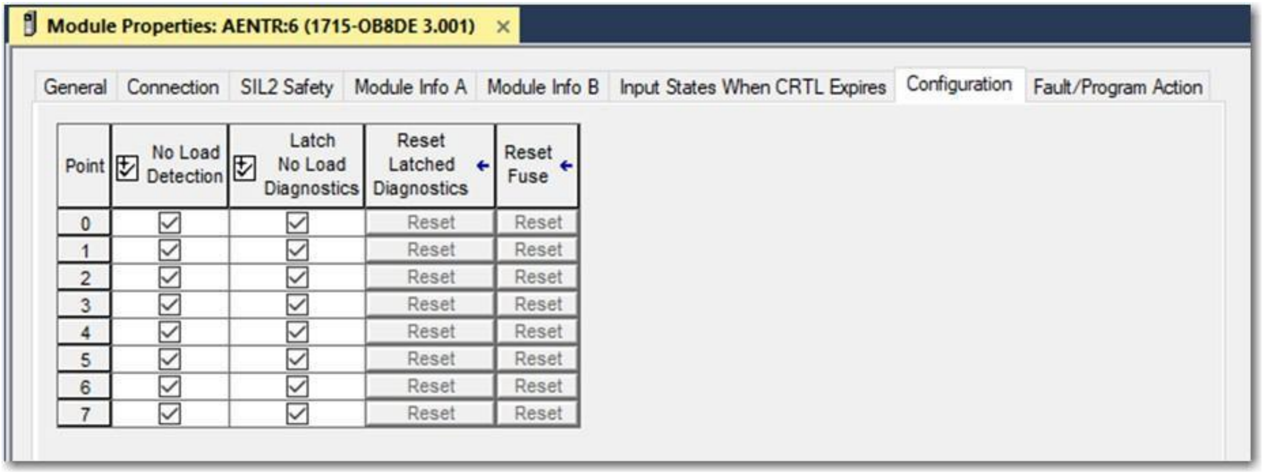
- Module presence
- Module health and status
- Channel health and status
- Field faults
- An echo of the front panel indicators for each module

If any of the following internal conditions exist, the output module fails safe:

- Internal software error is detected
- Over-temperature condition is detected
- Power supply rails are out of tolerance

The digital output module incorporates line test functionality that can detect and indicate 'no load' field faults. This functionality can be enabled or disabled.

Figure 56 - No Load Detection

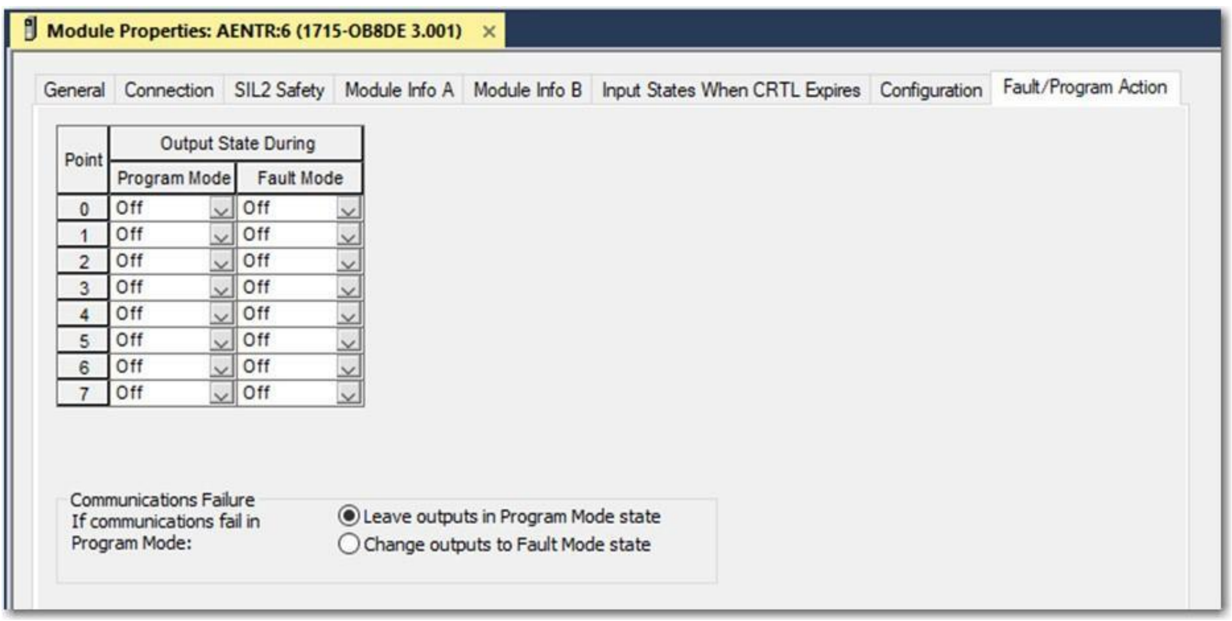


Shutdown Modes

When the module is in shutdown mode, the Ready and Run indicators turn red. During module configuration, you choose how you want the output channels to behave in the shutdown mode, whether due to fault or Program mode. Output module channels can be configured to provide the following channel values:

- De-energized (Off), which is the default fail-safe value
- Hold Last State

Figure 57 - Output States



Analog Output Modules

The analog output module can be used in applications where the output current is in the range 4...20 mA during normal operation, including a trip/action value and where 0 mA is the fail-safe value. In these applications, one 1715-OF8I output module is sufficient for SIL 2 requirements, two modules provide a 1oo2 level.

The analog output module is rated at SIL 2 as a fail-safe simplex module and when used in a 1oo2 configuration as a duplex module with these features:

- Commanded values and scaling factor

  The fail-safe lowest commanded value irrespective of the scaling factor is 0 mA. The application cannot change the scaling factor; only an online update can change the scaling factor.
- Fail-safe guard band

  The fail-safe guard is 1% (0...2 mA) and not user-configurable.

Reaction to Faults

If an output module faults, the following status information is reported:

- Module presence
- Module health and status
- Channel health and status
- Field faults
- An echo of the front panel indicators for each module

If any of the following internal conditions exist, the output module fails safe:

- An internal software error is detected
- A power feed combiner over-temperature condition is detected

Shutdown Mode

When the module is in the shutdown mode, the Ready and Run indicators turn red. The default state is OFF (de-energized).

Considerations for Sensor and Actuator Configurations

IMPORTANT	In safety-critical applications that use one sensor or single actuator, it is important that the sensor failure modes be predictable and understood so that there is little probability of a failed sensor not responding to a critical process condition. Test the sensor regularly, either by dynamic process conditions that are verified in the 1715 system, or by manual intervention testing. It is recommended that a written test plan is used for all testing.

The function of a signal must be considered. In many cases, redundant sensor and actuator configurations can be used, or differing sensor and actuator types provide alternate detection and control possibilities. Plant facilities frequently have related signals, such as start and stop signals. In these cases, it is important to make sure that failures beyond the fault-tolerant capability of the system do not result in either the inability to respond safely or in inadvertent operation. In some cases, this requires that channels are on the same module to make sure that if a module faults, the associated signals fail safe.

It is often necessary to separate signals across modules. Where non-redundant configurations are employed, it is especially important to make sure that the fail-safe action is generated if there are failures within the system.

Field-loop power and its effect on inputs (sensors and modules) and outputs (modules and actuators) must be considered. For normally energized configurations, field-loop power loss leads to fail-safe reaction.

Where separate supplies power field signals, power separation must be maintained between modules so that isolation is maintained.

Configure SIL 2 Operation

To configure 1715 modules for SIL 2 applications, you must enable each 1715 module in your system for SIL 2 operation and set its connection reaction time limit (CRTL) and module requested packet interval (RPI). For input modules, you must configure safe state input values.

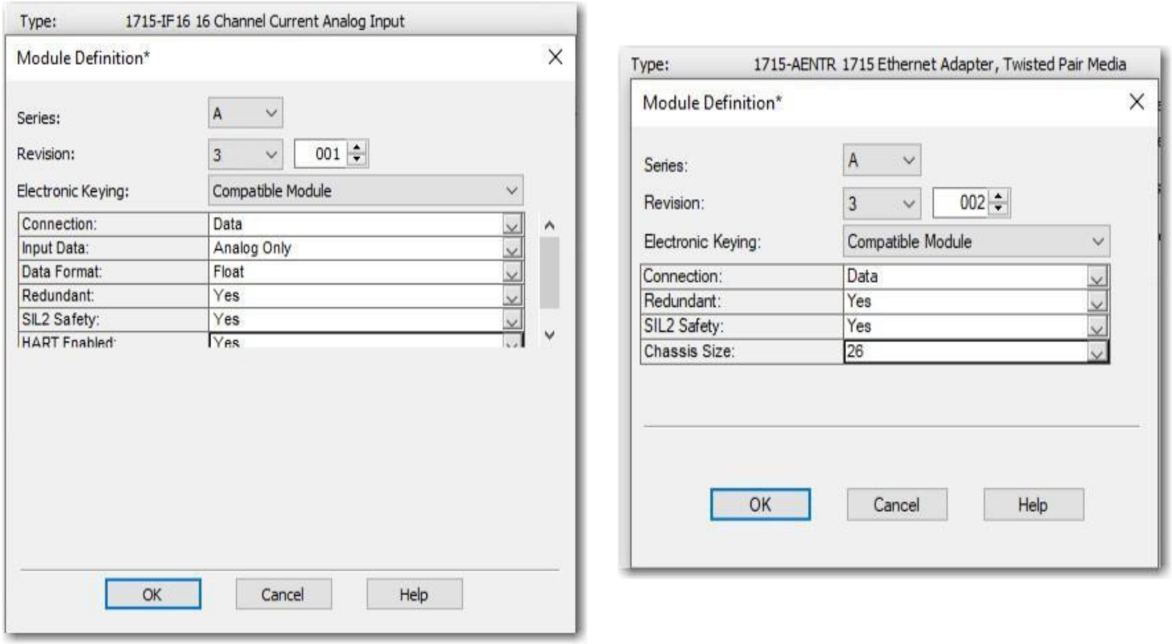
Enable SIL 2 Operation

To enable a module for SIL 2 operation, complete the fields on the Module Definition dialog box in the Logix Designer application as described in Table 3. The fields that appear vary depending on the type of module.

Table 3 - Module Definition Fields for SIL 2 Operation

Field	Description
Series	Choose Series A.
Revision	Choose 4.011 or later.
Electronic Keying	Choose Compatible Module.
Connection	Choose Data.
Input Data	Choose any input data type.
Data Format	Choose any data format.
Redundant	• For single modules with simplex termination assemblies, choose No. • For two modules with duplex termination assemblies, choose Yes.
SIL2 Safety	Choose Yes.
HART Enabled	To enable an analog input module for HART communication, choose Yes.
Chassis Size	Choose the chassis size.

Figure 58 - Module Definition Dialog Box - Examples for SIL 2 Operation



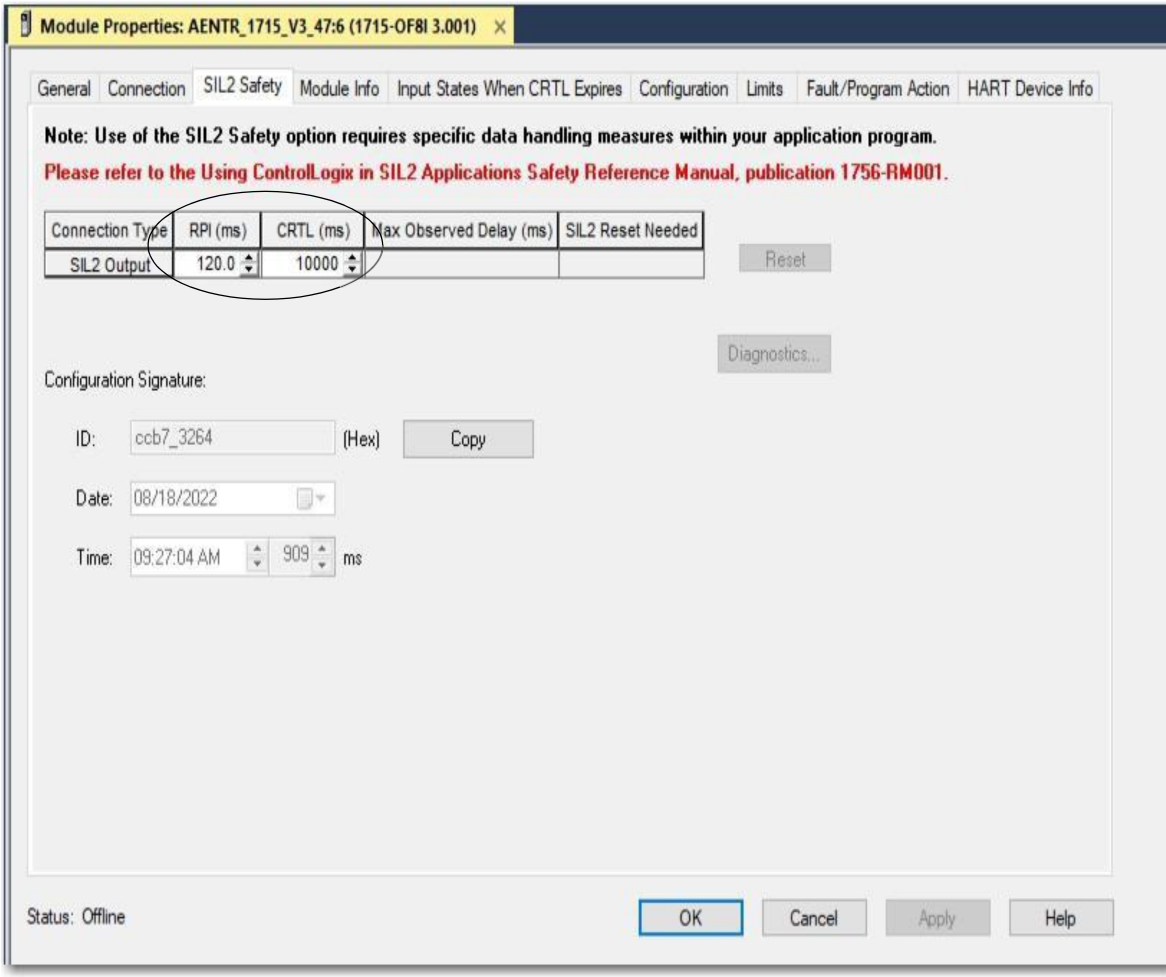
Specify the Connection Reaction Time Limit and Requested Packet Interval

On the SIL2 Safety tab of the module, enter the following:

- Requested packet interval (RPI). The module RPI must be the same as the setting on the Connection tab.
- Connection reaction time limit (CRTL). The default value for the CRTL is 10,000 ms. The valid range is 1000...60,000 ms.

IMPORTANT	When online, the Reset button on the SIL 2 Safety tab appears solid when only the output data on any 1715 output module must be reset. The Reset button resets only output data for the 1715-OF8I and 1715-OB8DE module outputs. To reset inputs for all 1715 modules, you must use the Reset Input parameter within the Add-On Instructions.

Figure 59 - SIL2 Safety Tab - RPI and CRTL Values



Considerations for Setting the CRTL

The value of the CRTL forms part of the safety considerations for the system. You are responsible for calculating and verifying that the CRTL meets the safety reaction time for your safety function.

IMPORTANT	For information about how to configure the safety reaction time for your safety application, see page 136.

- In a 1715 system, the CRTL value is assigned to individual modules during module configuration.
- If the input CRTL is not met, the controller presents fail-safe input values to the application logic. Each time a valid packet is received from an input module, the controller resets the CRTL. If the CRTL ever times out, the controllers present fail-safe input values to the application logic.
- Each time a valid packet is received from the controller, the output module resets the CRTL. If the CRTL ever times out, the output module assumes the fail-safe state.

IMPORTANT	The default fail-safe state for all 1715 modules is de-energized.

- It is recommended that the CRTL remain at the default of four times the RPI so that one invalid packet does not put the system into the safe state. For example, if the RPI = 120 ms, then consider 480 ms as the minimum CRTL. The information in the next section helps determine the maximum setting for the CRTL.

Determining the Appropriate CRTL Value

Use the following method to confirm whether the default value is acceptable or you must change the CRTL value for your application.

This equation governs the value of CRTL for the I/O connections:

$$CRTL \leq \frac{CRTL_{euc}}{2} - (\text{sensor delay} + \text{actuator delay})$$

where CRTLeuc is the process safety time for the equipment under control (euc).

EXAMPLE	Consider a system function that uses one sensor and one actuator with the following parameters: • CRTLeuc: 10,000 ms • Sensor delay: 250 ms • Time for an actuator (an ESD valve) to operate fully: 1750 ms In this example, the setting of CRTL for the I/O connections is less than or equal to 3000 ms.

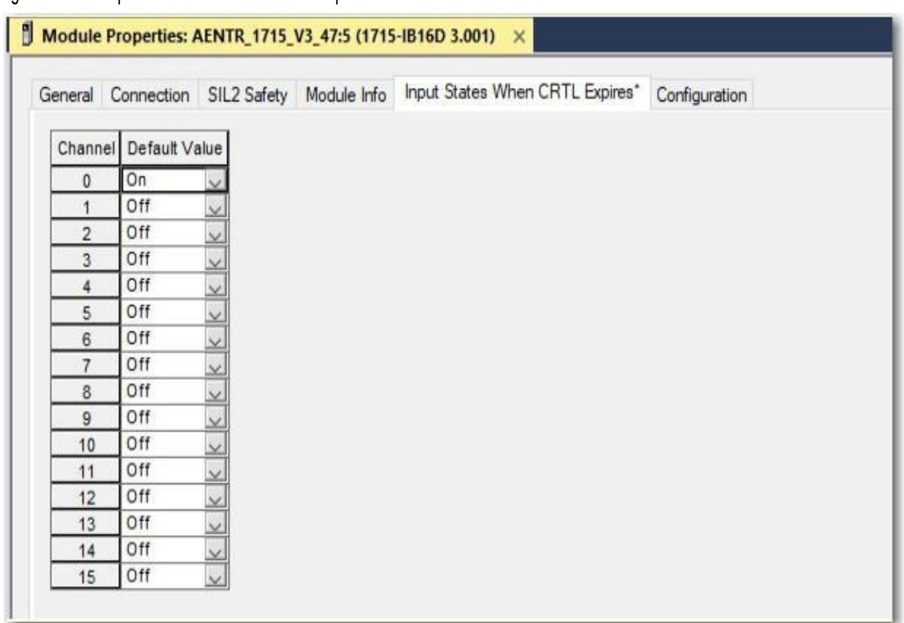
Set Safe State Values for Inputs

You must define the safe state values for inputs if the SIL 2 data verification checks have determined that the connection is not valid and the Connection Reaction Time Limit (CRTL) has expired.

The default safe state value for digital inputs is OFF; for analog input modules, the safe state value is 0. Follow these steps to change the default values.

1. Click the Input States When CRTL Expires tab.
2. In the Default Value column, choose values for each input point.
3. Click OK.

Figure 60 - Input States When CRTL Expires



Check SIL 2 Reset Status

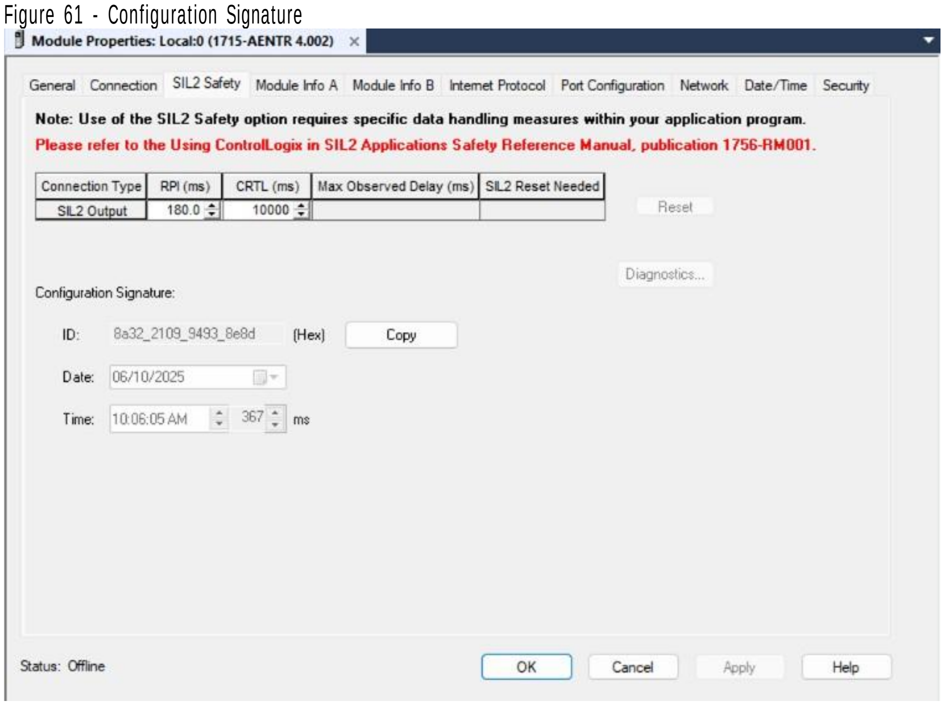
If one or more errors persist longer than the Connection Reaction Time Limit (CRTL), the connection uses safe state values and requires a reset to recover. When online, the SIL 2 reset status is displayed on the SIL 2 Safety tab for output modules.

Click Reset to reset the connection and enable the output modules to control their outputs based on logic. To reset the connection for input modules, create a reset tag within the Add-On Instruction.

View Module Information

The configuration signature that appears on the SIL 2 Safety tab is composed of an ID number, date, and time. The signature is updated whenever the module configuration is changed.

Figure 61 - Configuration Signature



You must use this signature to enforce the use of a specific configuration within your application. The signature is located in the CRC member of the SIL 2 configuration tag of the module.

Figure 62 - Configuration Signature Tag Location

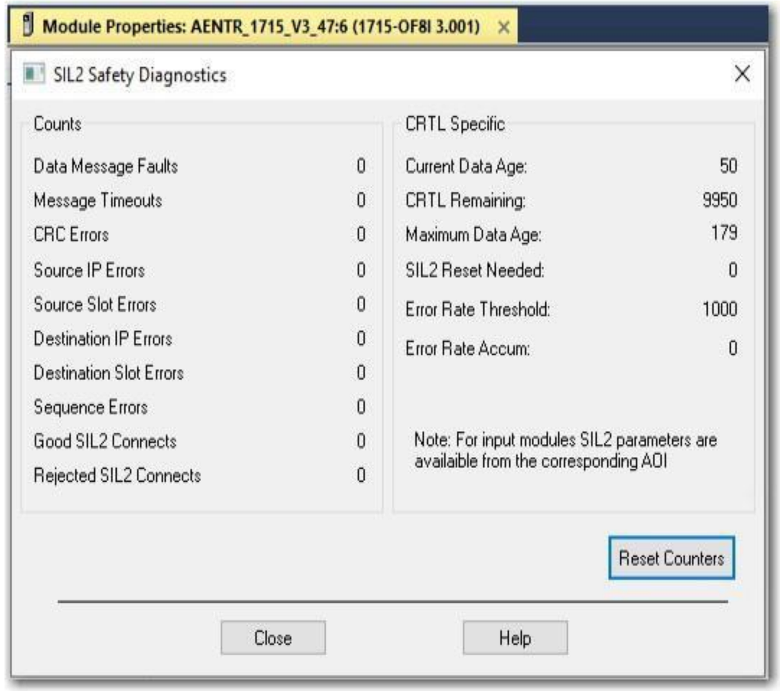
Name	Value	Data Type	Style
AENTR10:C.CRCLow	16#9493_8e8d	DINT	Hex
AENTR10:C.CRCHigh	16#8a32_2109	DINT	Hex

If you want to keep a record of the signature, you can click Copy to copy the signature to the Windows clipboard.

Diagnostic Data

While online, click Diagnostics on the SIL 2 Safety tab to view data on the SIL2 Safety Diagnostics dialog box (Figure 63).

Figure 63 - SIL2 Safety Diagnostics



IMPORTANT The Reset Counters button on the Diagnostics tab resets only the counters that are shown in the 1715 I/O module profiles.

It does not reset the counters that are displayed within the ControlLogix Add-On Instructions.

The values that are retrieved from the 1715 output modules populate the diagnostic information. Equivalent input module diagnostic data is made available by the Add-On Instructions.

Configure the SIL 2 Task Period and Watchdog

This SIL 2 task is a periodic task with priority (1). For more information, see Chapter 9.

SIL Task/Program Instructions

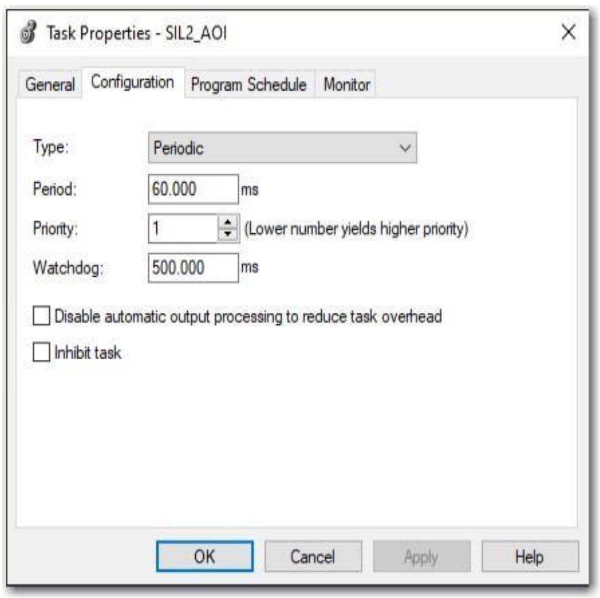
The user application must contain one SIL task that is composed of programs and routines. The SIL 2 task must be the top priority task of the controller and the user-defined watchdog must be set to accommodate the SIL 2 task.

IMPORTANT	Motion-related functions are not allowed and must not be used.

IMPORTANT	You must dedicate a specific task for safety-related functions and set that task to the highest priority (1). SIL 2 safety logic and logic that is intended for use in non-SIL 2 functions must be separate.

The task period and task watchdog are configured in the Task Properties dialog box.

Figure 64 - Task Properties



Configure the Output Module Program/Fault Actions

For a SIL 2 safety system, you are responsible for making sure that the SIL 2 related safety code, including the SIL 2 Add-On Instructions, are scanned by a safety task watchdog.

See Safety Watchdog for additional safety watchdog requirements.

Safety Watchdog

Configure the properties of the task that is used for safety correctly for your application.

- Priority: must be the highest-priority task in the application (lowest number).
- Watchdog: the value that is entered for the SIL 2 safety task must be large enough for all logic in the task to be scanned.

If the task execution time exceeds the watchdog time, a major fault occurs on the controller. Users must monitor the watchdog and program the system outputs to transition to the safe state (typically the OFF state) if there is a major fault on the controller. For more information on faults, see Chapter 10.

IMPORTANT	The preferred way to meet this controller requirement in a 1715 SIL 2 system is to configure both the PROGRAM MODE and FAULT MODE tables for the 1715-OB8DE and 1715-OF8I with safe state values.

This handles all fault scenarios:

- If a controller fault, such as a watchdog fault occurs, the controller goes to program mode, which causes the 1715 I/O to go to the Program Mode states.
- If there is a system fault that causes a communications loss to the I/O modules, then the 1715 I/O goes to the Fault Mode states.
- If there is a CRTL (Connection Reaction Time Limit) timeout in the 1715-AENTR adapter, then the 1715 output modules go to the Fault Mode states.

Figure 65 - Fault/Program Action Tab for 1715-OB8DE

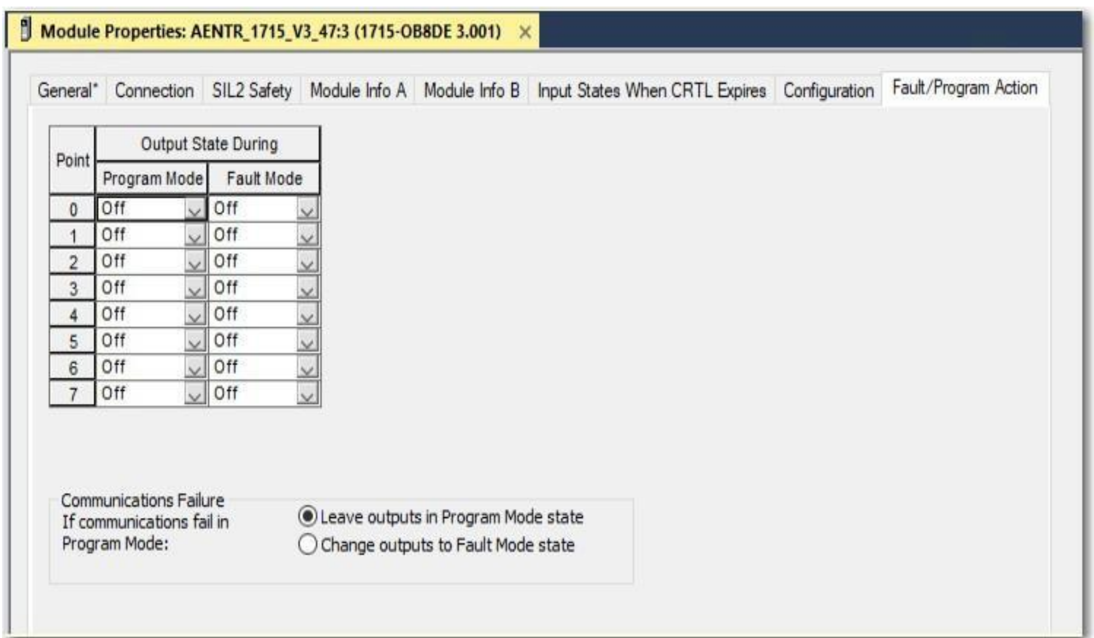
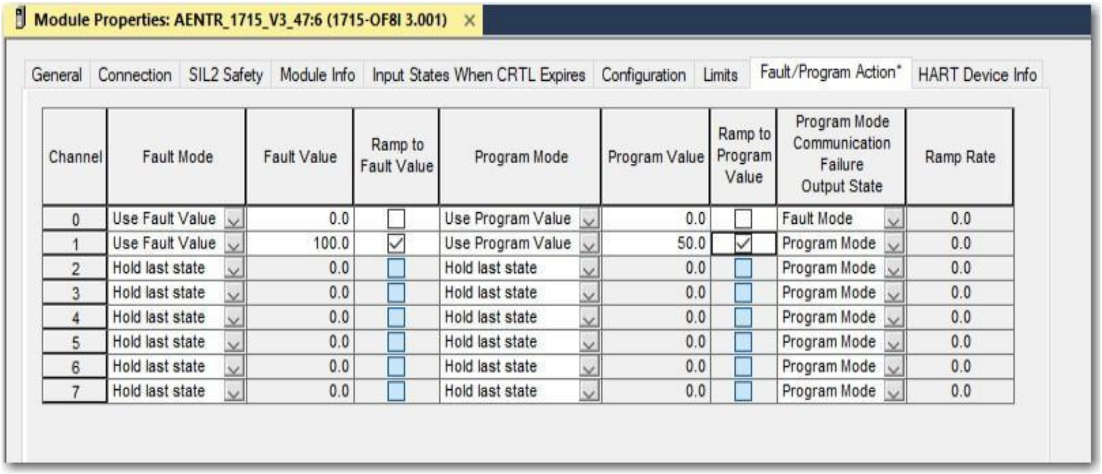


Figure 66 - Fault/Program Action Tab for 1715-OF8I



Channel	Fault Mode	Fault Value	Ramp to Fault Value	Program Mode	Program Value	Ramp to Program Value	Program Mode Communication Failure Output State	Ramp Rate
0	Use Fault Value	0.0	☐	Use Program Value	0.0	☐	Fault Mode	0.0
1	Use Fault Value	100.0	☑	Use Program Value	50.0	☑	Program Mode	0.0
2	Hold last state	0.0	☐	Hold last state	0.0	☐	Program Mode	0.0
3	Hold last state	0.0	☐	Hold last state	0.0	☐	Program Mode	0.0
4	Hold last state	0.0	☐	Hold last state	0.0	☐	Program Mode	0.0
5	Hold last state	0.0	☐	Hold last state	0.0	☐	Program Mode	0.0
6	Hold last state	0.0	☐	Hold last state	0.0	☐	Program Mode	0.0
7	Hold last state	0.0	☐	Hold last state	0.0	☐	Program Mode	0.0

Notes:

SIL 2 Add-On Instructions for 1715 Redundant I/O Modules

SIL 2 Add-On Instructions

IMPORTANT To achieve SIL 2 with 1715 I/O modules in a ControlLogix® system, you must use the Add-On Instructions in Table 4. The 1715 Add-On Instructions verify the validity of data that is transferred between the ControlLogix controller and the 1715 I/O modules via the 1715-AENTR adapter. The 1715 Add-On Instructions are different than the Add-On Instructions for 1756 I/O. See Download and Import the Add-On Instructions on page 102.

When you use 1715 SIL 2 Add-On Instructions, you do not read inputs directly from the input table, nor do you write directly to the output tags. You read inputs from an Add-On Instruction tag that is called 'reconciled input data,' and write outputs to an Add-On Instruction tag called 'requested output data.'

There is also an Add-On Instruction that is required for the 1715-AENTR adapter. The status data from the 1715-AENTR adapter must be validated by using this Add-On Instruction.

You cannot view the logic of each Add-On Instruction because it is source protected.

Table 4 - SIL 2 Add-On Instructions

Module	System Configuration	Add-On Instruction Name
1715-IB16D	Simplex	IB16D_Simplex_SIL2
		IB16D_Simplex_SIL2_V3
		IB16D_Simplex_SIL2_V4
	Duplex	IB16D_Duplex_SIL2
		IB16D_Duplex_SIL2_V3
		IB16D_Duplex_SIL2_V4
1715-OB8DE	Simplex	OB8DE_Simplex_SIL2
		OB8DE_Simplex_SIL2_V3
		OB8DE_Simplex_SIL2_V4
	Duplex	OB8DE_Duplex_SIL2
		OB8DE_Duplex_SIL2_V3
		OB8DE_Duplex_SIL2_V4
1715-IF16	Simplex	IF16_Simplex_SIL2
		IF16_Simplex_SIL2_V3
		IF16_Simplex_SIL2_V4
	Simplex with HART	IF16_Simplex_HART_SIL2_V3
		IF16_Simplex_HART_SIL2_V4
	Duplex	IF16_Duplex_SIL2
		IF16_Duplex_SIL2_V3
		IF16_Duplex_SIL2_V4
	Duplex with HART	IF16_Duplex_HART_SIL2_V3
		IF16_Duplex_HART_SIL2_V4
1715-OF8I	Simplex	OF8I_Simplex_SIL2
		OF8I_Simplex_SIL2_V3
		OF8I_Simplex_SIL2_V4
	Simplex with HART	OF8I_Simplex_HART_SIL2_V3
		OF8I_Simplex_HART_SIL2_V4
	Duplex	OF8I_Duplex_SIL2

		OF8I_Duplex_SIL2_V3
		OF8I_Duplex_SIL2_V4
	Duplex with HART	OF8I_Duplex_HART_SIL2_V3
		OF8I_Duplex_HART_SIL2_V4
1715-AENTR	Duplex	AENTR_SIL2
		AENTR_SIL2_V3
		AENTR_SIL2_V4

When you import any of the previously listed Add-On Instructions, the system also imports the CRC_calculator instruction. The CRC_calculator instruction calculates the CRC for incoming packets and compares the result against the actual CRC received in the packet. The instruction also calculates the CRC that is placed in the outgoing packet.

SIL 2 check data is added to data packets by the producer and the consumer verifies this check data to determine the validity of the data transfer.

For input data from the 1715 modules, the 1715-AENTR adapter is the producer and the ControlLogix controller is the consumer. The 1715-AENTR adapter adds the check data, and the Add-On Instructions verify that valid data is received within the connection reaction time limit (CRTL) of the module. If valid data is not received within the CRTL, the instruction substitutes the configured safe state values of the module in place of the invalid data.

For output data to the 1715 modules, the ControlLogix controller is the producer and the 1715-AENTR adapter is the consumer. The Add-On Instructions add SIL 2 diagnostic information (check data) to the module assemblies, including a sequence number, source and destination IDs, and CRC. The 1715-AENTR adapter verifies that valid data is received within the CRTL. Outputs are placed into the safe state if the CRTL expires.

The 1715 input modules send data only in one direction, from the 1715-AENTR adapter to the ControlLogix controller. In contrast, for the 1715 output modules, data is sent in both directions: status to the controller and output data from the controller.

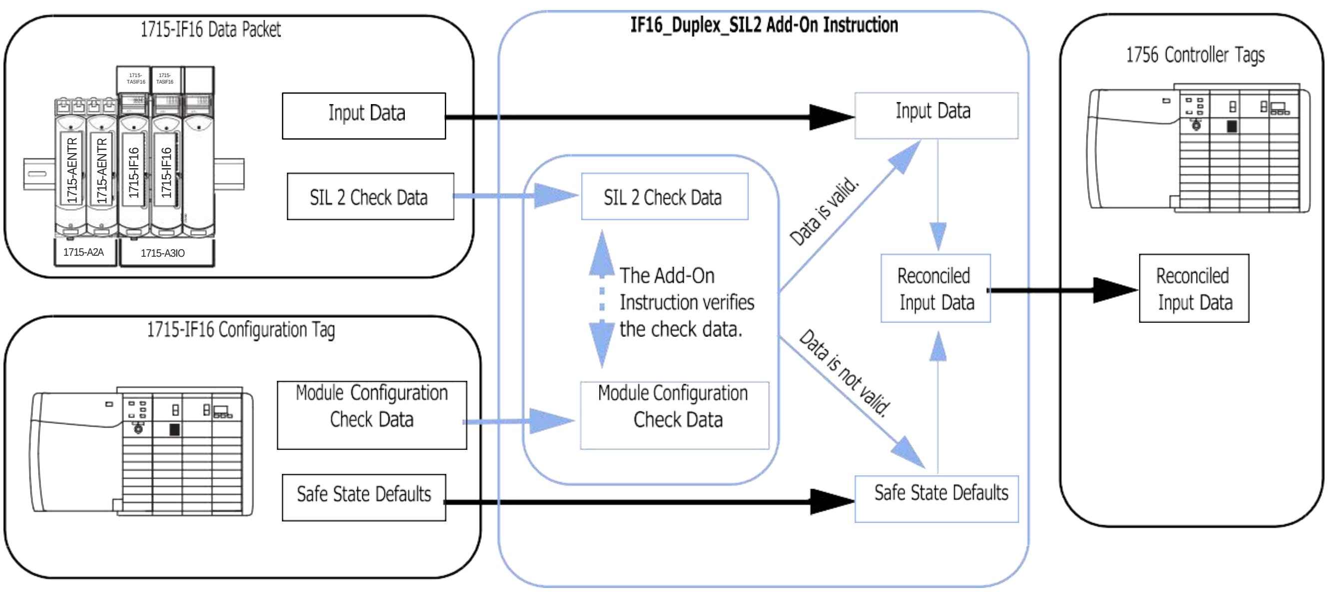
The Add-On Instructions automatically perform error rate monitoring on the input data that they process without any user configuration. The error rate monitoring does the following:

- Helps to make sure that the maximum allowed error rate for SIL 2 has not been exceeded.
- Shuts down a link immediately by forcing Add-On Instruction outputs to shut down states and require a SIL 2 reset

The Add-On Instructions provide an output (CRC_error) that indicates if this condition has occurred. A SIL 2 reset can be used to reset this condition.

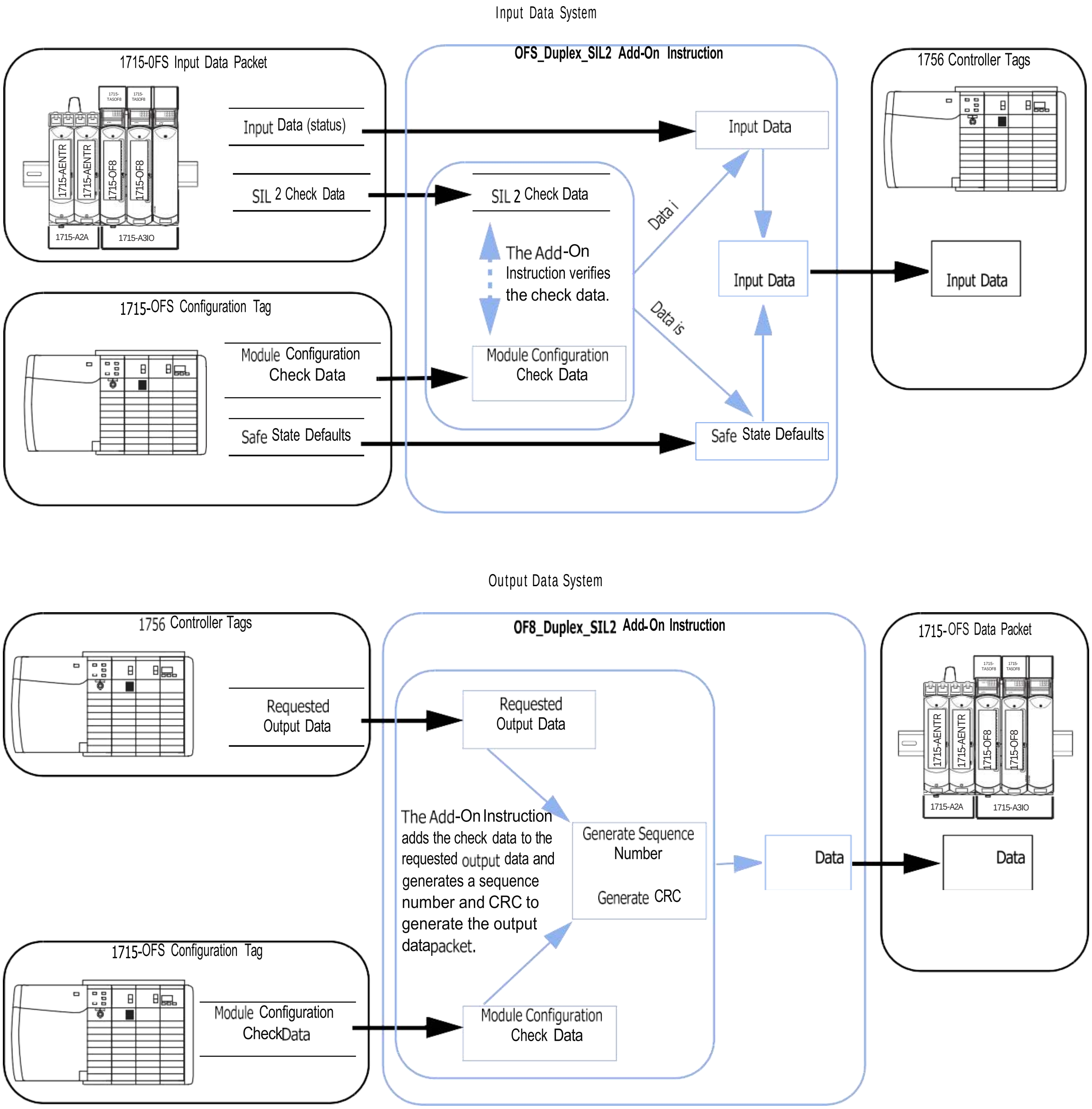
The following figures illustrate how the Add-On Instructions work with input and output data.

Figure 67 - Diagram of Input Module Add-On Instruction



IMPORTANT	The 1715-IF16 module is shown, but the example also applies to the 1715-IB16D module.

Figure 68 - Diagram of Output Module Add-On Instruction



IMPORTANT	The 1715-OF8 module is shown, but the example also applies to the 1715-OB8DE module.

SIL 2 Check Data

The instructions gather data from the module-defined configuration tags for the following check data values.

Table 5 - Check Data Values

Value	Description
VariantID	The revision of the module, which is always 3.
SourceIP	For input assemblies, this is the IP address of the 1715 adapter. For output assemblies, this is the IP address of the ControlLogix Ethernet module.
DestinationIP	For input assemblies, this is the IP address of the ControlLogix Ethernet module. For output assemblies, this is the IP address of the 1715 adapter.
SourceSlot	For input assemblies, this is the slot number of the 1715 module. For output assemblies, this is the slot number of the ControlLogix controller.
DestinationSlot	For input assemblies, this is the slot number of the ControlLogix controller. For output assemblies, this is the slot number of the 1715 module.

The instructions add or check data for these fields.

Table 6 - Add or Check Data Fields

Value	Description
SequenceNumber	The instruction monitors a sequence number in the module-defined Input Data tag. In normal operation, the sequence number increments by 1 with each incoming packet: • If the sequence number is a duplicate or is lower than expected, data is discarded as invalid. The CRTL is not reset. • If the sequence number is higher than expected but within a deadband of 10000, the data packet is accepted. Data remains valid and the CRTL is reset. • If the sequence number is more than 10000 greater than the expected number, the data is discarded as invalid. The CRTL is not reset. For each output packet, the instruction increments the sequence number, starting with 0 when the connection is initially established. In normal operation, the "effective deadband" is no more than 100 based on the worst case maximum RPI and the worst case minimum I/O scan time. Important: The sequence number is not configurable.
CRCLow CRCHigh	The instruction calculates a CRC on the input data based on the module-defined input tag and compares this value against the CRC in the input data. If the CRCs do not match, the data is discarded as invalid. The instruction calculates a CRC on the output data based on the complete module-defined output tag. This CRC is added to the 1715 module-defined output tag.
SIL2ResetNeeded (output modules only)	After the CRTL expires, the 1715-AENTR adapter adds this flag to the SIL 2 check data to indicate that it is providing the safe state values, not valid application data to the output modules. A reset is necessary begin providing valid application data.

Add-On Instruction Inputs

The Add-On Instructions use these inputs.

Table 7 - Add-On Instruction Inputs

Input	Description
Config_Data	The Add-On Instruction gets the appropriate SIL 2 check data values from this module-defined configuration tag. The instruction uses this check data to populate the 1715 output data and verify the 1715 input data. You must point to this tag when configuring the Add-On Instruction.
Requested_Output_Data	Only for output modules: This user-defined Requested Output Data tag contains data from the program logic. The output Add-On Instruction takes this requested output data, adds the check data, and places this data in the module -defined Output Data tag.
Output_Data	The raw data that is sent to the 1715 module. You must point to this tag when configuring the Add-On Instruction.
Reconciled_Input_Data	If the Add-On Instruction examines the check data and determines that the input data is valid, the data in this tag is a duplicate of the original data that is received from the input module. If the Add-On Instruction examines the check data and determines that the data is not valid, the safe state values are substituted in the Reconciled Input Data tag. This is the input data to be used in the logic program.
Input_Data	This is the raw data from the 1715 module. You must point to this tag when configuring the Add-On Instruction.
Module_RPI	Enter this value manually from the module properties. Use the exact value to optimize system bandwidth.
Reset	The reset function requires a LO to HI transition of this tag. It resets faults and directs the ControlLogix controller to stop transferring the safe state data and start transferring the actual data if the SIL 2 check data is verified. This tag is also sent to the 1715 output modules so that outputs can be reset from the safe state.

Add-On Instruction Outputs

The Add-On Instructions generate these outputs.

Table 8 - SIL 2 Check Data Diagnostics

Output	Description	Cause	Action
Data Valid	This value is HI if the Add-On Instruction is moving the input data to the Reconciled Input Data tag without substituting safe state values. This value remains HI if packets are being discarded but the CRTL has not timed out. During this time, the reconciled input data is not updated, and data is no longer current. If the CRTL expires, the safe state values are placed into the Reconciled Input Data tag.	This signal indicates a normal operating state.	If this signal is not HI and Valid Data Being Received is HI, pulse the AOI reset.
Valid Data Being Received	If valid data is being received from the module, this output is HI regardless of whether this data is being moved to the Reconciled Input Data tag. The periodic task rate can also affect this output. If the periodic task rate is too high, the packets are not processed often enough.	This output goes LO if a valid data packet is not received for a time equaling three module RPIs.	One-Shot the AOI reset. If this output is toggling LO, verify that the RPI value in the SIL2 Add-On Instruction matches the actual module RPI. This output must be HI before you perform a SIL 2 Reset to begin moving actual data to the Reconciled Input Data tag. For configuration recommendations, see 1715 SIL 2 Periodic Task Period Configuration.
Reset Tiedown Fault	If the reset button is HI for longer than 3 seconds, a tiedown fault is declared. The fault is cleared when the reset button transitions to LO.	Programming error or configuration.	Find and correct the Reset signal condition, including programming errors or physical device failure.
Duplicate Sequence Number	If the sequence number is a duplicate, data is discarded as invalid, and this output is set HI to indicate the reason.	Data is not arriving or is sent incorrect	Try AOI Reset first. Call Technical Support if persists.
Low Sequence Number	If the sequence number is lower than expected, data is discarded as invalid, and this output is set HI to indicate the reason.	Arriving sequence numbers are lower by a specific threshold.	
High Sequence Number	If the sequence number is higher than expected, data is discarded as invalid, and this output is set HI to indicate the reason.	Arriving sequence numbers are higher by a specific threshold.	
Module Connection Status	This output is set LO if the Add-On Instruction detects a connection loss. Input data is declared invalid and the CRTL is not reset. When the connection is reestablished, this output is set HI.	Controller cannot establish a connection to the module or module pairs.	Verify the following: • Module has powerand front LEDs are lit • Locking screw is in the horizontal position • Module is present in the rack
Add-On Instruction Running	If the 1715 module is at the correct firmware revision level (Variant ID = 2) and the logic in the Add-On Instruction is being scanned, this output toggles at the rate of the RPI.	Output is not blinking if the instruction is not scanned or IO module firmware present in the chassis does not match its definition in the controller organizer.	Compare module firmware in RSLinx or FactoryTalk Linx with Logix Designer module properties. Verify the AOI is getting scanned.
SIL 2 Output Reset Needed	Only for output modules: This output is set HI if a SIL 2 Reset is necessary. To reset the outputs from the safe state and begin controlling outputs programmatically.	Checks fail for a period less than the CRTL value that is assigned to the module.	Reset the AOI or press SIL2 reset in the output module AOP.
CRTL Countdown	A countdown of the amount of time that remains before the CRTL expires.	Packets are not properly received or sent.	Note how much time is left before the configured safe states are applied.
Number of Discarded Data Packets	A count of the data packets that have been discarded as invalid.	Reasons for discarded packets are listed above.	Refer to the actions listed above.

Figure 69 - Configuration Data Diagnostics

Output	Description	Cause	Action
Configuration CRC Error	Calculated CRC for Configuration Tags doesn't match the CRC calculated by the AOP and the Module Config Signature value.	Config CRC is verified after configuration changed and downloaded by the AOP. Data_Valid and CRTL are constantly monitored, and if anything changes, a Config CRC check determines if it was changed properly by the AOP or if something is writing to the Config tags. A fault is declared if changes are made as described.	Use AOP to change CRTL or any other configuration tag values.
Source IP Error	If any of these check data values, described on page 100, do not match the values in the 1715 module configuration, data is declared invalid and discarded. The appropriate output is set HI to indicate the reason.	For input assemblies, this is the IP address of the 1715 adapter. For output assemblies, this is the IP address of the ControlLogix Ethernet module.	The IP of the 1715-AENTR or its parent the CLX Ethernet module has changed. For more information, see Knowledgebase Technote, 16#0118 when configuring SIL2 with 1715 Modules.
Destination IP Error		For input assemblies, this is the IP address of the ControlLogix Ethernet module. For output assemblies, this is the IP address of the 1715 adapter.	
Source Slot Error		For input assemblies, this is the slot number of the 1715 module. For output assemblies, this is the slot number of the ControlLogix controller.	The slot number of the 1715 IO module or slot of the ControlLogix were changed after initial module definition. Manual correction is required.
Destination Slot Error		For input assemblies, this is the slot number of the ControlLogix controller. For output assemblies, this is the slot number of the 1715 module.	
Variant ID Error	SIL2 version of the module firmware does not match the required version of the Add-On Instruction.	Version mismatch between Firmware and AOI.	Verify that you are using the correct version of the AOI.

Download and Import the Add-On Instructions

The SIL 2 Add-On Instructions are available from the Product Compatibility and Download Center website.

IMPORTANT Before you import the Add-On Instructions to your project, you must do the following.

1) Add your I/O modules to the project in the I/O configuration tree and configure them properly.

2) SIL 2 = Yes must be selected when configuring the module.

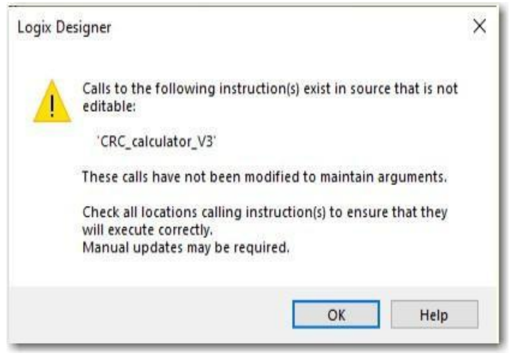
This creates the data types and tags that you must use in the Add-On Instruction.

Follow these steps to add the instructions to your project.

1. Expand Assets, right-click the Add-On Instructions folder and choose Import Add-On Instruction.
2. Select the appropriate Add-On Instruction and click Import.
3. Click OK on the Import Configuration dialog box.
4. Repeat steps 1...3 for each Add-On Instruction that you require.

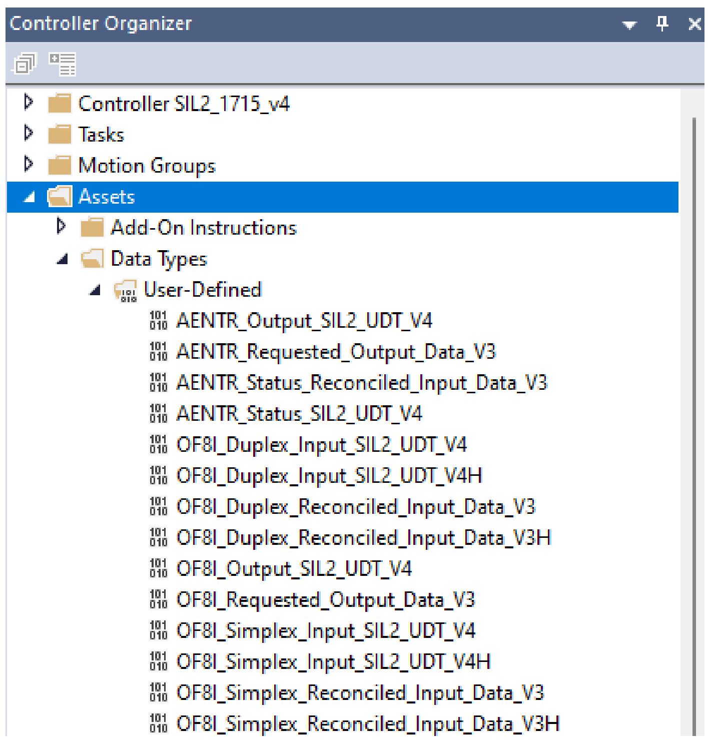
The Add-On Instructions folder now contains the instructions that you imported. The instructions also appear on the Add-On tab of the instruction toolbar. The CRC calculator Add-On Instruction also appears.

IMPORTANT You see the following warning for each Add-On Instruction import except the first one. Each Add-On Instruction import overwrites the Add-On Instruction that is called 'CRC Calculator,' and this warning appears because it is source protected. Click OK.



The appropriate data types are now available in your project.

Figure 70 - Data Types for 1715-IB16D Module with Duplex Configuration



Import Add-On Instructions to Upgraded Projects

To upgrade a project with new Add-On Instructions, follow these steps.

1. Upgrade the Add-on Profiles to SIL 2-capable versions.
2. Configure SIL 2=Yes in the module configuration and click Apply to create the required module defined data types.
3. Import the new Add-On Instructions.

Create a Periodic Task for SIL 2 Safety Functions

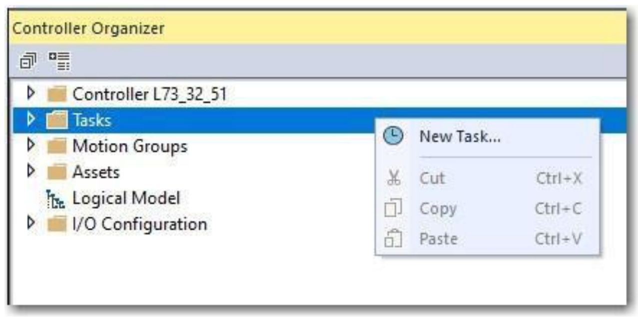
We recommend that your user application contains one SIL task that is composed of programs and routines that contain all the logic for the SIL 2-rated safety functions.

IMPORTANT	Create as many SIL 2 programs and routines as required for the SIL 2 logic. Keep in mind that the goal is to have logic with these characteristics: • Easy to understand • Easy to trace • Easy to change • Easy to test • Well-documented

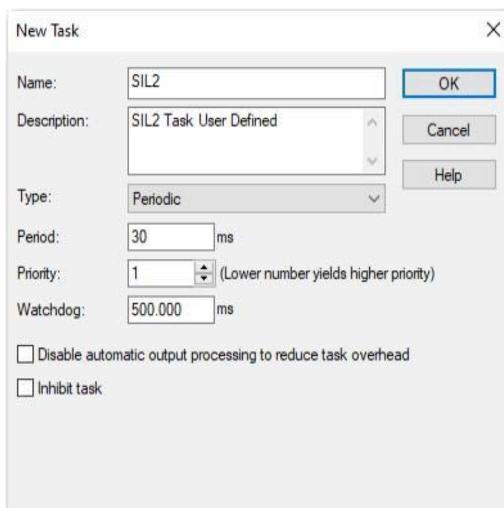
The SIL 2 task must be the top-priority task of the controller, and the user-defined watchdog must be set to accommodate the SIL task. This task must be separate from all logic for the non-SIL 2-rated functions.

Follow these steps to create the SIL 2 periodic task.

1. In the Controller Organizer, right-click the Tasks folder and choose New Task.



2. Name the task.
3. In the Type field, choose Periodic.



4. To define the Period, Priority, and Watchdog values, see the following section.
5. Click OK.

1715 SIL 2 Periodic Task Period Configuration

The following are recommendations to configure the Period value for a periodic task in SIL 2 applications. Set the period to the minimum 1715 SIL 2 module RPI divided by 2.

See the following example for when default RPIs are used.

Table 9 - Module Default RPIs

1715 Module	RPI
Adapters	180 ms
Digital modules	60 ms (lowest)
Analog modules	120 ms

1. Make the period 60/2 = 30 ms.

IMPORTANT	All 1715 SIL 2 Add-On Instructions have unique timer presets set to the module RPI / 2, so each Add-On Instruction processes packets at a rate that is based on its module RPI. In Table 9, the AENTR only processes a packet at 180/2=90 ms; every third task period. The analog modules process a packet at 120/2 = 60 ms; every other task period. The Add-On Instruction obtains the RPI from the RPI input parameter on the Add-On Instruction, which is why it is important to enter this value to match the actual module RPI. Although the timer preset within the Add-On Instructions equals RPI/2, the periodic task rate affects the actual rate the Add-On Instructions process packets and the periodic task scan time. As these values get lower, the timer resolution improves and packets are processed closer to the RPI/2 timer preset.

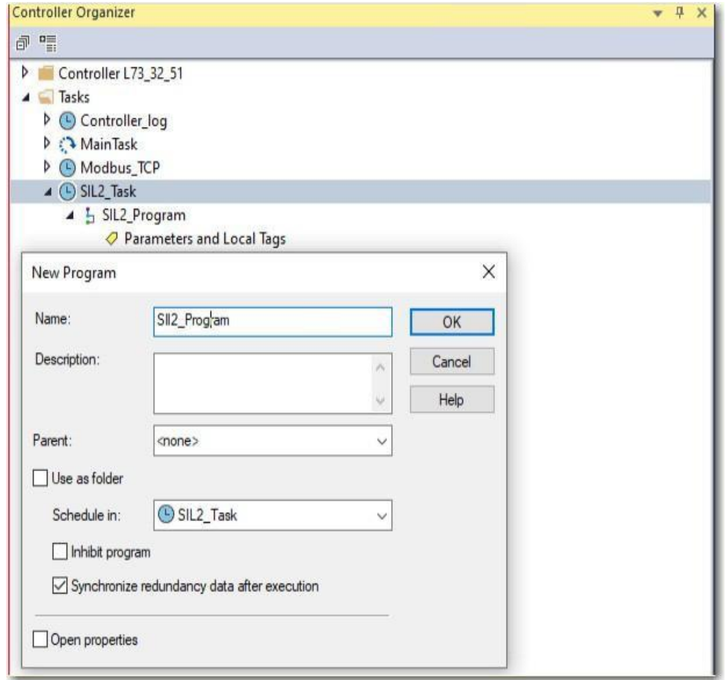
IMPORTANT	Make sure that the SIL 2 task period allows enough time for the SIL 2 task, including the Add-On Instructions, to complete. Adjusting the period time above the suggested value can be needed if many 1715 modules are used as this adds more Add-On Instructions. Any increase to the safety task period impacts the safety reaction time. See page 137.

2. Set the priority to 1.
3. Set the Task Watchdog based on the following:
   - How long it takes to run the SIL 2 code (see Add-On Instruction Scan Times on page 137)
   - How small the task watchdog must be to help verify that safety reaction times are met (see Safety Reaction Time Calculations on page page 137).

   If you do not have the information that is required to complete the watchdog time, leave the default of 500 ms and adjust it later when you have more information.

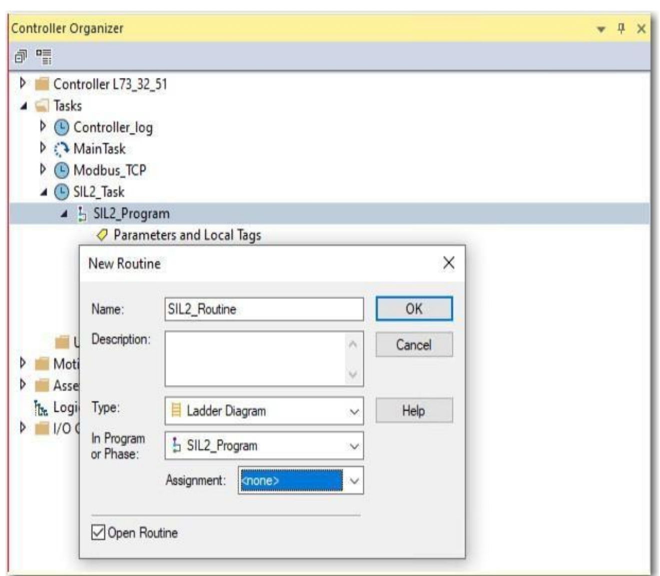
Create a Program for the SIL 2 Period Task

1. Right-click the newly created task and choose New Program.
2. Name the program.
3. Verify that it is scheduled in the SIL 2 task.
4. Click OK.



Create a Routine for the SIL 2 Program

1. Right-click the newly created SIL 2 program and choose New Routine.
2. Name the routine.
3. In the Type field, choose Ladder or Function Block as recommended for SIL 2 safety functions.
4. In the In Program or Phase field, choose the SIL 2 program you created.
5. Click OK.



Configure an Input Module Add-On Instruction

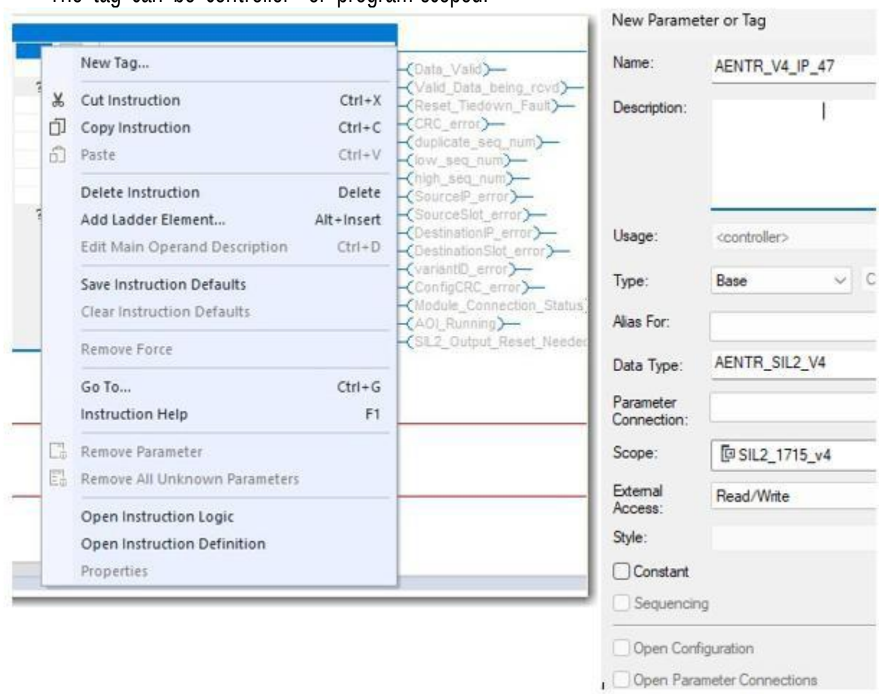
Use the following instructions to configure an input module.

IMPORTANT	The 1715-AENTR adapter functions as an input module when you use 1715 SIL 2 Add-On Instructions.

Follow these steps to configure an input module Add-On Instruction.

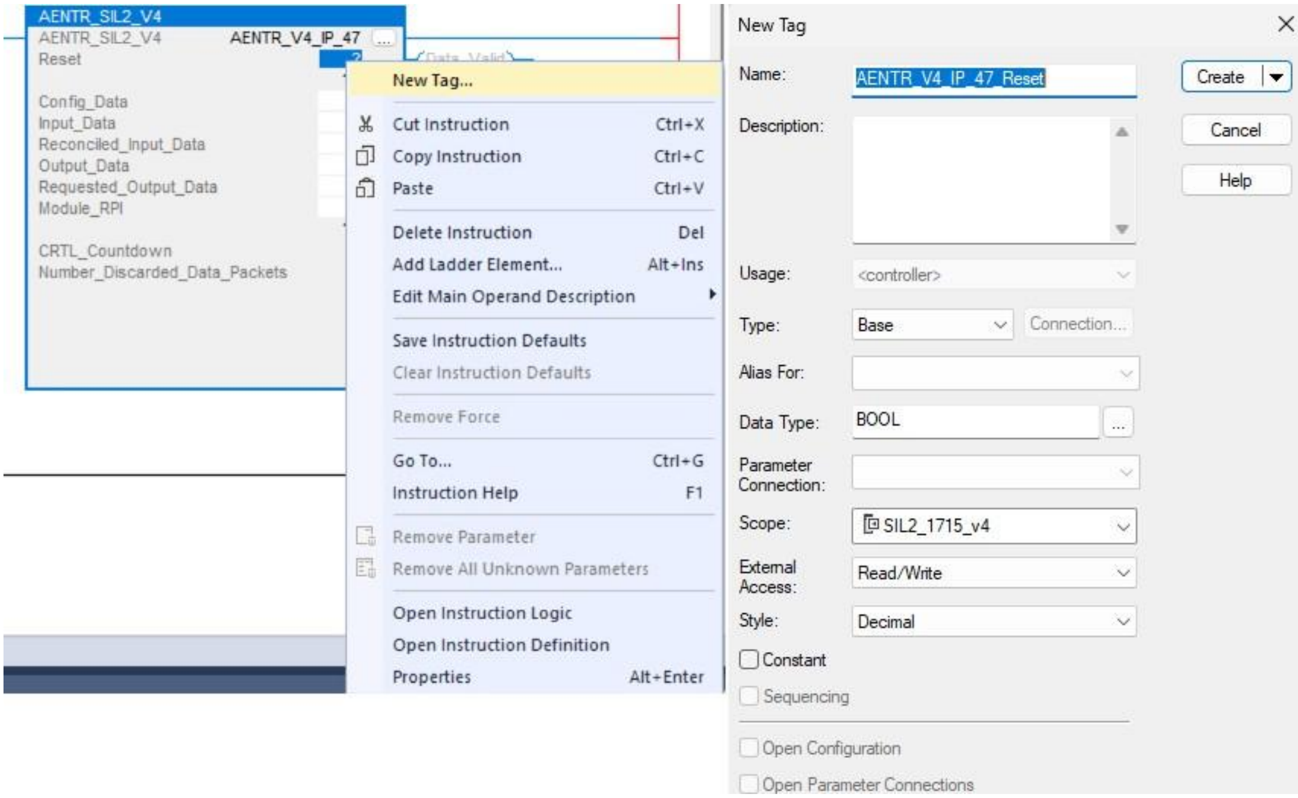
1. From your SIL 2 program, add a rung to the ladder logic.
2. From the Instruction toolbar Add-On tab, click AENTR_SIL2_V4 to insert the Add-On Instruction in your logic.
3. Create a tag for the Add-On Instruction by using the default data type and read/write external access.

   The tag can be controller- or program-scoped.



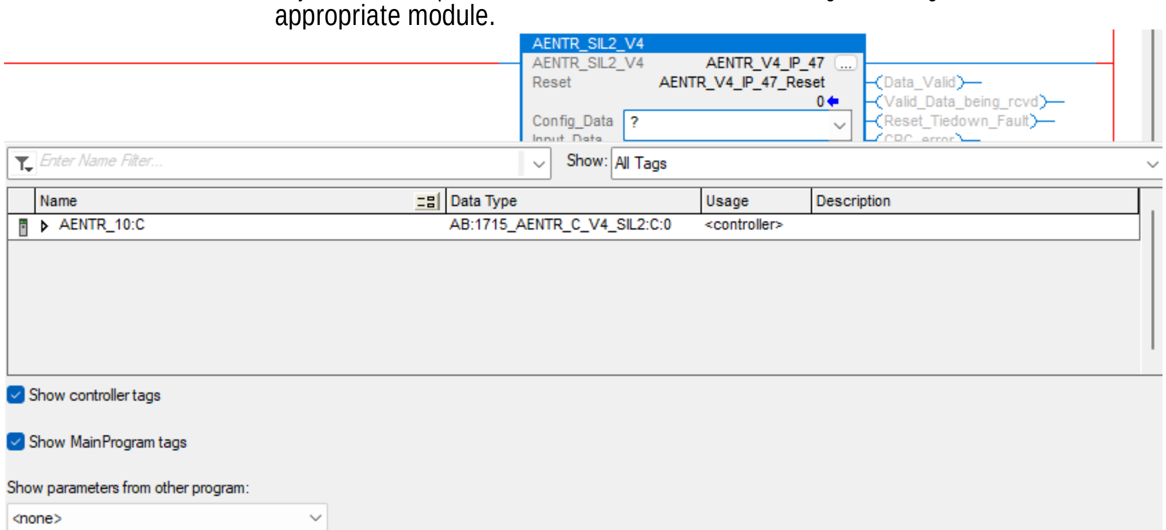
4. Create a reset tag by using the default data type and read/write external access.

   The tag can be controller- or program-scoped.



5. Double-click the Config_Data field and choose the module configuration tag.

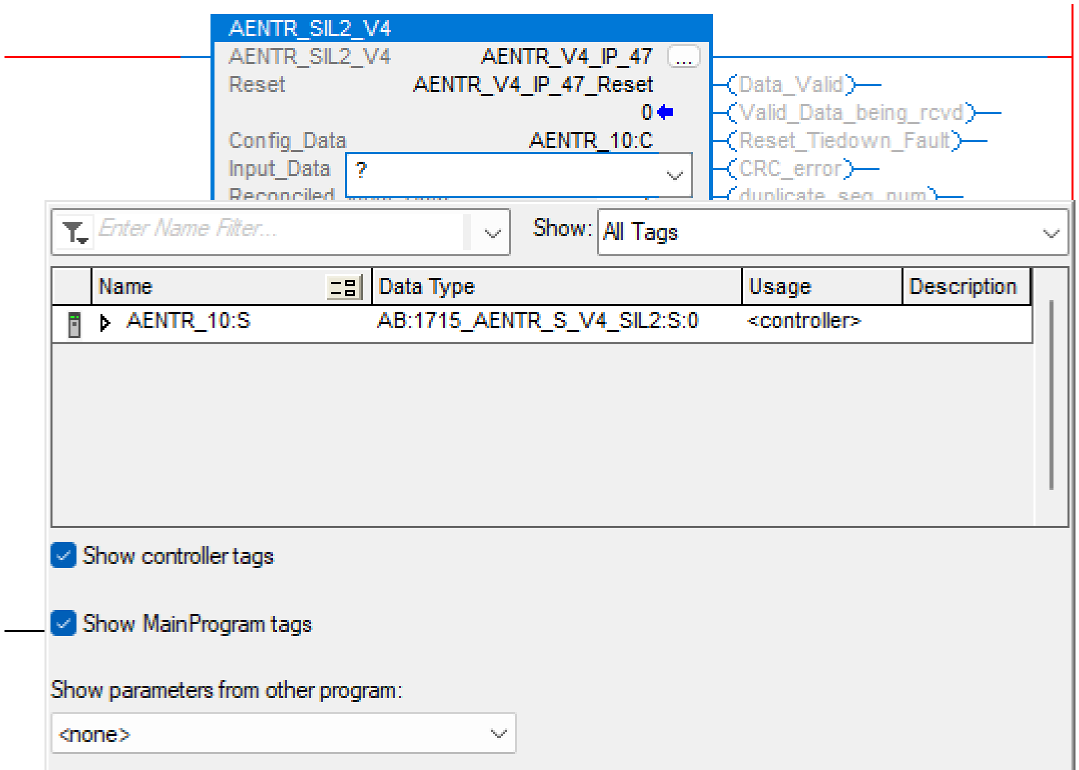
   If you have multiple modules, be sure to choose the configuration tag for the appropriate module.



6. Double-click the Input Data field and choose the module input tag.

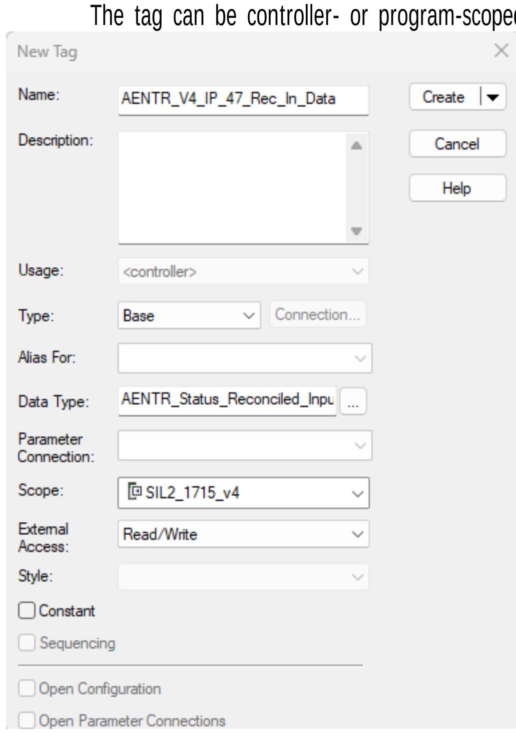
   If you have multiple I/O modules, be sure to choose the input tag for the appropriate module.

   For the 1715 adapters, choose the status tag.



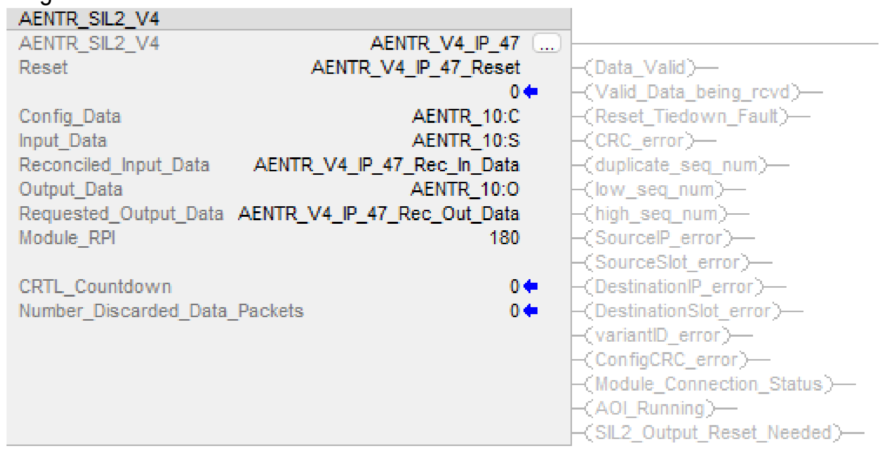
7. Create a tag for the Reconciled Input Data by using the default data type and read/write external access.

   The tag can be controller- or program-scoped.



8. Enter the module RPI.

   To optimize system bandwidth, type the same RPI value from the Module Configuration dialog box.

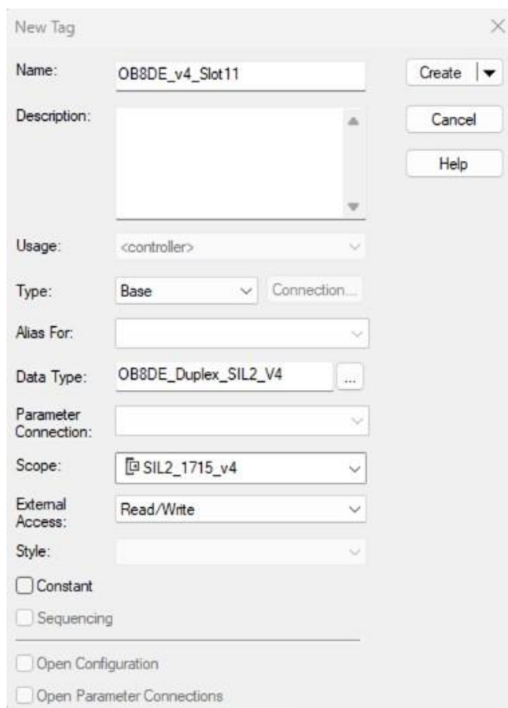


Configure an Output Module Add-On Instruction

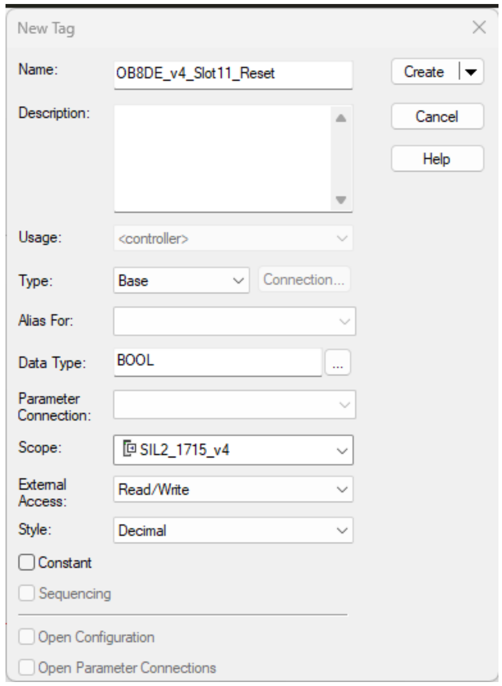
Follow these steps to configure an output module Add-On Instruction.

1. Add the Add-On Instruction to your routine from the Add-On tab of the instruction toolbar.
2. Create a tag for the Add-On Instruction by using the default data type and read/write external access.

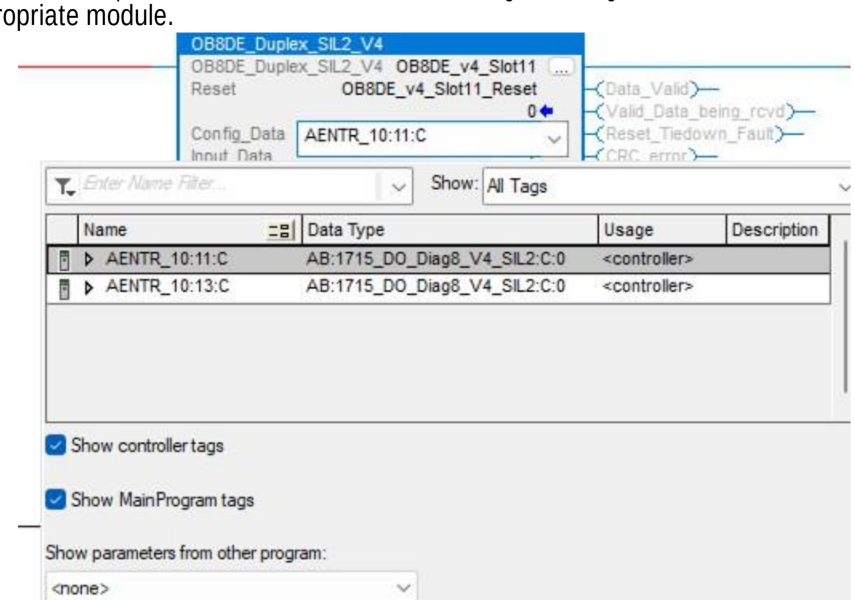
   The tag can be controller- or program-scoped.



3. Create a reset tag by using the default data type and read/write external access.
   The tag can be controller- or program-scoped.

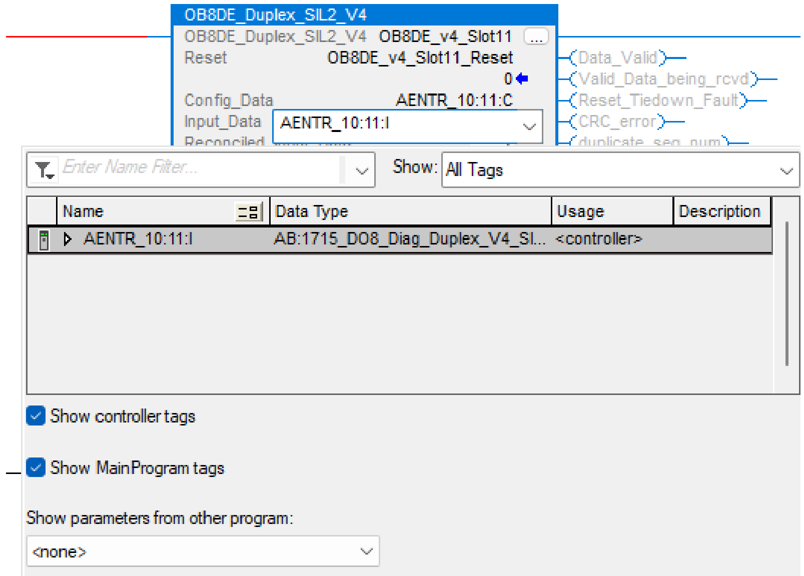


4. Choose the module configuration tag.
   If you have multiple modules, be sure to choose the configuration tag for the appropriate module.



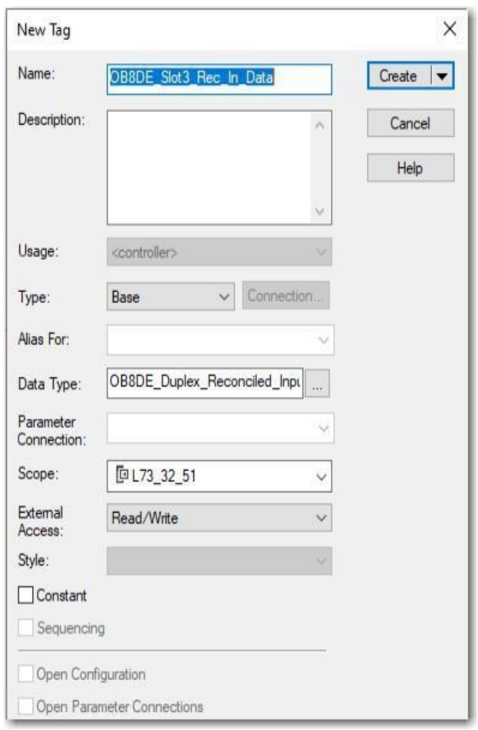
5. Choose the module input tag.

   If you have multiple modules, be sure to choose the input tag for the appropriate module.



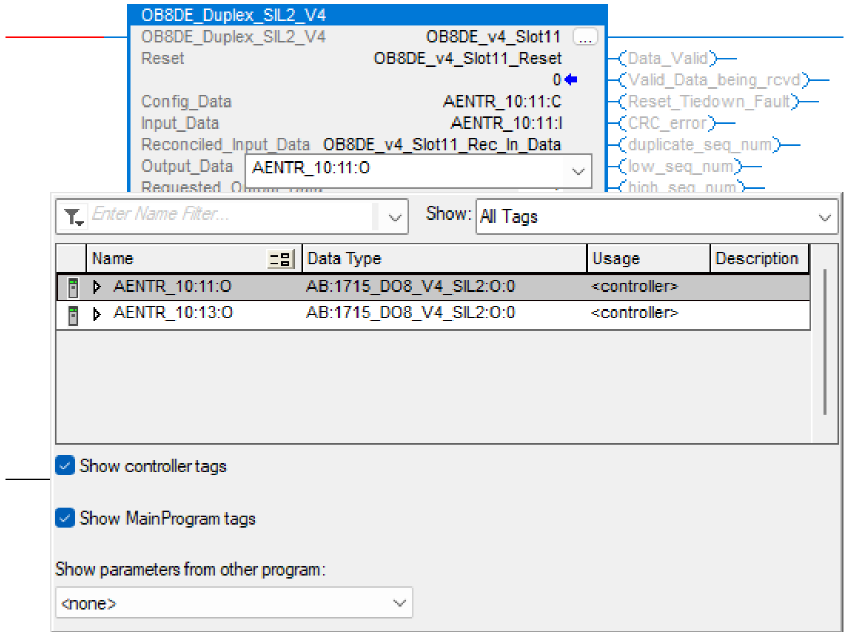
6. Create a tag for the Reconciled Input Data by using the default data type and read/write external access.

   The tag can be controller- or program-scoped.

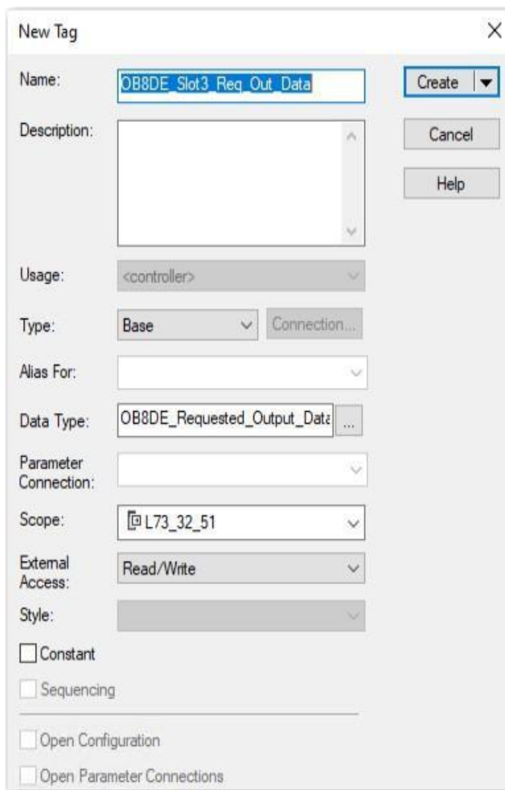


7. Choose the module-defined output tag.

   If you have multiple modules, be sure to choose the output tag for the appropriate module.

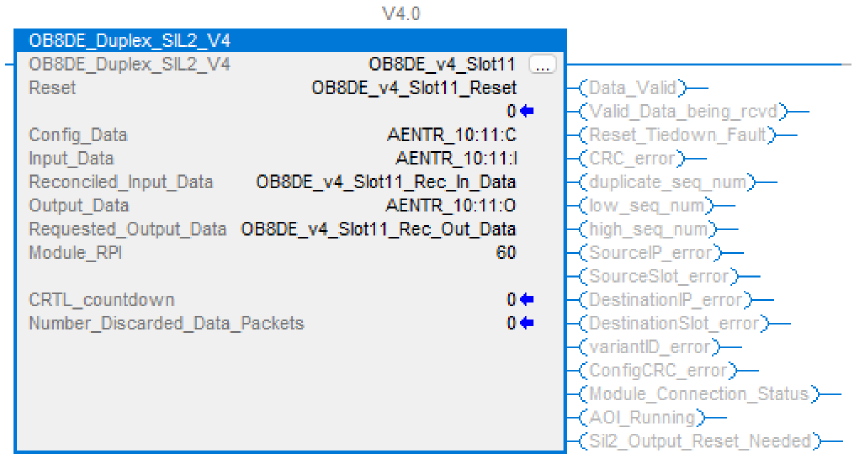


8. Create a tag with the appropriate Add-On Instruction data type for the Requested Output Data.



9. Enter the module RPI.

   To optimize system bandwidth, type the same RPI value from the module configuration.



Use the Add-On Instruction Data Tags in an Application Program

The following illustrations provide basic examples of how the Requested_Output_Data tag and the Reconciled_Input_Data tag could be used in program logic. Data is written to the requested output and read from the reconciled input, while the raw data in the module-defined input and output tags is ignored.

Figure 71 - Requested_Output_Data in Ladder Logic Example

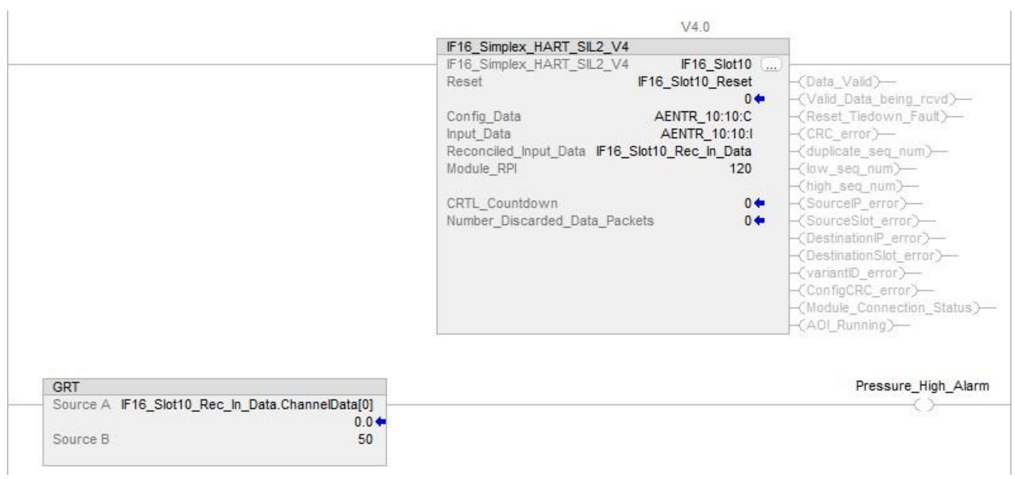


Figure 72 - Reconciled_Input_Data in Ladder Logic Example

Perform a SIL 2 Reset

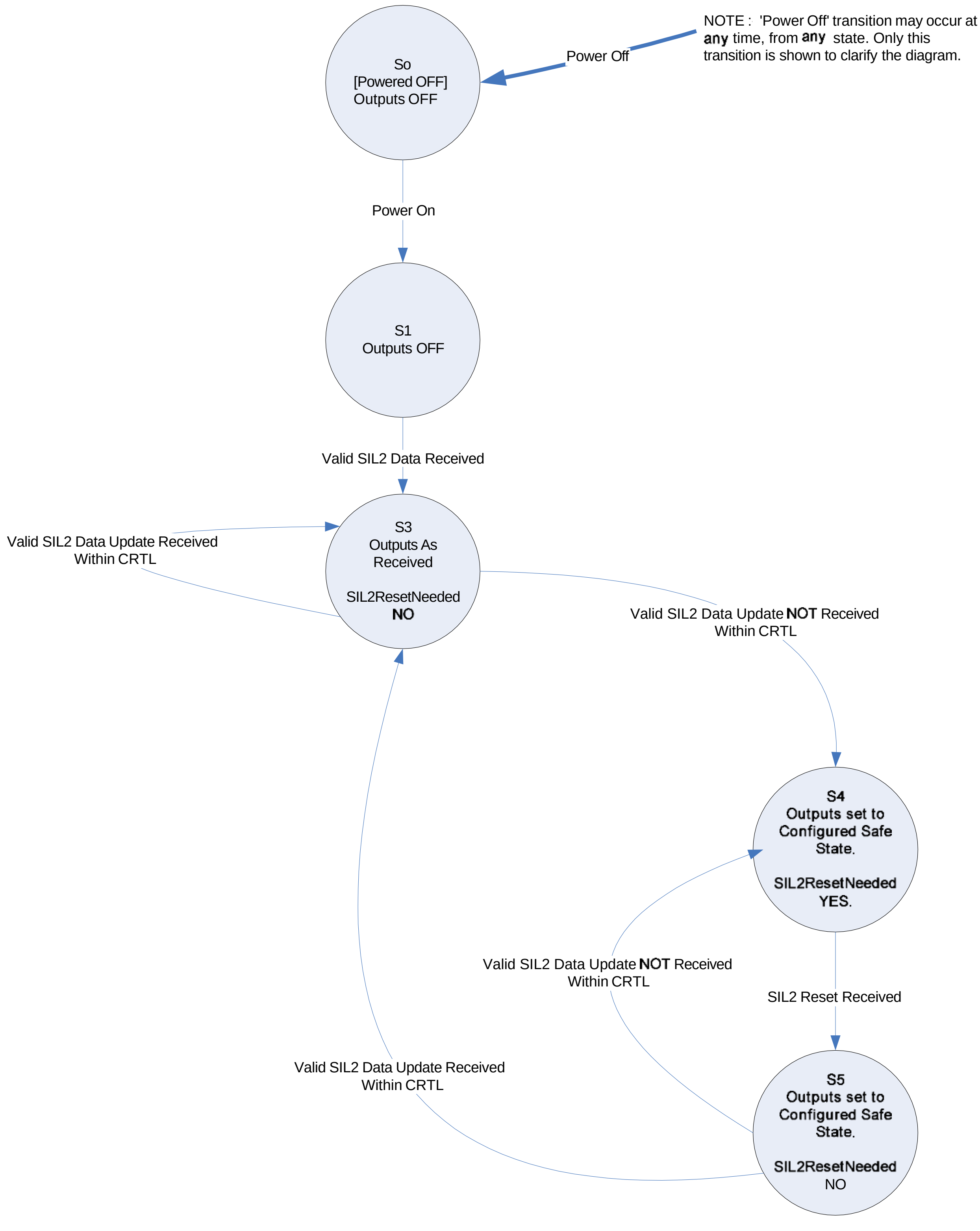
To enable SIL 2 communication between a Logix controller and 1715 I/O modules, the sender of the data encodes additional check data into a produced tag and the receiver of that tag. The extra data determines that received data is valid.

Data can travel from ControlLogix to 1715 and from 1715 to ControlLogix.

Each time the data passes the checks, it is deemed valid. If the checks fail for a period greater than the CRTL value that is assigned to the module, a SIL 2 Reset is required.

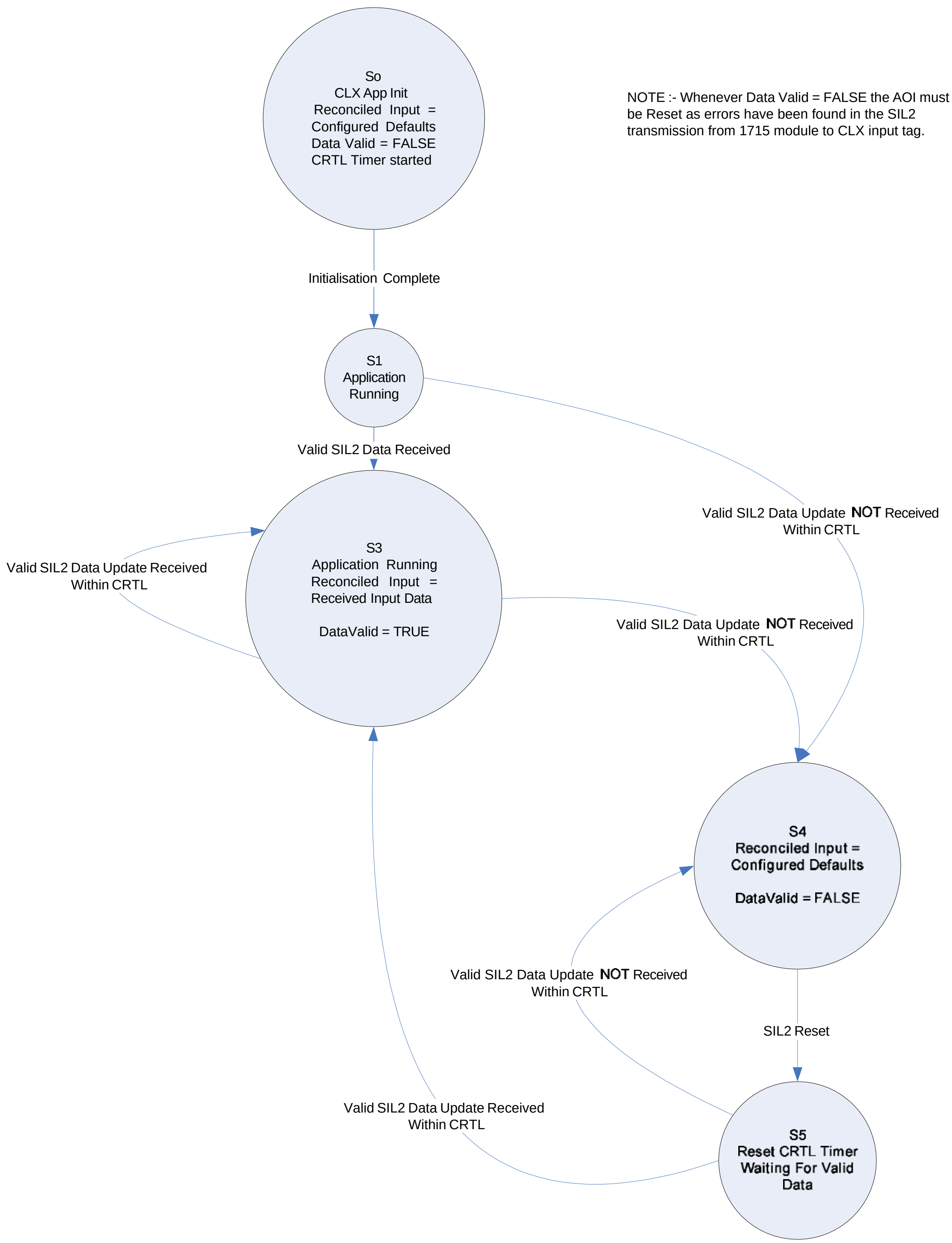
A SIL 2 reset acknowledges that there has been a fault within the data and that new data, if valid, must once again be used.

The following diagram shows 1715 module output behavior.



A SIL 2 reset of output modules can be performed only by clicking Reset on the SIL 2 Safety tab of the Module Properties dialog box, or a LO to HI transition of the reset tag in the 1715 SIL 2 Add-On Instructions.

When using input tags, that is, data from a 1715 input module to a ControlLogix controller, the 1715 module that produces the input tag generates more check data as part of the tag. It is the responsibility of the ControlLogix application to use appropriate Add-On Instructions to validate the received data. The behavior of the Add-On Instructions in processing input data is as follows.



Notes:

Requirements for Application Development

Software for SIL 2-Related Systems

The application software for a SIL 2-related automation system is created with RSLogix 5000® software or the Studio 5000 Logix Designer® application, according to IEC 61131-3.

The application program must be created by using the programming tool and contains the specific equipment functions that the ControlLogix® system implements. Parameters for the operating function are also entered into the system with the programming software.

SIL 2 Programming

The safety concept of the SIL 2 ControlLogix system assumes the following:

- The user who is responsible for creating, operating, and maintaining the application is fully qualified, specially trained, and experienced in safety systems.
- The programming software is installed correctly.
- Control system hardware is installed in accordance with product installation guidelines.
- User application code (user program) uses common and good design practices.
- A test plan is documented and adhered to, including well-understood proof test requirements and procedures.
- A well-designed validation process is defined and implemented.

For the initial startup of a safety-related ControlLogix system, the entire system must successfully complete a functional test. After a modification of the application program, the modified program or logic must be checked.

For more information on how you handle changes to the application program, see Changing Your Application Program on page 125.

Programming Languages

As a best practice, keep safety-related logic as simple and easy to understand as possible. The preferred language for safety-related functions is ladder logic, followed by function block. Structured text and sequential function chart are not recommended for safety-related functions. Use of the SequenceManager™ feature is not recommended for safety-related functions.

IMPORTANT	If Program Parameters are used, safety-related tags can be read by either standard or safety-related logic or other communication devices, but can be written by only safety-related logic.

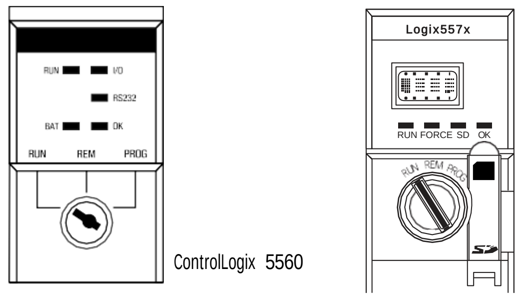
Security

In the ControlLogix system and in the programming software, protection mechanisms are available that help prevent unintentional or unauthorized modifications to the safety system.

- The following tools can be employed for security reasons in a SIL 2-certified ControlLogix application:
  - Source Protection
  - FactoryTalk® AssetCentre
  - FactoryTalk Security

  Each tool offers different levels of granularity. For more information about these tools, contact your local Rockwell Automation representative.
- The controller keyswitch must be in the RUN position, and remove the key during normal operating conditions.

Figure 73 - Keyswitch in Run Mode



- In RSLogix 5000 software, V18 and later, and in the Studio 5000 Logix Designer® application, tags have two attributes: External Access and Constant. External Access controls access from external applications like HMIs. It can have values of Read/Write, Read Only, or None. All SIL 2 safety-related tags should be set to Read Only. The Constant attribute is either on or off. When enabled, it helps prevent programmatic changes of a tag's value. Where possible, it is highly recommended to configure SIL 2 safety-related tags as Constant.

The requirements of the safety and application standards regarding the protection against manipulations must be observed. The authorization of employees and the necessary protection measures are the responsibility of the individuals who start and maintain the SIL 2 safety system.

Basics of Application Program Development and Testing

A system integrator develops the application program. The developer must consider general procedures for programming ControlLogix SIL 2 applications. (does not require independent third-party review).

- Specification of the SIL 2 safety control function, including the following:
  - Specifications
  - Flow and timing charts
  - Engineering diagrams
  - Sequence charts
  - Program description
  - Program review process
- Writing the application program
- Checking by independent reviewer
- Verification and validation

All application logic must be independently reviewed and tested. To facilitate reviews and reduce unintended responses, limit the set of instructions to basic Boolean/ladder logic (such as examine On/Off, timers, counters) whenever possible. Include instructions that can be used to accommodate analog variables, such as the following:

- Limit tests
- Comparisons
- Math instructions

For more information, see Proof Tests on page 28.

Functional Specification Guidelines

You must create a specification for your control function. Use this specification to verify that program logic correctly and fully addresses the functional and safety control requirements of your application. The specification can be in various formats, depending on your application. The specification must include a detailed description of the following (if applicable):

- Sequence of operations
- Flow and timing diagrams
- Sequence charts
- Program description
- Program print-out
- Written descriptions of the steps with step conditions and actuators to be controlled, including the following:
  - Input definitions
  - Output definitions
  - I/O wiring diagrams and references
  - Theory of operation
- Matrix- or table form of stepped conditions and the actuators to be controlled, including the sequence and timing diagrams
- Definition of marginal conditions, for example, operating modes, emergency stop, and others

The I/O-portion of the specification must contain the analysis of field circuits, that is, the type of sensors and actuators.

Sensors (digital or analog)

- Signal in standard operation (dormant current principle for digital sensors, sensors OFF means no signal)
- Determination of redundancies that are required for SIL levels
- Discrepancy monitoring and visualization, including diagnostic logic

Actuators

- Position and activation in standard operation (normally OFF)
- Safe reaction or positions when switching OFF
- Discrepancy monitoring and visualization, including diagnostic logic

Create the Application Program

Consider the following when developing the application program logic.

Logic and Instructions

The logic and instructions for programming the application must have these features:

- Easy to understand
- Easy to trace
- Easy to change
- Easy to test
- Well-documented

IMPORTANT Motion-related functions are not allowed anywhere in the application program and must not be used.

Program Language

You must implement simple, easy to understand program language with these features:

- Ladder
- Other IEC 61131-3-compliant language
- Function blocks with specified characteristics

We use ladder, for example, because it is easier to visualize and make partial program changes with this format.

Program Identification

Identify the application program by one of the following:

- Name
- Date
- Revision
- Any other user identification information

SIL Task/Program Instructions

Include one SIL task that is composed of programs and routines in the user application. The SIL 2 task must be the top priority task of the controller and the user-defined watchdog must be set to accommodate the SIL 2 task.

IMPORTANT You must dedicate a specific task for safety-related functions and set that task to the highest priority (1). SIL 2 safety logic and logic that is intended for use in non-SIL 2 functions must be separate, or everything in the task containing safety must be treated as safety-related.

Forcing

The following rules apply to forcing in a project:

- You must remove forces on all SIL 2 tags and disable forcing before beginning normal operation for the project.
- You must not force SIL 2 tags after validation is performed and during controller operation in Run mode.

IMPORTANT Forcing must not be used during normal operation, during final system test, and validation.

Check the Application Program

To check safety-related application logic for adherence to specific safety functions, you must generate a suitable set of test cases that cover the safety specification. The set of test cases must be well-written and filed as the test specification.

Suitable tests must also be generated for the numeric evaluation of formulas. Equivalent range tests are acceptable. Suitable tests are tests within defined value ranges, at the limits, and outside the defined value ranges. The test cases must be selected to prove the correctness of the calculation. The necessary number of test cases depends on the formula that is used and must comprise critical value pairs.

However, active simulation with sources cannot be omitted. It is the only means to detect the correct wiring of the sensors and actuators to the system. Furthermore, active simulation is the only means to test the system configuration. You must verify the correct programmed functions by forcing I/O or by manual manipulation of sensors and actuators.

Verify Download and Operation

Verify the download of the application program and its proper operation. A typical technique is to upload the completed program file and perform a compare of that file against what is stored in the programming terminal.

IMPORTANT	Do not use memory cards to transfer the safety application automatically. After a safety application is downloaded, you must verify the download. The AutoFlash firmware feature is not supported for SIL 2 safety applications and must not be used.

IMPORTANT	If the controller has a USB port, it is intended for temporary local-programming purposes only and not intended for permanent connection.

To perform program verification, follow these steps in RSLogix 5000 software or the Studio 5000 Logix Designer application.

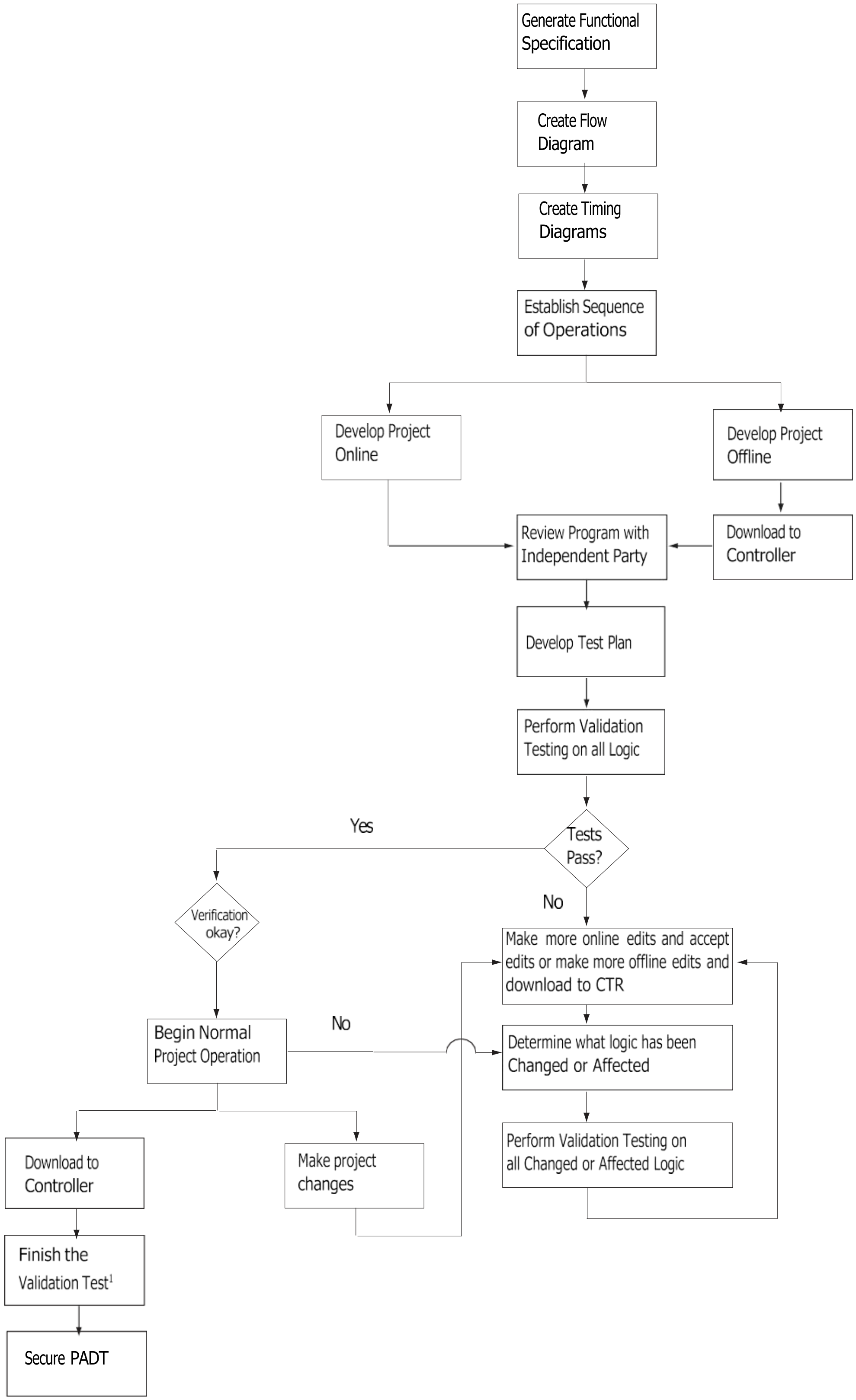
10. With the programming software closed, rename the project.
11. Start the programming software, upload the controller project, and save it.
12. Open the Compare Tool and select both files.
13. Start the compare operation.
14. Review the compare output results and verify that everything matches without error.

    Project documentation differences can exist.
15. Save the compare results as part of the verification process.
16. Delete the upload file.
17. To maintain project documentation, rename the original project file (change back) to the original project name.

Commissioning Lifecycle

The following figure shows the steps that are required to develop, debug, and commission an application program.

Figure 74 - Application Development Lifecycle



[1]You must periodically repeat the validation test (also known as proof tests) to make sure that module inputs and outputs are functioning properly and as commanded by the application programming. For more information on proof tests for I/O modules, see Chapter 1,.

Changing Your Application Program

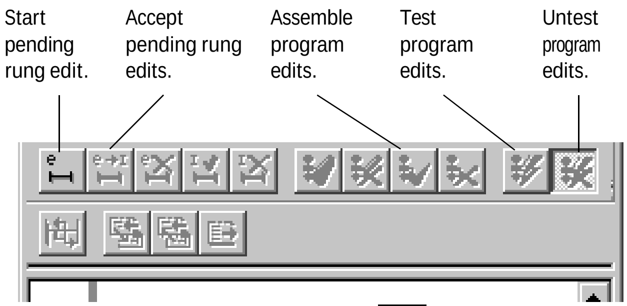
The following rules apply when you change your application program in RSLogix 5000 software or the Studio 5000 Logix Designer application:

IMPORTANT	You cannot make program edits while the program is online if the changes help prevent the system from executing the safety function or if alternative protection methods are not in place.

- Program edits are not recommended and must be limited. For example, minor changes such as changing a timer preset or analog setpoint are allowed.
- Only authorized, specially trained personnel can make program edits. These personnel must use all supervisory methods available, for example, use the controller keyswitch and software password protections.
- Anyone making data or programming edits to an operational system assumes the central safety responsibility while the changes are in progress. These personnel must also maintain safe application operation.
- Before you make any program edits, perform an impact analysis by following the safety specification and other lifecycle steps that are described in Figure 74 on page 124 as if the edits were an entirely new program.
- Sufficiently document all program edits, including:
  - Authorization.
  - Impact analysis.
  - Execution.
  - Test information.
  - Revision information.
- Multiple programmers cannot edit a program from multiple programming terminals simultaneously.
- Changes to the safety application software–in this case, RSLogix 5000 software or the Studio 5000 Logix Designer application– must comply with IEC 61511 standard on process safety section 11.7.1 Operator Interface requirements.
- When the ControlLogix controller keyswitch is in the RUN position (controller is in Run mode), you cannot make online edits.
- Use one of the following methods that are described in Table 10 on page 126 to edit the relay ladder logic portion of the safety program.
- The keyswitch must be in the RUN position to be SIL 2 certified. If you put the keyswitch into the REMOTE position to make an online edit, you are not in safety mode. When you are finished with the online edit, you must put the keyswitch into the RUN position and remove the key.

IMPORTANT	Making any edit always involves following your own MOC (Management of Change) procedures. There must be a validation before putting the changed code into service. Online edits are the most risky method of doing this and are not recommended.

Table 10 - Methods of Changing Your Application Program

Method	Required Steps	Controller Keyswitch Position	Key Points to this Method
Offline	Perform the tasks that are described in the flowchart in Figure 74 on page 124.	PROG	You must revalidate the entire application before returning to normal operation.
Online	1. Turn the controller key to the REM position. 2. To start, accept, test, and assemble your edits, use the Online Edit Toolbar. This is the toolbar.  a. Click the start pending rung edits button. A copy is made of the rung that you want to edit. b. Change your application program as needed. The original program is still active in the controller. Your program changes are made in the copied rungs. Changes do not affect the outputs until you test the program edits in step d. c. Click the accept pending rung edits button. Your program changes are verified and downloaded to the controller. The controller now has the changed program and the original program. However, the controller continues to execute the original program. You can see the state of the inputs, and changes do not affect the outputs. d. Click the test program edits button. e. To test the edits, click Yes. Changes are now executed and affect the outputs; the original program is no longer executed. However, if you are not satisfied with the test results of the edits, you can discard the new program by clicking the untest program edits button, if necessary. If you untest the edits, the controller returns to the original program. f. Click the assemble program edits button. g. To assemble the edits, click Yes. The changes are the only program in the controller, and the original program is discarded. 3. Perform a partial proof test of the portion of the application that is affected by the program edits. 4. To return the project to Run mode, turn the controller key back to the RUN position. We recommend that you upload the new program to your programming terminal to help make sure consistency between the application in the controller and on the programming terminal. 5. Remove the key.	REM	The project remains online but operates in the Remote Run mode. When edits are completed, you are required to validate only the changed portion of the application program. We recommend that online edits be limited to minor program modifications such as setpoint changes or ladder logic rung additions, deletions, and modifications. IMPORTANT: This option to change the application program is available for changes to relay ladder logic only. You cannot use this method to change function block programming. For more detailed information on how to edit ladder logic while online, see the Logix 5000 Controllers Quick Start, publication 1756-QS001.

Chapter 10

Faults in the ControlLogix System

Along with providing information on module fault reports, this chapter explains two example conditions that generate a fault in a SIL 2-certified ControlLogix® system:

- Keyswitch changing out of Run mode
- High alarm condition on an analog input module

Detect and React to Faults

The ControlLogix architecture provides many ways to detect and react to faults in the system.

- Various device objects can be interrogated to determine the current operating status.
- Modules provide runtime status of their operation and of the process that is executing.
- You can configure a ControlLogix system to identify and handle faults, including such tasks as:
  - Developing a fault routine.
  - Creating a user-defined major fault.
  - Monitoring minor faults.
  - Developing a power-up routine.

  See the Logix 5000 Controllers Common Procedures Programming Manual, publication 1756-PM001, for more information.

It is your responsibility to determine what data is most appropriate for your application to initiate a shutdown sequence.

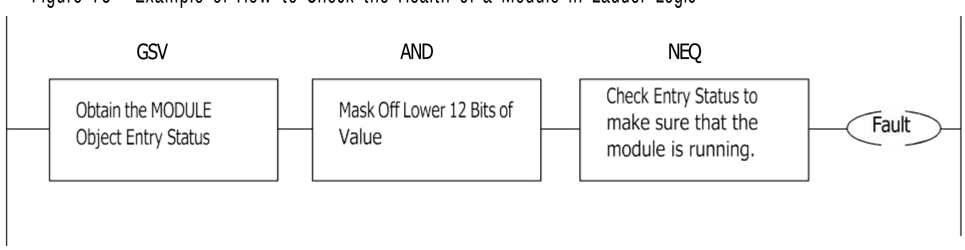
To help handle faults, make sure that you have completed the input and output checklists for their application.

Module Fault Reporting for Any ControlLogix 1715 or 1794 FLEX I/O Module

You must verify that all components in the system are operating properly. Verification can be accomplished in ladder logic by using the Get System Value instruction (GSV) and an examination of the MODULE Object Entry Status attribute for a running condition.

An example of how to verify is shown in Figure 75. This method, or something similar, must be used to interrogate the health of each I/O module in the system.

Figure 75 - Example of How to Check the Health of a Module in Ladder Logic



For more information on the GSV instruction, monitor the SlotStatusBits for the Input tag of the associated adapter. The lower 8 bits of this tag correspond to the associated slot. For example, the tag "Node3:I.Slot1StatusBits" is defined as follows:

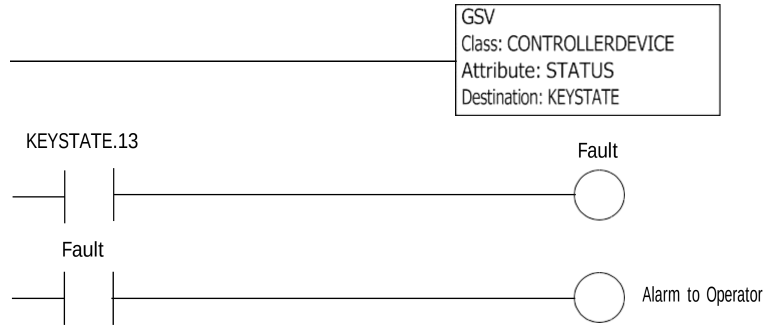
- Node 3 is the name that is given to the adapter, in this example, a 1794-ACNR15.
- I indicates the Input file.
- SlotStatusBits is a 32-bit value, where the lower 8 bits correspond to a FLEX™ I/O module, as shown.

Module 7	Module 6	Module 5	Module 4	Module 3	Module 2	Module 1	Module 0

Check Keyswitch Position with a GSV Instruction

The following rungs generate a fault if the keyswitch on the front of the controller is switched from the RUN position.

Figure 76 - Keyswitch State (Operation mode) Change Logic



In Figure 76 on page 128, the Get System Value (GSV) instruction interrogates the STATUS attribute of the CONTROLLERDEVICE object and stores the result in a word that is called KEYSTATE, where bits 12 and 13 define the state of the keyswitch as shown in Table 11.

Table 11 - Keyswitch State Bits

Bit 13	Bit 12	Description
0	1	Keyswitch in Run position
1	0	Keyswitch in Program position
1	1	Keyswitch in Remote position

If bit 13 is ever ON, then the keyswitch is not in the RUN position. Examine bit 13 of KEYSTATE for an ON state generates a fault.

It is your responsibility to determine appropriate behavior when a fault is present.

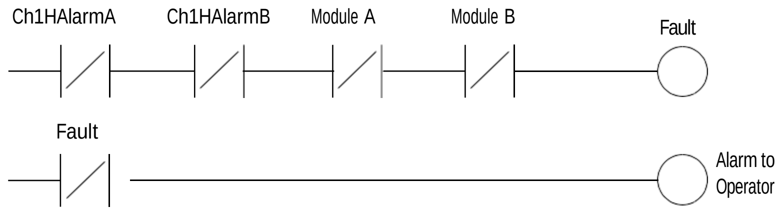
For more information on the accessing the CTROLLERDEVICE object, see the Logix 5000 Controllers General Instructions Reference Manual, publication 1756-RM003.

Examine High Alarm Bits for 1756 Analog Input Modules

ControlLogix analog modules process and compare field data values right on the module, which allows easy examination of status bits to initiate a fault.

For example, the 1756-IF8 module can be configured with user-defined alarm values that, when exceeded, sets a status bit on the module, which is then sent back to the controller. You can examine the state of these bits to initiate a fault as shown in Figure 77.

Figure 77 - High Alarm Bit to Trigger Fault



In the example above, the High Alarm bits for channels 1 and 2 are being examined for a condition to initiate a fault. During operation, as the analog input module processes analog signals from the field sensors, if the value exceeds the user-defined value for High Alarm, the alarm bit is set and a fault is declared.

It is your responsibility to determine appropriate behavior when a fault is present.

The ControlLogix architecture provides for the detecting and reacting to faults in the system. Various device objects can be interrogated to determine the current operating status. Additionally, modules provide runtime status of their operation and of the process.

Use of Human-to-Machine Interfaces

Precautions

You must exercise precautions on HMI devices. These precautions include, but are not restricted to the following:

- Limited access and security
- Specifications, testing, and validation
- Restrictions on data and access
- Limits on data and parameters

For more information on how HMI devices fit into a typical SIL loop, see Figure 10 on page 25.

Use sound techniques in the application software within the HMI and controller.

For specific HMI-related design information, see IEC 61511-1 11.7.2.

Access to Safety-related Systems

HMI-related functions consist of two primary activities: reading and writing data.

Reading Parameters in Safety-related Systems

Reading data is unrestricted because reading doesn't affect the operation or behavior of the safety system. However, the number, frequency, and size of the data being read can affect controller performance. To avoid safety-related spurious trips, use good communication practices to limit the impact of communication processing on the controller. Do not set read rates to the fastest rate possible.

Changing Safety-related Parameters in SIL-rated Systems

A parameter change in a safety-related loop via an external device outside of the SIF, such as an HMI, is allowed only with the following restrictions:

- Only authorized, specially trained personnel (operators) can change the parameters in safety-related systems via HMIs.
- The operator who changes a safety-related system via an HMI is responsible for the effect of those changes on the SIF.
- You must clearly document variables that need changed.
- You must use a clear, comprehensive, and explicit operator procedure to make safety-related changes via an HMI.
- Changes can only be accepted in a safety-related system if the following sequence of events occurs.
  a. The new variable must be sent twice to two different tags; that is, both values must not be written to with one command.
  b. Safety-related code that executes in the controller, must check both tags for equivalency and make sure that they are within range (boundary checks).
  c. Both new variables must be read back and displayed on the HMI device.
  d. Trained operators must visually check that both variables are the same and are the correct value.
  e. Trained operators must manually acknowledge that the values are correct on the HMI display that sends a command to the safety logic, which allows the new values to be used in the safety function.

  In every case, the operator must confirm the validity of the change before they are accepted and applied in the SIF.

- Test all changes as part of the safety validation procedure.
- Sufficiently document all safety-related changes that are made via HMI, including the following:
  - Authorization
  - Impact analysis
  - Execution
  - Test information
  - Revision information
- Changes to the safety-related system, must comply with IEC 61511 standard on process safety section 11.7.1 Operator Interface requirements.
- The developer must follow the same sound development techniques and procedures that are used for other application software development, including the verification and testing of the operator interface and its access to other parts of the program. The controller application software builds a table that is accessible by the HMI and limits access to required data points only.
- Similar to the controller program, you must secure and maintain the HMI software for SIL-level compliance after the system has been validated and tested.

IMPORTANT	The High-Speed Jog function is not allowed and must not be used in the entire project.

System Reaction Times

You can use the calculation formulas in this chapter to calculate the worst-case reaction times for a given change in input or fault condition and the corresponding output action.

1756 ControlLogix I/O and 1794 FLEX I/O Reaction Times

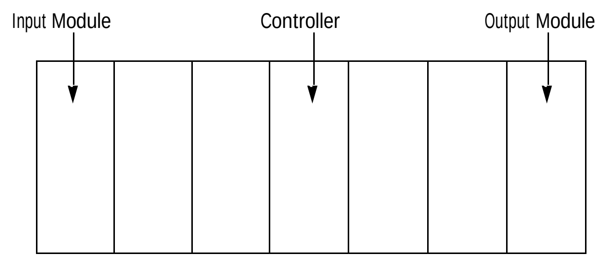
For a system with 1756 ControlLogix I/O or 1794 FLEX I/O™ modules, refer to the following sections.

Local Chassis Configuration

Figure 78 shows an example system with digital or analog modules where the following occurs:

- Field signal changes state.
- The data is transmitted to the controller.
- The controller runs its program scan and reacts to the data change.
- The controller transmits data to the output module.
- The output module processes data from the controller and turns the output device on or off.

Figure 78 - Local Chassis Configuration for Digital or Analog Modules

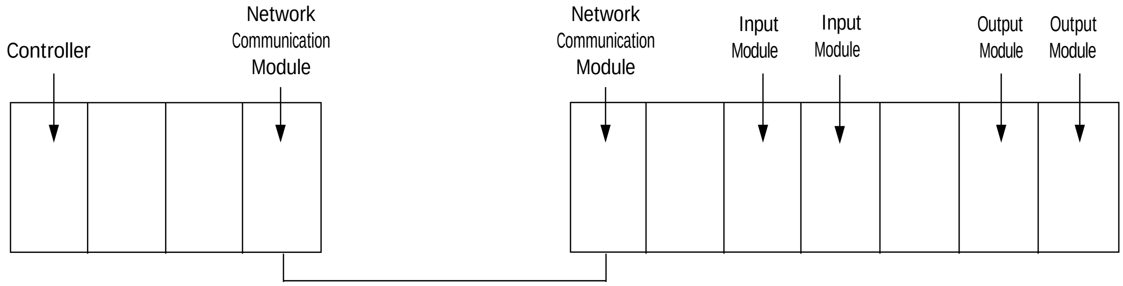


Remote Chassis Configuration

Figure 79 shows an example system where the following occurs:

- Input data changes on the input module.
- The data is transmitted to the controller via the network communication modules.
- The controller runs its program scan and reacts to the data change, including new data sent to the output module via the network communication modules.
- The output module behavior changes based on the new data that is received from the controller.

Figure 79 - Remote Chassis Configuration for Digital or Analog Modules



Calculate Worst-case Reaction Time

The formulas for calculating worst-case reaction times with no system faults or errors differ slightly for digital and analog I/O modules.

Digital Modules

Use this formula to determine worst-case reaction time for digital modules in local or remote configurations.

Worst-Case Reaction Time with no faults or errors =

(Input Module Delay + Input Filter Time) + (Input Module RPI x 4/8/16… ≥100 ms)[1] +

(SIL 2 Task Period + SIL 2 Task Watchdog) + (Output Module RPI x 4/8/16… ≥100 ms)[1] +

(Output Module Delay).

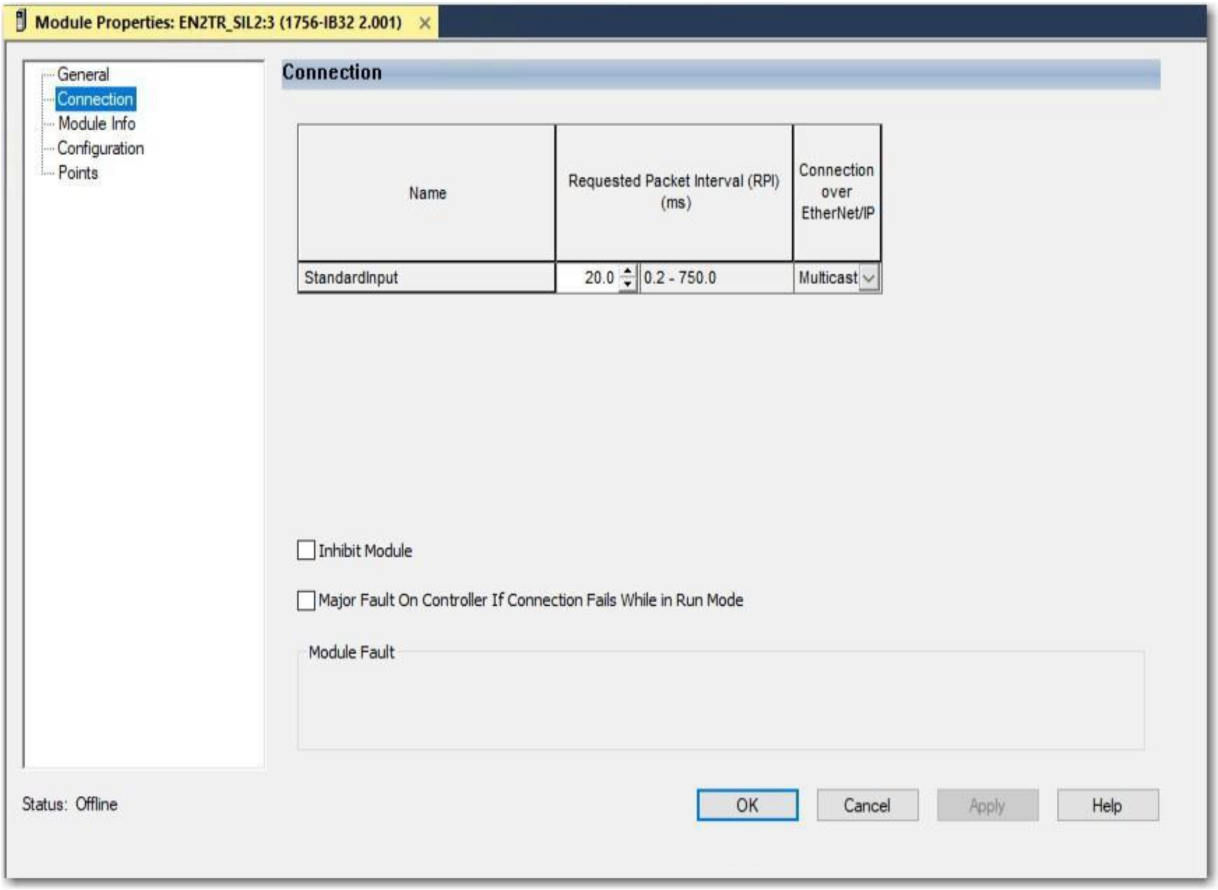
Module delay times are listed in the ControlLogix® I/O Modules Specifications Technical Data, publication 1756-TD002.

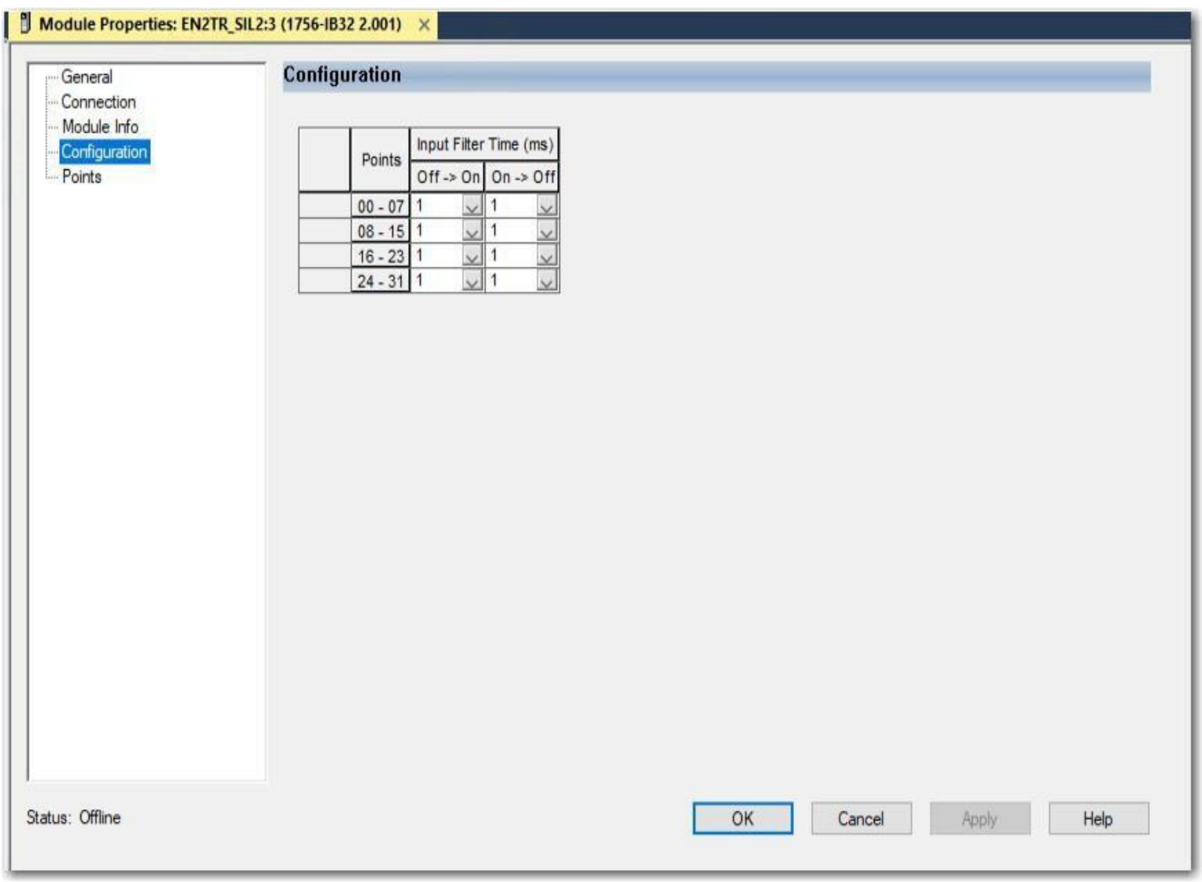
RPI and input filter time values are configurable in the module properties via the Logix Designer application, as shown in Figure 80:

- If the safe state in your application is low, use the On -> Off Input Filter Time.
- If the safe state in your application is high, use the Off -> On Input Filter Time.

(1) Multiply the module RPI by 4, then 8, then 16, and so on, until the result is at least 100 ms.

Figure 80 - Digital Module Configuration





Analog Modules

Use this formula to determine worst-case reaction time for analog modules in local or remote configurations.

Worst-Case Reaction Time with no faults or errors =
(Real Time Sample (RTS) Rate) +
(Input Module RPI x 4/8/16... $\geq$100 ms)[1] + (SIL 2 Task Period + SIL 2 Task Watchdog) +
(Output Module RPI x 4/8/16... $\geq$100 ms)[1] + (Output Module Delay).

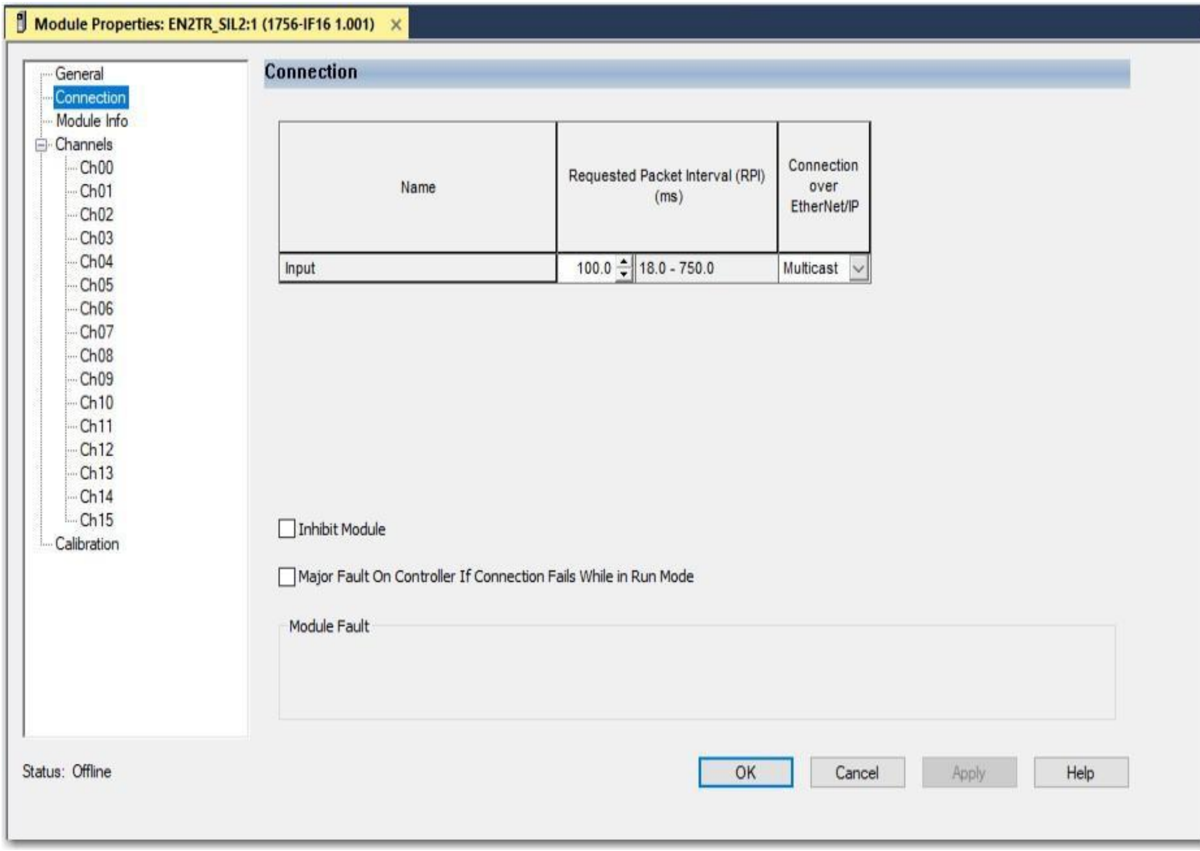
In this calculation for the 1756-IRT8I or 1756-IF8I module, use the RPI instead of the RTS.

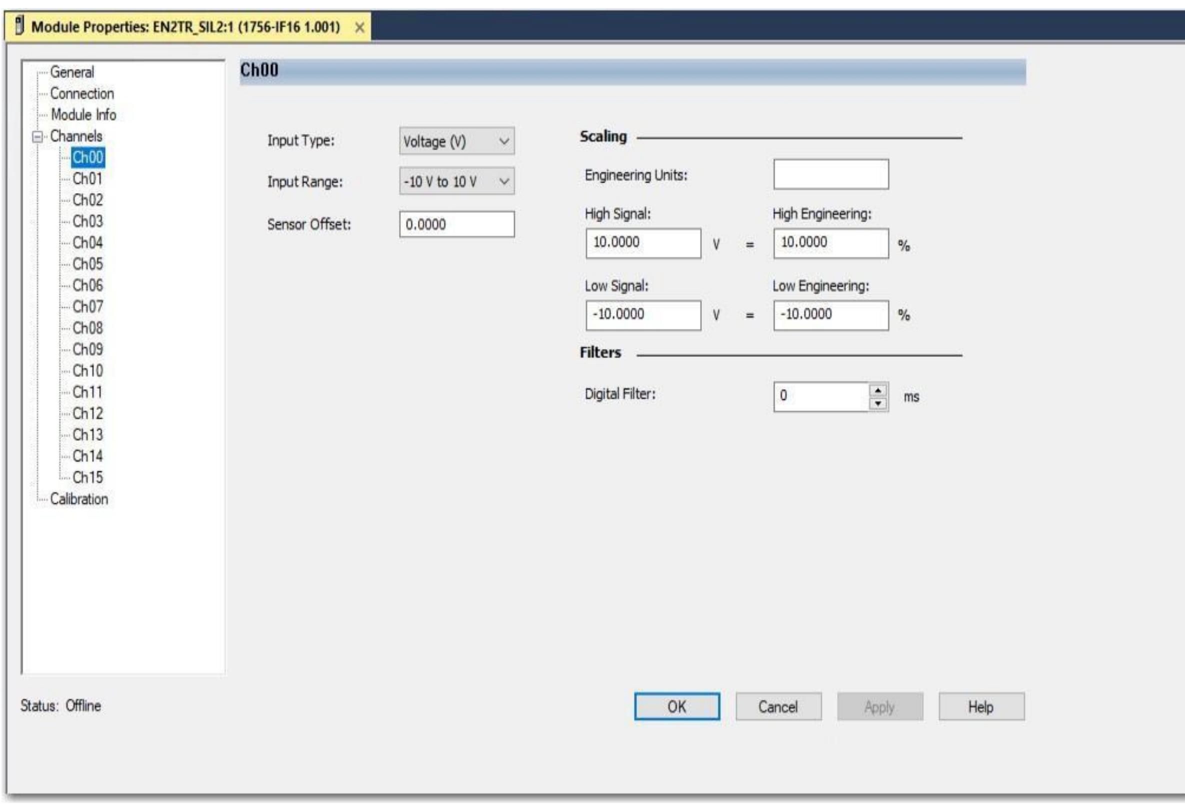
RPI and filter time values are configurable in the module properties via the Logix Designer application, as shown in Figure 81.

For information about setting filter and RTS values, see the ControlLogix Analog I/O Module User Manual, publication 1756-UM009.

Figure 81 - Analog Module Configuration

(1) Multiply the module RPI by 4, then 8, then 16, and so on, until the result is at least 100 ms.


Module Properties: EN2TR_SIL2:1 (1756-IF16 1.001)
General
Connection
Module Info
Channels
Ch00
Ch01
Ch02
Ch03
Ch04
Ch05
Ch06
Ch07
Ch08
Ch09
Ch10
Ch11
Ch12
Ch13
Ch14
Ch15
Calibration
Connection
Name
Requested Packet Interval (RPI) (ms)
Connection over EtherNet/IP
Input
100.0
18.0 - 750.0
Multicast
Inhibit Module
Major Fault On Controller If Connection Fails While in Run Mode
Module Fault
Status: Offline
OK
Cancel
Apply
Help


Module Properties: EN2TR_SIL2:1 (1756-IF16 1.001)
General
Connection
Module Info
Channels
Ch00
Ch01
Ch02
Ch03
Ch04
Ch05
Ch06
Ch07
Ch08
Ch09
Ch10
Ch11
Ch12
Ch13
Ch14
Ch15
Calibration
Ch00
Input Type:
Voltage (V)
Input Range:
-10 V to 10 V
Sensor Offset:
0.0000
Scaling
Engineering Units:
High Signal:
10.0000
V
=
High Engineering:
10.0000
%
Low Signal:
-10.0000
V
=
Low Engineering:
-10.0000
%
Filters
Digital Filter:
0
ms
Status: Offline
OK
Cancel
Apply
Help

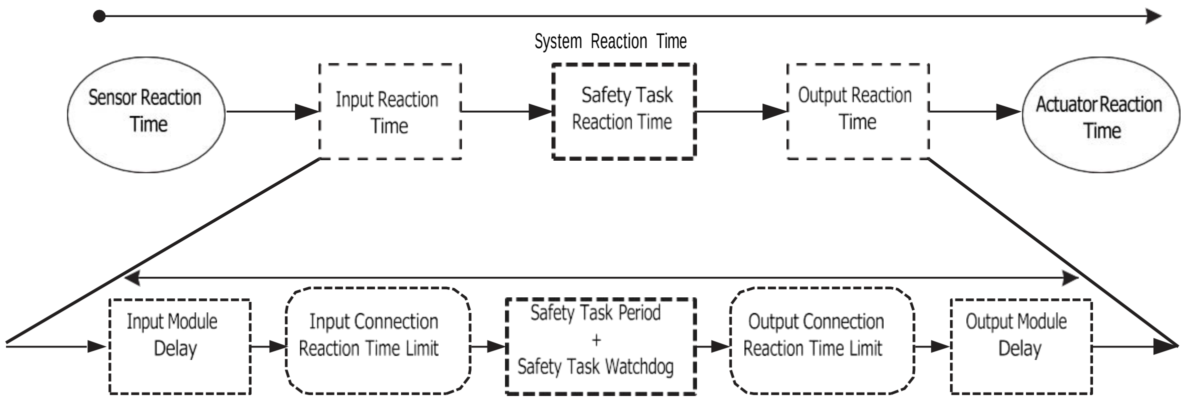
1715 Redundant I/O System Reaction Times

For a 1715 redundant I/O system, you can determine the reaction time for a control chain by adding the reaction times of all of components of the safety chain.

System Reaction Time

System Reaction Time = Sensor Reaction Time + Logix System Reaction Time + Actuator Reaction Time

Figure 82 - System Reaction Time

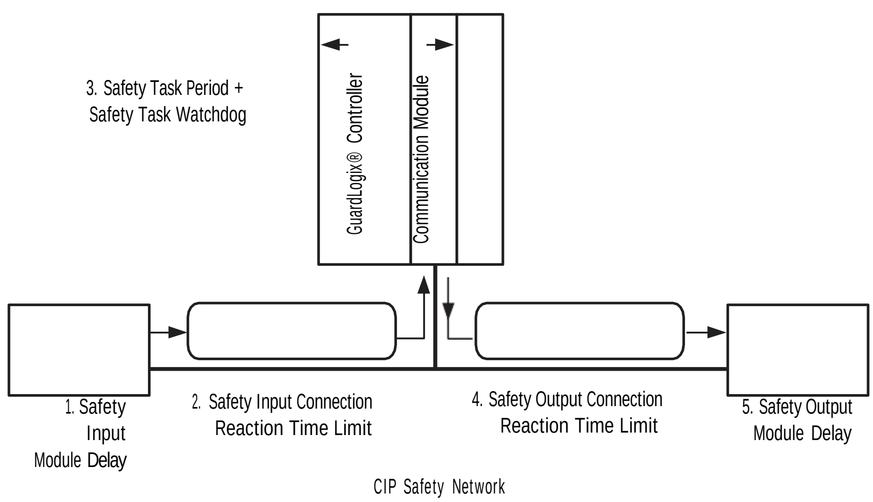


Logix System Reaction Time

The following sections provide information about calculating the Logix System Reaction Time for a simple input-logic-output chain and for a more complex application using produced/ consumed safety tags in the logic chain.

Simple Input-logic-output Chain

Figure 83 - Logix System Worst-case Reaction Time for Simple Input to Logic to Output



The Logix system reaction time for any simple input to logic to output chain consists of these five components.

1. Safety input module reaction time + input delay time
2. Safety input connection reaction time limit
3. Safety task period + safety task watchdog time
4. Safety output connection reaction time limit
5. Safety output module reaction time

Items 3...5 are read from the Module Properties dialog box in the Logix Designer application.

Add-On Instruction Scan Times

Table 12 - Maximum Scan Rates Measured - 1756-L75 controller was used to take measurements

Module	Add-On Instruction		Scan Rate µs (max measured)
1715-AENTR	AENTR_SIL2	Duplex	455
1715-IB16D	IB16D_Simplex_SIL2	Simplex	340
1715-IB16D	IB16D_Duplex_SIL2	Duplex	378
1715-IF16	IF16_Simplex_SIL2	Simplex	831
1715-IF16	IF16_Duplex_SIL2	Duplex	832
1715-OB8DE	OB8DE_Simplex_SIL2	Simplex	501
1715-OB8DE	OB8DE_Duplex_SIL2	Duplex	541
1715-OF8	OF8I_Simplex_SIL2	Simplex	951
1715-OF8	OF8I_Duplex_SIL2	Duplex	964
N/A	CRC Calculator	N/A	N/A

Table 13 - Maximum Scan Rates V3 Measured - 1756-L75 controller was used to take measurements

Module	Add-On Instruction		Scan Rate µs (max measured)
1715-AENTR	AENTR_SIL2_V3	Duplex	507
1715-IB16D	IB16D_Simplex_SIL2_V3	Simplex	982
1715-IB16D	IB16D_Duplex_SIL2_V3	Duplex	1035
1715-IF16	IF16_Simplex_SIL2_V3	Simplex	676
1715-IF16	IF16_Duplex_SIL2_V3	Duplex	696
1715-OB8DE	OB8DE_Simplex_SIL2_V3	Simplex	950
1715-OB8DE	OB8DE_Duplex_SIL2_V3	Duplex	1012
1715-OF8	OF8I_Simplex_SIL2_V3	Simplex	1048
1715-OF8	OF8I_Duplex_SIL2_V3	Duplex	1055
1715-IF16	IF16_Simplex_HART_SIL2_V3	Simplex	692
1715-IF16	IF16_Duplex_HART_SIL2_V3	Duplex	715
1715-OF8	OF8_Simplex_HART_SIL2_V3	Simplex	1058
1715-OF8	OF8_Duplex_HART_SIL2_V3	Duplex	1071
N/A	CRC Calculator_V3	N/A	N/A

Safety Reaction Time Calculations

The 1715 Add-On Instructions process data at a rate of the module RPI / 2. For example, if the 1715-IF16 RPI = 100 ms, the 1715 IF16 AOI processes the most recent packet every 50 ms. This provides a compromise between controller bandwidth (not processing the packets too often using old data) and overall 1715 screw to screw performance. Because the 1715 Add-On Instructions run on a time basis, the input module AOI and the output module Add-On Instruction can be asynchronous. The periodic task rate affects the actual process rate and periodic task scan time.

The worst-case safety reaction time can be calculated using the formulas that are shown in the following example. For the following example, assume the following:

- 1715 input module RPI = 60 ms
- 1715 output module RPI = 80 ms
- SIL 2 task period = 30 ms
- SIL 2 task watchdog = 20 ms
- Add-On Instruction module RPI=60 ms

Table 14 - Worst Case Reaction Time Calculations

Worst Case Factors		Value	Fixed Time (ms)	User Configurable Time (ms)	Description
1715 Input Module Delay			15		Signal propagation from field to bus
1715 Backplane Rate			65		Signal propagation across bus to dispatch ready in AENTR
1715-AENTR Delay			25		Signal propagation from AENTR to Logix (CIP)
Input Data to ControlLogix	COS = NO	1715 Input Module RPI		60	COS = Change of State
	COS = YES	Fixed	60		
Add-On Instruction Input Module RPI		AOI Input Module RPI/2		30	Value that is entered into the AOI Input Module RPI parameter / 2. The AOI processes data at a rate of twice the associated module.
ControlLogix SIL2 Task Period		SIL2 Task Period		30	The task period of the SIL2 task. Worse case calculation assumes that the currently executing task does not receive the input change. The subsequent execution will sample the input change
ControlLogix SIL2 Task Watchdog		SIL2 Task Watchdog		20	The SIL2 Task Watchdog timeout. The SIL2 Task will finish execution within this worst case value (without going to safe state mode) in order to provide output data to the output module AOI.
Add-On Instruction Output Module RPI		AOI Output Module RPI/2		40	Value that is entered into the AOI Output Module RPI parameter / 2. The AOI processes data at a rate of twice the associated module.
Output Data to 1715-AENTR		1715 Output Module RPI		80	
1715-AENTR Delay			25		Signal propagation from Logix to AENTR (CIP).
1715 Backplane Rate			65		Signal propagation across bus from AENTR to output module.
1715 Output Module Delay			15		Signal propagation from bus to field.

If you are not using COS, the worst-case reaction time from input screw terminal to output screw terminal is equal to 210 ms plus the following:

- Input RPI
- Input Module AOI RPI / 2
- SIL 2 Task Period
- SIL 2 Task Watchdog
- Output Module AOI RPI / 2
- Output RPI

If you are using COS, the worst-case reaction time from input screw terminal to output screw terminal is equal to 270 ms plus the following:

- Input Module AOI RPI / 2
- SIL 2 Task Period
- SIL 2 Task Watchdog
- Output Module AOI RPI / 2
- Output RPI

SIL 2-certified ControlLogix System Components

System components that are listed here are certified according to IEC 61508 2010 Edition 2, unless noted in the following tables.

Use only the series versions that are listed in Appendix C. These tables list publications that are related to these components. Publications are available from Rockwell Automation by visiting rok.auto/literature.

Table 15 - SIL 2-certified ControlLogix Components - Hardware

Cat. No.(1)	Description	Related Documentation
1756-A4, 1756-A7 1756-A10, 1756-A13, 1756-A17	ControlLogix® chassis	1756-IN619 1756-IN620 1756-IN621
1756-PA75(2)	ControlLogix AC power supply	
1756-PB75(2)	ControlLogix DC power supply	
1756-PA75R	ControlLogix AC redundant power supply	
1756-PB75R	ControlLogix DC redundant power supply	
1756-PA72	ControlLogix AC power supply	
1756-PB72	ControlLogix DC power supply	
1756-PC75	ControlLogix DC power supply	
1756-PH75	ControlLogix DC power supply	
1756-PSCA(3)	ControlLogix redundant power supply chassis adapter	
1756-PSCA2(3)	ControlLogix redundant power supply chassis adapter	

(1) Some catalog numbers have a K suffix. This indicates a version of the product that has conformal coating. These K versions have the same SIL 2 certification as the non-K versions.
(2) The 1756-PA75/A and 1756-PB75/A power supplies are no longer available. However, if your existing SIL 2 application uses these power supplies, they are SIL 2 certified.
(3) Existing systems that use the 1756-PSCA and 1756-PSCA2 are SIL 2-certified. However, when implementing new SIL 2-certified systems or upgrading existing systems, we recommend that you use the 1756-PSCA2 module if possible.

Table 16 - SIL 2-certified ControlLogix Components - 1756 Non-redundant Controllers, I/O, and Communication Modules

Cat. No.(1) (2)	Description	Related Documentation
1756-L61(3) (4)	ControlLogix 2 MB controller	1756-UM001
1756-L62(3) (4)	ControlLogix 4 MB controller	
1756-L63(3) (4)	ControlLogix 8 MB controller	
1756-L71(3)	ControlLogix 2 MB controller	
1756-L72(3)	ControlLogix 4 MB controller	
1756-L73(3)	ControlLogix 8 MB controller	
1756-L74(3)	ControlLogix 16 MB controller	
1756-L75(3)	ControlLogix 32 MB controller	
1756-L61S(3)(4)	GuardLogix® controller, 2 MB standard	1756-UM022
1756-L62S(3)(4)	GuardLogix controller, 4 MB standard	
1756-L63S(3)(4)	GuardLogix controller, 8 MB standard	
1756-L71S(3)	GuardLogix controller, 2 MB standard	
1756-L72S(3)	GuardLogix controller, 4 MB standard	
1756-L73S(3)	GuardLogix controller, 8 MB standard	
1756-L73SXT(3)	GuardLogix-XT™ controller, 8 MB standard	

Table 16 - SIL 2-certified ControlLogix Components - 1756 Non-redundant Controllers, I/O, and Communication Modules (Continued)

Cat. No.(1) (2)	Description	Related Documentation
1756-IA16I	ControlLogix AC isolated input module	1756-UM058
1756-IA8D	ControlLogix AC diagnostic input module	
1756-IB16D	ControlLogix DC diagnostic input module	
1756-IB16I	ControlLogix DC isolated input module	
1756-IB32	ControlLogix DC input module	
1756-IB16ISOE	ControlLogix Sequence of Events module	1756-UM528
1756-IH16ISOE	ControlLogix Sequence of Events module	
1756-OA16I	ControlLogix AC isolated output module	1756-UM058
1756-OA8D	ControlLogix AC diagnostic input module	
1756-OB16D	ControlLogix DC diagnostic output module	
1756-OB16E	ControlLogix DC electronically fused output module	
1756-OB16I	ControlLogix DC isolated output module	
1756-OB32	ControlLogix DC output module	
1756-OB8EI	ControlLogix DC isolated output module	
1756-OW16I	ControlLogix isolated relay output module	
1756-OX8I	ControlLogix isolated relay output module	
1756-IF8	ControlLogix analog input module	1756-UM009
1756-IF16	ControlLogix analog input module	
1756-IF6I	ControlLogix isolated analog input module	
1756-IF6CIS	ControlLogix isolated analog input module	
1756-IF8H	ControlLogix HART analog input module	1756-UM533
1756-IF16H	ControlLogix HART analog input module	
1756-IF8I	ControlLogix isolated analog input module	1756-UM540
1756-IRT8I	ControlLogix isolated analog RTD thermocouple input module	
1756-OF8I	ControlLogix isolated analog output module	

Table 16 - SIL 2-certified ControlLogix Components - 1756 Non-redundant Controllers, I/O, and Communication Modules (Continued)

Cat. No.(1) (2)	Description	Related Documentation
1756-IR6I	ControlLogix RTD input module	1756-UM009
1756-IT6I	ControlLogix Thermocouple input module	
1756-IT6I2	ControlLogix enhanced Thermocouple input module	
1756-OF4 Series B	ControlLogix analog output module	
1756-OF8	ControlLogix analog output module	
1756-OF6CI	ControlLogix isolated analog output module	
1756-OF6VI	ControlLogix isolated analog output module	
1756-OF8H	ControlLogix HART analog output module	1756-UM533
1756-CNB(5)	ControlLogix ControlNet® communication module	CNET-IN005 CNET-UM001
1756-CN2	ControlLogix ControlNet communication module	
1756-CN2R	ControlLogix redundant media ControlNet communication module	
1786-RPFS	ControlNet short-distance fiber repeater module	1786-IN012
1786-RPFM	ControlNet medium-distance fiber repeater module	1786-IN011
1786-RPFRL	ControlNet long-distance fiber repeater module	1786-IN003
1786-RPFRXL	ControlNet extra-long-distance fiber repeater module	
1786-RPA	ControlNet repeater adapter	1786-IN013
1786-RPCD	ControlNet Hub repeater module	1786-IN001
1756-EN2TR Series B	ControlLogix redundant media EtherNet/IP™ communication module	ENET-IN002 ENET-UM001
1756-EN2TR Series C	ControlLogix redundant media EtherNet/IP communication module	
1756-EN2T Series C	ControlLogix EtherNet/IP communication module	

(1) Some catalog numbers have a K suffix. This indicates a version of the product that has conformal coating. These K versions have the same SIL 2 certification as the non-K versions.
(2) Some catalog numbers have an XT suffix. This indicates a version of the product that is intended for harsh environments. These XT versions have the same SIL 2 certification as the non-XT versions.
(3) Use of any series B controller requires the use of the series B versions of the 1756-Px75 power supplies.
(4) Certified according to IEC 61508 1999 Edition 1.
(5) Specified ControlNet repeaters can be used in SIL 2 applications. See Chapter 4, ControlLogix Communication Modules for more information.

Table 17 - SIL 2-certified ControlLogix Components - 1756 Redundancy System Components

Cat. No.(1)	Description	Related Documentation
1756-L61(2) (3)	ControlLogix 2 MB controller	1756-UM001
1756-L62(2) (3)	ControlLogix 4 MB controller	
1756-L63(2) (3)	ControlLogix 8 MB controller	
1756-L71(2)	ControlLogix 2 MB controller	
1756-L72(2)	ControlLogix 4 MB controller	
1756-L73(2)	ControlLogix 8 MB controller	
1756-L74(2)	ControlLogix 16 MB controller	
1756-L75(2)	ControlLogix 32 MB controller	
1756-CNB	ControlLogix ControlNet communication module	CNET-IN005 CNET-UM001
1756-CNBR	ControlLogix redundant media ControlNet communication module	
1756-CN2	ControlLogix ControlNet communication module	
1756-CN2R	ControlLogix redundant media ControlNet communication module	
1756-EN2T Series C	ControlLogix EtherNet/IP communication module	ENET-IN002 ENET-UM001
1756-EN2TR Series B	ControlLogix redundant media EtherNet/IP communication module	
1756-EN2TR Series C		

(1) Some catalog numbers have a K suffix. This indicates a version of the product that has conformal coating. These K versions have the same SIL 2 certification as the non-K versions.
(2) Use of any series B controller requires the use of the series B versions of the 1756-Px75 power supplies or the redundant power supplies, that is, the 1756-Lx75R power supplies.
(3) Certified according to IEC 61508 1999 Edition 1.

Table 18 - SIL 2-certified ControlLogix-XT System Components

Cat. No.	Description	Related Documentation
1756-A4LXT 1756-A5XT 1756-A7XT 1756-A7LXT 1756-A10XT 1756-A7ZXT 1756-A10ZXT	ControlLogix-XT™ chassis	1756-IN621
1756-PAXT 1756-PBXT	ControlLogix-XT power supply	1756-IN619
1756-CN2RXT	ControlLogix-XT ControlNet communication module	CNET-IN005 CNET-UM001
1756-EN2TXT Series C	ControlLogix-XT EtherNet/IP communication module	ENET-IN002 ENET-UM001
1756-EN2TRXT Series C	ControlLogix-XT EtherNet/IP communication module for redundant systems	
1756-L63XT[1]	ControlLogix-XT controller	1756-UM001
1756-L73XT	ControlLogix-XT controller	
1756-L73SXT	GuardLogix-XT controller, 8 MB standard	1756-UM022

(1) Certified according to IEC 61508 1999 Edition 1.

IMPORTANT All catalog number variants, including standard, XT, and K variants use the same firmware. For example, 1756-EN2TXT modules use the same SIL 2-certified firmware as 1756-EN2T modules.

Firmware revisions are available from the Product Compatibility and Download Center at rok.auto/pcdc.

Table 19 - FLEX™ I/O Components For Use in the SIL 2 System

Cat. No.[1]	Description	Related Documentation[2]
1794-ACN15	FLEX I/O ControlNet single media adapter	1794-IN128
1794-ACNR15	FLEX I/O ControlNet redundant media adapter	
1794-ACNR15XT	FLEX I/O-XT™ ControlNet redundant media adapter	
1794-AENT	FLEX I/O EtherNet/IP communication adapter	1794-IN082
1794-AENTR	FLEX I/O EtherNet/IP redundant communication adapter	1794-IN131
1794-AENTRXT	FLEX I/O-XT EtherNet/IP redundant communication adapter	
1794-IB16	FLEX I/O input module	1794-IN093
1794-IB16XT	FLEX I/O-XT input module	1794-IN124
1794-IB10XOB6	FLEX I/O input/output module	1794-IN083
1794-IB10XOB6XT	FLEX I/O-XT input/output module	1794-IN124
1794-OB16	FLEX I/O output module	1794-IN094
1794-OB16P	FLEX I/O protected output module	1794-IN094
1794-OB16PXT	FLEX I/O-XT protected output module	1794-IN124
1794-OB8EP	FLEX I/O electronically fused output module	1794-IN094
1794-OB8EPXT	FLEX I/O-XT electronically fused output module	1794-IN124
1794-OW8	FLEX I/O relay output module	1794-IN019
1794-OW8XT	FLEX I/O-XT relay output module	
1794-IE8	FLEX I/O analog input module	1794-IN100 1794-UM002
1794-IF4I	FLEX I/O isolated analog input module	1794-IN038 1794-UM008
1794-IF4IXT	FLEX I/O-XT isolated analog input module	1794-IN129 1794-UM008
1794-IF4ICFXT	FLEX I/O-XT isolated analog input module	1794-IN130 1794-UM008
1794-IF2XOF2I	FLEX I/O isolated analog input/output module	1794-IN039 1794-UM008

Table 19 - FLEX™ I/O Components For Use in the SIL 2 System (Continued)

Cat. No.[1]	Description	Related Documentation[2]
1794-IF2XOF2IXT	FLEX I/O-XT isolated analog input/output module	1794-IN129 1794-UM008
1794-OE4	FLEX I/O analog output module	1794-IN100 1794-UM002
1794-OF4I	FLEX I/O isolated analog output module	1794-IN037 1794-UM008
1794-IT8	FLEX I/O Thermocouple input module	1794-IN021 1794-UM007
1794-IR8	FLEX I/O RTD input module	1794-IN021 1794-UM004
1794-IR8XT	FLEX I/O-XT RTD input module	
1794-IRT8	FLEX I/O Thermocouple/RTD input module	1794-IN050 1794-UM012
1794-IRT8XT	FLEX I/O-XT Thermocouple/RTD analog input module	
1794-IJ2	FLEX I/O counter module	1794-IN049 1794-UM011
1794-IJ2XT	FLEX I/O-XT counter module	
1794-IP4	FLEX I/O counter module	1794-IN064 1794-UM016
1794-IE4XOE2XT	FLEX I/O-XT analog input/output module	1794-IN125
1794-IE8XT	FLEX I/O-XT analog input module	1794-IN125
1794-OE4XT	FLEX I/O-XT analog output module	1794-IN125
1794-OF4IXT	FLEX I/O-XT isolated analog output module	1794-IN129 1794-UM008
1794-TB3	FLEX I/O terminal base unit	1794-IN092
1794-TB3S	FLEX I/O terminal base unit	
1794-TB3T	FLEX I/O temperature terminal base unit	
1794-TB3TS	FLEX I/O spring-clamp temperature terminal base unit	
1794-TB3G	FLEX I/O cage-clamp generic terminal base unit	
1794-TB3GS	FLEX I/O spring-clamp generic terminal base unit	
1794-TBN	FLEX I/O NEMA terminal base unit	
1794-TBNF	FLEX I/O NEMA fused terminal base unit	

(1) Some catalog numbers have a K suffix. This indicates a version of the product that has conformal coating. These K versions have the same SIL 2 certification as the non-K versions.
(2) These publications are available from Rockwell Automation by visiting https://www.rockwellautomation.com/literature.

Table 20 lists the 1715 devices that can be included in a SIL 2 system.

Table 20 - 1715 Devices in a SIL 2 System

Cat. No.	Firmware Revision	Description	Termination Assembly	
			Cat. No.	Description
1715-AENTR	2.001 or later	Ethernet adapter redundant module	N/A	
1715-IB16D	2.001 or later[1]	16-channel digital input module	1715-TASIB16D	Digital input simplex
			1715-TADIB16D	Digital input duplex
1715-OB8DE	2.001 or later[1]	8-channel digital output module	1715-TASOB8DE	Digital output simplex
			1715-TADOB8DE	Digital output duplex
1715-IF16	2.001 or later[1]	16-channel analog input module	1715-TASIF16	Analog input simplex
			1715-TADIF16	Analog input duplex
1715-OF8I	2.001 or later[1]	8-channel analog output module	1715-TASOF8	Analog output simplex
			1715-TADOF8	Analog output duplex
1715-A2A	N/A	Adapter base unit	N/A	
1715-A3IO	N/A	I/O module base unit	N/A	
1715-N2T	N/A	Tall slot filler cover	N/A	
1715-N2S	N/A	Short slot filler cover	N/A	
1715-C2	N/A	Expansion cable - 2 m (6.56 ft)	N/A	

(1) For revision 3.001 and later, the 1715 I/O module firmware is the revision that is installed on the I/O module.
For earlier revisions, the 1715 I/O module firmware is the same revision as the 1715-AENTR module regardless of the firmware revision in the 1715 I/O module.

Notes:

PFD and PFH Calculations for 1756 ControlLogix and 1794 FLEX I/O Modules

The probability of a dangerous failure on demand (PFD) is the SIL value for a safety-related system as related directly to the order-of-magnitude ranges of its average probability of failure to satisfactorily perform its safety function on demand. IEC 61508 quantifies this classification by stating that the frequency of demands for operation of the safety system is no greater than once per year in the Low Demand mode.

PFD calculations are commonly used for process safety applications and applications where emergency stop devices (ESDs) are used.

Although PFD values are associated with each of the three elements that constitute a safety-related system (the sensors, the actuators, and the logic element), they can be associated with each module of a controller.

Average frequency of a dangerous failure per hour (PFH) is typically used to describe safety performance for high demand applications. Because ControlLogix® is suitable for high demand applications up to and including 10 demands per year, PFH values for those applications are provided.

Tables in this chapter present PFD and PFH values for ControlLogix and ControlLogix-XT™ components that TÜV evaluates.

Determine Values To Use

IMPORTANT	You are responsible for determining which of the values that are provided are appropriate for your SIL 2-certified system. Determine which values to use based on the modules used your system and the system configuration.

IMPORTANT	If a safety-module in an existing application is replaced by a replacement-type module, The whole safety loop must be recalculated with the new module's data.

Each of the PFD and PFH calculated values that are provided in this manual is based on the configuration that the module can be used in (1oo1 or 1oo2).

- Controllers only have a 1oo1 configuration, even when used in a redundant chassis pair.
- You can architect communication modules in a 1oo1 or 1oo2 configuration. If the I/O module pair is split among two separate chassis, use 1oo2.
- Input or output modules have PFD values typically for use in a 1oo2 configuration. But 1oo1 values are provided in the event diversity is used for input modules, or the output module that controls the actuator and secondary relay are diverse.

About the Calculations in This Manual

For the example calculations presented in this chapter, these values were used as the two application-dependent variables:

- Mean time to restoration (MTTR) is ten hours.
- Mean repair time (MRT) is ten hours.
- Proof test interval (T_1) is listed for each table.

Both the common cause failure rate (ß) and common cause failure rate dangerous ($ß_d$) values that are used in calculations are 5%.

Common Terms
λ = failure rate = 1/MTBF
λ_s = rate of safe failures = λ x 50%
λ_d = rate of dangerous failures = λ x 50%
λ_{dd}= dangerous, detected failure rate = λ/2 x DC
λ_{du}= dangerous, undetected failure rate = λ/2 x (1-DC)
SFF = safe failure fraction =(λ_s +λ_{dd})/λ
T_{CE1oo1} = channel equivalent down time = λ_{du}/λ_d x (T_1/2 + MRT) + (λ_{dd}/λ_d x MTTR)
DC = diagnostic coverage
ß = common cause failure rate
$ß_d$ = common cause failure rate, dangerous
1oo1 Configuration
STR_{1oo1} = spurious trip rate = $\lambda_s + \lambda_{dd}$
PFD_{1oo1} = (λ_{dd} + λ_{du}) x T_{CE}
PFH_{1oo1} = λ_{du}
1oo2 Configuration
STR_{1oo2} = spurious trip rate = 2 x ($\lambda_s + \lambda_{dd}$)
T_{GE1oo2} = system equivalent down time = λ_{du}/λ_d x (T_1/3 + MRT) + (λ_{dd}/λ_d x MTTR)
PFD_{1oo2}= 2 x [(1-$ß_D$) x λ_{dd} + (1-ß) x $\lambda_{du}]^2$ x T_{CE} x T_{GE} + ($ß_D$ x λ_{dd} x MTTR) + ß x λ_{du} x (T_1/2 + MRT)
PFH_{1oo2} = 2 x [(1-$ß_D$) x λ_{dd} + (1-ß) x λ_{du}] x (1-ß) x λ_{du} x T_{CE} + ß x λ_{du}

The PFD and PFH values in this manual are calculated with formulas that are explained in IEC 61508, Part 6, Annex B. See IEC 61508, Part 6, for more information about how to calculate PFD values for your system.

1-Year PFD Calculations

The PFD calculations in this table are calculated for a 1-year proof test interval (8760 hours) and are specific to ControlLogix system components.

Table 21 - 1-Year PFD Calculations

Cat No.(1)(2)	Series	Description	Mean Time between Failure (MTBF)(2)	Common Terms(3)						1oo1 Configuration			1oo2 Configuration			
				λ(4)	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	Spurious Trip Rate STR	PFH(5)	PFD	Spurious Trip Rate STR	TGE	PFH(5)	PFD
1756-AXX(6)	C	ControlLogix chassis	22,652,010	4.41E-08	2.21E-08	95%	2.21E-09	1.99E-08	448	4.19E-08	2.21E-09	9.89E-06	Not applicable			
1756-A4LXT	B	4-slot ControlLogix-XT chassis	1,069,120	9.35E-07	4.68E-07	95%	4.68E-08	4.21E-07	448	8.89E-07	4.68E-08	2.10E-04				
1756-A5XT	C	5-slot ControlLogix-XT chassis	734,420	1.36E-06	6.81E-07	95%	6.81E-08	6.13E-07	448	1.29E-06	6.81E-08	3.05E-04				
1756-A7LXT	B	7-slot ControlLogix-XT chassis	27,628,178	3.62E-08	1.81E-08	95%	1.81E-09	1.63E-08	448	3.44E-08	1.81E-09	8.11E-06				
1756-A7XT	C	7-slot ControlLogix-XT chassis	1,081,600	9.25E-07	4.62E-07	95%	4.62E-08	4.16E-07	448	8.78E-07	4.62E-08	2.07E-04				
1756-PB72	C	18-32V DC 10 A ControlLogix power supply	31,561,095	3.17E-08	1.58E-08	95%	1.58E-09	1.43E-08	448	3.01E-08	1.58E-09	7.10E-06				
1756-PA72	C	85-265V AC 10 A ControlLogix power supply	18,336,146	5.45E-08	2.73E-08	95%	2.73E-09	2.45E-08	448	5.18E-08	2.73E-09	1.22E-05				
1756-PA75	B	85-265V AC 13 A ControlLogix power supply (75 W)	18,693,044	5.35E-08	2.67E-08	95%	2.67E-09	2.41E-08	448	5.08E-08	2.67E-09	1.20E-05				
1756-PA75R	A	85-265V AC 13 A redundant ControlLogix power supply	1,412,877	7.08E-07	3.54E-07	95%	3.54E-08	3.18E-07	448	6.72E-07	3.54E-08	1.59E-04				
1756-PB75	B	18-32V DC 13 A ControlLogix power supply	15,675,475	6.38E-08	3.19E-08	95%	3.19E-09	2.87E-08	448	6.06E-08	3.19E-09	1.43E-05				
1756-PB75R	A	18-32V DC 13 A redundant ControlLogix power supply	1,736,020	5.76E-07	2.88E-07	95%	2.88E-08	2.59E-07	448	5.47E-07	2.88E-08	1.29E-04				
1756-PAXT	B	ControlLogix-XT AC power supply	18,693,044	5.35E-08	2.67E-08	95%	2.67E-09	2.41E-08	448	5.08E-08	2.67E-09	1.20E-05				
1756-PBXT	B	ControlLogix-XT DC power supply	1,855,360	5.39E-07	2.69E-07	95%	2.69E-08	2.43E-07	448	5.12E-07	2.69E-08	1.21E-04				
1756-PC75	B	30-60V DC 13 A ControlLogix power supply	5,894,836	1.70E-07	8.48E-08	95%	8.48E-09	7.63E-08	448	1.61E-07	8.48E-09	3.80E-05				
1756-PH75	B	90-143V DC 13 A ControlLogix power supply	2,119,520	4.72E-07	2.36E-07	95%	2.36E-08	2.12E-07	448	4.48E-07	2.36E-08	1.06E-04				
1756-PSCA	A	Redundant power supply adapter	45,146,727	2.21E-08	1.11E-08	95%	1.11E-09	9.97E-09	448	2.10E-08	1.11E-09	4.96E-06				
1756-PSCA2	A	Redundant power supply adapter	38,461,280	2.60E-08	1.30E-08	95%	1.30E-09	1.17E-08	448	2.47E-08	1.30E-09	5.82E-06				
1786-RPFS	A	ControlNet® fiber repeater - short	26,461,760	3.78E-08	1.89E-08	95%	1.89E-09	1.70E-08	448	3.59E-08	1.89E-09	8.47E-06				
1786-RPFM	A	ControlNet fiber repeater - medium	16,697,862	5.99E-08	2.99E-08	95%	2.99E-09	2.69E-08	448	5.69E-08	2.99E-09	1.34E-05				
1786-RPFRL	A	ControlNet fiber repeater - long	5,717,227	1.75E-07	8.75E-08	95%	8.75E-09	7.87E-08	448	1.66E-07	8.75E-09	3.92E-05				
1786-RPCD	A	ControlNet hub repeater	28,654,080	3.49E-08	1.74E-08	95%	1.74E-09	1.57E-08	448	3.32E-08	1.74E-09	7.82E-06				
1786-RPA	B	ControlNet repeater adapter	11,826,146	8.46E-08	4.23E-08	95%	4.23E-09	3.81E-08	448	8.03E-08	4.23E-09	1.89E-05				
1786-RPFRXL	B	ControlNet Fiber repeater - extra long	11,373,440	8.79E-08	4.40E-08	95%	4.40E-09	3.96E-08	448	8.35E-08	4.40E-09	1.97E-05				

Table 21 - 1-Year PFD Calculations (Continued)

Cat No.(1)(2)	Series	Description	Mean Time between Failure (MTBF)(2)	Common Terms(3)						1oo1 Configuration			1oo2 Configuration			
				λ(4)	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	Spurious Trip Rate STR	PFH(5)	PFD	Spurious Trip Rate STR	TGE	PFH(5)	PFD
1756-L61(7)	B	ControlLogix controller, 2 MB	1,000,053	1.00E-06	5.00E-07	95%	5.00E-08	4.50E-07	448	9.50E-07	5.00E-08	2.24E-04				
1756-L62(7)	B	ControlLogix controller, 4 MB	1,034,830	9.66E-07	4.83E-07	95%	4.83E-08	4.35E-07	448	9.18E-07	4.83E-08	2.16E-04				
1756-L63(7)	B	ControlLogix controller, 8 MB	1,055,910	9.47E-07	4.74E-07	95%	4.74E-08	4.26E-07	448	9.00E-07	4.74E-08	2.12E-04				
1756-L63XT(7)	B	ControlLogix-XT controller, 8 MB	357760	2.80E-06	1.40E-06	95%	1.40E-07	1.26E-06	448	2.66E-06	1.40E-07	6.26E-04				
1756-L71(8)	B	ControlLogix controller, 2 MB	Calculated MTBF and PFD via FMEA	2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	340	2.91E-06	1.01E-07	4.50E-04				
1756-L72(8)	B	ControlLogix controller, 4 MB		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	340	2.91E-06	1.01E-07	4.50E-04				
1756-L73(8)	B	ControlLogix controller, 8 MB		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	340	2.91E-06	1.01E-07	4.50E-04				
1756-L73XT(8)	B	ControlLogix-XT controller, 8 MB		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	340	2.91E-06	1.01E-07	4.50E-04				
1756-L74(8)	B	ControlLogix controller, 16 MB		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	340	2.91E-06	1.01E-07	4.50E-04				
1756-L75(7)	B	ControlLogix controller, 32 MB		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	340	2.91E-06	1.01E-07	4.50E-04	Not applicable			
1756-L61S(7)	B	GuardLogix® controller, 2 MB standard	1,000,053	1.00E-06	5.00E-07	95%	5.00E-08	4.50E-07	448	9.50E-07	5.00E-08	2.24E-04				
1756-L62S(7)	B	GuardLogix controller, 4 MB standard	1,034,830	9.66E-07	4.83E-07	95%	4.83E-08	4.35E-07	448	9.18E-07	4.83E-08	2.16E-04				
1756-L63S(7)	B	GuardLogix controller, 8 MB standard	1,055,910	9.47E-07	4.74E-07	95%	4.74E-08	4.26E-07	448	9.00E-07	4.74E-08	2.12E-04				
1756-L71S(8)	B	GuardLogix controller, 2 MB standard	Calculated MTBF and PFD via FMEA	2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	340	2.91E-06	1.01E-07	4.50E-04				
1756-L72S(8)	B	GuardLogix controller, 4 MB standard		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	340	2.91E-06	1.01E-07	4.50E-04				
1756-L73S(8)	B	GuardLogix controller, 8 MB standard		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	340	2.91E-06	1.01E-07	4.50E-04				
1756-L73SXT(8)	B	GuardLogix-XT™ controller, 8 MB standard		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	340	2.91E-06	1.01E-07	4.50E-04				

Table 21 - 1-Year PFD Calculations (Continued)

Cat No.[1][2]	Series	Description	Mean Time between Failure (MTBF)[2]	Common Terms[3]						1oo1 Configuration			1oo2 Configuration			
				λ[4]	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	Spurious Trip Rate STR	PFH[5]	PFD	Spurious Trip Rate STR	TGE	PFH[5]	PFD
1756-CNB	E	ControlLogix ControlNet communication module	1,786,977	5.60E-07	2.80E-07	95%	2.80E-08	2.52E-07	448	5.32E-07	2.80E-08	1.25E-04	Not applicable			
1756-CNBR	E	ControlLogix ControlNet redundant communication module	2,608,543	3.83E-07	1.92E-07	95%	1.92E-08	1.73E-07	448	3.64E-07	1.92E-08	8.59E-05	Not applicable			
1756-CN2	B	ControlLogix ControlNet communication module	1,096,299	9.12E-07	4.56E-07	95%	4.56E-08	4.10E-07	448	8.67E-07	4.56E-08	2.04E-04	Not applicable			
1756-CN2[8]	C	ControlLogix ControlNet communication module	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	303.63	1.91E-06	6.62E-08	3.0E-04	Not applicable			
1756-CN2R	B	ControlLogix ControlNet redundant communication module	1,096,299	9.12E-07	4.56E-07	95%	4.56E-08	4.10E-07	448	8.67E-07	4.56E-08	2.04E-04	Not applicable			
1756-CN2R[8]	C	ControlLogix ControlNet redundant communication module	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	303.63	1.91E-06	6.62E-08	3.0E-04	Not applicable			
1756-CN2RXT	B	ControlLogix-XT ControlNet redundant communication module	1,980,160	5.05E-07	2.53E-07	95%	2.53E-08	2.27E-07	448	4.80E-07	2.53E-08	1.13E-04	Not applicable			
1756-CN2RXT[8]	C	ControlLogix-XT ControlNet redundant communication module	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	303.63	1.91E-06	6.62E-08	3.0E-04	Not applicable			
1756-DHRIO[9]	E	ControlLogix Data Highway Plus™ remote I/O module	2,503,396	Non-interference only						2.90E-07	Not applicable		5.79E-07	Not applicable		
1756-DHRIOXT[9]	E	ControlLogix-XT Data Highway Plus remote I/O module	2,503,396	Non-interference only						2.90E-07	Not applicable		5.79E-07	Not applicable		
1756-DNB[9]	D	ControlLogix DeviceNet® communication module	2,192,202	Non-interference only						3.31E-07	Not applicable		6.61E-07	Not applicable		
1756-ENBT[9]	A	ControlLogix EtherNet/IP™ communication module	2,088,198	Non-interference only						3.47E-07	Not applicable		6.94E-07	Not applicable		
1756-EN2T	C	ControlLogix EtherNet/IP communication module	1,312,712	7.62E-07	3.81E-07	95%	3.81E-08	3.43E-07	448	7.24E-07	3.81E-08	1.71E-04	Not applicable			
1756-EN2T[9]	D	ControlLogix EtherNet/IP communication module	269,774	Non-interference only						3.71E-06	Not applicable		Not applicable			
1756-EN2TR	B	ControlLogix EtherNet/IP communication module with fault tolerance	3,664,960	2.73E-07	1.36E-07	95%	1.36E-08	1.23E-07	448	2.59E-07	1.36E-08	6.11E-05	Not applicable			
1756-EN2TR[8]	C	ControlLogix EtherNet/IP communication module with fault tolerance	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	303.63	1.91E-06	6.62E-08	3.0E-04	3.82E-06	258.2	1.36E-09	6.11E-06
1756-EN2TRXT[8]	C	ControlLogix EtherNet/IP communication module with fault tolerance	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	303.63	1.91E-06	6.62E-08	3.0E-04	3.82E-06	258.2	1.36E-09	6.11E-06
1756-EN2TXT	C	ControlLogix-XT EtherNet/IP communication module	1,300,000	7.69E-07	3.85E-07	95%	3.85E-08	3.46E-07	448	7.31E-07	3.85E-08	1.72E-04	Not applicable			

Table 21 - 1-Year PFD Calculations (Continued)

Cat No.(1)(2)	Series	Description	Mean Time between Failure (MTBF)(2)	Common Terms(3)						1oo1 Configuration			1oo2 Configuration			
				λ(4)	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	Spurious Trip Rate STR	PFH(5)	PFD	Spurious Trip Rate STR	TGE	PFH(5)	PFD
1756-EN2TXT(9)	D	ControlLogix-XT EtherNet/IP communication module	269,774	Non-interference only						3.71E-06	Not applicable					
1756-EN3TR(9)	B	ControlLogix EtherNet/IP communication module with fault tolerance	269,774							3.71E-06						
1756-RM(9)	B	ControlLogix redundancy module	1,373,840							7.28E-07						
1756-RMXT(9)	B	ControlLogix-XT redundancy module	980,096							1.02E-06						
1756-RM2(9)	A	ControlLogix redundancy module	250,182							4.00E-06						
1756-RM2XT(9)	A	ControlLogix-XT redundancy module	250,182							4.00E-06						
1756-RM3(9)	A	ControlLogix redundancy module	213,749							4.68E-06						
1756-RM3-2SFP(9)	A	ControlLogix redundancy module	213,749							4.68E-06						
1756-RM3XT(9)	A	ControlLogix-XT redundancy module	213,749							4.68E-06						
1756-SYNCH(9)	A	ControlLogix SynchLink™ Module	6,932,640							1.05E-07	Not applicable		2.09E-07	Not applicable		
1756-IA16I	A	ControlLogix isolated V AC input module	20,801,920	4.81E-08	2.40E-08	80%	9.61E-09	1.44E-08	1762	3.85E-08	9.61E-09	4.24E-05	7.69E-08	1178	4.81E-10	2.12E-06
1756-IA8D	A	ControlLogix diagnostic V AC input module	15,966,080	6.26E-08	3.13E-08	80%	1.25E-08	1.88E-08	1762	5.01E-08	1.25E-08	5.52E-05	1.00E-07	1178	6.28E-10	2.76E-06
1756-IB16D	A	ControlLogix diagnostic V DC input module	30,228,640	3.31E-08	1.65E-08	80%	6.62E-09	9.92E-09	1762	2.65E-08	6.62E-09	2.91E-05	5.29E-08	1178	3.31E-10	1.46E-06
1756-IB16I	A	ControlLogix isolated V DC input module	81,443,094	1.23E-08	6.14E-09	80%	2.46E-09	3.68E-09	1762	9.82E-09	2.46E-09	1.08E-05	1.96E-08	1178	1.23E-10	5.41E-07
1756-IB16ISOE	A	ControlLogix isolated V DC Sequence Of Events input module	11,537,760	8.67E-08	4.33E-08	80%	1.73E-08	2.60E-08	1762	6.93E-08	1.73E-08	7.64E-05	1.39E-07	1178	8.69E-10	3.82E-06
1756-IB32	B	ControlLogix V DC input module	10,462,329	9.56E-08	4.78E-08	80%	1.91E-08	2.87E-08	1762	7.65E-08	1.91E-08	8.42E-05	1.53E-07	1178	9.59E-10	4.22E-06
1756-IF8	A	ControlLogix analog input module	8,699,254	1.15E-07	5.75E-08	80%	2.30E-08	3.45E-08	1762	9.20E-08	2.30E-08	1.01E-04	1.84E-07	1178	1.15E-09	5.08E-06
1756-IF8(8)	B	ControlLogix analog input module	Calculated MTBF and PFD via FMEA	9.43E-07	4.71E-07	79%	1.98E-07	2.73E-07	1855	7.45E-07	1.99E-07	8.80E-04	1.49E-06	1240	1.00E-08	4.5E-05
1756-IF8I(8)	A	ControlLogix isolated analog input module	2,337,541	4.28E-07	2.14E-07	77%	9.81E-08	1.16E-07	2019	3.30E-07	9.81E-08	4.32E-04	6.59E-07	1349	2.04E-09	8.88E-06
1756-IF8I(8)	B	ControlLogix isolated analog input module	Calculated MTBF and PFD via FMEA	5.83E-07	2.92E-07	78%	1.26E-07	1.66E-07	1897	4.58E-07	1.26E-07	5.56E-04	9.15E-07	1268	2.65E-09	1.15E-05
1756-IF8H	A	ControlLogix HART analog input module	1,291,978	7.74E-07	3.87E-07	80%	1.55E-07	2.32E-07	1762	6.19E-07	1.55E-07	6.82E-04	1.24E-06	1178	7.93E-09	3.47E-05
1756-IF8H	B	ControlLogix HART analog input module	Calculated MTBF and PFD via FMEA	9.75E-07	4.88E-07	92%	7.67E-08	4.11E-07	698	Not applicable			2.77E-06	468	3.88E-09	1.72E-05
1756-IF16	A	ControlLogix analog input module	4,592,506	2.18E-07	1.09E-07	80%	4.35E-08	6.53E-08	1762	1.74E-07	4.35E-08	1.92E-04	3.48E-07	1178	2.19E-09	9.64E-06
1756-IF16(8)	B	ControlLogix analog input module	Calculated MTBF and PFD via FMEA	9.43E-07	4.71E-07	79%	1.98E-07	2.73E-07	1855	7.45E-07	1.99E-07	8.80E-04	1.49E-06	1240	1.00E-08	4.5E-05

Table 21 - 1-Year PFD Calculations (Continued)

Cat No.(1)(2)	Series	Description	Mean Time between Failure (MTBF)(2)	Common Terms(3)						1oo1 Configuration			1oo2 Configuration			
				λ(4)	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	Spurious Trip Rate STR	PFH(5)	PFD	Spurious Trip Rate STR	TGE	PFH(5)	PFD
1756-IF16H	A	ControlLogix HART analog input module	442,914	2.26E-06	1.13E-06	80%	4.52E-07	6.77E-07	1762	1.81E-06	4.52E-07	1.99E-03	3.61E-06	1178	2.42E-08	1.04E-04
1756-IF16H	B	ControlLogix HART analog input module	Calculated MTBF and PFD via FMEA	1.08E-06	5.38E-07	92%	8.32E-08	4.54E-07	687	Not applicable			3.06E-06	461	4.21E-09	1.86E-05
1756-IF6CIS	A	ControlLogix isolated analog input module	2,654,080	3.77E-07	1.88E-07	80%	7.54E-08	1.13E-07	1762	3.01E-07	7.54E-08	3.32E-04	6.03E-07	1178	3.81E-09	1.67E-05
1756-IF6I	A	ControlLogix isolated analog input module	4,176,185	2.39E-07	1.20E-07	80%	4.79E-08	7.18E-08	1762	1.92E-07	4.79E-08	2.11E-04	3.83E-07	1178	2.41E-09	1.06E-05
1756-IH16ISOE	A	ControlLogix V DC Sequence Of Events input module	2,150,720	4.65E-07	2.32E-07	80%	9.30E-08	1.39E-07	1762	3.72E-07	9.30E-08	4.10E-04	7.44E-07	1178	4.72E-09	2.07E-05
1756-IR6I	A	ControlLogix isolated RTD input module	4,268,525	2.34E-07	1.17E-07	80%	4.69E-08	7.03E-08	1762	Not allowed for 1oo1 configurations			3.75E-07	1178	2.36E-09	1.04E-05
1756-IRT8I(8)	A	ControlLogix isolated RTD / thermocouple input module	1,896,813	5.27E-07	2.64E-07	76%	1.27E-07	1.36E-07	2127				8.00E-07	1421	2.69E-09	1.16E-05
1756-IRT8I(8)	B	ControlLogix isolated RTD / thermocouple input module	Calculated MTBF and PFD via FMEA	6.11E-07	3.06E-07	80%	1.24E-07	1.82E-07	1783				9.75E-07	1192	2.61E-09	1.13E-05
1756-IT6I	A	ControlLogix isolated thermocouple input module	3,957,824	2.53E-07	1.26E-07	80%	5.05E-08	7.58E-08	1762				4.04E-07	1178	2.55E-09	1.12E-05
1756-IT6I2	A	ControlLogix isolated enhanced thermocouple input module	2,720,046	3.68E-07	1.84E-07	80%	7.35E-08	1.10E-07	1762				5.88E-07	1178	3.72E-09	1.63E-05
1756-OA16I	A	ControlLogix V AC output module	32,891,456	3.04E-08	1.52E-08	80%	6.08E-09	9.12E-09	1762	2.43E-08	6.08E-09	2.68E-05	4.86E-08	1178	3.04E-10	1.34E-06
1756-OA8D	A	ControlLogix V AC diagnostic output module	11,311,040	8.84E-08	4.42E-08	80%	1.77E-08	2.65E-08	1762	7.07E-08	1.77E-08	7.79E-05	1.41E-07	1178	8.87E-10	3.90E-06
1756-OB16D	A	ControlLogix V DC diagnostic output module	8,884,374	1.13E-07	5.63E-08	80%	2.25E-08	3.38E-08	1762	9.00E-08	2.25E-08	9.92E-05	1.80E-07	1178	1.13E-09	4.97E-06
1756-OB16E	A	ControlLogix V DC electronically fused output module	14,997,714	6.67E-08	3.33E-08	80%	1.33E-08	2.00E-08	1762	5.33E-08	1.33E-08	5.87E-05	1.07E-07	1178	6.68E-10	2.94E-06
1756-OB16I	A	ControlLogix V DC isolated output module	7,388,160	1.35E-07	6.77E-08	80%	2.71E-08	4.06E-08	1762	1.08E-07	2.71E-08	1.19E-04	2.17E-07	1178	1.36E-09	5.98E-06
1756-OB32	A	ControlLogix V DC output module	2,681,316	3.73E-07	1.86E-07	80%	7.46E-08	1.12E-07	1762	2.98E-07	7.46E-08	3.29E-04	5.97E-07	1178	3.77E-09	1.66E-05
1756-OB8EI	A	ControlLogix V DC isolated electronically fused output module	14,019,200	7.13E-08	3.57E-08	80%	1.43E-08	2.14E-08	1762	5.71E-08	1.43E-08	6.28E-05	1.14E-07	1178	7.15E-10	3.15E-06
1756-OX8I	A	ControlLogix isolated relay output module	6,059,635	1.65E-07	8.25E-08	80%	3.30E-08	4.95E-08	1762	1.32E-07	3.30E-08	1.45E-04	2.64E-07	1178	1.66E-09	7.29E-06
1756-OW16I	A	ControlLogix isolated relay output module	13,695,899	7.30E-08	3.65E-08	80%	1.46E-08	2.19E-08	1762	5.84E-08	1.46E-08	6.43E-05	1.17E-07	1178	7.32E-10	3.22E-06
1756-OF4(8)	B	ControlLogix analog output module	Calculated MTBF and PFD via FMEA	1.03E-06	5.17E-07	78%	2.23E-07	2.93E-07	1902	8.11E-07	2.23E-07	9.8E-04	1.62E-06	1271	1.20E-08	5.0E-05
1756-OF8	A	ControlLogix analog output module	10,629,795	9.41E-08	4.70E-08	80%	1.88E-08	2.82E-08	1762	7.53E-08	1.88E-08	8.29E-05	1.51E-07	1178	9.44E-10	4.15E-06
1756-OF8(8)	B	ControlLogix analog output module	Calculated MTBF and PFD via FMEA	1.03E-06	5.17E-07	78%	2.23E-07	2.93E-07	1902	8.11E-07	2.23E-07	9.8E-04	1.62E-06	1271	1.20E-08	5.0E-05
1756-OF8I(8)	A	ControlLogix isolated analog output module	2,213,369	4.52E-07	2.26E-07	76%	1.08E-07	1.18E-07	2106	3.44E-07	1.08E-07	4.76E-04	6.87E-07	1407	2.26E-09	9.80E-06
1756-OF8I(8)	B	ControlLogix isolated analog output module	Calculated MTBF and PFD via FMEA	6.08E-07	3.04E-07	78%	1.37E-07	1.67E-07	1982	4.71E-07	1.37E-07	6.03E-04	9.42E-07	1325	2.90E-09	1.25E-05

Table 21 - 1-Year PFD Calculations (Continued)

Cat No.[1][2]	Series	Description	Mean Time between Failure (MTBF)[2]	Common Terms[3]						1oo1 Configuration			1oo2 Configuration			
				λ[4]	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	Spurious Trip Rate STR	PFH[5]	PFD	Spurious Trip Rate STR	TGE	PFH[5]	PFD
1756-OF6VI	A	ControlLogix isolated analog output module	21,604,960	4.63E-08	2.31E-08	80%	9.26E-09	1.39E-08	1762	3.70E-08	9.26E-09	4.08E-05	7.41E-08	1178	4.64E-10	2.04E-06
1756-OF6CI	A	ControlLogix isolated analog output module	8,354,667	1.20E-07	5.98E-08	80%	2.39E-08	3.59E-08	1762	9.58E-08	2.39E-08	1.05E-04	1.92E-07	1178	1.20E-09	5.29E-06
1756-OF8H	A	ControlLogix HART analog output module	5,118,187	1.95E-07	9.77E-08	80%	3.91E-08	5.86E-08	1762	1.56E-07	3.91E-08	1.72E-04	3.13E-07	1178	1.97E-09	8.64E-06
1794-ACN15	D	FLEX™ I/O ControlNet adapter	8,223,684	1.22E-07	6.08E-08	80%	2.43E-08	3.65E-08	1762				1.95E-07	1178	1.22E-09	5.37E-06
1794-ACNR15	D	FLEX I/O ControlNet redundant adapter	8,223,684	1.22E-07	6.08E-08	80%	2.43E-08	3.65E-08	1762				1.95E-07	1178	1.22E-09	5.37E-06
1794-ACNR15XT	D	FLEX I/O-XT™ ControlNet adapter	8,223,684	1.22E-07	6.08E-08	80%	2.43E-08	3.65E-08	1762				1.95E-07	1178	1.22E-09	5.37E-06
1794-AENT	B	FLEX I/O EtherNet/IP adapter	1,779,827	5.62E-07	2.81E-07	80%	1.12E-07	1.69E-07	1762	Not allowed for 1oo1 configurations			8.99E-07	1178	5.72E-09	2.50E-05
1794-AENTR	A	FLEX I/O EtherNet/IP adapter, Ring media	1,268,070	7.89E-07	3.94E-07	80%	1.58E-07	2.37E-07	1762				1.26E-06	1178	8.08E-09	3.53E-05
1794-AENTRXT	A	FLEX I/O EtherNet/IP adapter, Ring media	1,268,070	7.89E-07	3.94E-07	80%	1.58E-07	2.37E-07	1762				1.26E-06	1178	8.08E-09	3.53E-05
1794-IB16	A	FLEX I/O 24V DC input module	179,506,158	5.57E-09	2.79E-09	80%	1.11E-09	1.67E-09	1762				8.91E-09	1178	5.57E-11	2.45E-07
1794-IB16XT	A	FLEX I/O-XT™ 24V DC input module	35,587,189	2.81E-08	1.40E-08	80%	5.62E-09	8.43E-09	1762				4.50E-08	1178	2.81E-10	1.24E-06
1794-IJ2	A	FLEX I/O counter module	55,344,640	1.81E-08	9.03E-09	80%	3.61E-09	5.42E-09	1762				2.89E-08	1178	1.81E-10	7.96E-07
1794-IJ2XT	A	FLEX I/O-XT counter module	11,714,128	8.54E-08	4.27E-08	80%	1.71E-08	2.56E-08	1762	Not allowed for 1oo1 configurations			1.37E-07	1178	8.56E-10	3.77E-06
1794-IP4	B	FLEX I/O counter module	22,027,200	4.54E-08	2.27E-08	80%	9.08E-09	1.36E-08	1762				7.26E-08	1178	4.55E-10	2.00E-06
1794-IB10XOB6	A	FLEX I/O 24V DC input/output module	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	1762				1.60E-08	1178	1.00E-10	4.41E-07
1794-IB10XOB6XT	A	FLEX I/O-XT 24V DC input/output module	22,202,487	4.50E-08	2.25E-08	80%	9.01E-09	1.35E-08	1762				7.21E-08	1178	4.51E-10	1.99E-06
1794-OB8EP	A	FLEX I/O 24V DC electronically fused output module	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	1762				1.60E-08	1178	1.00E-10	4.41E-07
1794-OB8EPXT	A	FLEX I/O-XT 24V DC electronically fused output module	14,771,049	6.77E-08	3.38E-08	80%	1.35E-08	2.03E-08	1762				1.08E-07	1178	6.78E-10	2.99E-06
1794-OB16	A	FLEX I/O 24V DC output module	54,322,632	1.84E-08	9.20E-09	80%	3.68E-09	5.52E-09	1762				2.95E-08	1178	1.84E-10	8.11E-07
1794-OB16P	A	FLEX I/O 24V DC protected output module	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	1762	Not allowed for 1oo1 configurations			1.60E-08	1178	1.00E-10	4.41E-07
1794-OB16PXT	A	FLEX I/O-XT 24V DC protected output module	26,709,401	3.74E-08	1.87E-08	80%	7.49E-09	1.12E-08	1762				5.99E-08	1178	3.75E-10	1.65E-06
1794-OW8	A	FLEX I/O isolated relay output module	29,088,895	3.44E-08	1.72E-08	80%	6.88E-09	1.03E-08	1762				5.50E-08	1178	3.44E-10	1.52E-06
1794-OW8XT	A	FLEX I/O-XT isolated relay output module	18,518,519	5.40E-08	2.70E-08	80%	1.08E-08	1.62E-08	1762				8.64E-08	1178	5.41E-10	2.38E-06

Table 21 - 1-Year PFD Calculations (Continued)

Cat No.[1][2]	Series	Description	Mean Time between Failure (MTBF)[2]	Common Terms[3]						1oo1 Configuration			1oo2 Configuration			
				λ[4]	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	Spurious Trip Rate STR	PFH[5]	PFD	Spurious Trip Rate STR	TGE	PFH[5]	PFD
1794-IE8	B	FLEX I/O analog input module	18,914,770	5.29E-08	2.64E-08	80%	1.06E-08	1.59E-08	1762				8.46E-08	1178	5.30E-10	2.33E-06
1794-IE8XT	B	FLEX I/O-XT analog input module	14,041,000	7.12E-08	3.56E-08	80%	1.42E-08	2.14E-08	1762				1.14E-07	1178	7.14E-10	3.14E-06
1794-IF4I	A	FLEX I/O isolated analog input module	9,885,959	1.01E-07	5.06E-08	80%	2.02E-08	3.03E-08	1762				1.62E-07	1178	1.01E-09	4.47E-06
1794-IF4IXT	A	FLEX I/O-XT isolated analog input module	7,297,140	1.37E-07	6.85E-08	80%	2.74E-08	4.11E-08	1762				2.19E-07	1178	1.38E-09	6.05E-06
1794-IF4ICFXT	A	FLEX I/O-XT isolated analog input module	7,297,140	1.37E-07	6.85E-08	80%	2.74E-08	4.11E-08	1762				2.19E-07	1178	1.38E-09	6.05E-06
1794-IF8IHNFXT	A	Flex, 8 Isolated HART Analog Input, extended env	926,808	1.08E-06	5.39E-07	80%	2.16E-07	3.24E-07	1762				1.73E-06	1178	1.12E-08	4.86E-05
1794-IR8	A	FLEX I/O RTD input module	5,016,231	1.99E-07	9.97E-08	80%	3.99E-08	5.98E-08	1762				3.19E-07	1178	2.01E-09	8.82E-06
1794-IR8XT	A	FLEX I/O-XT RTD input module	9,585,890	1.04E-07	5.22E-08	80%	2.09E-08	3.13E-08	1762	Not allowed for 1oo1 configurations			1.67E-07	1178	1.05E-09	4.61E-06
1794-IRT8	B	FLEX I/O RTD/ Thermocouple input module	1,407,269	7.11E-07	3.55E-07	80%	1.42E-07	2.13E-07	1762				1.14E-06	1178	7.27E-09	3.18E-05
1794-IRT8XT	B	FLEX I/O-XT RTD/ Thermocouple input module	8,204,792	1.22E-07	6.09E-08	80%	2.44E-08	3.66E-08	1762				1.95E-07	1178	1.22E-09	5.38E-06
1794-IT8	A	FLEX I/O Thermocouple input module	2,097,509	4.77E-07	2.38E-07	80%	9.54E-08	1.43E-07	1762				7.63E-07	1178	4.84E-09	2.12E-05
1794-IF2XOF2I	A	FLEX I/O isolated analog input/ output module	8,464,844	1.18E-07	5.91E-08	80%	2.36E-08	3.54E-08	1762				1.89E-07	1178	1.19E-09	5.22E-06
1794-IF2XOF2IXT	A	FLEX I/O-XT isolated analog input/output module	6,317,918	1.58E-07	7.91E-08	80%	3.17E-08	4.75E-08	1762				2.53E-07	1178	1.59E-09	7.00E-06
1794-IE4XOE2XT	B	FLEX I/O-XT analog input/output module	11,800,802	8.47E-08	4.24E-08	80%	1.69E-08	2.54E-08	1762				1.36E-07	1178	8.50E-10	3.74E-06
1794-OE4	B	FLEX I/O analog output module	18,433,610	5.42E-08	2.71E-08	80%	1.08E-08	1.63E-08	1762				8.68E-08	1178	5.43E-10	2.39E-06
1794-OE4XT	B	FLEX I/O-XT analog output module	11,381,744	8.79E-08	4.39E-08	80%	1.76E-08	2.64E-08	1762	Not allowed for 1oo1 configurations			1.41E-07	1178	8.81E-10	3.88E-06
1794-OF4I	A	FLEX I/O analog output module	23,884,409	4.19E-08	2.09E-08	80%	8.37E-09	1.26E-08	1762				6.70E-08	1178	4.19E-10	1.85E-06
1794-OF4IXT	A	FLEX I/O-XT analog output module	5,493,902	1.82E-07	9.10E-08	80%	3.64E-08	5.46E-08	1762				2.91E-07	1178	1.83E-09	8.05E-06
1794-TB3	A	FLEX I/O terminal base unit	250,000,000	4.00E-09	2.00E-09	80%	8.00E-10	1.20E-09	1762				6.40E-09	1178	4.00E-11	1.76E-07
1794-TB3G	A	FLEX I/O cage-clamp generic terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	1762				1.60E-08	1178	1.00E-10	4.41E-07
1794-TB3GS	A	FLEX I/O spring-clamp generic terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	1762				1.60E-08	1178	1.00E-10	4.41E-07
1794-TB3S	A	FLEX I/O terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	1762				1.60E-08	1178	1.00E-10	4.41E-07
1794-TB3T	A	FLEX I/O temperature terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	1762	Not allowed for 1oo1 configurations			1.60E-08	1178	1.00E-10	4.41E-07
1794-TB3TS	A	FLEX I/O spring-clamp temperature terminal base unit	52,312,000	1.91E-08	9.56E-09	80%	3.82E-09	5.73E-09	1762				3.06E-08	1178	1.91E-10	8.42E-07
1794-TBN	A	FLEX I/O NEMA terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	1762				1.60E-08	1178	1.00E-10	4.41E-07
1794-TBNF	A	FLEX I/O NEMA fused terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	1762				1.60E-08	1178	1.00E-10	4.41E-07
1492-TIFM40F-F24A-2[9]	A	DC input termination board	7,779,000							1.03E-07			7.90E-08			
1492-TAIFM16-F-3[9]	A	Analog input termination board	11,362,000	Non-interference only						7.04E-08	Not applicable		1.03E-07	Not applicable		
1492-TIFM4OF-24-2[9]	A	DC output termination board	10,127,000							7.90E-08			7.04E-08			

(1) Some catalog numbers have a K suffix. This indicates a version of the product that has conformal coating. These K versions have the same SIL 2 certification as the non-K versions.
(2) MTBF measured in hours unless calculated (as noted). Field return values – January 2012.
(3) Calculations performed on a per module basis.
(4) λ = Failure Rate = 1/MTBF.
(5) Demand rate must be less than 10 per year.
(6) Average of 1756-A4, -A7, -A10, -A13, and -A17 chassis.
(7) Suitable for use only in applications requiring compliance with IEC 61508 1999 Edition 1.
(8) Calculated MTBF and PFD by FMEA to 61508-2010.
(9) SIL 2-rated for non-interference in the chassis. Data not required within a safety function.

2- Year PFD Calculations

The PFD calculations in this table are calculated for a 2-year proof test interval (17,520 hours) and are specific to ControlLogix system components.

Table 22 - 2-Year PFD Calculations

Cat No.(1)(2)	Series	Description	Mean Time between Failure (MTBF)(2)	Common Terms(3)						1oo1 Configuration			1oo2 Configuration			
				λ(4)	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	Spurious Trip Rate STR	PFH(5)	PFD	Spurious Trip Rate STR	TGE	PFH(5)	PFD
1756-AXX(6)	C	ControlLogix chassis	22,652,010	4.41E-08	2.21E-08	95%	2.21E-09	1.99E-08	886	4.19E-08	2.21E-09	1.96E-05				
1756-A4LXT	B	4-slot ControlLogix-XT chassis	1,069,120	9.35E-07	4.68E-07	95%	4.68E-08	4.21E-07	886	8.89E-07	4.68E-08	4.14E-04				
1756-A5XT	C	5-slot ControlLogix-XT chassis	734,420	1.36E-06	6.81E-07	95%	6.81E-08	6.13E-07	886	1.29E-06	6.81E-08	6.03E-04				
1756-A7LXT	B	7-slot ControlLogix-XT chassis	27,628,178	3.62E-08	1.81E-08	95%	1.81E-09	1.63E-08	886	3.44E-08	1.81E-09	1.60E-05				
1756-A7XT	C	7-slot ControlLogix-XT chassis	1,081,600	9.25E-07	4.62E-07	95%	4.62E-08	4.16E-07	886	8.78E-07	4.62E-08	4.10E-04				
1756-PB72	C	18-32V DC 10 A ControlLogix power supply	31,561,095	3.17E-08	1.58E-08	95%	1.58E-09	1.43E-08	886	3.01E-08	1.58E-09	1.40E-05				
1756-PA72	C	85-265V AC 10 A ControlLogix power supply	18,336,146	5.45E-08	2.73E-08	95%	2.73E-09	2.45E-08	886	5.18E-08	2.73E-09	2.42E-05				
1756-PA75	B	85-265V AC 13 A ControlLogix power supply (75 W)	18,693,044	5.35E-08	2.67E-08	95%	2.67E-09	2.41E-08	886	5.08E-08	2.67E-09	2.37E-05				
1756-PA75R	A	85-265V AC 13 A Redundant ControlLogix power supply	1,412,877	7.08E-07	3.54E-07	95%	3.54E-08	3.18E-07	886	6.72E-07	3.54E-08	3.14E-04				
1756-PB75	B	18-32V DC 13 A ControlLogix power supply	15,675,475	6.38E-08	3.19E-08	95%	3.19E-09	2.87E-08	886	6.06E-08	3.19E-09	2.83E-05				
1756-PB75R	A	18-32V DC 13 A Redundant ControlLogix power supply	1,736,020	5.76E-07	2.88E-07	95%	2.88E-08	2.59E-07	886	5.47E-07	2.88E-08	2.55E-04	Not applicable			
1756-PAXT	B	ControlLogix-XT AC power supply	18,693,044	5.35E-08	2.67E-08	95%	2.67E-09	2.41E-08	886	5.08E-08	2.67E-09	2.37E-05				
1756-PBXT	B	ControlLogix-XT DC power supply	1,855,360	5.39E-07	2.69E-07	95%	2.69E-08	2.43E-07	886	5.12E-07	2.69E-08	2.39E-04				
1756-PC75	B	30-60V DC 13 A ControlLogix power supply	5,894,836	1.70E-07	8.48E-08	95%	8.48E-09	7.63E-08	886	1.61E-07	8.48E-09	7.52E-05				
1756-PH75	B	90-143V DC 13 A ControlLogix power supply	2,119,520	4.72E-07	2.36E-07	95%	2.36E-08	2.12E-07	886	4.48E-07	2.36E-08	2.09E-04				
1756-PSCA	A	Redundant power supply adapter	45,146,727	2.21E-08	1.11E-08	95%	1.11E-09	9.97E-09	886	2.10E-08	1.11E-09	9.81E-06				
1756-PSCA2	A	Redundant power supply adapter	38,461,280	2.60E-08	1.30E-08	95%	1.30E-09	1.17E-08	886	2.47E-08	1.30E-09	1.15E-05				
1786-RPFS	A	ControlNet Fiber repeater - short	26,461,760	3.78E-08	1.89E-08	95%	1.89E-09	1.70E-08	886	3.59E-08	1.89E-09	1.67E-05				
1786-RPFM	A	ControlNet Fiber repeater - medium	16,697,862	5.99E-08	2.99E-08	95%	2.99E-09	2.69E-08	886	5.69E-08	2.99E-09	2.65E-05				
1786-RPFRL	A	ControlNet Fiber repeater - long	5,717,227	1.75E-07	8.75E-08	95%	8.75E-09	7.87E-08	886	1.66E-07	8.75E-09	7.75E-05				
1786-RPCD	A	ControlNet Hub repeater	28,654,080	3.49E-08	1.74E-08	95%	1.74E-09	1.57E-08	886	3.32E-08	1.74E-09	1.55E-05				
1786-RPA	B	ControlNet repeater adapter	11,826,146	8.46E-08	4.23E-08	95%	4.23E-09	3.81E-08	886	8.03E-08	4.23E-09	3.75E-05				
1786-RPFRXL	B	ControlNet Fiber repeater - extra long	11,373,440	8.79E-08	4.40E-08	95%	4.40E-09	3.96E-08	886	8.35E-08	4.40E-09	3.90E-05				

Table 22 - 2-Year PFD Calculations (Continued)

Cat No.(1)(2)	Series	Description	Mean Time between Failure (MTBF)(2)	Common Terms(3)						1oo1 Configuration			1oo2 Configuration			
				λ(4)	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	Spurious Trip Rate STR	PFH(5)	PFD	Spurious Trip Rate STR	TGE	PFH(5)	PFD
1756-L61(7)	B	ControlLogix controller, 2 MB	1,000,053	1.00E-06	5.00E-07	95%	5.00E-08	4.50E-07	886	9.50E-07	5.00E-08	4.43E-04	Not applicable			
1756-L62(7)	B	ControlLogix controller, 4 MB	1,034,830	9.66E-07	4.83E-07	95%	4.83E-08	4.35E-07	886	9.18E-07	4.83E-08	4.28E-04				
1756-L63(7)	B	ControlLogix controller, 8 MB	1,055,910	9.47E-07	4.74E-07	95%	4.74E-08	4.26E-07	886	9.00E-07	4.74E-08	4.20E-04				
1756-L63XT(7)	B	ControlLogix-XT controller, 8 MB	357,760	2.80E-06	1.40E-06	95%	1.40E-07	1.26E-06	886	2.66E-06	1.40E-07	1.24E-03				
1756-L71(8)	B	ControlLogix controller, 2 MB	Calculated MTBF and PFD via FMEA	2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	670	2.91E-06	1.01E-07	8.90E-04				
1756-L72(8)	B	ControlLogix controller, 4 MB		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	670	2.91E-06	1.01E-07	8.90E-04				
1756-L73(8)	B	ControlLogix controller, 8 MB		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	670	2.91E-06	1.01E-07	8.90E-04				
1756-L73XT(8)	B	ControlLogix-XT controller, 8 MB		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	670	2.91E-06	1.01E-07	8.90E-04				
1756-L74(8)	B	ControlLogix controller, 16 MB		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	670	2.91E-06	1.01E-07	8.90E-04				
1756-L75(8)	B	ControlLogix controller, 32 MB		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	670	2.91E-06	1.01E-07	8.90E-04				
1756-L61S(7)	B	GuardLogix controller, 2 MB standard	1,000,053	1.00E-06	5.00E-07	95%	5.00E-08	4.50E-07	886	9.50E-07	5.00E-08	4.43E-04				
1756-L62S(7)	B	GuardLogix controller, 4 MB standard	1,034,830	9.66E-07	4.83E-07	95%	4.83E-08	4.35E-07	886	9.18E-07	4.83E-08	4.28E-04				
1756-L63S(7)	B	GuardLogix controller, 8 MB standard	1,055,910	9.47E-07	4.74E-07	95%	4.74E-08	4.26E-07	886	9.00E-07	4.74E-08	4.20E-04				
1756-L71S(8)	B	GuardLogix controller, 2 MB standard	Calculated MTBF and PFD via FMEA	2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	670	2.91E-06	1.01E-07	8.90E-04				
1756-L72S(8)	B	GuardLogix controller, 4 MB standard		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	670	2.91E-06	1.01E-07	8.90E-04				
1756-L73S(8)	B	GuardLogix controller, 8 MB standard		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	670	2.91E-06	1.01E-07	8.90E-04				
1756-L73SXT(8)	B	GuardLogix-XT controller, 8 MB standard		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	670	2.91E-06	1.01E-07	8.90E-04				

Table 22 - 2-Year PFD Calculations (Continued)

Cat No.[1][2]	Series	Description	Mean Time between Failure (MTBF)[2]	Common Terms[3]						1oo1 Configuration			1oo2 Configuration			
				λ[4]	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	Spurious Trip Rate STR	PFH[5]	PFD	Spurious Trip Rate STR	TGE	PFH[5]	PFD
1756-CNB	E	ControlLogix ControlNet communication module	1,786,977	5.60E-07	2.80E-07	95%	2.80E-08	2.52E-07	886	5.32E-07	2.80E-08	2.48E-04				
1756-CNBR	E	ControlLogix ControlNet redundant communication module	2,608,543	3.83E-07	1.92E-07	95%	1.92E-08	1.73E-07	886	3.64E-07	1.92E-08	1.70E-04				
1756-CN2	B	ControlLogix ControlNet communication module	1,096,299	9.12E-07	4.56E-07	95%	4.56E-08	4.10E-07	886	8.67E-07	4.56E-08	4.04E-04				
1756-CN2[8]	C	ControlLogix ControlNet communication module	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	597.25	1.91E-06	6.62E-08	5.90E-04				
1756-CN2R	B	ControlLogix ControlNet redundant communication module	1,096,299	9.12E-07	4.56E-07	95%	4.56E-08	4.10E-07	886	8.67E-07	4.56E-08	4.04E-04	Not applicable			
1756-CN2R[8]	C	ControlLogix ControlNet redundant communication module	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	597.25	1.91E-06	6.62E-08	5.90E-04				
1756-CN2RXT	B	ControlLogix-XT ControlNet redundant communication module	1,980,160	5.05E-07	2.53E-07	95%	2.53E-08	2.27E-07	886	4.80E-07	2.53E-08	2.24E-04				
1756-CN2RXT[8]	C	ControlLogix-XT ControlNet redundant communication module	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	597.25	1.91E-06	6.62E-08	5.90E-04				
1756-DHRIO[9]	E	ControlLogix Data Highway Plus remote I/O module	2,503,396							3.79E-07			7.59E-07			
1756-DHRIOXT[9]	E	ControlLogix-XT Data Highway Plus remote I/O module	2,503,396							3.79E-07			7.59E-07			
1756-DNB[9]	D	ControlLogix DeviceNet communication module	2,192,202	Non-interference only						4.33E-07	Not applicable		8.67E-07	Not applicable		
1756-ENBT[9]	A	ControlLogix EtherNet/IP communication module	2,088,198							4.55E-07			9.10E-07			
1756-EN2T	C	ControlLogix EtherNet/IP communication module	1,312,712	7.62E-07	3.81E-07	95%	3.81E-08	3.43E-07	886	7.24E-07	3.81E-08	3.37E-04				
1756-EN2T[9]	D	ControlLogix EtherNet/IP communication module	269,774	Non-interference only						3.71E-06	Not applicable		Not applicable			
1756-EN2TR	B	ControlLogix EtherNet/IP communication module with fault tolerance	3,664,960	2.73E-07	1.36E-07	95%	1.36E-08	1.23E-07	886	2.59E-07	1.36E-08	1.21E-04				
1756-EN2TR[8]	C	ControlLogix EtherNet/IP communication module with fault tolerance	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	597.25	1.91E-06	6.62E-08	5.90E-04	3.82E-06	401.50	1.40E-09	1.22E-05
1756-EN2TRXT[8]	C	ControlLogix EtherNet/IP communication module with fault tolerance		1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	597.25	1.91E-06	6.62E-08	5.90E-04	3.82E-06	401.50	1.40E-09	1.22E-05
1756-EN2TXT	C	ControlLogix-XT EtherNet/IP communication module	1,300,000	7.69E-07	3.85E-07	95%	3.85E-08	3.46E-07	886	7.31E-07	3.85E-08	3.41E-04	Not applicable			

Table 22 - 2-Year PFD Calculations (Continued)

Cat No.(1)(2)	Series	Description	Mean Time between Failure (MTBF)(2)	Common Terms(3) λ(4)	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	1oo1 Configuration Spurious Trip Rate STR	PFH(5)	PFD	1oo2 Configuration Spurious Trip Rate STR	TGE	PFH(5)	PFD
1756-EN2TXT(9)	D	ControlLogix-XT EtherNet/IP communication module	269,774	Non-interference only						3.71E-06	Not applicable					
1756-EN3TR(9)	B	ControlLogix EtherNet/IP communication module with fault tolerance	269,774							3.71E-06						
1756-RM(9)	B	ControlLogix redundancy module	1,373,840							6.91E-07						
1756-RMXT(9)	B	ControlLogix-XT redundancy module	980,096							9.69E-07						
1756-RM2(9)	A	ControlLogix redundancy module	250,182							4.00E-06						
1756-RM2XT(9)	A	ControlLogix-XT redundancy module	250,182							4.00E-06						
1756-RM3(9)	A	ControlLogix redundancy module	213,749							4.68E-06						
1756-RM3-2SFP(9)	A	ControlLogix redundancy module	213,749							4.68E-06						
1756-RM3XT(9)	A	ControlLogix-XT redundancy module	213,749							4.68E-06						
1756-SYNCH(9)	A	ControlLogix SynchLink Module	6,932,640							1.37E-07	Not applicable		2.74E-07	Not applicable		
1756-IA16I	A	ControlLogix isolated V AC input module	20,801,920	4.81E-08	2.40E-08	80%	9.61E-09	1.44E-08	3514	3.85E-08	9.61E-09	8.45E-05	7.69E-08	2346	4.82E-10	4.23E-06
1756-IA8D	A	ControlLogix diagnostic V AC input module	15,966,080	6.26E-08	3.13E-08	80%	1.25E-08	1.88E-08	3514	5.01E-08	1.25E-08	1.10E-04	1.00E-07	2346	6.29E-10	5.52E-06
1756-IB16D	A	ControlLogix diagnostic V DC input module	30,228,640	3.31E-08	1.65E-08	80%	6.62E-09	9.92E-09	3514	2.65E-08	6.62E-09	5.81E-05	5.29E-08	2346	3.32E-10	2.91E-06
1756-IB16I	A	ControlLogix isolated V DC input module	81,443,094	1.23E-08	6.14E-09	80%	2.46E-09	3.68E-09	3514	9.82E-09	2.46E-09	2.16E-05	1.96E-08	2346	1.23E-10	1.08E-06
1756-IB16ISOE	A	ControlLogix isolated V DC Sequence Of Events input module	11,537,760	8.67E-08	4.33E-08	80%	1.73E-08	2.60E-08	3514	6.93E-08	1.73E-08	1.52E-04	1.39E-07	2346	8.71E-10	7.64E-06
1756-IB32	B	ControlLogix V DC input module	10,462,329	9.56E-08	4.78E-08	80%	1.91E-08	2.87E-08	3514	7.65E-08	1.91E-08	1.68E-04	1.53E-07	2346	9.62E-10	8.43E-06
1756-IF8	A	ControlLogix analog input module	8,699,254	1.15E-07	5.75E-08	80%	2.30E-08	3.45E-08	3514	9.20E-08	2.30E-08	2.02E-04	1.84E-07	2346	1.16E-09	1.01E-05
1756-IF8(8)	B	ControlLogix analog input module	Calculated MTBF and PFD via FMEA	9.43E-07	4.71E-07	79%	1.98E-07	2.73E-07	3699	7.45E-07	1.99E-07	1.7E-03	1.49E-06	2469	1.10E-08	9.1E-05
1756-IF8I(8)	A	ControlLogix isolated analog input module	2,337,541	4.28E-07	2.139E-07	77%	9.81E-08	1.16E-07	4028	3.3E-07	9.81E-08	8.61E-04	6.59E-07	2688	2.12E-09	1.82E-05
1756-IF8I(8)	B	ControlLogix isolated analog input module	Calculated MTBF and PFD via FMEA	5.83E-07	2.92E-07	78%	1.26E-07	1.66E-07	3784	4.58E-07	1.26E-07	1.11E-03	9.15E-07	2526	2.79E-09	2.37E-05
1756-IF8H	A	ControlLogix HART analog input module	1,291,978	7.74E-07	3.87E-07	80%	1.55E-07	2.32E-07	3514	6.19E-07	1.55E-07	1.36E-03	1.24E-06	2346	8.12E-09	7.02E-05
1756-IF8H	B	ControlLogix HART analog input module	Calculated MTBF and PFD via FMEA	9.75E-07	4.88E-07	92%	7.67E-08	4.11E-07	1388	Not applicable			2.77E-06	928	3.93E-09	3.44E-05
1756-IF16	A	ControlLogix analog input module	4,592,506	2.18E-07	1.09E-07	80%	4.35E-08	6.53E-08	3514	1.74E-07	4.35E-08	3.83E-04	3.48E-07	2346	2.21E-09	1.93E-05
1756-IF16(8)	B	ControlLogix analog input module	Calculated MTBF and PFD via FMEA	9.43E-07	4.71E-07	79%	1.98E-07	2.73E-07	3699	7.45E-07	1.99E-07	1.7E-03	1.49E-06	2469	1.10E-08	9.1E-05

Table 22 - 2-Year PFD Calculations (Continued)

Cat No.(1)(2)	Series	Description	Mean Time between Failure (MTBF)(2)	Common Terms(3)						1oo1 Configuration			1oo2 Configuration			
				λ(4)	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	Spurious Trip Rate STR	PFH(5)	PFD	Spurious Trip Rate STR	TGE	PFH(5)	PFD
1756-IF16H	A	ControlLogix HART analog input module	442,914	2.26E-06	1.13E-06	80%	4.52E-07	6.77E-07	3514	1.81E-06	4.52E-07	3.97E-03	3.61E-06	2346	2.58E-08	2.17E-04
1756-IF16H	B	ControlLogix HART analog input module	Calculated MTBF and PFD via FMEA	1.08E-06	5.38E-07	92%	8.32E-08	4.54E-07	1364	Not applicable			4.27E-09	912	4.27E-09	3.73E-05
1756-IF6CIS	A	ControlLogix isolated analog input module	2,654,080	3.77E-07	1.88E-07	80%	7.54E-08	1.13E-07	3514	3.01E-07	7.54E-08	6.62E-04	6.03E-07	2346	3.86E-09	3.36E-05
1756-IF6I	A	ControlLogix isolated analog input module	4,176,185	2.39E-07	1.20E-07	80%	4.79E-08	7.18E-08	3514	1.92E-07	4.79E-08	4.21E-04	3.83E-07	2346	2.43E-09	2.12E-05
1756-IH16ISOE	A	ControlLogix V DC Sequence Of Events input module	2,150,720	4.65E-07	2.32E-07	80%	9.30E-08	1.39E-07	3514	3.72E-07	9.30E-08	8.17E-04	7.44E-07	2346	4.79E-09	4.17E-05
1756-IR6I	A	ControlLogix isolated RTD input module	4,268,525	2.34E-07	1.17E-07	80%	4.69E-08	7.03E-08	3514				3.75E-07	2346	2.38E-09	2.08E-05
1756-IRT8I(8)	A	ControlLogix isolated RTD / thermocouple input module	1,896,813	5.272E-07	2.636E-07	76%	1.27E-07	1.36E-07	4244				8.00E-07	2833	2.82E-09	2.40E-05
1756-IRT8I(8)	B	ControlLogix isolated RTD / thermocouple input module	Calculated MTBF and PFD via FMEA	6.11E-07	3.06E-07	80%	1.24E-07	1.82E-07	3556	Not allowed for 1oo1 configurations			9.75E-07	2374	2.74E-09	2.33E-05
1756-IT6I	A	ControlLogix isolated thermocouple input module	3,957,824	2.53E-07	1.26E-07	80%	5.05E-08	7.58E-08	3514				4.04E-07	2346	2.57E-09	2.24E-05
1756-IT6I2	A	ControlLogix isolated enhanced thermocouple input module	2,720,046	3.68E-07	1.84E-07	80%	7.35E-08	1.10E-07	3514				5.88E-07	2346	3.76E-09	3.28E-05
1756-OA16I	A	ControlLogix V AC output module	32,891,456	3.04E-08	1.52E-08	80%	6.08E-09	9.12E-09	3514	2.43E-08	6.08E-09	5.34E-05	4.86E-08	2346	3.05E-10	2.67E-06
1756-OA8D	A	ControlLogix V AC diagnostic output module	11,311,040	8.84E-08	4.42E-08	80%	1.77E-08	2.65E-08	3514	7.07E-08	1.77E-08	1.55E-04	1.41E-07	2346	8.89E-10	7.80E-06
1756-OB16D	A	ControlLogix V DC diagnostic output module	8,884,374	1.13E-07	5.63E-08	80%	2.25E-08	3.38E-08	3514	9.00E-08	2.25E-08	1.98E-04	1.80E-07	2346	1.13E-09	9.94E-06
1756-OB16E	A	ControlLogix V DC electronically fused output module	14,997,714	6.67E-08	3.33E-08	80%	1.33E-08	2.00E-08	3514	5.33E-08	1.33E-08	1.17E-04	1.07E-07	2346	6.70E-10	5.87E-06
1756-OB16I	A	ControlLogix V DC isolated output module	7,388,160	1.35E-07	6.77E-08	80%	2.71E-08	4.06E-08	3514	1.08E-07	2.71E-08	2.38E-04	2.17E-07	2346	1.37E-09	1.20E-05
1756-OB32	A	ControlLogix V DC output module	2,681,316	3.73E-07	1.86E-07	80%	7.46E-08	1.12E-07	3514	2.98E-07	7.46E-08	6.55E-04	5.97E-07	2346	3.82E-09	3.33E-05
1756-OB8EI	A	ControlLogix V DC isolated electronic ally fused output module	14,019,200	7.13E-08	3.57E-08	80%	1.43E-08	2.14E-08	3514	5.71E-08	1.43E-08	1.25E-04	1.14E-07	2346	7.17E-10	6.29E-06
1756-OX8I	A	ControlLogix isolated relay output module	6,059,635	1.65E-07	8.25E-08	80%	3.30E-08	4.95E-08	3514	1.32E-07	3.30E-08	2.90E-04	2.64E-07	2346	1.67E-09	1.46E-05
1756-OW16I	A	ControlLogix isolated relay output module	13,695,899	7.30E-08	3.65E-08	80%	1.46E-08	2.19E-08	3514	5.84E-08	1.46E-08	1.28E-04	1.17E-07	2346	7.34E-10	6.43E-06
1756-OF4(8)	B	ControlLogix analog output module	Calculated MTBF and PFD via FMEA	1.03E-06	5.17E-07	78%	2.23E-07	2.93E-07	3794	8.11E-07	2.23E-07	2.0E-03	1.62E-06	2533	1.20E-08	1.0E-04
1756-OF8	A	ControlLogix analog output module	10,629,795	9.41E-08	4.70E-08	80%	1.88E-08	2.82E-08	3514	7.53E-08	1.88E-08	1.65E-04	1.51E-07	2346	9.46E-10	8.30E-06
1756-OF8(8)	B	ControlLogix analog output module	Calculated MTBF and PFD via FMEA	1.03E-06	5.17E-07	78%	2.23E-07	2.93E-07	3794	8.11E-07	2.23E-07	2.0E-03	1.62E-06	2533	1.20E-08	1.0E-04
1756-OF8I(8)	A	ControlLogix isolated analog output module	2,213,369	4.52E-07	2.259E-07	76%	1.08E-07	1.18E-07	4202	3.44E-07	1.08E-07	9.49E-04	6.87E-07	2805	2.36E-09	2.01E-05
1756-OF8I(8)	B	ControlLogix isolated analog output module	Calculated MTBF and PFD via FMEA	6.08E-07	3.04E-07	78%	1.37E-07	1.67E-07	3954	4.71E-07	1.37E-07	1.2E-03	9.42E-07	2639	3.06E-09	2.59E-05

Table 22 - 2-Year PFD Calculations (Continued)

Cat No.(1)(2)	Series	Description	Mean Time between Failure (MTBF)(2)	Common Terms(3) λ(4)	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	1oo1 Configuration Spurious Trip Rate STR	PFH(5)	PFD	1oo2 Configuration Spurious Trip Rate STR	TGE	PFH(5)	PFD
1756-OF6VI	A	ControlLogix isolated analog output module	21,604,960	4.63E-08	2.31E-08	80%	9.26E-09	1.39E-08	3514	3.70E-08	9.26E-09	8.13E-05	7.41E-08	2346	4.64E-10	4.07E-06
1756-OF6CI	A	ControlLogix isolated analog output module	8,354,667	1.20E-07	5.98E-08	80%	2.39E-08	3.59E-08	3514	9.58E-08	2.39E-08	2.10E-04	1.92E-07	2346	1.21E-09	1.06E-05
1756-OF8H	A	ControlLogix HART analog output module	5,118,187	1.95E-07	9.77E-08	80%	3.91E-08	5.86E-08	3514	1.56E-07	3.91E-08	3.43E-04	3.13E-07	2346	1.98E-09	1.73E-05
1794-ACN15	D	FLEX I/O ControlNet adapter	8,223,684	1.22E-07	6.08E-08	80%	2.43E-08	3.65E-08	3514				1.95E-07	2346	1.23E-09	1.07E-05
1794-ACNR15	D	FLEX I/O ControlNet redundant adapter	8,223,684	1.22E-07	6.08E-08	80%	2.43E-08	3.65E-08	3514				1.95E-07	2346	1.23E-09	1.07E-05
1794-ACNR15XT	D	FLEX I/O-XT ControlNet adapter	8,223,684	1.22E-07	6.08E-08	80%	2.43E-08	3.65E-08	3514	Not allowed for 1oo1 configurations			1.95E-07	2346	1.23E-09	1.07E-05
1794-AENT	B	FLEX I/O EtherNet/ IP adapter	1,779,827	5.62E-07	2.81E-07	80%	1.12E-07	1.69E-07	3514				8.99E-07	2346	5.82E-09	5.05E-05
1794-AENTR	A	FLEX I/O EtherNet/ IP adapter, Ring media	1,268,070	7.89E-07	3.94E-07	80%	1.58E-07	2.37E-07	3514				1.26E-06	2346	8.28E-09	7.16E-05
1794-AENTRXT	A	FLEX I/O EtherNet/ IP adapter, Ring media	1,268,070	7.89E-07	3.94E-07	80%	1.58E-07	2.37E-07	3514				1.26E-06	2346	8.28E-09	7.16E-05
1794-IB16	A	FLEX I/O 24V DC input module	179,506,158	5.57E-09	2.79E-09	80%	1.11E-09	1.67E-09	3514				8.91E-09	2346	5.57E-11	4.90E-07
1794-IB16XT	A	FLEX I/O-XT 24V DC input module	35,587,189	2.81E-08	1.40E-08	80%	5.62E-09	8.43E-09	3514				4.50E-08	2346	2.82E-10	2.47E-06
1794-IJ2	A	FLEX I/O counter module	55,344,640	1.81E-08	9.03E-09	80%	3.61E-09	5.42E-09	3514				2.89E-08	2346	1.81E-10	1.59E-06
1794-IJ2XT	A	FLEX I/O-XT counter module	11,714,128	8.54E-08	4.27E-08	80%	1.71E-08	2.56E-08	3514	Not allowed for 1oo1 configurations			1.37E-07	2346	8.58E-10	7.53E-06
1794-IP4	B	FLEX I/O counter module	22,027,200	4.54E-08	2.27E-08	80%	9.08E-09	1.36E-08	3514				7.26E-08	2346	4.55E-10	4.00E-06
1794-IB10XOB6	A	FLEX I/O 24V DC input/output module	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	3514				1.60E-08	2346	1.00E-10	8.79E-07
1794-IB10XOB6XT	A	FLEX I/O-XT 24V DC input/output module	22,202,487	4.50E-08	2.25E-08	80%	9.01E-09	1.35E-08	3514				7.21E-08	2346	4.52E-10	3.96E-06
1794-OB8EP	A	FLEX I/O 24V DC electronically fused output module	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	3514				1.60E-08	2346	1.00E-10	8.79E-07
1794-OB8EPXT	A	FLEX I/O-XT 24V DC electronically fused output module	14,771,049	6.77E-08	3.38E-08	80%	1.35E-08	2.03E-08	3514				1.08E-07	2346	6.80E-10	5.96E-06
1794-OB16	A	FLEX I/O 24V DC output module	54,322,632	1.84E-08	9.20E-09	80%	3.68E-09	5.52E-09	3514				2.95E-08	2346	1.84E-10	1.62E-06
1794-OB16P	A	FLEX I/O 24V DC protected output module	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	3514	Not allowed for 1oo1 configurations			1.60E-08	2346	1.00E-10	8.79E-07
1794-OB16PXT	A	FLEX I/O-XT 24V DC protected output module	26,709,401	3.74E-08	1.87E-08	80%	7.49E-09	1.12E-08	3514				5.99E-08	2346	3.75E-10	3.29E-06
1794-OW8	A	FLEX I/O isolated relay output module	29,088,895	3.44E-08	1.72E-08	80%	6.88E-09	1.03E-08	3514				5.50E-08	2346	3.45E-10	3.02E-06
1794-OW8XT	A	FLEX I/O-XT isolated relay output module	18,518,519	5.40E-08	2.70E-08	80%	1.08E-08	1.62E-08	3514				8.64E-08	2346	5.42E-10	4.75E-06

Table 22 - 2-Year PFD Calculations (Continued)

Cat No.[1][2]	Series	Description	Mean Time between Failure (MTBF)[2]	Common Terms[3]						1oo1 Configuration			1oo2 Configuration			
				λ[4]	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	Spurious Trip Rate STR	PFH[5]	PFD	Spurious Trip Rate STR	TGE	PFH[5]	PFD
1794-IE8	B	FLEX I/O analog input module	18,914,770	5.29E-08	2.64E-08	80%	1.06E-08	1.59E-08	3514				8.46E-08	2346	5.30E-10	4.65E-06
1794-IE8XT	B	FLEX I/O-XT analog input module	14,041,000	7.12E-08	3.56E-08	80%	1.42E-08	2.14E-08	3514				1.14E-07	2346	7.15E-10	6.28E-06
1794-IF4I	A	FLEX I/O isolated analog input module	9,885,959	1.01E-07	5.06E-08	80%	2.02E-08	3.03E-08	3514				1.62E-07	2346	1.02E-09	8.92E-06
1794-IF4IXT	A	FLEX I/O-XT isolated analog input module	7,297,140	1.37E-07	6.85E-08	80%	2.74E-08	4.11E-08	3514				2.19E-07	2346	1.38E-09	1.21E-05
1794-IF4ICFXT	A	FLEX I/O-XT isolated analog input module	7,297,140	1.37E-07	6.85E-08	80%	2.74E-08	4.11E-08	3514				2.19E-07	2346	1.38E-09	1.21E-05
1794-IF8IHNFXT	A	Flex, 8 Isolated HART Analog Input, extended env	926,808	1.08E-06	5.39E-07	80%	2.16E-07	3.24E-07	3514				1.73E-06	2346	1.15E-08	9.91E-05
1794-IR8	A	FLEX I/O RTD input module	5,016,231	1.99E-07	9.97E-08	80%	3.99E-08	5.98E-08	3514				3.19E-07	2346	2.02E-09	1.77E-05
1794-IR8XT	A	FLEX I/O-XT RTD input module	9,585,890	1.04E-07	5.22E-08	80%	2.09E-08	3.13E-08	3514	Not allowed for 1oo1 configurations			1.67E-07	2346	1.05E-09	9.20E-06
1794-IRT8	B	FLEX I/O RTD/ Thermocouple input module	1,407,269	7.11E-07	3.55E-07	80%	1.42E-07	2.13E-07	3514				1.14E-06	2346	7.43E-09	6.43E-05
1794-IRT8XT	B	FLEX I/O-XT RTD/ Thermocouple input module	8,204,792	1.22E-07	6.09E-08	80%	2.44E-08	3.66E-08	3514				1.95E-07	2346	1.23E-09	1.08E-05
1794-IT8	A	FLEX I/O Thermocouple input module	2,097,509	4.77E-07	2.38E-07	80%	9.54E-08	1.43E-07	3514				7.63E-07	2346	4.91E-09	4.27E-05
1794-IF2XOF2I	A	FLEX I/O isolated analog input/ output module	8,464,844	1.18E-07	5.91E-08	80%	2.36E-08	3.54E-08	3514				1.89E-07	2346	1.19E-09	1.04E-05
1794-IF2XOF2IXT	A	FLEX I/O-XT isolated analog input/output module	6,317,918	1.58E-07	7.91E-08	80%	3.17E-08	4.75E-08	3514				2.53E-07	2346	1.60E-09	1.40E-05
1794-IE4XOE2XT	B	FLEX I/O-XT analog input/output module	11,800,802	8.47E-08	4.24E-08	80%	1.69E-08	2.54E-08	3514				1.36E-07	2346	8.52E-10	7.47E-06
1794-OE4	B	FLEX I/O analog output module	18,433,610	5.42E-08	2.71E-08	80%	1.08E-08	1.63E-08	3514				8.68E-08	2346	5.44E-10	4.78E-06
1794-OE4XT	B	FLEX I/O-XT analog output module	11,381,744	8.79E-08	4.39E-08	80%	1.76E-08	2.64E-08	3514	Not allowed for 1oo1 configurations			1.41E-07	2346	8.83E-10	7.75E-06
1794-OF4I	A	FLEX I/O analog output module	23,884,409	4.19E-08	2.09E-08	80%	8.37E-09	1.26E-08	3514				6.70E-08	2346	4.20E-10	3.68E-06
1794-OF4IXT	A	FLEX I/O-XT analog output module	5,493,902	1.82E-07	9.10E-08	80%	3.64E-08	5.46E-08	3514				2.91E-07	2346	1.84E-09	1.61E-05
1794-TB3	A	FLEX I/O terminal base unit	250,000,000	4.00E-09	2.00E-09	80%	8.00E-10	1.20E-09	3514				6.40E-09	2346	4.00E-11	3.51E-07
1794-TB3G	A	FLEX I/O cage-clamp generic terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	3514				1.60E-08	2346	1.00E-10	8.79E-07
1794-TB3GS	A	FLEX I/O spring-clamp generic terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	3514				1.60E-08	2346	1.00E-10	8.79E-07
1794-TB3S	A	FLEX I/O terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	3514				1.60E-08	2346	1.00E-10	8.79E-07
1794-TB3T	A	FLEX I/O temperature terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	3514	Not allowed for 1oo1 configurations			1.60E-08	2346	1.00E-10	8.79E-07
1794-TB3TS	A	FLEX I/O spring-clamp temperature terminal base unit	52,312,000	1.91E-08	9.56E-09	80%	3.82E-09	5.73E-09	3514				3.06E-08	2346	1.91E-10	1.68E-06
1794-TBN	A	FLEX I/O NEMA terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	3514				1.60E-08	2346	1.00E-10	8.79E-07
1794-TBNF	A	FLEX I/O NEMA fused terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	3514				1.60E-08	2346	1.00E-10	8.79E-07

Table 22 - 2-Year PFD Calculations (Continued)

Cat No.(1)(2)	Series	Description	Mean Time between Failure (MTBF)(2)	Common Terms(3)						1oo1 Configuration			1oo2 Configuration			
				λ(4)	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	Spurious Trip Rate STR	PFH(5)	PFD	Spurious Trip Rate STR	TGE	PFH(5)	PFD
1492-TIFM40F-F24A-2(9)	A	DC Input Termination Board	7,779,000	Non-interference only						1.03E-07	Not applicable		1.03E-07	Not applicable		
1492-TAIFM16-F-3(9)	A	Analog Input Termination Board	11,362,000							7.04E-08			7.04E-08			
1492-TIFM4OF-24-2(9)	A	DC Output Termination Board	10,127,000							7.90E-08			7.90E-08			

(1) Some catalog numbers have a K suffix. This indicates a version of the product that has conformal coating. These K versions have the same SIL 2 certification as the non-K versions.
(2) MTBF measured in hours unless calculated (as noted). Field return values – January 2012.
(3) Calculations performed on a per module basis.
(4) λ = Failure Rate = 1/MTBF.
(5) Demand rate must be less than 10 per year.
(6) Average of 1756-A4, -A7, -A10, -A13, and -A17 chassis.
(7) Suitable for use only in applications that require compliance with IEC 61508 1999 Edition 1.
(8) Calculated MTBF and PFD by FMEA to 61508-2010.
(9) SIL 2-rated for non-interference in the chassis. Data not required within a safety function.

5-year PFD Calculations

The PFD calculations in this table are calculated for a 5-year proof test interval (43,800 hours) and are specific to ControlLogix system components.

Table 23 - 5-Year PFD Calculations

Cat No.(1)(2)	Series	Description	Mean Time between Failure (MTBF)(2)	Common Terms(3)						1oo1 Configuration			1oo2 Configuration			
				λ(4)	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	Spurious Trip Rate STR	PFH(5)	PFD	Spurious Trip Rate STR	TGE	PFH(5)	PFD
1756-AXX(6)	C	ControlLogix chassis	22,652,010	4.41E-08	2.21E-08	95%	2.21E-09	1.99E-08	2200	4.19E-08	2.21E-09	4.86E-05				
1756-A4LXT	B	ControlLogix-XT chassis	1,069,120	9.35E-07	4.68E-07	95%	4.68E-08	4.21E-07	2200	8.89E-07	4.68E-08	1.03E-03				
1756-A5XT	C	ControlLogix-XT chassis	734,420	1.36E-06	6.81E-07	95%	6.81E-08	6.13E-07	2200	1.29E-06	6.81E-08	1.50E-03				
1756-A7LXT	B	ControlLogix-XT chassis	27,628,178	3.62E-08	1.81E-08	95%	1.81E-09	1.63E-08	2200	3.44E-08	1.81E-09	3.98E-05				
1756-A7XT	C	ControlLogix-XT chassis	1,081,600	9.25E-07	4.62E-07	95%	4.62E-08	4.16E-07	2200	8.78E-07	4.62E-08	1.02E-03				
1756-PB72	C	ControlLogix power supply	31,561,095	3.17E-08	1.58E-08	95%	1.58E-09	1.43E-08	2200	3.01E-08	1.58E-09	3.49E-05				
1756-PA72	C	ControlLogix power supply	18,336,146	5.45E-08	2.73E-08	95%	2.73E-09	2.45E-08	2200	5.18E-08	2.73E-09	6.00E-05				
1756-PA75	B	85-265V AC 13 A ControlLogix power supply (75 W)	18,693,044	5.35E-08	2.67E-08	95%	2.67E-09	2.41E-08	2200	5.08E-08	2.67E-09	5.88E-05				
1756-PA75R	A	85-265V AC 13 A Redundant ControlLogix power supply	1,412,877	7.08E-07	3.54E-07	95%	3.54E-08	3.18E-07	2200	6.72E-07	3.54E-08	7.79E-04				
1756-PB75	B	ControlLogix power supply	15,675,475	6.38E-08	3.19E-08	95%	3.19E-09	2.87E-08	2200	6.06E-08	3.19E-09	7.02E-05				
1756-PB75R	A	18-32V DC 13 A Redundant ControlLogix power supply	1,736,020	5.76E-07	2.88E-07	95%	2.88E-08	2.59E-07	2200	5.47E-07	2.88E-08	6.34E-04	Not applicable			
1756-PAXT	B	ControlLogix-XT AC power supply	18,693,044	5.35E-08	2.67E-08	95%	2.67E-09	2.41E-08	2200	5.08E-08	2.67E-09	5.88E-05				
1756-PBXT	B	ControlLogix-XT DC power supply	1,855,360	5.39E-07	2.69E-07	95%	2.69E-08	2.43E-07	2200	5.12E-07	2.69E-08	5.93E-04				
1756-PC75	B	ControlLogix power supply	5,894,836	1.70E-07	8.48E-08	95%	8.48E-09	7.63E-08	2200	1.61E-07	8.48E-09	1.87E-04				
1756-PH75	B	ControlLogix power supply	2,119,520	4.72E-07	2.36E-07	95%	2.36E-08	2.12E-07	2200	4.48E-07	2.36E-08	5.19E-04				
1756-PSCA	A	Redundant power supply adapter	45,146,727	2.21E-08	1.11E-08	95%	1.11E-09	9.97E-09	2200	2.10E-08	1.11E-09	2.44E-05				
1756-PSCA2	A	Redundant power supply adapter	38,461,280	2.60E-08	1.30E-08	95%	1.30E-09	1.17E-08	2200	2.47E-08	1.30E-09	2.86E-05				
1786-RPFS	A	ControlNet Fiber repeater - short	26,461,760	3.78E-08	1.89E-08	95%	1.89E-09	1.70E-08	2200	3.59E-08	1.89E-09	4.16E-05				
1786-RPFM	A	repeater - medium	16,697,862	5.99E-08	2.99E-08	95%	2.99E-09	2.69E-08	2200	5.69E-08	2.99E-09	6.59E-05				
1786-RPFRL	A	ControlNet Fiber repeater - long	5,717,227	1.75E-07	8.75E-08	95%	8.75E-09	7.87E-08	2200	1.66E-07	8.75E-09	1.92E-04				
1786-RPCD	A	ControlNet Hub repeater	28,654,080	3.49E-08	1.74E-08	95%	1.74E-09	1.57E-08	2200	3.32E-08	1.74E-09	3.84E-05				
1786-RPA	B	ControlNet repeater adapter	11,826,146	8.46E-08	4.23E-08	95%	4.23E-09	3.81E-08	2200	8.03E-08	4.23E-09	9.30E-05				
1786-RPFRXL	B	repeater - extra long	11,373,440	8.79E-08	4.40E-08	95%	4.40E-09	3.96E-08	2200	8.35E-08	4.40E-09	9.67E-05				

Cat No.(1)(2)	Series	Description	Mean Time between Failure (MTBF)(2)	Common Terms(3)						1oo1 Configuration			1oo2 Configuration			
				λ(4)	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	Spurious Trip Rate STR	PFH(5)	PFD	Spurious Trip Rate STR	TGE	PFH(5)	PFD
1756-L61(7)	B	controller, 2 MB	1,000,053	1.00E-06	5.00E-07	95%	5.00E-08	4.50E-07	2200	9.50E-07	5.00E-08	1.10E-03				
1756-L62(7)	B	ControlLogix controller, 4 MB	1,034,830	9.66E-07	4.83E-07	95%	4.83E-08	4.35E-07	2200	9.18E-07	4.83E-08	1.06E-03				
1756-L63(7)	B	ControlLogix controller, 8 MB	1,055,910	9.47E-07	4.74E-07	95%	4.74E-08	4.26E-07	2200	9.00E-07	4.74E-08	1.04E-03				
1756-L63XT(7)	B	ControlLogix-XT controller, 8 MB	357,760	2.80E-06	1.40E-06	95%	1.40E-07	1.26E-06	2200	2.66E-06	1.40E-07	3.07E-03				
1756-L71(8)	B	ControlLogix controller, 2 MB		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	1661	2.91E-06	1.01E-07	2.20E-03				
1756-L72(8)	B	ControlLogix controller, 4 MB		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	1661	2.91E-06	1.01E-07	2.20E-03				
1756-L73(8)	B	ControlLogix controller, 8 MB	Calculated MTBF and PFD via FMEA	2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	1661	2.91E-06	1.01E-07	2.20E-03				
1756-L73XT(8)	B	ControlLogix-XT controller, 8 MB		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	1661	2.91E-06	1.01E-07	2.20E-03				
1756-L74(8)	B	ControlLogix controller, 16 MB		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	1661	2.91E-06	1.01E-07	2.20E-03	Not applicable			
1756-L75(8)	B	ControlLogix controller, 32 MB		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	1661	2.91E-06	1.01E-07	2.20E-03				
1756-L61S(7)	B	GuardLogix controller, 2 MB standard	1,000,053	1.00E-06	5.00E-07	95%	5.00E-08	4.50E-07	2200	9.50E-07	5.00E-08	1.10E-03				
1756-L62S(7)	B	GuardLogix controller, 4 MB standard	1,034,830	9.66E-07	4.83E-07	95%	4.83E-08	4.35E-07	2200	9.18E-07	4.83E-08	1.06E-03				
1756-L63S(7)	B	GuardLogix controller, 8 MB standard	1,055,910	9.47E-07	4.74E-07	95%	4.74E-08	4.26E-07	2200	9.00E-07	4.74E-08	1.04E-03				
1756-L71S(8)	B	GuardLogix controller, 2 MB standard		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	1661	2.91E-06	1.01E-07	2.20E-03				
1756-L72S(8)	B	GuardLogix controller, 4 MB standard	Calculated MTBF and PFD via FMEA	2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	1661	2.91E-06	1.01E-07	2.20E-03				
1756-L73S(8)	B	GuardLogix controller, 8 MB standard		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	1661	2.91E-06	1.01E-07	2.20E-03				
1756-L73SXT(8)	B	GuardLogix-XT controller, 8 MB standard		2.86E-06	1.42E-06, 1.44E-06	96%	1.01E-07	1.34E-06	1661	2.91E-06	1.01E-07	2.20E-03				

Table 23 - 5-Year PFD Calculations (Continued)

Cat No.(1)(2)	Series	Description	Mean Time between Failure (MTBF)(2)	Common Terms(3)						1oo1 Configuration			1oo2 Configuration			
				λ(4)	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	Spurious Trip Rate STR	PFH(5)	PFD	Spurious Trip Rate STR	TGE	PFH(5)	PFD
1756-CNB	E	ControlLogix ControlNet communication module	1,786,977	5.60E-07	2.80E-07	95%	2.80E-08	2.52E-07	2200	5.32E-07	2.80E-08	6.16E-04				
1756-CNBR	E	ControlLogix ControlNet redundant communication module	2,608,543	3.83E-07	1.92E-07	95%	1.92E-08	1.73E-07	2200	3.64E-07	1.92E-08	4.22E-04				
1756-CN2	B	ControlLogix ControlNet communication module	1,096,299	9.12E-07	4.56E-07	95%	4.56E-08	4.10E-07	2200	8.67E-07	4.56E-08	1.00E-03				
1756-CN2(8)	C	ControlLogix ControlNet communication module	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	1478.14	1.91E-06	6.62E-08	1.50E-03				
1756-CN2R	B	ControlLogix ControlNet redundant communication module	1,096,299	9.12E-07	4.56E-07	95%	4.56E-08	4.10E-07	2200	8.67E-07	4.56E-08	1.00E-03	Not applicable			
1756-CN2R(8)	C	ControlLogix ControlNet redundant communication module	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	1478.14	1.91E-06	6.62E-08	1.50E-03				
1756-CN2RXT	B	ControlLogix-XT ControlNet redundant communication module	1,980,160	5.05E-07	2.53E-07	95%	2.53E-08	2.27E-07	2200	4.80E-07	2.53E-08	5.56E-04				
1756-CN2RXT(8)	C	ControlLogix-XT ControlNet redundant communication module	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	1478.14	1.91E-06	6.62E-08	1.50E-03				
1756-DHRIO(9)	E	ControlLogix Data Highway Plus Remote I/O Module	2,503,396							3.79E-07	2.00E-08		7.59E-07			
1756-DHRIOXT(9)	E	ControlLogix-XT Data Highway Plus remote I/O module	2,503,396	Non-interference only						3.79E-07	2.00E-08	Not applicable	7.59E-07	Not applicable		
1756-DNB(9)	D	ControlLogix DeviceNet communication module	2,192,202							4.33E-07	2.28E-08		8.67E-07			
1756-ENBT(9)	A	ControlLogix EtherNet/IP communication module	2,088,198							4.55E-07	2.39E-08		9.10E-07			
1756-EN2T	C	ControlLogix EtherNet/IP communication module	1,312,712	7.62E-07	3.81E-07	95%	3.81E-08	3.43E-07	2200	7.24E-07	3.81E-08	8.38E-04				
1756-EN2T(9)	D	ControlLogix EtherNet/IP communication module	269,774	Non-interference only						3.71E-06	Not applicable		Not applicable			
1756-EN2TR	B	ControlLogix EtherNet/IP communication module with fault tolerance	3,664,960	2.73E-07	1.36E-07	95%	1.36E-08	1.23E-07	2200	2.59E-07	1.36E-08	3.00E-04				
1756-EN2TR(8)	C	ControlLogix EtherNet/IP communication module with fault tolerance	Calculated MTBF and PFD via FMEA	1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	1478.14	1.91E-06	6.62E-08	1.50E-03	3.82E-06	988.76	1.51E-09	3.19E-05
1756-EN2TRXT(8)	C	ControlLogix EtherNet/IP communication module with fault tolerance		1.97E-06	9.87E-07	96.6%	6.62E-08	9.21E-07	1478.14	1.91E-06	6.62E-08	1.50E-03	3.82E-06	988.76	1.51E-09	3.19E-05
1756-EN2TXT	C	ControlLogix-XT EtherNet/IP communication module	1,300,000	7.69E-07	3.85E-07	95%	3.85E-08	3.46E-07	2200	7.31E-07	3.85E-08	8.46E-04	Not applicable			

Table 23 - 5-Year PFD Calculations (Continued)

Cat No.[1][2]	Series	Description	Mean Time between Failure (MTBF)[2]	Common Terms[3]						1oo1 Configuration			1oo2 Configuration			
				λ[4]	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	Spurious Trip Rate STR	PFH[5]	PFD	Spurious Trip Rate STR	TGE	PFH[5]	PFD
1756-EN2TXT[9]	D	ControlLogix-XT EtherNet/IP communication module	269,774	Non-interference only						3.71E-06	Not applicable					
1756-EN3TR	B	ControlLogix EtherNet/IP communication module with fault tolerance	269,774	Non-interference only						3.71E-06	Not applicable					
1756-RM[9]	B	ControlLogix redundancy module	1,373,840	Non-interference only						6.91E-07	Not applicable					
1756-RMXT[9]	B	ControlLogix-XT redundancy module	980,096	Non-interference only						9.69E-07	Not applicable					
1756-RM2[9]	A	ControlLogix redundancy module	250,182	Non-interference only						4.00E-06	Not applicable					
1756-RM2XT[9]	A	ControlLogix-XT redundancy module	250,182	Non-interference only						4.00E-06	Not applicable					
1756-RM3[9]	A	ControlLogix redundancy module	213,749	Non-interference only						4.68E-06	Not applicable					
1756-RM3-2SFP[9]	A	ControlLogix redundancy module	213,749	Non-interference only						4.68E-06	Not applicable					
1756-RM3XT[9]	A	ControlLogix-XT redundancy module	213,749	Non-interference only						4.68E-06	Not applicable					
1756-SYNCH[9]	A	ControlLogix SynchLink Module	6,932,640	Non-interference only						1.37E-07	Not applicable		2.74E-07	Not applicable		
1756-IA16I	A	ControlLogix isolated V AC input module	20,801,920	4.81E-08	2.40E-08	80%	9.61E-09	1.44E-08	8770	3.85E-08	9.61E-09	2.11E-04	7.69E-08	5850	4.84E-10	1.06E-05
1756-IA8D	A	ControlLogix diagnostic V AC input module	15,966,080	6.26E-08	3.13E-08	80%	1.25E-08	1.88E-08	8770	5.01E-08	1.25E-08	2.75E-04	1.00E-07	5850	6.33E-10	1.38E-05
1756-IB16D	A	ControlLogix diagnostic V DC input module	30,228,640	3.31E-08	1.65E-08	80%	6.62E-09	9.92E-09	8770	2.65E-08	6.62E-09	1.45E-04	5.29E-08	5850	3.33E-10	7.28E-06
1756-IB16I	A	ControlLogix isolated V DC input module	81,443,094	1.23E-08	6.14E-09	80%	2.46E-09	3.68E-09	8770	9.82E-09	2.46E-09	5.38E-05	1.96E-08	5850	1.23E-10	2.70E-06
1756-IB16ISOE	A	ControlLogix isolated V DC Sequence Of Events input module	11,537,760	8.67E-08	4.33E-08	80%	1.73E-08	2.60E-08	8770	6.93E-08	1.73E-08	3.80E-04	1.39E-07	5850	8.79E-10	1.92E-05
1756-IB32	B	ControlLogix V DC input module	10,462,329	9.56E-08	4.78E-08	80%	1.91E-08	2.87E-08	8770	7.65E-08	1.91E-08	4.19E-04	1.53E-07	5850	9.70E-10	2.12E-05
1756-IF8	A	ControlLogix analog input module	8,699,254	1.15E-07	5.75E-08	80%	2.30E-08	3.45E-08	8770	9.20E-08	2.30E-08	5.04E-04	1.84E-07	5850	1.17E-09	2.55E-05
1756-IF8[8]	B	ControlLogix analog input module	Calculated MTBF and PFD via FMEA	9.43E-07	4.71E-07	79%	1.98E-07	2.73E-07	9233	7.45E-07	1.99E-07	4.4E-03	1.49E-06	6159	1.10E-08	2.4E-04
1756-IF8I[8]	A	ControlLogix isolated analog input module	2,337,541	4.28E-07	2.139E-07	77%	9.81E-08	1.16E-07	10054	3.3E-07	9.81E-08	2.15E-03	6.59E-07	6706	2.37E-09	4.89E-05
1756-IF8I[8]	B	ControlLogix isolated analog input module	Calculated MTBF and PFD via FMEA	5.83E-07	2.92E-07	78%	1.26E-07	1.66E-07	9445	4.58E-07	1.26E-07	2.77E-03	9.15E-07	6300	3.19E-09	6.51E-05
1756-IF8H	A	ControlLogix HART analog input module	1,291,978	7.74E-07	3.87E-07	80%	1.55E-07	2.32E-07	8770	6.19E-07	1.55E-07	3.39E-03	1.24E-06	5850	8.69E-09	1.84E-04
1756-IF8H	B	ControlLogix HART analog input module	Calculated MTBF and PFD via FMEA	9.75E-07	4.88E-07	92%	7.67E-08	4.11E-07	3456	Not applicable			2.77E-06	2307	4.07E-09	8.77E-05
1756-IF16	A	ControlLogix analog input module	4,592,506	2.18E-07	1.09E-07	80%	4.35E-08	6.53E-08	3514	1.74E-07	4.35E-08	3.83E-04	3.48E-07	2346	2.21E-09	1.93E-05
1756-IF16[8]	B	ControlLogix analog input module	Calculated MTBF and PFD via FMEA	9.43E-07	4.71E-07	79%	1.98E-07	2.73E-07	9233	7.45E-07	1.99E-07	4.4E-03	1.49E-06	6159	1.10E-08	2.4E-04
1756-IF16H	A	ControlLogix HART analog input module	442,914	2.26E-06	1.13E-06	80%	4.52E-07	6.77E-07	8770	1.81E-06	4.52E-07	9.90E-03	3.61E-06	5850	3.06E-08	6.13E-04
1756-IF16H	B	ControlLogix HART analog input module	Calculated MTBF and PFD via FMEA	1.08E-06	5.38E-07	92%	8.32E-08	4.54E-07	3398	Not applicable			3.06E-06	2268	4.43E-09	9.53E-05
1756-IF6CIS	A	ControlLogix isolated analog input module	2,654,080	3.77E-07	1.88E-07	80%	7.54E-08	1.13E-07	8770	3.01E-07	7.54E-08	1.65E-03	6.03E-07	5850	3.99E-09	8.59E-05

Table 23 - 5-Year PFD Calculations (Continued)

Cat No.[1][2]	Series	Description	Mean Time between Failure (MTBF)[2]	Common Terms[3] λ[4]	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	1oo1 Configuration Spurious Trip Rate STR	PFH[5]	PFD	1oo2 Configuration Spurious Trip Rate STR	TGE	PFH[5]	PFD
1756-IF6I	A	ControlLogix isolated analog input module	4,176,185	2.39E-07	1.20E-07	80%	4.79E-08	7.18E-08	8770	1.92E-07	4.79E-08	1.05E-03	3.83E-07	5850	2.49E-09	5.38E-05
1756-IH16ISOE	A	ControlLogix V DC Sequence Of Events input module	2,150,720	4.65E-07	2.32E-07	80%	9.30E-08	1.39E-07	8770	3.72E-07	9.30E-08	2.04E-03	7.44E-07	5850	4.99E-09	1.07E-04
1756-IR6I	A	ControlLogix isolated RTD input module	4,268,525	2.34E-07	1.17E-07	80%	4.69E-08	7.03E-08	8770				3.75E-07	5850	2.43E-09	5.26E-05
1756-IRT8I[8]	A	ControlLogix isolated RTD/ thermocouple input module	1,896,813	5.27E-07	2.636E-07	76%	1.274E-07	1.362E-07	10594				8.00E-07	7066	3.23E-09	6.58E-05
1756-IRT8I[8]	B	ControlLogix isolated RTD/ thermocouple input module	Calculated MTBF and PFD via FMEA	6.11E-07	3.06E-07	80%	1.24E-07	1.82E-07	8874	Not allowed for 1oo1 configurations			9.75E-07	5919	3.13E-09	6.39E-05
1756-IT6I	A	ControlLogix isolated thermocouple input module	3,957,824	2.53E-07	1.26E-07	80%	5.05E-08	7.58E-08	8770				4.04E-07	5850	2.63E-09	5.69E-05
1756-IT6I2	A	ControlLogix isolated enhanced thermocouple input module	2,720,046	3.68E-07	1.84E-07	80%	7.35E-08	1.10E-07	8770				5.88E-07	5850	3.89E-09	8.37E-05
1756-OA16I	A	ControlLogix V AC output module	32,891,456	3.04E-08	1.52E-08	80%	6.08E-09	9.12E-09	8770	2.43E-08	6.08E-09	1.33E-04	4.86E-08	5850	3.05E-10	6.69E-06
1756-OA8D	A	ControlLogix V AC diagnostic output module	11,311,040	8.84E-08	4.42E-08	80%	1.77E-08	2.65E-08	8770	7.07E-08	1.77E-08	3.88E-04	1.41E-07	5850	8.96E-10	1.96E-05
1756-OB16D	A	ControlLogix V DC diagnostic output module	8,884,374	1.13E-07	5.63E-08	80%	2.25E-08	3.38E-08	8770	9.00E-08	2.25E-08	4.94E-04	1.80E-07	5850	1.15E-09	2.50E-05
1756-OB16E	A	ControlLogix V DC electronically fused output module	14,997,714	6.67E-08	3.33E-08	80%	1.33E-08	2.00E-08	8770	5.33E-08	1.33E-08	2.92E-04	1.07E-07	5850	6.74E-10	1.47E-05
1756-OB16I	A	ControlLogix V DC isolated output module	7,388,160	1.35E-07	6.77E-08	80%	2.71E-08	4.06E-08	8770	1.08E-07	2.71E-08	5.94E-04	2.17E-07	5850	1.38E-09	3.01E-05
1756-OB32	A	ControlLogix V DC output module	2,681,316	3.73E-07	1.86E-07	80%	7.46E-08	1.12E-07	8770	2.98E-07	7.46E-08	1.64E-03	5.97E-07	5850	3.95E-09	8.50E-05
1756-OB8EI	A	ControlLogix V DC isolated electronically fused output module	14,019,200	7.13E-08	3.57E-08	80%	1.43E-08	2.14E-08	8770	5.71E-08	1.43E-08	3.13E-04	1.14E-07	5850	7.21E-10	1.58E-05
1756-OX8I	A	ControlLogix isolated relay output module	6,059,635	1.65E-07	8.25E-08	80%	3.30E-08	4.95E-08	8770	1.32E-07	3.30E-08	7.24E-04	2.64E-07	5850	1.69E-09	3.68E-05
1756-OW16I	A	ControlLogix isolated relay output module	13,695,899	7.30E-08	3.65E-08	80%	1.46E-08	2.19E-08	8770	5.84E-08	1.46E-08	3.20E-04	1.17E-07	5850	7.39E-10	1.61E-05
1756-OF4[8]	B	ControlLogix analog output module	Calculated MTBF and PFD via FMEA	1.03E-06	5.17E-07	78%	2.23E-07	2.93E-07	9470	8.11E-07	2.23E-07	4.9E-03	1.62E-06	6317	1.30E-08	2.7E-04
1756-OF8	A	ControlLogix analog output module	10,629,795	9.41E-08	4.70E-08	80%	1.88E-08	2.82E-08	8770	7.53E-08	1.88E-08	4.13E-04	1.51E-07	5850	9.55E-10	2.08E-05
1756-OF8[8]	B	ControlLogix analog output module	Calculated MTBF and PFD via FMEA	1.03E-06	5.17E-07	78%	2.23E-07	2.93E-07	9470	8.11E-07	2.23E-07	4.9E-03	1.62E-06	6317	1.30E-08	2.7E-04
1756-OF8I[8]	A	ControlLogix isolated analog output module	2,213,369	4.52E-07	2.259E-07	76%	1.08E-07	1.18E-07	10490	3.44E-07	1.08E-07	2.37E-03	6.87E-07	6997	2.65E-09	5.46E-05
1756-OF8I[8]	B	ControlLogix isolated analog output module	Calculated MTBF and PFD via FMEA	6.08E-07	3.04E-07	78%	1.37E-07	1.67E-07	9869	4.71E-07	1.37E-07	3.0E-03	9.42E-07	6583	3.53E-09	7.16E-05
1756-OF6VI	A	ControlLogix isolated analog output module	21,604,960	4.63E-08	2.31E-08	80%	9.26E-09	1.39E-08	8770	3.70E-08	9.26E-09	2.03E-04	7.41E-08	5850	4.66E-10	1.02E-05
1756-OF6CI	A	ControlLogix isolated analog output module	8,354,667	1.20E-07	5.98E-08	80%	2.39E-08	3.59E-08	8770	9.58E-08	2.39E-08	5.25E-04	1.92E-07	5850	1.22E-09	2.66E-05
1756-OF8H	A	ControlLogix HART analog output module	5,118,187	1.95E-07	9.77E-08	80%	3.91E-08	5.86E-08	8770	1.56E-07	3.91E-08	8.57E-04	3.13E-07	5850	2.01E-09	4.37E-05

Table 23 - 5-Year PFD Calculations (Continued)

Cat No.(1)(2)	Series	Description	Mean Time between Failure (MTBF)(2)	Common Terms(3)						1oo1 Configuration			1oo2 Configuration			
				λ(4)	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	Spurious Trip Rate STR	PFH(5)	PFD	Spurious Trip Rate STR	TGE	PFH(5)	PFD
1794-ACN15	D	FLEX I/O ControlNet adapter	8,223,684	1.22E-07	6.08E-08	80%	2.43E-08	3.65E-08	8770				1.95E-07	5850	1.24E-09	2.70E-05
1794-ACNR15	D	FLEX I/O ControlNet redundant adapter	8,223,684	1.22E-07	6.08E-08	80%	2.43E-08	3.65E-08	8770				1.95E-07	5850	1.24E-09	2.70E-05
1794-ACNR15XT	D	FLEX I/O-XT ControlNet adapter	8,223,684	1.22E-07	6.08E-08	80%	2.43E-08	3.65E-08	8770				1.95E-07	5850	1.24E-09	2.70E-05
1794-AENT	B	FLEX I/O EtherNet/IP adapter	1,779,827	5.62E-07	2.81E-07	80%	1.12E-07	1.69E-07	8770	Not allowed for 1oo1 configurations			8.99E-07	5850	6.12E-09	1.30E-04
1794-AENTR	A	FLEX I/O EtherNet/IP adapter, Ring media	1,268,070	7.89E-07	3.94E-07	80%	1.58E-07	2.37E-07	8770				1.26E-06	5850	8.87E-09	1.87E-04
1794-AENTRXT	A	FLEX I/O EtherNet/IP adapter, Ring media	1,268,070	7.89E-07	3.94E-07	80%	1.58E-07	2.37E-07	8770				1.26E-06	5850	8.87E-09	1.87E-04
1794-IB16	A	FLEX I/O 24V DC input module	179,506,158	5.57E-09	2.79E-09	80%	1.11E-09	1.67E-09	8770				8.91E-09	5850	5.58E-11	1.22E-06
1794-IB16XT	A	FLEX I/O-XT 24V DC input module	35,587,189	2.81E-08	1.40E-08	80%	5.62E-09	8.43E-09	8770				4.50E-08	5850	2.82E-10	6.18E-06
1794-IJ2	A	FLEX I/O counter module	55,344,640	1.81E-08	9.03E-09	80%	3.61E-09	5.42E-09	8770				2.89E-08	5850	1.81E-10	3.97E-06
1794-IJ2XT	A	FLEX I/O-XT counter module	11,714,128	8.54E-08	4.27E-08	80%	1.71E-08	2.56E-08	8770	Not allowed for 1oo1 configurations			1.37E-07	5850	8.65E-10	1.89E-05
1794-IP4	B	FLEX I/O counter module	22,027,200	4.54E-08	2.27E-08	80%	9.08E-09	1.36E-08	8770				7.26E-08	5850	4.57E-10	1.00E-05
1794-IB10XOB6	A	FLEX I/O 24V DC input/output module	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	8770				1.60E-08	5850	1.00E-10	2.19E-06
1794-IB10XOB6XT	A	FLEX I/O-XT 24V DC input/output module	22,202,487	4.50E-08	2.25E-08	80%	9.01E-09	1.35E-08	8770				7.21E-08	5850	4.54E-10	9.92E-06
1794-OB8EP	A	FLEX I/O 24V DC electronically fused output module	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	8770				1.60E-08	5850	1.00E-10	2.19E-06
1794-OB8EPXT	A	FLEX I/O-XT 24V DC electronically fused output module	14,771,049	6.77E-08	3.38E-08	80%	1.35E-08	2.03E-08	8770				1.08E-07	5850	6.84E-10	1.49E-05
1794-OB16	A	FLEX I/O 24V DC output module	54,322,632	1.84E-08	9.20E-09	80%	3.68E-09	5.52E-09	8770				2.95E-08	5850	1.85E-10	4.04E-06
1794-OB16P	A	FLEX I/O 24V DC protected output module	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	8770	Not allowed for 1oo1 configurations			1.60E-08	5850	1.00E-10	2.19E-06
1794-OB16PXT	A	FLEX I/O-XT 24V DC protected output module	26,709,401	3.74E-08	1.87E-08	80%	7.49E-09	1.12E-08	8770				5.99E-08	5850	3.77E-10	8.24E-06
1794-OW8	A	FLEX I/O isolated relay output module	29,088,895	3.44E-08	1.72E-08	80%	6.88E-09	1.03E-08	8770				5.50E-08	5850	3.46E-10	7.56E-06
1794-OW8XT	A	FLEX I/O-XT isolated relay output module	18,518,519	5.40E-08	2.70E-08	80%	1.08E-08	1.62E-08	8770				8.64E-08	5850	5.45E-10	1.19E-05

Table 23 - 5-Year PFD Calculations (Continued)

Cat No.[1][2]	Series	Description	Mean Time between Failure (MTBF)[2]	Common Terms[3]						1oo1 Configuration			1oo2 Configuration			
				λ[4]	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	Spurious Trip Rate STR	PFH[5]	PFD	Spurious Trip Rate STR	TGE	PFH[5]	PFD
1794-IE8	B	FLEX I/O analog input module	18,914,770	5.29E-08	2.64E-08	80%	1.06E-08	1.59E-08	8770				8.46E-08	5850	5.33E-10	1.17E-05
1794-IE8XT	B	FLEX I/O-XT analog input module	14,041,000	7.12E-08	3.56E-08	80%	1.42E-08	2.14E-08	8770				1.14E-07	5850	7.20E-10	1.57E-05
1794-IF4I	A	FLEX I/O isolated analog input module	9,885,959	1.01E-07	5.06E-08	80%	2.02E-08	3.03E-08	8770				1.62E-07	5850	1.03E-09	2.24E-05
1794-IF4IXT	A	FLEX I/O-XT isolated analog input module	7,297,140	1.37E-07	6.85E-08	80%	2.74E-08	4.11E-08	8770				2.19E-07	5850	1.40E-09	3.05E-05
1794-IF4ICFXT	A	FLEX I/O-XT isolated analog input module	7,297,140	1.37E-07	6.85E-08	80%	2.74E-08	4.11E-08	8770				2.19E-07	5850	1.40E-09	3.05E-05
1794-IF8IHNFXT	A	Flex, 8 Isolated HART analog input, extended env	926,808	1.08E-06	5.39E-07	80%	2.16E-07	3.24E-07	8770				1.73E-06	5850	1.26E-08	2.64E-04
1794-IR8	A	FLEX I/O RTD input module	5,016,231	1.99E-07	9.97E-08	80%	3.99E-08	5.98E-08	8770				3.19E-07	5850	2.06E-09	4.46E-05
1794-IR8XT	A	FLEX I/O-XT RTD input module	9,585,890	1.04E-07	5.22E-08	80%	2.09E-08	3.13E-08	8770	Not allowed for 1oo1 configurations			1.67E-07	5850	1.06E-09	2.31E-05
1794-IRT8	B	FLEX I/O RTD/ Thermocouple input module	1,407,269	7.11E-07	3.55E-07	80%	1.42E-07	2.13E-07	8770				1.14E-06	5850	7.91E-09	1.67E-04
1794-IRT8XT	B	FLEX I/O-XT RTD/ Thermocouple input module	8,204,792	1.22E-07	6.09E-08	80%	2.44E-08	3.66E-08	8770				1.95E-07	5850	1.24E-09	2.71E-05
1794-IT8	A	FLEX I/O Thermocouple input module	2,097,509	4.77E-07	2.38E-07	80%	9.54E-08	1.43E-07	8770				7.63E-07	5850	5.13E-09	1.10E-04
1794-IF2XOF2I	A	FLEX I/O isolated analog input/ output module	8,464,844	1.18E-07	5.91E-08	80%	2.36E-08	3.54E-08	8770				1.89E-07	5850	1.20E-09	2.62E-05
1794-IF2XOF2IXT	A	FLEX I/O-XT isolated analog input/output module	6,317,918	1.58E-07	7.91E-08	80%	3.17E-08	4.75E-08	8770				2.53E-07	5850	1.62E-09	3.53E-05
1794-IE4XOE2XT	B	FLEX I/O-XT analog input/output module	11,800,802	8.47E-08	4.24E-08	80%	1.69E-08	2.54E-08	8770				1.36E-07	5850	8.59E-10	1.87E-05
1794-OE4	B	FLEX I/O analog output module	18,433,610	5.42E-08	2.71E-08	80%	1.08E-08	1.63E-08	8770				8.68E-08	5850	5.47E-10	1.20E-05
1794-OE4XT	B	FLEX I/O-XT analog output module	11,381,744	8.79E-08	4.39E-08	80%	1.76E-08	2.64E-08	8770	Not allowed for 1oo1 configurations			1.41E-07	5850	8.91E-10	1.94E-05
1794-OF4I	A	FLEX I/O analog output module	23,884,409	4.19E-08	2.09E-08	80%	8.37E-09	1.26E-08	8770				6.70E-08	5850	4.21E-10	9.22E-06
1794-OF4IXT	A	FLEX I/O-XT analog output module	5,493,902	1.82E-07	9.10E-08	80%	3.64E-08	5.46E-08	8770				2.91E-07	5850	1.87E-09	4.07E-05
1794-TB3	A	FLEX I/O terminal base unit	250,000,000	4.00E-09	2.00E-09	80%	8.00E-10	1.20E-09	8770				6.40E-09	5850	4.00E-11	8.77E-07
1794-TB3G	A	FLEX I/O cage-clamp generic terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	8770				1.60E-08	5850	1.00E-10	2.19E-06
1794-TB3GS	A	FLEX I/O spring-clamp generic terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	8770				1.60E-08	5850	1.00E-10	2.19E-06
1794-TB3S	A	FLEX I/O terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	8770				1.60E-08	5850	1.00E-10	2.19E-06
1794-TB3T	A	FLEX I/O temperature terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	8770	Not allowed for 1oo1 configurations			1.60E-08	5850	1.00E-10	2.19E-06
1794-TB3TS	A	FLEX I/O spring-clamp temperature terminal base unit	52,312,000	1.91E-08	9.56E-09	80%	3.82E-09	5.73E-09	8770				3.06E-08	5850	1.92E-10	4.20E-06
1794-TBN	A	FLEX I/O NEMA terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	8770				1.60E-08	5850	1.00E-10	2.19E-06
1794-TBNF	A	FLEX I/O NEMA fused terminal base unit	100,000,000	1.00E-08	5.00E-09	80%	2.00E-09	3.00E-09	8770				1.60E-08	5850	1.00E-10	2.19E-06

Table 23 - 5-Year PFD Calculations (Continued)

Cat No.(1)(2)	Series	Description	Mean Time between Failure (MTBF)(2)	Common Terms(3)						1oo1 Configuration			1oo2 Configuration			
				λ(4)	λs, λd	Safe Failure Fraction (SFF) %	λdu	λdd	TCE1oo1	Spurious Trip Rate STR	PFH(5)	PFD	Spurious Trip Rate STR	TGE	PFH(5)	PFD
1492-TIFM40F-F24A-2(9)	A	DC input termination board	7,779,000	Non-interference only						7.04E-08	Not applicable		1.03E-07	Not applicable		
1492-TAIFM16-F-3(9)	A	Analog input termination board	11,362,000							7.90E-08			7.04E-08			
1492-TIFM4OF-24-2(9)	A	DC output termination board	10,127,000							0.00E+00			0.00E+00			

(1) Some catalog numbers have a K suffix. This indicates a version of the product that has conformal coating. These K versions have the same SIL 2 certification as the non-K versions.
(2) MTBF measured in hours unless calculated (as noted). Field return values – January 2012.
(3) Calculations performed on a per module basis.
(4) λ = Failure Rate = 1/MTBF.
(5) Demand rate must be less than 10 per year
(6) Average of 1756-A4, -A7, -A10, -A13, and -A17 chassis.
(7) Suitable for use only in applications that require compliance with IEC 61508 1999 Edition 1
(8) Calculated MTBF and PFD by FMEA to 61508-2010.
(9) SIL 2-rated for non-interference in the chassis. Data not required within a safety function.

Use Component Values to Calculate System PFD

The system PFD value is calculated by totaling the PFD value of each component in the system. To calculate a system PFD value, use this equation:

modA PFD + modB PFD + modC PFD = system PFD

where mod*X* PFD is the PFD value for one component or module in the system. When calculating your system PFD, verify that all components that are used in the system are totaled.

Example: 1-year PFD Calculation for a ControlLogix System (1oo1 Configuration)

This example shows an example of a PFD calculation for a traditional ControlLogix system in a fail-safe configuration. This example system uses one chassis for the controller and a second chassis for the I/O. For an example, see the top two chassis in Figure 3 on page 17.

Cat. No.	Description	Calculated
1756-IB16D	ControlLogix V DC diagnostic input module	1.46E-06 (1oo2)
1756-EN2TR Series C	ControlLogix EtherNet/IP communication module - I/O chassis	3.00E-04 (1oo1)
1756-L72	ControlLogix controller, 4 MB	4.50E-04 (1oo1)
1756-EN2TR Series C	ControlLogix EtherNet/IP communication module - controller chassis	3.00E-04 (1oo1)
1756-OB16D	ControlLogix V DC diagnostic output module	4.97E-06 (1oo2)(1)
Total safety loop PFD:		1.056E-03
Percent of SIL 2 budget:		10.56%

(1) 1oo2 represents using a 1756-OB16D module to control the SIL 2 actuator and using a second 1756-OB16D module to control the secondary relay output.

Example: 1-year PFD Calculation for a ControlLogix System (1oo2 Configuration)

See Figure 6 on page 20 for a system diagram of the example calculation that is shown here.

Cat. No.	Description	Calculated
1756-IB16D	ControlLogix V DC diagnostic input module	1.46E-06 (1oo2)
1756-EN2TR Series C	ControlLogix EtherNet/IP communication module - I/O chassis	6.11E-06 (1oo2)(1)
1756-L72	ControlLogix controller, 4 MB	4.50E-04 (1oo1)
1756-EN2TR Series C	ControlLogix EtherNet/IP communication module - controller chassis	6.11E-06 (1oo2)
1756-OB16D	ControlLogix V DC diagnostic output module	4.97E-06 (1oo2)
Total safety loop PFD:		4.69E-04
Percent of SIL 2 budget:		4.69%

(1) 1oo2 is being used because the I/O modules are being split among two chassis.

Notes:

PFD and PFH Calculations for 1715 Redundant I/O Modules

About PFD and PFH Calculations

The tables and examples in this document provide failure rates and PFH and PFDavg channel data. You can use the data to calculate SIL performance for SIFs using combinations of 1715 I/O modules in applications with the following characteristics:

- Mean time to restoration (MTTR) is twenty four hours.
- Mean repair time (MRT) is twenty four hours.
- Proof test interval (T1) is 20 years.
- Common cause failure rate (ß) is 1%.
- Common cause failure rate dangerous (ßd) is 0.5%.
- Mission Time is 20 years.

Where appropriate, the data is provided for Single and Dual module configurations. If a de-energize to action system is configured to provide a shutdown on the first fault, the MTTR has a negligible effect, hence, the tables in the PFD Data can be used for any MTTR.

Assumptions

The following assumptions apply to the PFD and PFH calculations of the 1715 system:

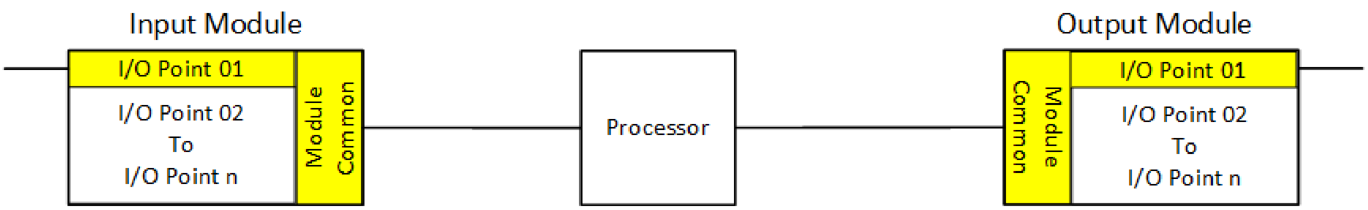
- PFD and PFH values in this manual are calculated with formulas that are explained in IEC 61508, Part 6, Annex B. For more information about calculating PFD values for your system, see IEC 61508, Part 6.
- Base units and termination assemblies are included in the module calculations or the binding and peer-to-peer communications data.
- The random hardware failure rates assume the ambient temperature of the environment in which the system is operating is 40 °C (104 °F). System operation at an elevated ambient is likely to have a detrimental effect on failure rates.
- Exposure to Neutrons is assumed to be at sea level (NY, NY) in common with industry standard (JESD89A). The exposure to Neutrons experienced by a system under use at altitude is expected to be at much greater levels.
- Capacitors are operated at 50% of the maximum ratings.
- The mission time is assumed to be 20 years.
- The Module Failure Rates are the sum of the individual component failure rates for every component in the product.
- The λ values are calculated based on the internal architecture of the products for an individual SIF.
- For I/O Modules, the Common Part and the I/O Point Part λs are calculated separately.
- $ß = 1\%$, $ß_D = 0.5\%$

I/O Module Common Part and I/O Point Part

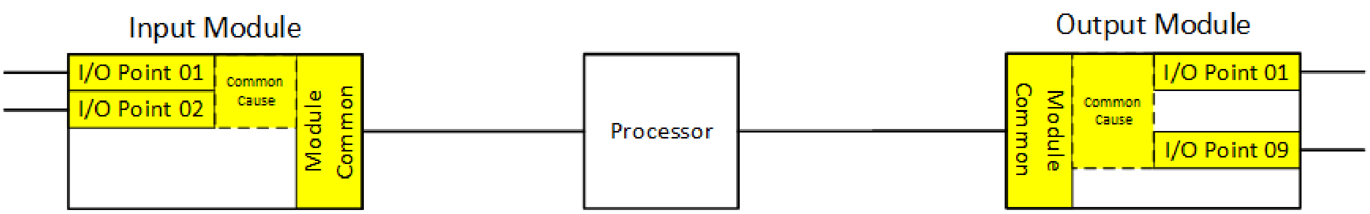
In addition to the Single and Dual data, the values in the tables are provided in three forms for I/O modules:

- Common Part
- I/O Point Part
- Common + 1 I/O Point

The Common + 1 I/O Point values can be used when one I/O point on a module is used in a Safety Function.



When multiple I/O on the same module are used in a Safety Function, the Common Part and I/O Point Part values can be used.



Module failure rates

See this table for information about module failure rates.

Module	Module Description		MTBF Years	FPMH
1715-AENTR	Ethernet adapter	-	45.72	2.50
1715-IB16D	16-channel digital input module	Common + 1 I/O Point	106.24	1.07
		Common + All Points	51.11	2.23
1715-IF16	16-channel analog input module	Common + 1 I/O Point	106.24	1.07
		Common + All Points	51.11	2.23
1715-OB8DE	8-channel digital output module	Common + 1 I/O Point	106.24	1.07
		Common + All Points	51.11	2.23
1715-OF8I	8-channel analog output module	Common + 1 I/O Point	106.24	1.07
		Common + All Points	51.11	2.23

1715 Failure Rates

See these tables for information about 1715 failure rates.

Table 24 - De-energize to Action Failure Rates

Module	Module Configuration		λs	λd	λsu	λdu	λsd	λdd
1715-AENTR	Duplex Adapter		1.26E-08	1.27E-08	1.51E-10	1.53E-10	1.24E-08	1.26E-08
1715-IB16D Digital Input	Simplex	Common	4.98E-07	4.99E-07	5.08E-10	5.08E-10	4.98E-07	4.98E-07
		1 IO Point	3.85E-08	3.88E-08	3.15E-10	3.18E-10	3.82E-08	3.85E-08
	Duplex	Common	2.60E-09	2.69E-09	9.07E-11	9.40E-11	2.51E-09	2.60E-09
		1 IO Point	3.11E-10	4.04E-10	7.10E-11	9.20E-11	2.40E-10	3.11E-10
1715-IF16 Analog Input	Single	Common	4.98E-07	4.99E-07	5.08E-10	5.08E-10	4.98E-07	4.98E-07
		1 IO Point	3.85E-08	3.88E-08	3.15E-10	3.18E-10	3.82E-08	3.85E-08
	Dual	Common	2.60E-09	2.69E-09	9.07E-11	9.40E-11	2.51E-09	2.60E-09
		1 IO Point	3.11E-10	4.04E-10	7.10E-11	9.20E-11	2.40E-10	3.11E-10
1715-OB8DE Digital Output	Single	Common	1.21E-06	2.31E-08	1.56E-08	2.99E-10	1.19E-06	2.28E-08
		1 IO Point	2.04E-08	6.78E-10	5.59E-12	1.86E-13	2.04E-08	6.77E-10
	Dual	Common	3.49E-09	4.09E-09	5.11E-10	5.98E-10	2.98E-09	3.49E-09
		1 IO Point	7.35E-11	7.39E-11	3.69E-13	3.71E-13	7.31E-11	7.35E-11

Table 24 - De-energize to Action Failure Rates

1715-OF8I Analog Output	Single	Common	5.27E-08	5.31E-08	4.11E-10	4.15E-10	5.23E-08	5.27E-08
		1 IO Point	7.41E-08	1.38E-07	5.00E-11	9.34E-11	7.40E-08	1.38E-07
	Dual	Common	3.53E-10	1.18E-09	2.47E-10	8.29E-10	1.05E-10	3.53E-10
		1 IO Point	7.48E-10	9.35E-10	1.49E-10	1.87E-10	5.98E-10	7.48E-10

Table 25 - Energize to Action Failure Rates

Module	Module Description		λs	λd	λsu	λdu	λsd	λdd
1715-AENTR	Duplex Adapter		1.11E-08	1.13E-08	2.38E-10	2.43E-10	1.08E-08	1.11E-08
1715-IB16D Digital Input	Simplex	Common	5.22E-07	5.23E-07	7.62E-10	7.63E-10	5.21E-07	5.22E-07
		1 IO Point	3.85E-08	3.88E-08	3.15E-10	3.18E-10	3.82E-08	3.85E-08
	Duplex	Common	2.56E-09	2.66E-09	9.31E-11	9.66E-11	2.47E-09	2.56E-09
		1 IO Point	3.11E-10	4.51E-10	9.63E-11	1.39E-10	2.15E-10	3.11E-10
1715-IF16 Analog Input	Single	Common	5.22E-07	5.23E-07	7.62E-10	7.63E-10	5.21E-07	5.22E-07
		1 IO Point	3.85E-08	3.88E-08	3.15E-10	3.18E-10	3.82E-08	3.85E-08
	Dual	Common	2.56E-09	2.66E-09	9.31E-11	9.66E-11	2.47E-09	2.56E-09
		1 IO Point	3.11E-10	4.51E-10	9.63E-11	1.39E-10	2.15E-10	3.11E-10
1715-OB8DE Digital Output	Single	Common	2.39E-06	2.23E-07	7.74E-09	7.22E-10	2.38E-06	2.22E-07
		1 IO Point	2.94E-08	1.57E-09	8.06E-12	4.30E-13	2.94E-08	1.57E-09
	Dual	Common	5.16E-06	8.25E-08	8.01E-09	1.28E-10	5.16E-06	8.23E-08
		1 IO Point	6.22E-08	8.77E-11	6.02E-10	8.49E-13	6.16E-08	8.69E-11
1715-OF8I Analog Output	Single	Common	8.11E-07	8.13E-07	1.51E-09	1.51E-09	8.10E-07	8.11E-07
		1 IO Point	5.39E-08	1.57E-07	4.78E-11	1.39E-10	5.38E-08	1.57E-07
	Dual	Common	3.25E-06	7.73E-09	6.54E-09	1.55E-11	3.25E-06	7.71E-09
		1 IO Point	4.21E-07	2.23E-09	2.63E-10	1.39E-12	4.21E-07	2.23E-09

PFH and PFD Data—24-Hour MTTR

The following table provides the probability of failures per hour and the probability of failures upon demand for the energize to action and de-energize to action SIF configurations. The Mission Time is 20 years. The table includes PFD and PFH values when two inputs or outputs are used in a 1oo2 configuration. Their values are provided when the 1oo2 I/O are connected to the same module and when the 1oo2 I/O are connected to two different modules. A ß value of 1% and a $ß_D$ of 0.5% are used in the 1oo2 calculations.

Table 26 - PFD Data for a SIF with Mission Time = 20 years

			De-energize to action		Energize to action	
Module	Module Configuration		PFHde	PFDde	PFHe	PFDe
1715-AENTR	Duplex Adapter		1.53E-10	1.37E-05	2.43E-10	2.16E-05
1715-IB16D Digital Input	Simplex	Common + 1 I/O Point	8.26E-10	8.53E-05	1.08E-09	1.08E-04
		Common Part	5.08E-10	5.65E-05	7.63E-10	7.94E-05
		I/O Point Part	3.18E-10	2.88E-05	3.18E-10	2.88E-05
		1oo2 Same Module	5.12E-10	5.68E-05	7.66E-10	7.97E-05
		1oo2 Different Module	8.40E-12	7.99E-07	3.20E-12	2.84E-07
	Duplex	Common + 1 I/O Point	1.86E-10	1.64E-05	2.36E-10	2.07E-05
		Common Part	9.40E-11	8.29E-06	9.66E-11	8.52E-06
		I/O Point Part	9.20E-11	8.07E-06	1.39E-10	1.22E-05
		1oo2 Same Module	9.49E-11	8.38E-06	9.80E-11	8.64E-06
		1oo2 Different Module	1.87E-12	1.64E-07	1.40E-12	1.22E-07

Table 26 - PFD Data for a SIF with Mission Time = 20 years (Continued)

1715-IF16 Analog Input	Simplex	Common + 1 I/O Point	8.26E-10	8.53E-05	1.08E-09	1.08E-04
		Common Part	5.08E-10	5.65E-05	7.63E-10	7.94E-05
		I/O Point Part	3.18E-10	2.88E-05	3.18E-10	2.88E-05
		1oo2 Same Module	5.12E-10	5.68E-05	7.66E-10	7.97E-05
		1oo2 Different Module	8.40E-12	7.99E-07	3.20E-12	2.84E-07
	Duplex	Common + 1 I/O Point	1.86E-10	1.64E-05	2.36E-10	2.07E-05
		Common Part	9.40E-11	8.29E-06	9.66E-11	8.52E-06
		I/O Point Part	9.20E-11	8.07E-06	1.39E-10	1.22E-05
		1oo2 Same Module	9.49E-11	8.38E-06	9.80E-11	8.64E-06
		1oo2 Different Module	1.87E-12	1.64E-07	1.40E-12	1.22E-07
1715-OB8DE Digital Output	Simplex	Common + 1 I/O Point	2.99E-10	2.68E-05	7.23E-10	6.87E-05
		Common Part	2.99E-10	2.67E-05	7.22E-10	6.86E-05
		I/O Point Part	1.86E-13	3.25E-08	4.30E-13	7.52E-08
		1oo2 Same Module	2.99E-10	2.67E-05	7.22E-10	6.86E-05
		1oo2 Different Module	3.01E-12	2.66E-07	4.30E-15	5.64E-10
	Duplex	Common + 1 I/O Point	5.98E-10	5.25E-05	1.29E-10	1.33E-05
		Common Part	5.98E-10	5.25E-05	1.28E-10	1.32E-05
		I/O Point Part	3.71E-13	3.43E-08	8.49E-13	7.64E-08
		1oo2 Same Module	5.98E-10	5.25E-05	1.28E-10	1.32E-05
		1oo2 Different Module	6.05E-12	5.28E-07	8.49E-15	7.54E-10
1715-OF8I Analog Output	Simplex	Common + 1 I/O Point	5.08E-10	4.91E-05	1.65E-09	1.68E-04
		Common Part	4.15E-10	3.76E-05	1.51E-09	1.52E-04
		I/O Point Part	9.34E-11	1.15E-05	1.39E-10	1.60E-05
		1oo2 Same Module	4.15E-10	3.77E-05	1.51E-09	1.52E-04
		1oo2 Different Module	5.13E-12	4.71E-07	1.40E-12	1.41E-07
	Duplex	Common + 1 I/O Point	1.02E-09	8.90E-05	1.69E-11	1.72E-06
		Common Part	8.29E-10	7.27E-05	1.55E-11	1.55E-06
		I/O Point Part	1.87E-10	1.64E-05	1.39E-12	1.76E-07
		1oo2 Same Module	8.31E-10	7.28E-05	1.55E-11	1.55E-06
		1oo2 Different Module	1.03E-11	9.01E-07	1.39E-14	1.49E-09

Communications Data

The PFH value for the I/O Communications Data with the Controller is PFH = 9.3E-10.

Safe Failure Fraction (SFF) and Hardware Fault Tolerance (HFT)

The following tables provide the SFF and HFT data for SIF configurations energize to action and de-energize to action mode.

SFFde applies to a normally energized system that is de-energized to action.

Table 27 - Module SFFde, SFFe

Module	Module Description	SFFde	SFFe
1715-AENTR	Ethernet adapter redundant module	>99%	>99%
1715-IB16D	16-channel digital input module	>99%	>99%
1715-IF16	16-channel analog input module	>99%	>99%
1715-OB8DE	8-channel digital output module	>99%	>99%
1715-OF8I	8-channel analog output module	>99%	>99%

Table 28 - Module HFT

Module	Module Description	Simplex	Dual
1715-AENTR	Ethernet adapter redundant module	0	1
1715-IB16D	16-channel digital input module	0	1

Table 28 - Module HFT

1715-IF16	16-channel analog input module	0	1
1715-OB8DE	8-channel digital output module	1	1
1715-OF8I	8-channel analog output module	1	1

System Configurations

The PFH and PFD calculations are derived from IEC61508-6:2010, and the

Examples below show how the calculations are used to define the probability of failure for a Safety Instrumented Function.

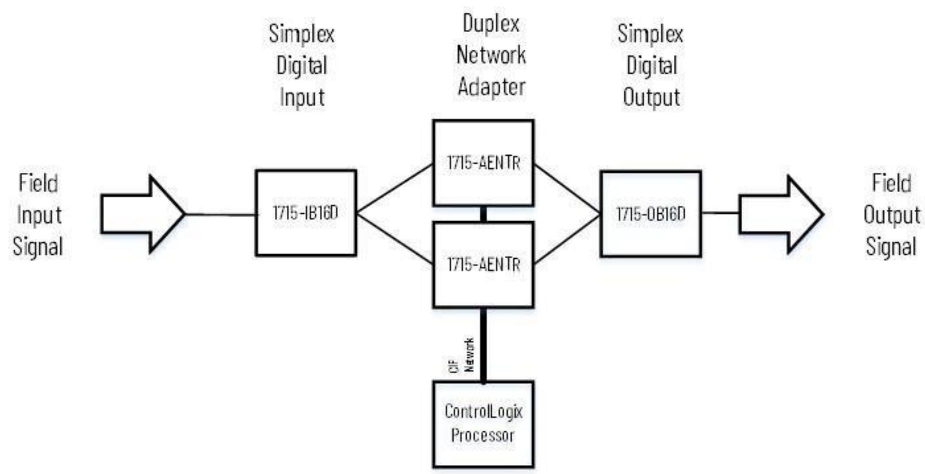
IMPORTANT The Soft Error values used to calculate PFD/PFH figures are, in line with industry common practice and JESD89a, calculated with Neutron flux values at sea level (NY, NY).

Values that are measured at high altitude would be expected to yield worse values. Similarly subsea applications are likely to experience lower values of Neutron flux.

Contact Rockwell Automation for additional information.

Example 1

This diagram illustrates a SIL 2 SIF with one signal input and one signal output; it has a Mission Time of 20 years and an MTTR of 24 hours, it is configured as a de-energized to action arrangement.



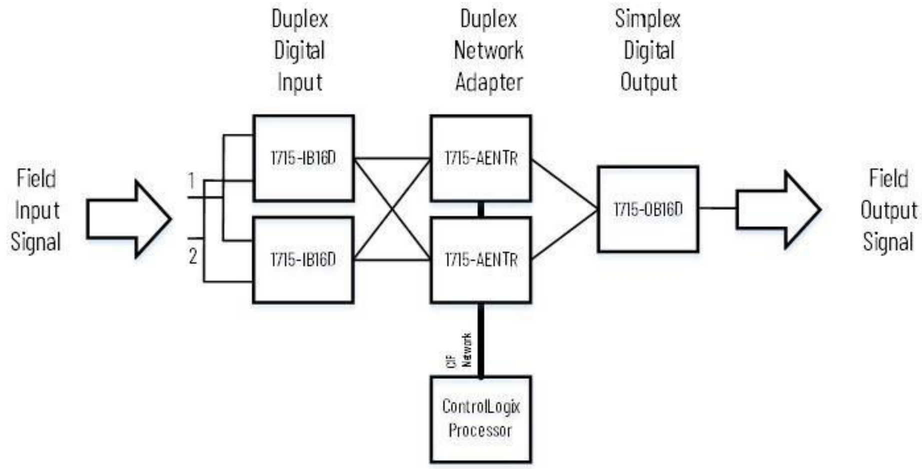
See Table 26.

1715 SIF PFDavg = PFDavg (1715-IB16D Single, Common + 1 I/O Point)
+ PFDavg (1715-AENTR Dual)
+ PFDavg (1715-OB16D Single, Common + 1 I/O Point)
+ PFDavg (ControlLogix Controller)

= 8.53E-05 + 1.37E-05 + 2.68E-05 + PFDavg (ControlLogix Controller)
= 1.26E-04 + PFDavg (ControlLogix Controller)

Example 2

This diagram illustrates a SIL 2 SIF with 2 inputs that are configured as 1oo2 on dual-input modules and 1 output with a Mission Time of 20 years and MTTR = 24 hours, configured as 1oo2 de-energize to action.



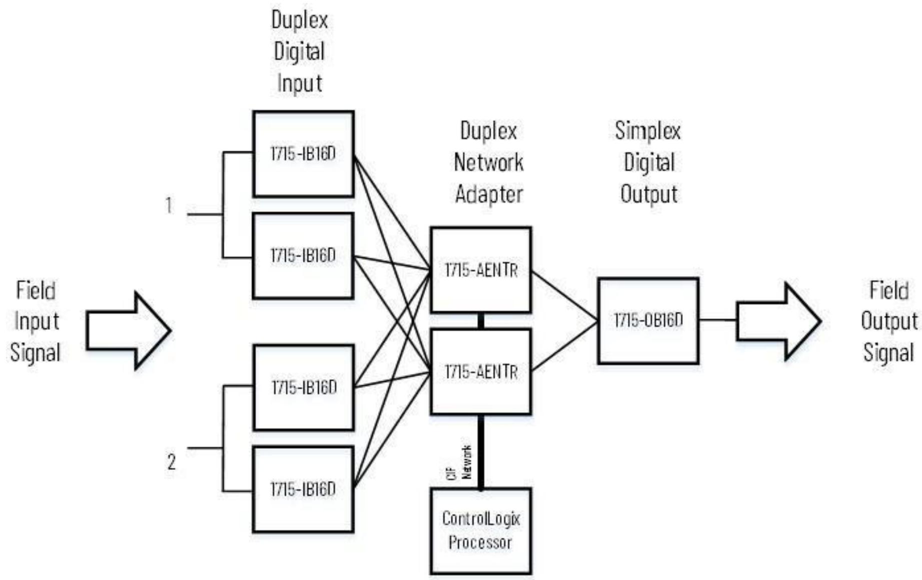
See Table 26.

1715 SIF PFDavg = PFDavg (1715-IB16D Dual, 1oo2 Same Module)
+ PFDavg (1715-AENTR Dual)
+ PFDavg (1715-OB16D Single, Common + 1 I/O Point)
+ PFDavg (ControlLogix Controller)

= 8.38E-06 + 1.37E-05 + 2.68E-05 + PFDavg (ControlLogix Controller)
= 4.89E -05 + PFDavg (ControlLogix Controller)

Example 3

This diagram illustrates a SIL 2 SIF with two inputs on dual-input modules and one output, with a Mission Time of 20 years and MTTR = 24 hours. The two inputs are configured as 1oo2 de-energize to action.



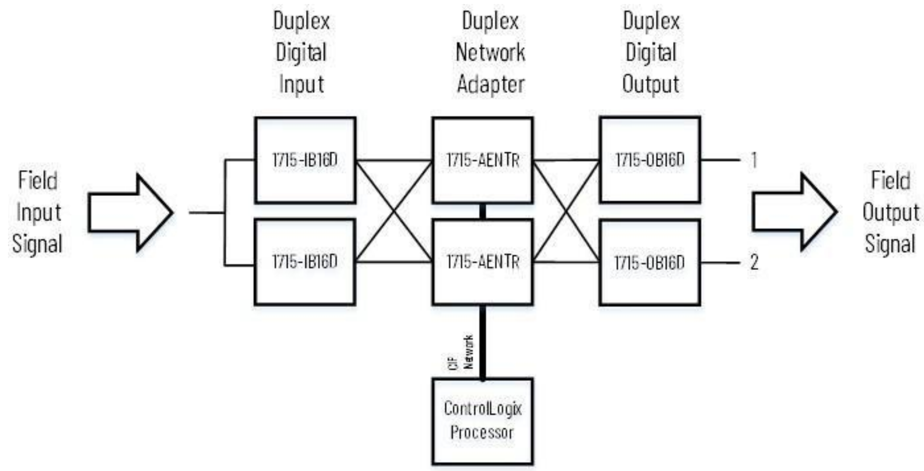
See Table 26.

1715 SIF PFDavg = PFDavg (1715-IB16D Dual, 1oo2 Different Modules)
+ PFDavg (1715-AENTR Dual)
+ PFDavg (1715-OB16D Single, Common + 1 I/O Point)
+ PFDavg (ControlLogix Controller)

= 7.99E-07 + 1.37E-05 + 2.68E-05 + PFDavg (ControlLogix Controller)
= 4.13E-05 + PFDavg (ControlLogix Controller)

Example 4

This diagram illustrates a SIL 2 SIF with one dual-input and two outputs, with a Mission Time of 20 years and MTTR = 24 hours. The two outputs are configured as 1oo2 de-energize to action.



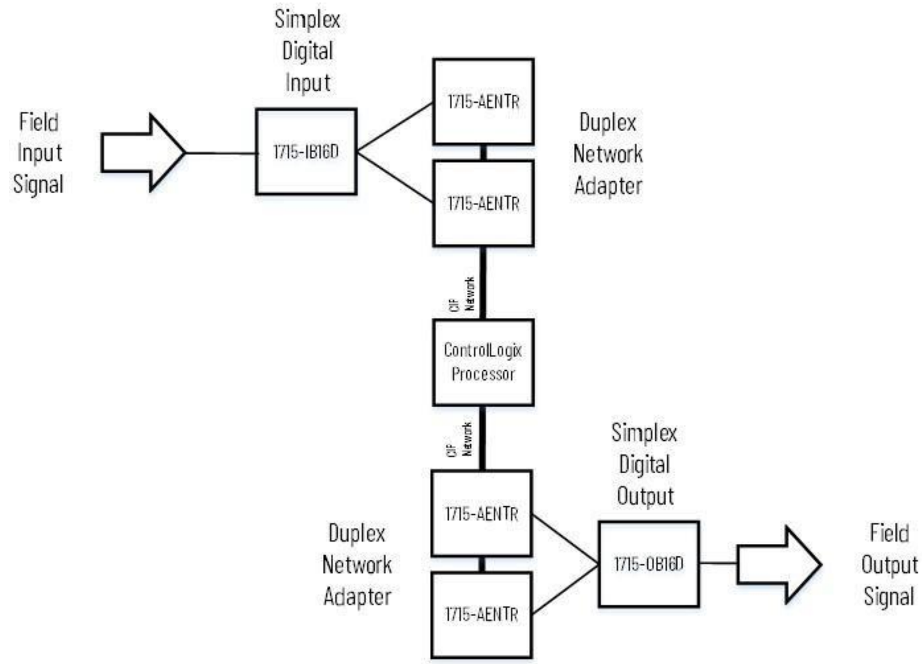
See Table 26.

1715 SIF PFDavg = PFDavg (1715-IB16D Dual, Common + 1 I/O Point)
+ PFDavg (1715-AENTR Dual)
+ PFDavg (1715-OB16D Dual, 1oo2 Same Module)
+ PFDavg (ControlLogix Controller)

= 1.64E-05 + 1.37E-05 + 5.25E-05 + PFDavg (ControlLogix Controller
= 8.26E-05 + PFDavg (ControlLogix Controller)

Example 5

This diagram illustrates a SIL 2 SIF distributed between two 1715 racks and a ControlLogix® controller. It has one signal input, one signal output, a Mission Time of 20 years, and an MTTR of 24 hours. It is configured as a de-energize to action arrangement.



See Table 26.

1715 SIF PFDavg = PFDavg (1715-IB16D Dual, Common + 1 I/O Point)
+ PFDavg (1715-AENTR Dual)
+ PFDavg (ControlLogix Controller)
+ PFDavg (1715-AENTR Dual)
+ PFDavg (1715-OB16D Single, Common + 1 I/O Point)

= 8.53E-05 + 1.37E-05 + PFDavg (ControlLogix Controller) + 1.37E-05 + 2.68E-05
= 1.40E-04 + PFDavg (ControlLogix Controller)

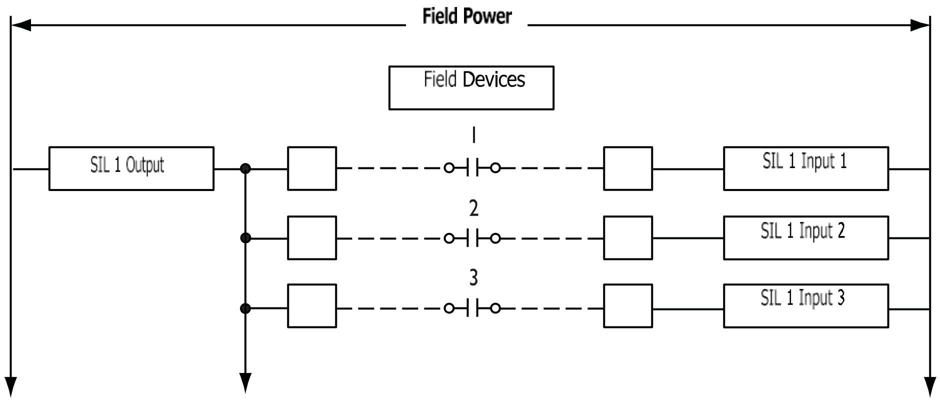
1756 ControlLogix and 1794 FLEX I/O Modules in SIL 1 Applications

If you plan to use the 1756 ControlLogix® I/O or the 1794 FLEX™ I/O modules in a SIL 1 1oo1 configuration, Table 29 guidelines must be implemented, including either the use diagnostic modules or implementing appropriate field diagnostics as defined here for limited high demand applications with up to 10 demands per year.

- Field diagnostics must execute once every 8 hours for limited high demand applications with up to 10 demands per year.
- An output or other sensing device must be used to provide field power control to the digital inputs. See the SIL 2 output guidelines in Chapter 5.
- When determining the safety reaction time, consider the time that a diagnostic takes to execute. Safety demands are not detectable if they occur during a diagnostic.

  The diagnostic you implement must monitor the ability of all SIL 1 inputs to detect a change of state. One example method is to turn off the output and make sure that all SIL 1 inputs detect the loss of signal within a short period. Then, when the output turns back on, make sure that all SIL 1 inputs properly detect the change. Consider and mitigate any impact to your system while the diagnostic is executing.

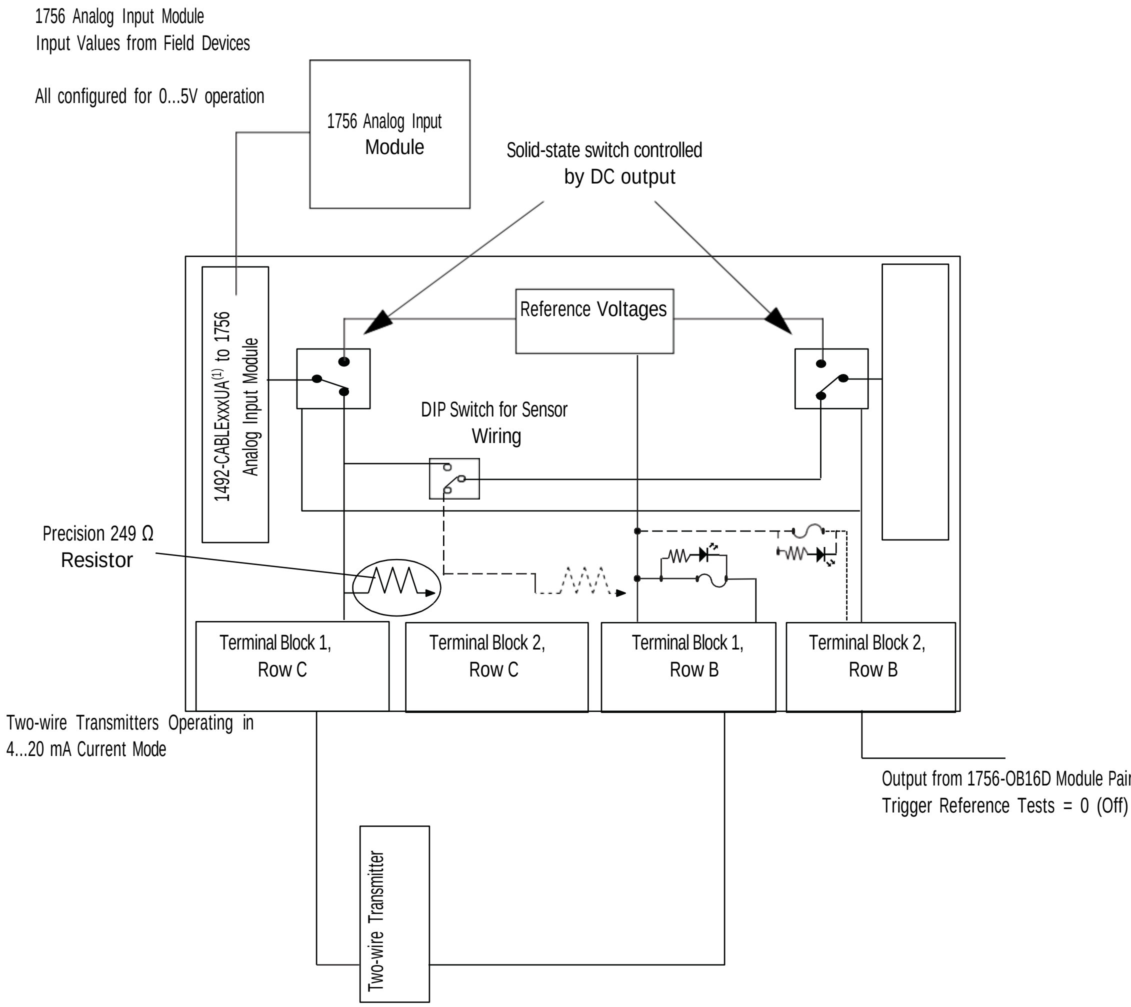
Figure 84 - SIL 1 Digital Input Wiring Example for 1794 I/O Modules



Field diagnostics as described for 1794 FLEX I/O modules can also be used to meet the requirements for proof tests with either 1794 FLEX I/O or 1756 ControlLogix I/O modules.

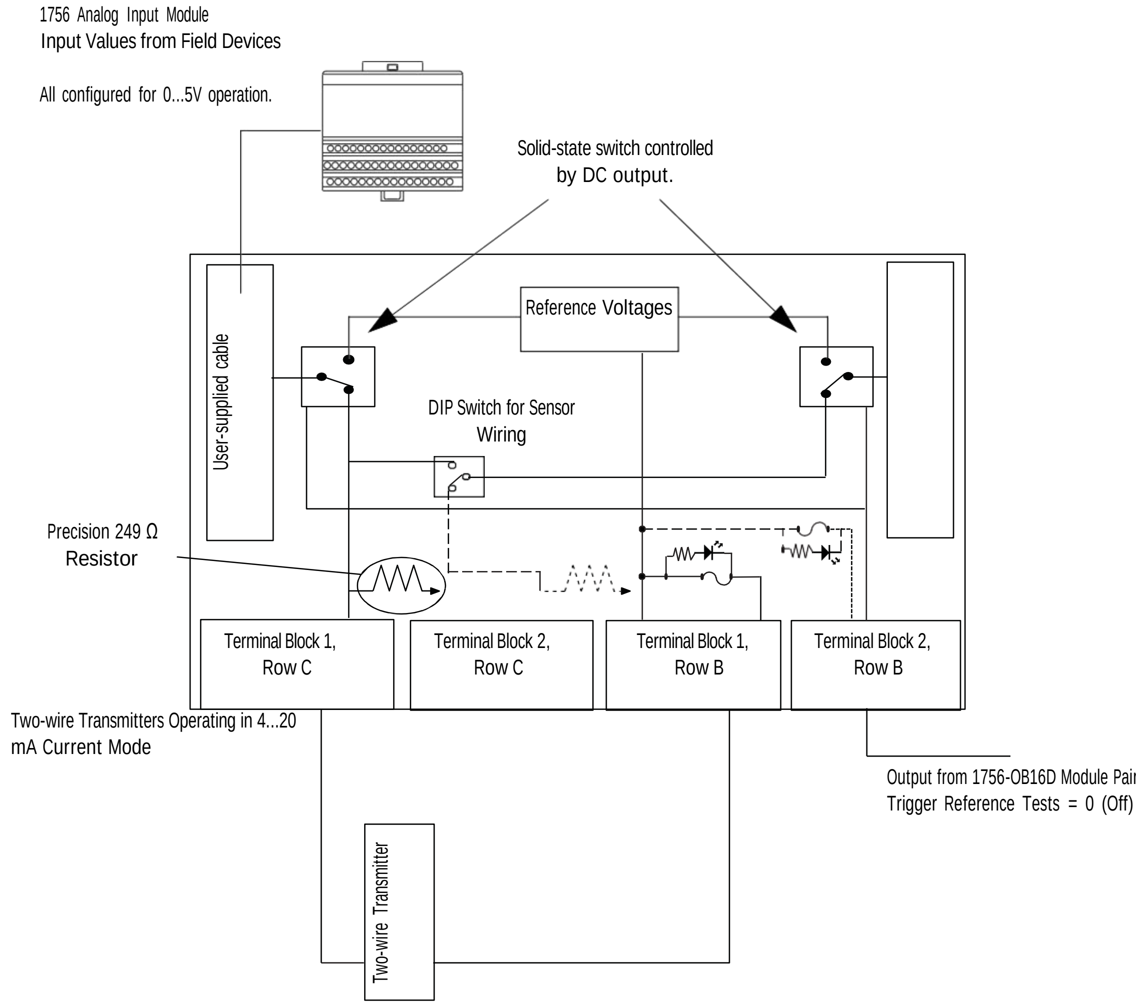
Termination boards 1492-TIFM16-F-3 can be used to provide a voltage reference for proof tests as shown here.

Figure 85 - SIL 1 1756 Analog Input Wiring Example (Simplex)



(1) xxx is cable length (005=0.5 m, 010=1.0 m, 025=2.5 m, 050=5.0 m)

Figure 86 - SIL 1 1794 Analog Input Wiring Example (Simplex)



To make your own cable, follow the termination board pinout that is shown here.

P1 Pins	Description
3	Input 0
2	Input 1
1	Input 2
14	Input 3
15	Input 4
16	Input 5
17	Input 6
18	Input 7
12	Input 8
13	Input 9
25	Input 10
24	Input 11
23	Input 12
22	Input 13
20	Input 14
21	Input 15
4	RTN
6	RTN
8	RTN
10	RTN

When using controllers and network communication modules, follow the guidelines that are listed in this safety manual.

IMPORTANT	When using 1756 or 1794 non-diagnostic outputs in SIL 1 configurations, you must implement a secondary means to shut off the outputs.

Table 29 lists additional considerations that must be made with various ControlLogix® modules in a SIL 1 application.

Table 29 - Considerations for SIL 1 Applications by Module

Module	Additional Considerations
Controllers	None. Use the controller exactly as described previously in this manual.
ControlNet® modules	None. Use the modules exactly as described previously in this manual.
Ethernet modules	None. Use the modules exactly as described previously in this manual.
Digital output modules(1)	Diagnostic output modules are recommended, but not required, in a SIL 1 application. Implement a secondary shutdown path if the SIL 1 application requires a fail-safe OFF if there is a shorted output.
Digital input modules(2)	Only one module is required in a SIL 1 application. Proof tests of the inputs must be performed as described previously in this manual.
Analog output modules(1)	Analog output modules should be wired as described previously in this manual.
Analog input modules(2)	Only 1 module is required in a SIL 1 application. Proof tests of the inputs must be performed as described previously in this manual.

(1) The user should be alerted to any detected output failures.
(2) The test interval of module inputs must be specified according to application-dependent standards. For example, according to EN50156, the time for fault detection and tripping must be less than or equal to the fault tolerance time.

Checklists

Checklist for the ControlLogix System

The following checklist is required for planning, programming, and startup of a SIL 2-certified ControlLogix® system. It can be used as a planning guide and during proof testing. If used as a planning guide, the checklist can be saved as a record of the plan.

Checklist for ControlLogix System[1]				
Company:				
Site:				
Loop definition:				
No.		Fulfilled		Comment
		Yes	No	
1	Do you use only SIL 2-certified ControlLogix modules with the corresponding firmware revision in the revision release list? See ControlLogix Safety Certificate, publication LOGIX-CT007.	☐	☐	
2	Have you calculated the system's response time?	☐	☐	
3	Does the system's response time include both the user-defined, SIL-task program watchdog (software watchdog) time and the SIL-task duration time?	☐	☐	
4	Is the system response time in proper relation to the process safety time?	☐	☐	
5	Have PFD values been calculated according to the system's configuration?	☐	☐	
6	Have you performed all the appropriate proof tests?	☐	☐	
7	Have you defined your process parameters that are monitored by fault routines?	☐	☐	
8	Have you determined how your system handles faults?	☐	☐	
9	Have you considered the checklists for SIL inputs and outputs that are listed on pages 185 and 186?	☐	☐	

(1) For more information on the specific tasks in this checklist, see the previous sections in the chapter or Chapter 1, SIL Policy on page 13.

Checklist for SIL Inputs

The following checklist is required for planning, programming, and startup of SIL inputs. It can be used as a planning guide and during proof testing. If used as a planning guide, the checklist can be saved as a record of the plan.

For programming or startup, an individual checklist can be completed for every SIL input channel in a system. This is the only way to make sure that the requirements were fully and clearly implemented. This checklist can also be used as documentation on the connection of external wiring to the application program.

Input Module Checklist for ControlLogix System				
Company:				
Site:				
Loop definition:				
SIL input channels in the:				
No.	All Input Module Requirements (apply to both digital and analog input modules)	Yes	No	Comment
1	Is Exact Match selected as the electronic keying option whenever possible?	☐	☐	
2	Is the RPI value set to an appropriate value for your application?	☐	☐	
3	Are all modules owned by the same controller?	☐	☐	
4	Have you performed proof tests on the system and modules?	☐	☐	
5	Have you set up the fault routines?	☐	☐	
6	Are control, diagnostics, and alarm functions performed in sequence in application logic?	☐	☐	
7	For applications using FLEX™ I/O modules, is the application logic monitoring one ControlNet® status bit for the associated module, and is the appropriate action invoked via the application logic by these bits?	☐	☐	

Input Module Checklist for ControlLogix System				
No.	Additional Digital Input Module-Only Requirements	Yes	No	Comment
1	When two digital input modules are wired in the same application, do the following conditions exist: • Both modules are owned by the same controller. • Sensors are wired to separate input points. • The operational state is ON. • The non-operational state is. OFF. • Configuration parameters (for example, RPI, filter values) are identical. • For FLEX input modules, both modules are on different rails/chassis	☐	☐	
2	For the standard input modules, is the Communication Format set to one of the Input Data choices?	☐	☐	
3	For the diagnostic input modules, is the Communication Format set to Full Diagnostics-Input Data?	☐	☐	
4	For the diagnostic input modules, are all diagnostics enabled on the module?	☐	☐	
5	For the diagnostic input modules, are enabled diagnostic bits monitored by fault routines?	☐	☐	
6	For the diagnostic input modules, is the controller connection a direct connection?	☐	☐	
No.	Additional Analog Input Module-Only Requirements	Yes	No	Comment
1	Is the Communication Format set to Float Data?	☐	☐	
2	Have you calibrated the modules as often as required by your application?	☐	☐	
3	Do you use ladder logic to compare the analog input data on two channels to make sure that there is concurrence within an acceptable range and that redundant data is used properly?	☐	☐	
4	Have you written application logic to examine bits for any condition that can cause a fault and appropriate fault routines to handle the fault condition?	☐	☐	
5	When two FLEX I/O analog input modules are wired in the same application, are both modules on different rails/ chassis?	☐	☐	
6	When wiring an analog input module in Voltage mode, are the transmitter grounds tied together?	☐	☐	
7	When wiring an analog input module in Current mode, are loop devices placed properly?	☐	☐	
8	When wiring thermocouple modules in parallel, have you wired to the same channel on each module as shown in Figure 30 on page 55?	☐	☐	
9	When wiring two RTD modules, are two sensors used, as shown in Figure 31 on page 56?	☐	☐	

Checklist for SIL Outputs

The following checklist is required for planning, programming, and startup of SIL outputs. It can be used as a planning guide and during proof testing. If used as a planning guide, the checklist can be saved as a record of the plan.

For programming or startup, an individual requirement checklist must be completed for every SIL output channel in a system. This is the only way to make sure that the requirements are fully and clearly implemented. This checklist can also be used as documentation on the connection of external wiring to the application program.

Output Checklist for ControlLogix System				
Company:				
Site:				
Loop definition:				
SIL output channels in the:				
No.	All Output Module Requirements (apply to both digital and analog output modules)	Yes	No	Comment
1	Have you performed proof tests on the modules?	☐	☐	
2	Is Exact Match selected as the electronic keying option whenever possible?	☐	☐	
3	Is the RPI value set to an appropriate value for your application?	☐	☐	
4	Have you built fault routines, including comparing output data with a corresponding input point?	☐	☐	
5	It is required that if you have used external relays in your application to disconnect module power if a short or other fault is detected on the module or isolated output in series?	☐	☐	
6	Is the control of the external relay implemented in ladder logic?	☐	☐	
7	Have you examined the Output Data Echo signal in application logic?	☐	☐	
8	Are all outputs configured to de-energize if there is a fault or the controller entering Program mode?	☐	☐	
9	Do two modules of the same type, which are used in the same application, use identical configurations?	☐	☐	

Output Checklist for ControlLogix System				
10	Does one controller own both the output module that controls the actuator and the output module that controls the secondary relay?	☐	☐	
11	Are control, diagnostics, and alarm functions performed in sequence in application logic?	☐	☐	
No.	Digital Output Module-Only Requirements	Yes	No	Comment
1	For the standard output modules, is the Communication Format set to Output Data?	☐	☐	
2	For standard output modules, have you wired the outputs to a corresponding input to validate that the output is following its commanded state?	☐	☐	
3	For the diagnostic output modules, are all diagnostics enabled on the module?	☐	☐	
4	For the diagnostic output modules, are enabled diagnostic bits monitored by fault routines?	☐	☐	
5	For the diagnostic output modules, is the Communication Format set to Full Diagnostics-Output Data?	☐	☐	
6	For diagnostic output modules, have you periodically performed a Pulse Test to make sure that the output is capable of change state?	☐	☐	
7	For diagnostic output modules, is the controller connection a direct connection?	☐	☐	
No.	Analog Output Module Requirements - Analog Only	Yes	No	Comment
1	Is the Communication Format set to Float Data?	☐	☐	
2	Have you calibrated the modules as often as required by your application?	☐	☐	
3	When wiring an analog output module in Current mode, are loop devices placed properly?	☐	☐	
4	Have you written application logic to examine bits for any condition that can cause a fault and appropriate fault routines to handle the fault condition?	☐	☐	
5	Did you wire the analog output to a monitoring analog input to verify that the output is within range?	☐	☐	

Checklist for the Creation of an Application Program

The following checklist is recommended to maintain safety technical aspects when programming, before and after loading the new or modified program.

Checklist for Creation of an Application Program Safety Manual ControlLogix System
Company:
Site:
Project definition:
File definition / Archive number:

Notes / Checks	Yes	No	Comment
Before a Modification			
Are the configuration of the ControlLogix system and the application program created based on safety aspects?	☐	☐	
Are programming guidelines used for the creation of the application program?	☐	☐	
After a Modification - Before Loading			
Has a review of the application program regarding the binding system specification been carried out by a person not involved in the program creation?	☐	☐	
Has the result of the review been documented and released (date/signature)?	☐	☐	
Was a backup of the complete program created before loading a program in the ControlLogix system?	☐	☐	
After a Modification - After Loading			
Was a sufficient number of tests conducted for the safety relevant logical linking (including I/O) and for all mathematical calculations?	☐	☐	
Was all force information removed before safety operation?	☐	☐	
Has it been verified that the system is operating properly?	☐	☐	
Have the appropriate security procedures been followed?	☐	☐	
Is the controller keyswitch in Run mode and the key removed?	☐	☐	

Checklist for 1715 I/O Modules

The following checklist is required for planning, programming, and startup of a SIL 2-certified system that uses 1715 I/O modules. It can be used as a planning guide and during proof testing. If used as a planning guide, the checklist can be saved as a record of the plan.

Checklist for 1715 I/O Modules

Company:				
Site:				
Loop definition:				
No.	For SIL 2 Applications	Fulfilled		Comment
		Yes	No	
1.	Do you use only SIL 2-certified 1715 modules with the corresponding firmware revision in the revision release list? See 1715 Redundant I/O System - Safety Certificate, publication 1715-CT007.	☐	☐	
2.	Have all modules been installed in accordance with the instructions in this manual?	☐	☐	
3.	Has a risk analysis been completed to determine the required SIL for your application?	☐	☐	
4.	Has fault detection time been specified?	☐	☐	
5.	Where fault detection time is greater than the controller reaction time limit (CRTL), does the safety-related I/O configuration provide a fail-safe configuration?	☐	☐	
6.	Has the safety-related timing for each safety-related function, including CRTL and fault tolerance period been established?	☐	☐	
7.	Does the application program shut down the SIL 2 safety functions if a faulty module has not been replaced within the Mean Time to Restoration (MTTR) assumed for the system in the probability of a dangerous failure on demand (PFD) calculations?	☐	☐	
8.	Has the application program been configured to monitor the discrepancy alarms and alert operators when a discrepancy alarm occurs?	☐	☐	
9.	Is the safety accuracy adequate for the application?	☐	☐	
10.	Have variables been configured to report the safety accuracy value for each channel?	☐	☐	
11.	Have variables been configured to report safe values when the safety accuracy value of a channel fails because it is reported to be below the 1% accuracy figure?	☐	☐	
12.	Has the maximum duration for single channel operation of an I/O module been specified in accordance with the application requirements?	☐	☐	
13.	Have you used two 1715-AENTR adapters in SIL 2 simplex and duplex configurations?	☐	☐	
14.	Have you set the shutdown mode option for each output channel to OFF?	☐	☐	
15.	If digital output channels have been configured for Hold Last State, has the impact on the safety functions been addressed?	☐	☐	
16.	Have you used the SIL 2 Add-On Instructions in accordance with the information in this manual?	☐	☐	
17.	Have you performed all appropriate proof tests?	☐	☐	
18.	Does your application program take the SIS to safe state if the configuration signature (CRC) of your module has changed after validation?	☐	☐	
No.	For Energize-to-action SIL 2 Applications	Fulfilled		Comment
		Yes	No	
1.	Are the redundant power sources inherently constrained to output less than 32 volts	☐	☐	
2.	If there any safety-related, normally de-energized outputs, have you provided redundant power sources, power failure warning, and line monitoring?	☐	☐	
3.	Do energize-to-action configurations conform to the restrictions (defined in this manual) that must be applied when using these configurations?	☐	☐	
4.	For energize-to-action SIL 2 applications, have dual output modules been configured?	☐	☐	

Numerics

A

B

C

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K

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P

Notes:

Rockwell Automation Support

Use these resources to access support information.

Technical Support Center	Find help with how-to videos, FAQs, chat, user forums, Knowledgebase, and product notification updates.	rok.auto/support
Local Technical Support Phone Numbers	Locate the telephone number for your country.	rok.auto/phonesupport
Technical Documentation Center	Quickly access and download technical specifications, installation instructions, and user manuals.	rok.auto/techdocs
Literature Library	Find installation instructions, manuals, brochures, and technical data publications.	rok.auto/literature
Product Compatibility and Download Center (PCDC)	Download firmware, associated files (such as AOP, EDS, and DTM), and access product release notes.	rok.auto/pcdc

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