Application Technique

Actuator Subsystems - Stop Cat. 0 or 1 via a PowerFlex Drive with Integrated Safe Torque Off Safety Function

Products: GuardLogix 5570 or Compact GuardLogix 5370 Controller, PowerFlex 527, or PowerFlex 755 AC Drive or PowerFlex 755T AC Drive Product

Safety Rating: Cat. 3, PLe to ISO 13849-1: 2015

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.

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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.

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).

Summary of Changes

This publication contains new and updated information as indicated in the following table.

Topic	Pages
Added section on accessing components of the safety function.	5
Shortened the Configuration section because the Logix Designer project ACD file is now attached to this document.	10
The Verification and Validation Checklist is now attached to this document as a spreadsheet.	16

General Safety Information

Contact Rockwell Automation to learn more about our safety risk assessment services.

IMPORTANT This application example is for advanced users and assumes that you are trained and experienced in safety system requirements.

ATTENTION: Perform a risk assessment to make sure that all task and hazard combinations have been identified and addressed. The risk assessment can require additional circuitry to reduce the risk to a tolerable level. Safety circuits must consider safety distance calculations, which are not part of the scope of this document.

Safety Distance Calculations

ATTENTION: While safety distance or access time calculations are beyond the scope of this document, compliant safety circuits must often consider a safety distance or access time calculation.

Non-separating safeguards provide no physical barrier to help prevent access to a hazard. Publications that offer guidance for calculating compliant safety distances for safety systems that use non-separating safeguards, such as light curtains, scanners, two-hand controls, or safety mats, include the following:

EN ISO 13855:2010 (Safety of Machinery – Positioning of safeguards with respect to the approach speeds of parts of the human body)

EN ISO 13857:2008 (Safety of Machinery – Safety distances to prevent hazardous zones being reached by upper and lower limbs)

ANSI B11:19 2010 (Machines – Performance Criteria for Safeguarding)

Separating safeguards monitor a movable, physical barrier that guards access to a hazard. Publications that offer guidance for calculating compliant access times for safety systems that use separating safeguards, such as gates with limit switches or interlocks (including SensaGuard™ switches), include the following:

EN ISO 14119:2013 (Safety of Machinery – Interlocking devices associated with guards - Principles for design and selection)

EN ISO 13855:2010 (Safety of Machinery – Positioning of safeguards with respect to the approach speeds of parts of the human body)

EN ISO 13857:2008 (Safety of Machinery – Safety distances to prevent hazardous zones being reached by upper and lower limbs)

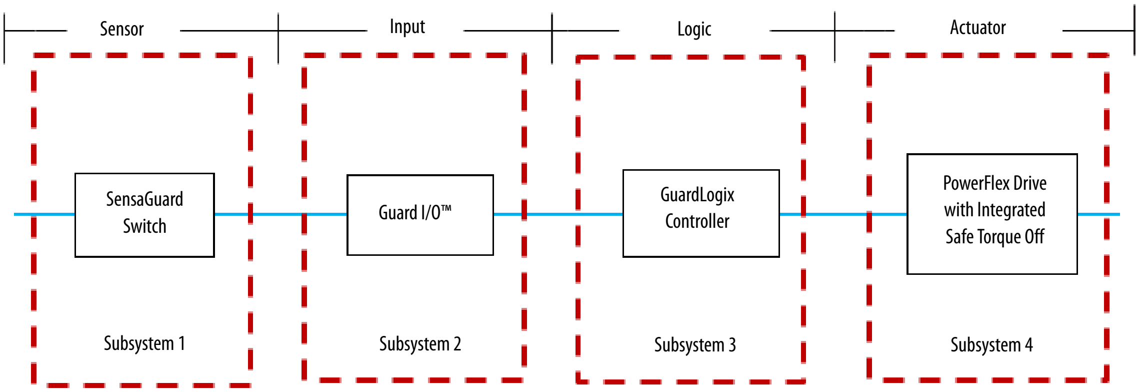
ANSI B11:19 2010 (Machines – Performance Criteria for Safeguarding)

In addition, consult relevant national or local safety standards to assure compliance.

Introduction

This application technique explains how to program the logic (GuardLogix® controller) and configure the actuator (PowerFlex® drive with Integrated Safe Torque Off) subsystems of a safety function. In this application technique, the GuardLogix controller de-energizes the final control devices, in this case the integrated Safe Torque Off (STO) communication inputs on PowerFlex drive products with integrated STO. The final control element is de-energized immediately for a stop category 0, and a delay (or monitoring that the hazard is stopped or in a safe state) is introduced before de-energizing for a stop category 1. This example uses a 1756-L73S GuardLogix controller, but is applicable to any GuardLogix 5570 controller (1756-L7xS) that uses the Studio 5000 Logix Designer® application, version 30 and later. The SISTEMA calculations that are shown later in this document must be recalculated if different products are used.

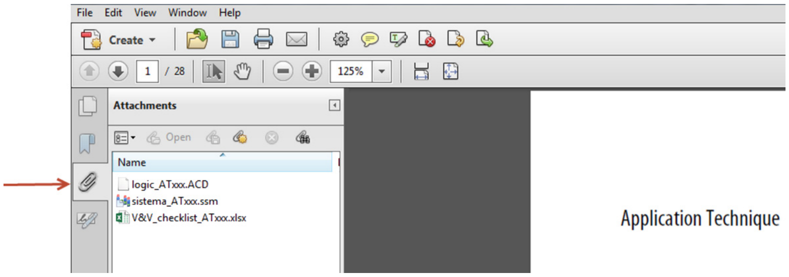
Use this application technique with the sensor subsystems from any other GuardLogix® safety function application technique. For example, you can use sensor subsystems 1 and 2 from Door-monitoring Interlock Switch with an Integrated Safety Controller Safety Function Application Technique, publication SAFETY-AT034, along with the actuator subsystems from this application technique, to create the following overall safety function.



IMPORTANT You must add the PFH values for each subsystem together to create a PFH for the overall safety function. Depending on the sensor subsystems and devices you choose, the overall safety rating of your system could be reduced. The results of an example calculation for a complete safety function are shown in the section titled Calculation of the Performance Level on page 13.

Access Components of the Safety Function

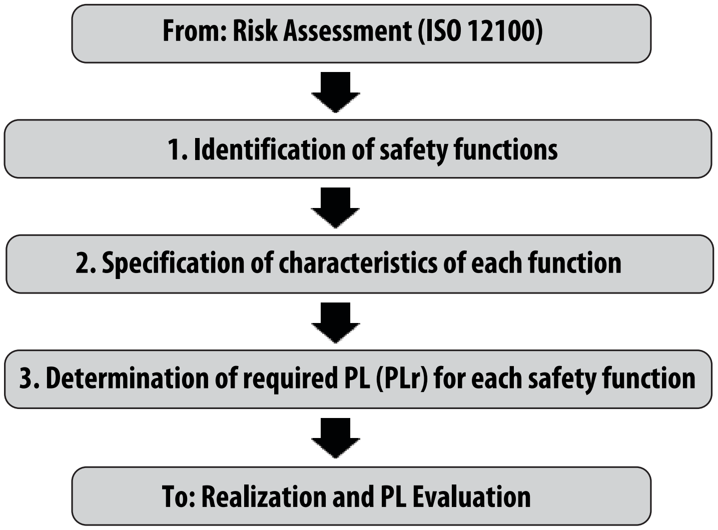
The component files (ACD, SISTEMA, and Verification and Validation checklist) that are attached to this document help you implement this safety function. To access these components, click the Attachments link 📎 and double-click the component that you want to use, as shown in the example. If the PDF file opens in a browser and you don't see the Attachments link 📎, save the PDF file to your computer and then reopen the file.



logic_ATxxx.ACD
sistema_ATxxx.ssm
V&V_checklist_ATxxx.xlsx

Safety Function Realization: Risk Assessment

The Performance Level required (PLr) is the result of a risk assessment and refers to the amount of the risk reduction to be conducted by the safety-related parts of the control system. Part of the risk reduction process is to determine the safety functions of the machine. In this application, the Performance Level required by the risk assessment is category 3, Performance Level d (cat. 3, PLd), for each safety function. A safety system that achieves cat. 3, PLd, or higher, can be considered control reliable. Each safety product has its own rating and can be combined to create a safety function that meets or exceeds the PLr.


From: Risk Assessment (ISO 12100)
1. Identification of safety functions
2. Specification of characteristics of each function
3. Determination of required PL (PLr) for each safety function
To: Realization and PL Evaluation

Safe Stop Safety Function

This application technique includes one partial safety function. The safety function is the stopping of a motor when the safety system detects that one or more sensor subsystems have placed a demand on the safety function. The stopping of the motor removes the hazard.

- Stop category 0 – coast-to-stop
- Stop category 1 – controlled stop

Safety Function Requirements

When a demand is placed on the sensor subsystem, this action generates a stop command that helps prevent hazardous motion. Once the stop command is reset, a secondary action (the Start button is pressed) lets hazardous motion resume. Faults within these complex subsystems are unknown and must be detected at a rate that enables the overall safety function to meet the requirements for Performance Level d (PLd), per ISO 13849-1. The vendor must provide Probability of Dangerous Failure per Hour (PFHd) values for these subsystems.

The safety functions in this application technique each meet or exceed the requirements for category 3, Performance Level d (cat. 3, PLd), per ISO 13849-1 and control reliable operation per ANSI B11.19.

Considerations for Safety Distance and Stopping Performance

Based on the selection of a sensor subsystem, the risk assessment determines if a safety distance calculation is required. Typically, a safety distance calculation is required if a non-separating sensor subsystem (such as a light curtain) is selected for the safety function. If a safety distance calculation is required for this safety function, the following documents can be referenced:

- GuardLogix 5570 and Compact GuardLogix 5370 Controller Systems Safety Reference Manual, publication1756-RM099
- SafeBook 4 – Safety related control systems for machinery, publication SAFEBK-RM002
- Safety Function: Light Curtain Products: Light Curtain GuardLogix® Controller, publication SAFETY-AT056

Functional Safety Description

The GuardLogix controller and PowerFlex drives with integrated Safe Torque Off (STO) all use 1oo2 architectures to achieve the PFHd value that is used in the PL calculation section of this document.

- The PowerFlex 527 drive includes on board hard-wire and integrated safety STO functionality.
- The integrated STO function of the PowerFlex 755 drive or PowerFlex 755T drive product requires the addition of a 20-750-S3 STO integrated safety option module. The 20-750-S3 STO option module can be used with integrated safety or hardwired STO.

PowerFlex drives with integrated STO have one module-defined, integrated STO safety tag that is controlled within the safety task of the GuardLogix controller. These drives are connected via CIP Safety™ protocol over an EtherNet/IP™ network to the GuardLogix safety controller.

CIP Safety protocol inserts the data into the CIP Safety packet twice. One piece of data is normal and the other is inverted. CIP Safety packets are also time stamped by the producer so that the consumer can determine the age of the packet when it arrives. If a good packet does not arrive before the Connection Reaction Time Limit (CRTL) expires, then the STO function within the PowerFlex drive goes to the safe state: OFF.

CIP Safety protocol supports a direct connection between the PowerFlex drive and the GuardLogix controller, which makes the EtherNet/IP hardware between these two end devices a black channel. Therefore, the EtherNet/IP hardware does not have to be included in the Performance Level (PL) calculation. The Probability of Failure per Hour (PFH) of the CIP Safety protocol has already been included in the controller PFH value.

The STO function forces the drive output power transistors to a disabled state when the STO command from the GuardLogix controller is de-energized, which results in a condition where the drive coasts. This function does not provide electrical power isolation.

For safety distance calculations and reaction time calculations, the response-time delay between when the drive STO function receives the STO request, and when power that produces the motion is removed from the motor, is stated as:

- Less than 12 ms in the PowerFlex 527 drive
- Less than 15 ms for the PowerFlex 755 drive or PowerFlex 755T drive product with 20-750-S3 STO option module

When all safety input interlocks are satisfied, no faults are detected, and a proper reset occurs, the STO tags within the GuardLogix controller are set to high (1).

In summary, when a demand is placed on the safety function, the STO tag is de-energized and the motor coasts to a stop for a stop category 0. If a stop category 1 is used, then the demand on the safety function drives the speed to zero (by using a STOP command that is issued from the Logix controller to the PowerFlex drive), and after a pre-determined delay, the STO tag is de-energized. When the safety interlocks are returned to the active state (closed), and a proper reset function occurs, the PowerFlex drive STO is enabled.

Integrated Safety: Safe Torque Off Considerations for a Stop Category 1

In the event of a malfunction, the most likely stop category is stop category 0. When designing the machine application, timing and distance must be considered for a coast-to-stop, and the possibility of the loss of control of a vertical load. These malfunctions include a transition (programmatic or keyswitch) from Run to Program mode, or any loss of communications that drops out the STO networked tags. Use additional protective measures if this occurrence might introduce unacceptable risks to personnel.

Bill of Material

This application technique uses these products.

Cat. No.	Description	Quantity
1734-AENTR	POINT I/O™ EtherNet/IP communication adapter	1
1734-IB8S	POINT Guard I/O™ input safety module 24V DC	1
1734-OB8S	POINT Guard I/O output safety module 24V DC	1

Choose one of the following safety-controller hardware groups.

Controller	Cat. No.	Description	Quantity
GuardLogix 5570	1756-L71S 1756-L72S 1756-L73S	GuardLogix processor, 2.0 MB standard memory, 1.0 MB safety memory, or GuardLogix processor, 4.0 MB standard memory, 2.0 MB safety memory, or GuardLogix processor, 8.0 MB standard memory, 4.0 MB safety memory	1
	1756-L7SP	GuardLogix Safety Partner	1
	1756-EN2TR	ControlLogix® EtherNet/IP bridge, 10/100 Mbps, 2-port, twisted-pair media	1
	1756-PA72	Power supply, 120/240V AC input, 3.5 A @ 24V DC	1
	1756-A7	Seven-slot ControlLogix chassis	1

Controller	Cat. No.	Description	Quantity
Compact GuardLogix 5370	1769-L30ERMS 1769-L33ERMS 1769-L36ERMS 1769-L37ERMS 1769-L38ERMS	Compact GuardLogix processor, 1.0 MB standard memory, 0.5 MB safety memory, or Compact GuardLogix processor, 2.0 MB standard memory,1.0 MB safety memory, or Compact GuardLogix processor, 3.0 MB standard memory, 1.5 MB safety memory, or Compact GuardLogix processor, 4.0 MB standard memory, 1.5 MB safety memory, or Compact GuardLogix processor, 5.0 MB standard memory, 1.5 MB safety memory	1
	1769-PA4	Power supply, 120V/240V AC input, 2.0 A @ 24V DC	1

Choose a PowerFlex 527 drive or choose a PowerFlex 755 drive or PowerFlex 755T drive product with STO option module.

Cat. No.	Description	Quantity
25C-xxx	PowerFlex 527 drive, any ratings	1
20G-xxx or 21G-xxx	PowerFlex 755 drive or PowerFlex 755T drive product, any ratings	1
20-750-S3	PowerFlex 755 STO option module	1

Setup and Wiring

The GuardLogix controller and PowerFlex drive are connected in a linear Device Level Ring EtherNet/IP communication configuration. For detailed information on installation, refer to the publications that are listed in Additional Resources.

PowerFlex 750-Series Products Hardware Preparation

Use the following guidelines to prepare the PowerFlex hardware:

- Use of the 20-750-S3 STO option module requires that the SAFETY jumper on the drive's main control board be removed and the ENABLE jumper be installed.
- The option module (20-750-S3) must be installed in Port 4, 5, or 6 of the drive.
- Only one safety option module at a time can be installed in the drive. Multiple option modules or duplicate option module installations are not supported.
- See the PowerFlex 755 Integrated Safety - Safe Torque Off Option Module User Manual, publication 750-UM004, for detailed information about how to install the 20-750-S3 option module in the drive.

For detailed information on how to install and wire, see the publications that are listed in Additional Resources.

System Overview

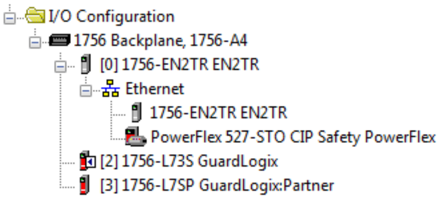
The final control device is a PowerFlex drive with integrated Safe Torque Off (STO). Because these drives use CIP Safety communication STO inputs, rather than hard-wired safety inputs, there is no need for a safety output module in this safety function.

The GuardLogix controller and the PowerFlex drive must have a direct connection to one another on an EtherNet/IP network. The use of CIP Safety protocol makes the EtherNet/IP hardware between these two end devices a black channel. Therefore, any EtherNet/IP hardware can be used.

The overall safety function must have individual reset buttons for resetting faults and for resetting safety outputs. These reset buttons can be wired to any input module (safety or standard) in your system. The safety rating of the reset button must not diminish the rating of the relevant safety function. This condition is accomplished by the trailing edge or falling edge of the button that generates the reset command, which tolerates faults in the reset circuit.

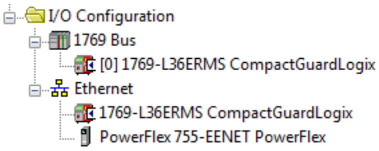
Network Architecture

A schematic for this actuator subsystem is not needed because the PowerFlex drive and the GuardLogix controller are connected on an EtherNet/IP network. The I/O configurations in the graphics show the differences between the GuardLogix 5570 and Compact GuardLogix 5370 connections to the PowerFlex drive over the EtherNet/IP network. These screen captures show valid I/O configurations using GuardLogix or Compact GuardLogix controller, and PowerFlex integrated safety STO drives. The required safety input devices, and a Guard I/O module that is required to interface with the input subsystems 1 and 2, are not shown on this actuator-only I/O configuration example. Other configurations are possible, but all communication safety subsystems must be connected to the parent EtherNet network and backplane or bus that serves the GuardLogix controller.



```
I/O Configuration
  1756 Backplane, 1756-A4
    [0] 1756-EN2TR EN2TR
      Ethernet
        1756-EN2TR EN2TR
        PowerFlex 527-STO CIP Safety PowerFlex
    [2] 1756-L73S GuardLogix
    [3] 1756-L7SP GuardLogix:Partner
```

GuardLogix 5570 Controller with PowerFlex 527 Drive



```
I/O Configuration
  1769 Bus
    [0] 1769-L36ERMS CompactGuardLogix
  Ethernet
    1769-L36ERMS CompactGuardLogix
    PowerFlex 755-EENET PowerFlex
```

Compact GuardLogix 5370 Controller with PowerFlex 755 Drive

Configuration

The GuardLogix controller is configured by using the Studio 5000 Logix Designer® application. You must create a project and add the safety input and I/O devices, GuardLogix controller, and PowerFlex drive that you plane to use. A detailed description of each step is beyond the scope of this document. Knowledge of the Logix Designer application is assumed.

For a Studio 5000 Logix Designer project file that you can import into your own project, see the attached ACD file.

- GuardLogix_StopCat1_Logic_AT141.ACD file uses a GuardLogix controller in a stop category 1 application
- CompactGuardLogix_StopCat0_Logic_AT141.ACD file uses a Compact GuardLogic controller in a stop category 0 application

Minimum Logix Designer Application Version	Product
20	GuardLogix 5570 controller
28	Compact GuardLogix 5370 controller (1769-L30ERMS, 1769-L33ERMS, 1769-L36ERMS)
24	PowerFlex 527 drive with integrated Safe Torque Off
30	PowerFlex 755 drive or PowerFlex 755T drive product with 20-750-S3 integrated Safe Torque Off option mode
31	Compact GuardLogix 5370 controller (1769-L37ERMS, 1769-L38ERMS)

IMPORTANT Studio 5000® Add-On-Profile (AOP) required versions are:

- For PowerFlex 527 drives, AOP version 1.01 (and later)
- For PowerFlex 755 drives, AOP version 4.09 (and later).
- For PowerFlex 755T drive products, AOP version 1.00 PF755T (and later).

PowerFlex drive firmware required versions are:

- For PowerFlex 527 drives, version 1.1 (and later)
- For PowerFlex 755 drives, version 13.0 (and later)
- For PowerFlex 755T drive products, version 1.0 (and later)

Log in to the Rockwell Automation® Knowledgebase and search for article 946912 for updates on firmware revision support status.

Integrated Safety requires that certain controller, communication, and drive properties are configured to use the CIP safety connections. The following steps are the minimum requirements for configuring your GuardLogix 5570 or Compact GuardLogix 5370 Logix Designer project to use the Integrated Safety Safe Torque Off (STO) features of the PowerFlex 527 drive and PowerFlex 755 drive or PowerFlex 755T drive product with 20-750-S3 STO option module.

The following discussion does not cover all the steps that are required to properly configure the GuardLogix controller and PowerFlex drive applications. See the following PowerFlex user manuals that provide detailed instructions about how to use the Logix Designer PowerFlex device Add-On-Profiles (AOP) for Ethernet communication adapters:

- PowerFlex 527 Adjustable Frequency AC Drive User Manual, publication 520-UM002
- PowerFlex 755 Drive Embedded EtherNet/IP Adapter User Manual, publication 750COM-UM001
- PowerFlex 750-Series Drives with TotalFORCE™ Control Built-in EtherNet/IP Adapter User Manual, publication 750COM-UM009
- PowerFlex 20-750-ENETR Dual-port EtherNet/IP Option Module User Manual, publication 750COM-UM008

Configure the GuardLogix Controller and PowerFlex Drive

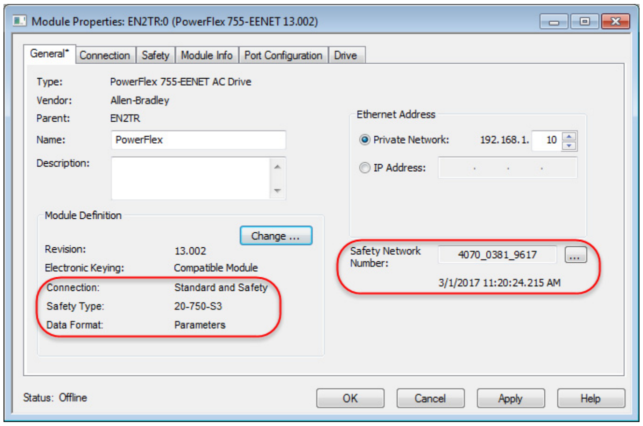
If you are not using the attached ACD file, follow these steps to create a project.

1. In the Logix Designer application, create a project with a GuardLogix controller that includes the following:
   - A connection to an Ethernet network

     GuardLogix 5570 controllers require the use of an Ethernet communication module, but Compact GuardLogix 5370 controller has an Ethernet port.
   - Time Synchronization enabled on the controller and any Ethernet communication modules, if used

   This safety function application technique uses a Compact GuardLogix controller for the stop category 0 function and a GuardLogix controller for stop category 1 safety function project. The project includes a PowerFlex 755 drive with the 20-750-S3 STO option.
2. Set the IP Address for the controller and any Ethernet communication modules, if used.
3. Add a PowerFlex drive to your project.
4. Set a unique IP address for your drive.
5. If you are using a PowerFlex 755 drive, you must select version 13 or later on the Module Definition dialog box.
6. If you are using a PowerFlex 755 drive or PowerFlex 755T drive product, add a 20-750-53 Integrated Safety - Safe Torque Off option module as a peripheral device in port 4, 5, or 6.
7. Choose a connection type for your drive on the Module Definition dialog box.
   - For a PowerFlex 755 drive or PowerFlex 755T drive product, choose standard and safety because the safety controller is managing the safety and drive control.
   - For a PowerFlex 527 drive, choose motion and safety because the safety controller is managing the safety and drive control.

8. When all drive and safety module properties are configured correctly, the Module Properties General tab should show the safety connection and Safety Network Number.



Module Properties: EN2TR:0 (PowerFlex 755-EENET 13.002)

Type: PowerFlex 755-EENET AC Drive
Vendor: Allen-Bradley
Parent: EN2TR
Name: PowerFlex
Description:

Module Definition
Revision: 13.002
Electronic Keying: Compatible Module
Connection: Standard and Safety
Safety Type: 20-750-S3
Data Format: Parameters

Ethernet Address
● Private Network: 192. 168. 1. 10
○ IP Address: . . .

Safety Network Number: 4070_0381_9617
3/1/2017 11:20:24.215 AM

Status: Offline

This screen capture is for a PowerFlex 755 drive. The dialog boxes for the PowerFlex 527 drive and PowerFlex 755T drive product have another appearance.

Programming

For controller logic that you can download to your controller, see the attached ACD files.

- GuardLogix_StopCat1_Logic_AT141.ACD file uses a GuardLogix controller in a stop category 1 application
- CompactGuardLogix_StopCat0_Logic_AT141.ACD file uses a Compact GuardLogix controller in a stop category 0 application

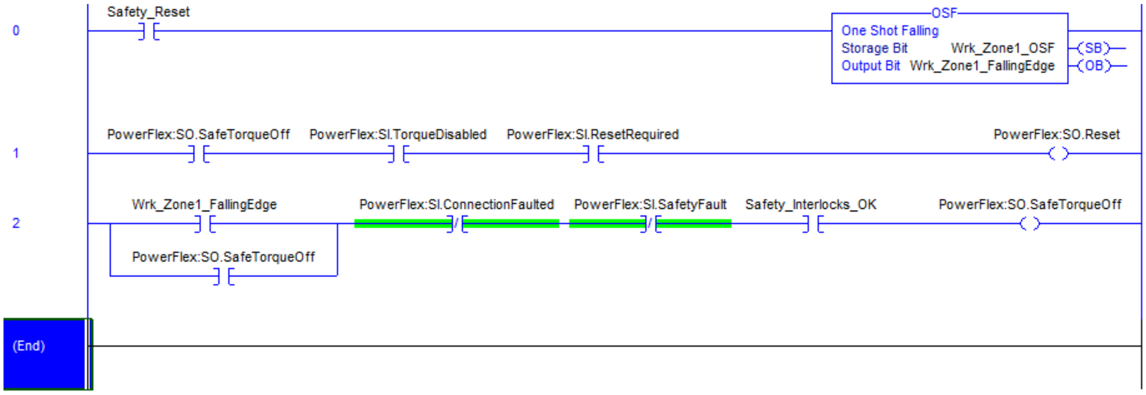
The accumulated 'Safety_Interlocks_OK' tag is the resultant output from the safety input and logic subsystems. It is used as a permissive in the Safe Torque Off logic. Rung 2 in the safety program logic screen captures show this tag. If the 'Safety_Interlocks_OK' tag goes false (0), it initiates the Safe Torque Off function. The Safe Torque Off function remains false (0) until a manual reset action is implemented after the 'Safety_Interlocks_OK' tag goes true (1).

The PowerFlex integrated safety Safe Torque Off function requires a reset after the STO function is initially energized. Rung 1 in the safety program logic accomplishes this reset. For details on the reset function, see the STO Reset topic in the appropriate PowerFlex drive manual, which is listed in Additional Resources on page 18.

The STO output is energized if the safety interlocks are satisfied, there are no faults, there is a valid connection, and there is a falling edge on the reset button.

Safety Program Logic – Stop Category 0

The following code is an example for a stop category 0. When a demand is placed on safety interlocks, and the accumulated 'Safety_Interlocks_OK' tag goes to false (0), then the 'PowerFlex:SO.SafeTorqueOff' output immediately goes to false (0) as well.


0
Safety_Reset
OSF
One Shot Falling
Storage Bit Wrk_Zone1_OSF
Output Bit Wrk_Zone1_FallingEdge
(SB)
(OB)
1
PowerFlex:SO.SafeTorqueOff
PowerFlex:SI.TorqueDisabled
PowerFlex:SI.ResetRequired
PowerFlex:SO.Reset
2
Wrk_Zone1_FallingEdge
PowerFlex:SO.SafeTorqueOff
PowerFlex:SI.ConnectionFaulted
PowerFlex:SI.SafetyFault
Safety_Interlocks_OK
PowerFlex:SO.SafeTorqueOff
(End)

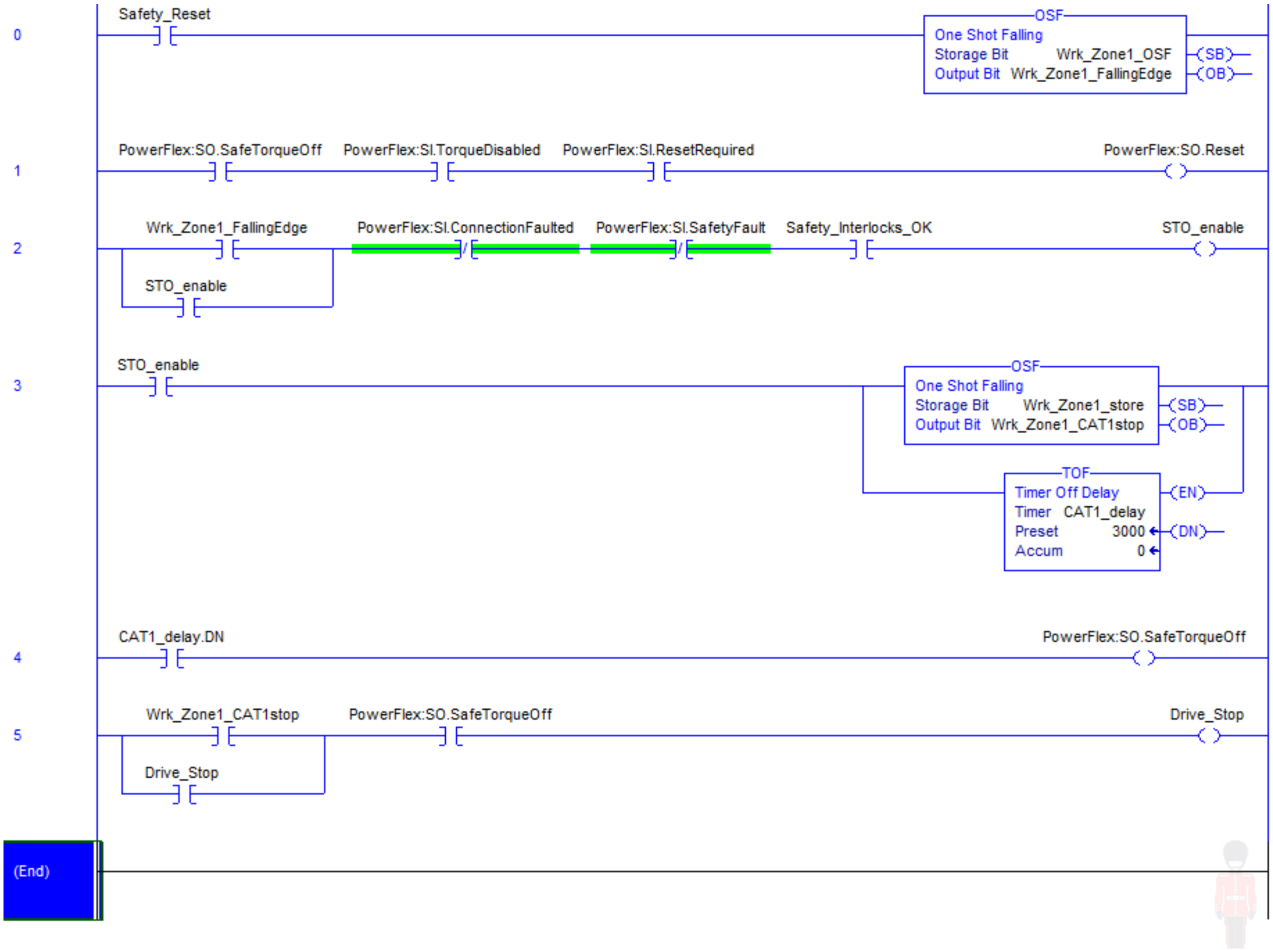
Safety Program Logic – Stop Category 1

The following code is an example for a stop category 1. When a demand is placed on safety interlocks, and the accumulated 'Safety_Interlocks_OK' tag goes to false (0), the 'STO_enable' tag goes false (0) immediately. This action energizes the 'Drive_Stop' tag. The 'PowerFlex:SO.SafetTorqueOff' output goes to false (0) after the 'CAT1-delay' timer times out. The length of the delay is determined in the risk assessment. In this example, the delay time is three seconds.

The 'Drive_Stop' tag is used to initiate a controlled stop of the drive, for example:

- The PowerFlex 755 drive in standard I/O parameter mode 'Drive_Stop' could control the 'PowerFlex:O.LogicCommand_Stop' tag in a standard controller Task.

- The PowerFlex 527 drive 'Drive_Stop' could control a Motion Axis Stop (MAS) instruction.



Falling Edge Reset

ISO 13849-1 stipulates that instruction reset functions must occur on falling edge signals. To comply with this requirement, a One Shot Falling (OSF) instruction is used on the reset rung. Then, the OSF instruction Output Bit tag is used as the reset bit for the STO output rung.

Calculation of the Performance Level

When properly implemented, the PowerFlex 527 subsystem can be used in a safety function that achieves a safety rating of category 3, Performance Level e (cat. 3, PLe), according to ISO 13849-1: 2015, as calculated by using the SISTEMA software PL calculation tool.

When properly implemented, the PowerFlex 755 drive or the PowerFlex 755T drive product with the 20-750-S3 module subsystem can be used in a safety function that achieves a safety rating of category 3, Performance Level e (cat. 3, PLe), according to ISO 13849-1: 2015, as calculated by using the SISTEMA software PL calculation tool.

IMPORTANT To calculate the PL of your entire safety function, you must include the sensor subsystems along with the logic and actuator subsystems that are shown here. Depending on the sensor subsystems and devices you choose, the overall safety rating of your system could be reduced. An example that describes how to calculate the safety rating for a complete safety function appears in the section titled Complete Safety Function PL Calculation Example on page 15.

The SISTEMA file that is referenced in this safety function application technique is attached to this document.

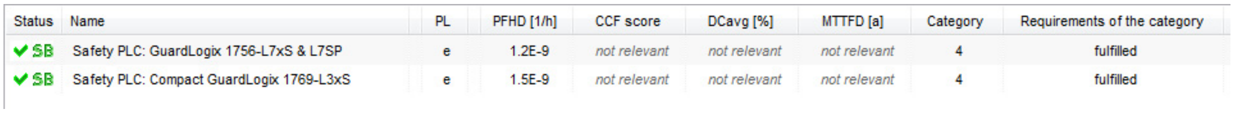
The PFH for electromechanical subsystems may be calculated differently based on the version of ISO 13849 supported by SISTEMA. ISO 13849-1:2015, which changed the maximum MTTFd from 100 to 2500 years, is supported starting in version 2.0.3 of SISTEMA. As a result, the same SISTEMA data file that is opened in two different versions of SISTEMA can yield different calculated results.

Logic and Actuator Subsystem Calculation

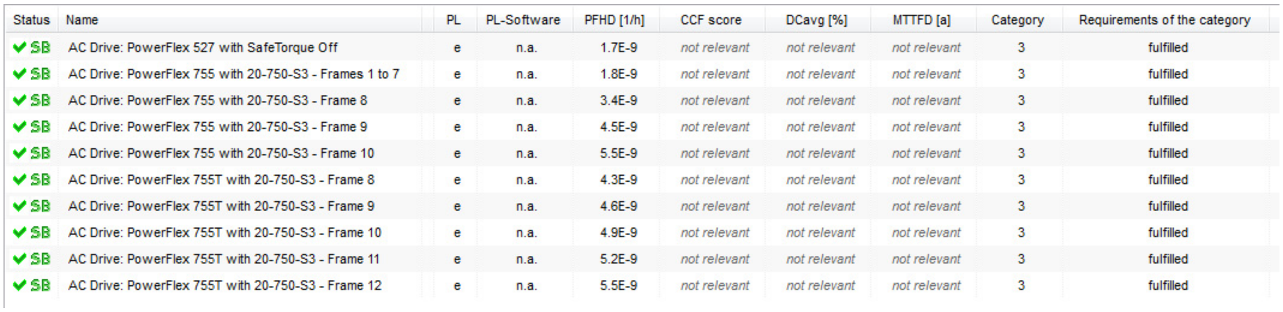
The table shows the percentage of Ple bandwidth that each subsystem uses, and the proof test interval (PTI) of that subsystem.

Controller/Subsystem	Function	% of PLe Bandwidth Used	PTI (years)
GuardLogix 5570 controller	Logic	1.2%	20
Compact GuardLogix 5370 controller		1.5%	
PowerFlex 755 Frame 1…7, 20-750-S3 STO subsystem	Actuator	1.79%	
PowerFlex 755 Frame 8, 20-750-S3 STO subsystem		3.41%	
PowerFlex 755 Frame 9, 20-750-S3 STO subsystem		4.46%	
PowerFlex 755 Frame 10, 20-750-S3 STO subsystem		5.51%	
PowerFlex 755T Frame 8, 20-750-S3 STO subsystem		4.28%	
PowerFlex 755T Frame 9, 20-750-S3 STO subsystem		4.57%	
PowerFlex 755T Frame 10, 20-750-S3 STO subsystem		4.87%	
PowerFlex 755T Frame 11, 20-750-S3 STO subsystem		5.17%	
PowerFlex 755T Frame 12, 20-750-S3 STO subsystem		5.47%	
PowerFlex 527 integrated STO subsystem		1.70%	

The category and Performance Level of each subsystem are shown in the graphics.

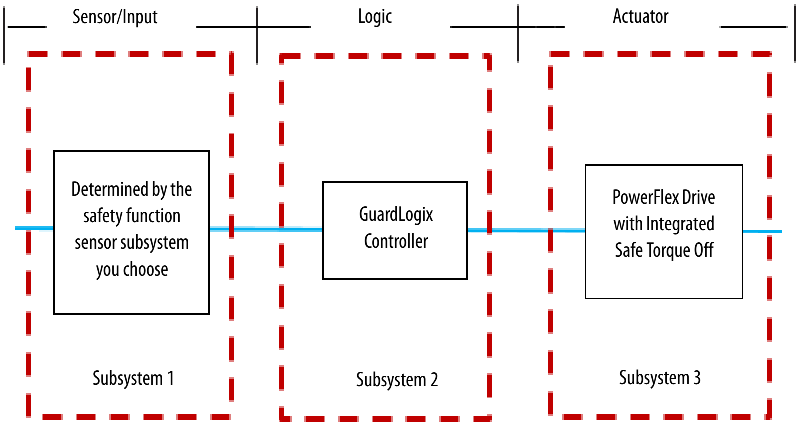


Status	Name	PL	PFHD [1/h]	CCF score	DCavg [%]	MTTFD [a]	Category	Requirements of the category
✓ SB	Safety PLC: GuardLogix 1756-L7xS & L7SP	e	1.2E-9	*not relevant*	*not relevant*	*not relevant*	4	fulfilled
✓ SB	Safety PLC: Compact GuardLogix 1769-L3xS	e	1.5E-9	*not relevant*	*not relevant*	*not relevant*	4	fulfilled



Status	Name	PL	PL-Software	PFHD [1/h]	CCF score	DCavg [%]	MTTFD [a]	Category	Requirements of the category
✓ SB	AC Drive: PowerFlex 527 with SafeTorque Off	e	n.a.	1.7E-9	*not relevant*	*not relevant*	*not relevant*	3	fulfilled
✓ SB	AC Drive: PowerFlex 755 with 20-750-S3 - Frames 1 to 7	e	n.a.	1.8E-9	*not relevant*	*not relevant*	*not relevant*	3	fulfilled
✓ SB	AC Drive: PowerFlex 755 with 20-750-S3 - Frame 8	e	n.a.	3.4E-9	*not relevant*	*not relevant*	*not relevant*	3	fulfilled
✓ SB	AC Drive: PowerFlex 755 with 20-750-S3 - Frame 9	e	n.a.	4.5E-9	*not relevant*	*not relevant*	*not relevant*	3	fulfilled
✓ SB	AC Drive: PowerFlex 755 with 20-750-S3 - Frame 10	e	n.a.	5.5E-9	*not relevant*	*not relevant*	*not relevant*	3	fulfilled
✓ SB	AC Drive: PowerFlex 755T with 20-750-S3 - Frame 8	e	n.a.	4.3E-9	*not relevant*	*not relevant*	*not relevant*	3	fulfilled
✓ SB	AC Drive: PowerFlex 755T with 20-750-S3 - Frame 9	e	n.a.	4.6E-9	*not relevant*	*not relevant*	*not relevant*	3	fulfilled
✓ SB	AC Drive: PowerFlex 755T with 20-750-S3 - Frame 10	e	n.a.	4.9E-9	*not relevant*	*not relevant*	*not relevant*	3	fulfilled
✓ SB	AC Drive: PowerFlex 755T with 20-750-S3 - Frame 11	e	n.a.	5.2E-9	*not relevant*	*not relevant*	*not relevant*	3	fulfilled
✓ SB	AC Drive: PowerFlex 755T with 20-750-S3 - Frame 12	e	n.a.	5.5E-9	*not relevant*	*not relevant*	*not relevant*	3	fulfilled

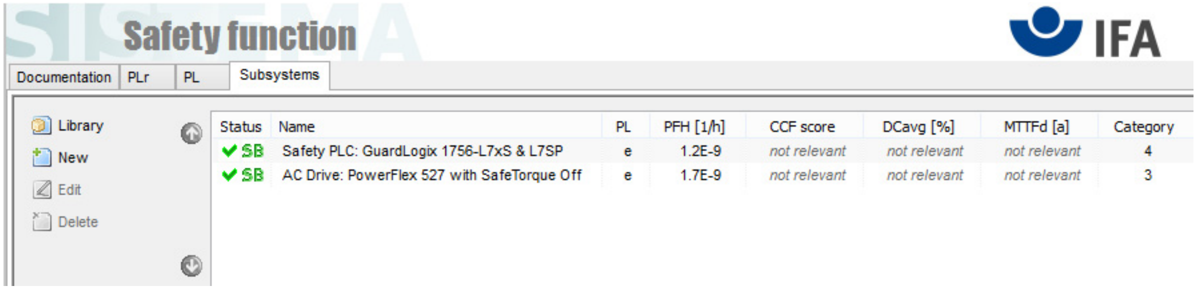
Model the logic and actuator subsystems as follows.


Sensor/Input
Logic
Actuator
Determined by the safety function sensor subsystem you choose
GuardLogix Controller
PowerFlex Drive with Integrated Safe Torque Off
Subsystem 1
Subsystem 2
Subsystem 3

Complete Safety Function PL Calculation Example

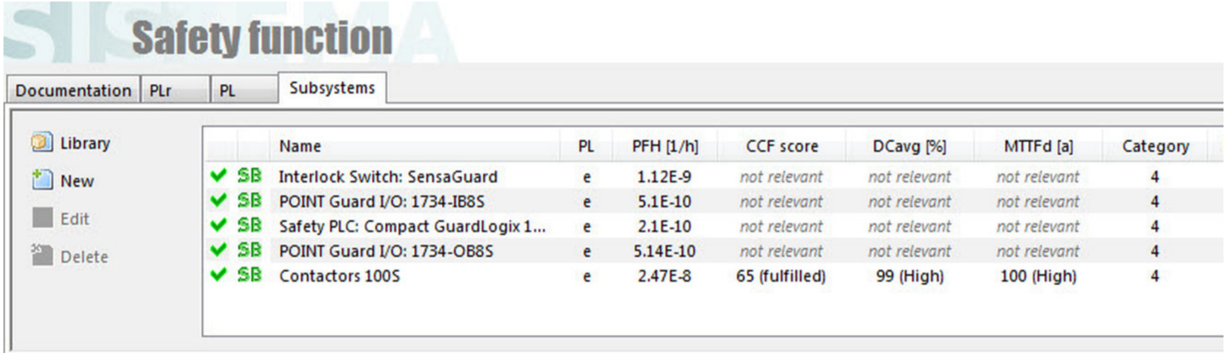
This example takes one of the logic subsystems and the PowerFlex 527 actuator subsystem from this document and combines them with the sensor subsystems from Door-monitoring Interlock Switch with an Integrated Safety Controller Safety Function Application Technique, publication SAFETY-AT034, to illustrate how any sensor subsystems can be added to the output subsystems within this publication. If you choose different products, you need new calculations.

Assuming the use of the following subsystem choices, the overall Performance Level that is achieved is shown in the graphic:



Status	Name	PL	PFH [1/h]	CCF score	DCavg [%]	MTTFd [a]	Category
✓ SB	Safety PLC: GuardLogix 1756-L7xS & L7SP	e	1.2E-9	*not relevant*	*not relevant*	*not relevant*	4
✓ SB	AC Drive: PowerFlex 527 with SafeTorque Off	e	1.7E-9	*not relevant*	*not relevant*	*not relevant*	3

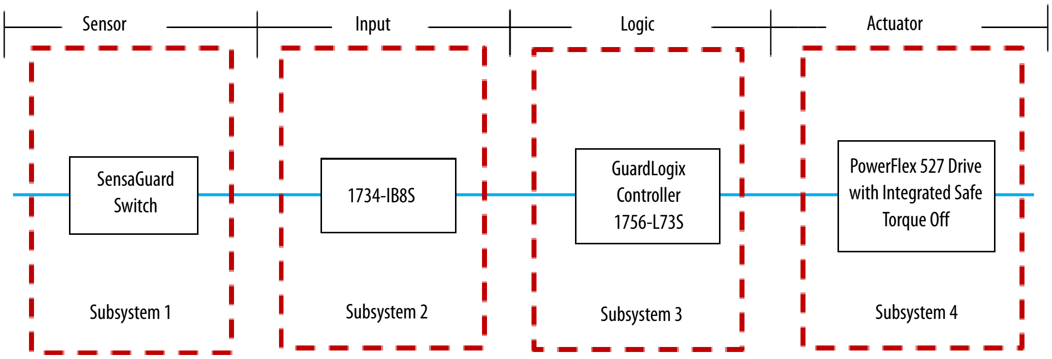
Here are the subsystems from Door-monitoring Interlock Switch with an Integrated Safety Controller Safety Function Application Technique, publication SAFETY-AT034 – sensor, logic, and actuator:



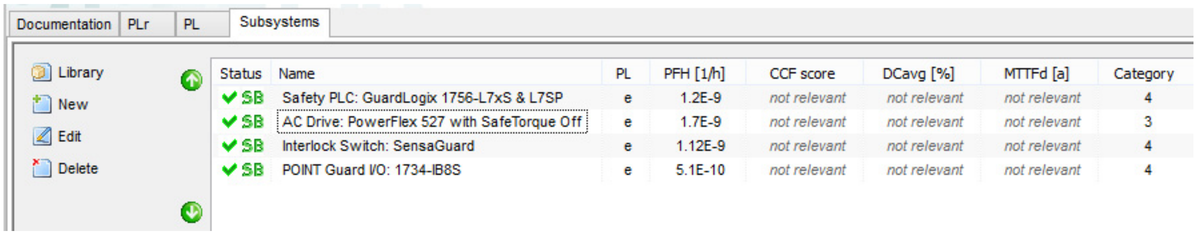
	Name	PL	PFH [1/h]	CCF score	DCavg [%]	MTTFd [a]	Category
✓ SB	Interlock Switch: SensaGuard	e	1.12E-9	*not relevant*	*not relevant*	*not relevant*	4
✓ SB	POINT Guard I/O: 1734-IB8S	e	5.1E-10	*not relevant*	*not relevant*	*not relevant*	4
✓ SB	Safety PLC: Compact GuardLogix 1...	e	2.1E-10	*not relevant*	*not relevant*	*not relevant*	4
✓ SB	POINT Guard I/O: 1734-OB8S	e	5.14E-10	*not relevant*	*not relevant*	*not relevant*	4
✓ SB	Contactors 100S	e	2.47E-8	65 (fulfilled)	99 (High)	100 (High)	4

The sensor subsystems from Door-monitoring Interlock Switch with an Integrated Safety Controller Safety Function Application Technique, publication SAFETY-AT034, are the SensaGuard Interlock Switch and the 1734-IB8S POINT

Guard I/O input module. The overall safety function is shown here. It combines those sensor subsystems from publication SAFETY-AT034, and the logic and actuator subsystems from this document.

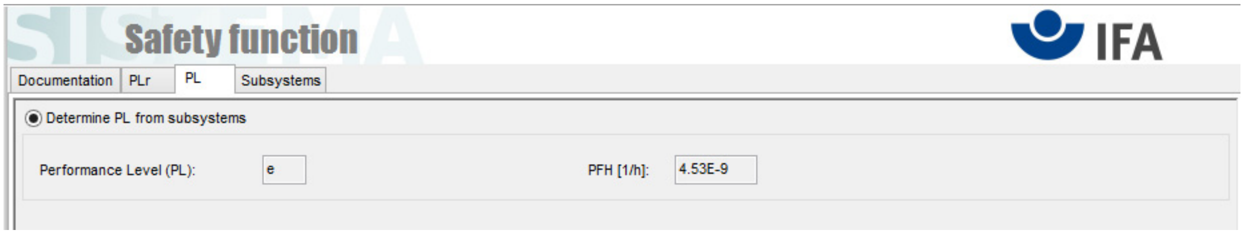


The PFH values for each subsystem in the safety function that is modeled in the graphic are taken from their respective publications and combined.



Status	Name	PL	PFH [1/h]	CCF score	DCavg [%]	MTTFd [a]	Category
✓ SB	Safety PLC: GuardLogix 1756-L7xS & L7SP	e	1.2E-9	*not relevant*	*not relevant*	*not relevant*	4
✓ SB	AC Drive: PowerFlex 527 with SafeTorque Off	e	1.7E-9	*not relevant*	*not relevant*	*not relevant*	3
✓ SB	Interlock Switch: SensaGuard	e	1.12E-9	*not relevant*	*not relevant*	*not relevant*	4
✓ SB	POINT Guard I/O: 1734-IB8S	e	5.1E-10	*not relevant*	*not relevant*	*not relevant*	4

IMPORTANT The PFH for this complete safety function, with the sensor, logic, and actuator subsystems, is 4.53E-09, which consumes 4.53% of the PLe bandwidth. The PL for the complete safety function is PLe.



● Determine PL from subsystems

Performance Level (PL): e

PFH [1/h]: 4.53E-9

Verification and Validation Plan

Verification and validation play important roles in the avoidance of faults throughout the safety system design and development process. ISO 13849-2 sets the requirements for verification and validation. The standard calls for a documented plan to confirm that all safety functional requirements have been met.

Verification is an analysis of the resulting safety control system. The Performance Level (PL) of the safety control system is calculated to confirm that the system meets the required Performance Level (PLr) specified. The SISTEMA software is typically used to perform the calculations and assist with satisfying the requirements of ISO 13849-1.

Validation is a functional test of the safety control system to demonstrate that the system meets the specified requirements of the safety function. The safety control system is tested to confirm that all safety-related outputs respond appropriately to their corresponding safety-related inputs. The functional test includes normal operating conditions and potential fault injection of failure modes. A checklist is typically used to document the validation of the safety control system.

Before you validate the GuardLogix Safety System, confirm that the safety system and safety application program have been designed in accordance with the GuardLogix 5570 and Compact GuardLogix 5370 Controller Systems Safety Reference Manual, publication 1756- RM099, and the GuardLogix Safety Application Instruction Set Safety Reference Manual, publication 1756-RM095.

The attached plan assumes a stop category 0 stop is being used. You must make appropriate adaptations to the plan if your safety function requires a stop category 1.

For a validation checklist, see the attached spreadsheet.

IMPORTANT In addition to using the verification and validation steps that are provided in the attached spreadsheet, consult the application technique for your input subsystem for the steps that are required to validate the input device. For the input subsystem example used in this safety function application technique, we reference Door-monitoring Interlock Switch with an Integrated Safety Controller Safety Function Application Technique, publication SAFETY-AT034.

Additional Resources

These documents contain more information about related products from Rockwell Automation.

Resource	Description
GuardLogix 5570 and Compact GuardLogix 5370 Controller Systems Safety Reference Manual, publication 1756-RM099	Describes the GuardLogix 5570 controller and Compact GuardLogix 5370 controller system. Provides instructions on how to develop, operate, or maintain a controller-based safety system that uses the Studio 5000 Logix Designer application.
GuardLogix 5570 Controllers User Manual, publication 1756-UM022	Provides information on how to install, configure, and program the GuardLogix 5570 controllers in the Logix Designer application.
Compact GuardLogix 5370 Controllers User Manual, publication 1769-UM022	Provides information on how to install, configure, and program the Compact GuardLogix 5370 controllers in the Logix Designer application.
GuardLogix Safety Application Instruction Set Safety Reference Manual, publication 1756-RM095	Describes the Rockwell Automation GuardLogix Safety Application Instruction Set. Provides instructions on how to design, program, or troubleshoot safety applications that use GuardLogix controllers.
PowerFlex 527 Adjustable Frequency AC Drive User Manual, publication 520-UM002	Provides information on how to install and configure the PowerFlex 527 AC drive.
PowerFlex 750-Series AC Drives Programming Manual, publication 750-PM001	Provides information on how to configure the PowerFlex 750 series AC drives.
PowerFlex 750 Series AC Drives Installation Instructions, publication 750-IN001	Provides information on how to install the PowerFlex 750 series AC drives.
PowerFlex Drives with TotalFORCE Control Programming Manual, publication 750-PM100	Provides information on how to configure the PowerFlex 755T series AC drives.
PowerFlex 750-Series Products with TotalFORCE Control Installation Instructions, publication 750-IN100	Provides information on how to install the PowerFlex 755T series AC drives.
PowerFlex 755 Integrated Safety - Safe Torque Off Option Module User Manual, publication 750-UM004	Provides information on how to install and configure the 20-750-S3 integrated STO option module.
PowerFlex 750-Series Drives with TotalFORCE Control Built-in EtherNet/IP Adapter User Manual, publication 750COM-UM009	Provides information on how to configure the PowerFlex 755T embedded EtherNet Adapter.
PowerFlex 20-750-ENETR Dual-port EtherNet/IP Option Module User Manual, publication 750COM-UM008	Provides information on how to configure the PowerFlex 750-series EtherNet option module.
Door-monitoring Interlock Switch with an Integrated Safety Controller Safety Function Application Technique, publication SAFETY-AT034	Provides instructions on how to wire, configure, and program a Compact GuardLogix® controller and POINT Guard I/O™ module to monitor a safety gate by using a SensaGuard™ safety switch.
Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1	Provides general guidelines on how to install a Rockwell Automation® industrial system.
Product Certifications website, rok.auto/certifications	Provides declarations of conformity, certificates, and other certification details.

You can view or download publications at http://www.rockwellautomation.com/global/literature-library/overview.page. To order paper copies of technical documentation, contact your local Allen-Bradley distributor or Rockwell Automation sales representative.

Notes:

Rockwell Automation Support

Use the following resources to access support information.

Technical Support Center	Knowledgebase Articles, How-to Videos, FAQs, Chat, User Forums, and Product Notification Updates.	www.rockwellautomation.com/knowledgebase
Local Technical Support Phone Numbers	Locate the phone number for your country.	www.rockwellautomation.com/global/support/get-support-now.page
Direct Dial Codes	Find the Direct Dial Code for your product. Use the code to route your call directly to a technical support engineer.	www.rockwellautomation.com/global/support/direct-dial.page
Literature Library	Installation Instructions, Manuals, Brochures, and Technical Data.	www.rockwellautomation.com/literature
Product Compatibility and Download Center (PCDC)	Get help determining how products interact, check features and capabilities, and find associated firmware.	www.rockwellautomation.com/global/support/pcdc.page

Documentation Feedback

Your comments will help us serve your documentation needs better. If you have any suggestions on how to improve this document, complete the How Are We Doing? form at http://literature.rockwellautomation.com/idc/groups/literature/documents/du/ra-du002_-en-e.pdf.

For more information on Safety Function Capabilities, visit:

http://marketing.rockwellautomation.com/safety/en/safety_functions

Rockwell Automation maintains current product environmental information on its website at http://www.rockwellautomation.com/rockwellautomation/about-us/sustainability-ethics/product-environmental-compliance.page.

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Publication SAFETY-AT141D-EN-P - September 2018

Supersedes Publication SAFETY-AT141C-EN-P - August 2017