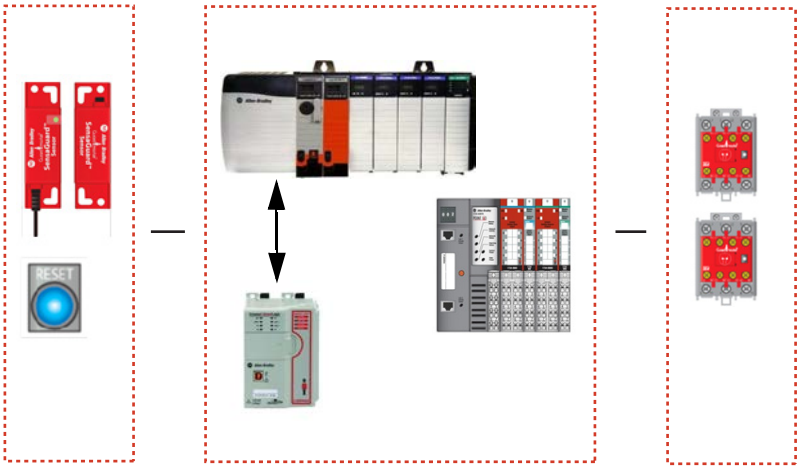
Application Technique

Original Instructions

Door-monitoring Interlock Switch with an Integrated Safety Controller Safety Function

Products: GuardLogix 5570 or Compact GuardLogix 5370 Controller, POINT Guard I/O Safety Module, SensaGuard Switch

Safety Rating: Cat. 4, 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.

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

Reproduction of the contents of this manual, in whole or in part, without written permission of Rockwell Automation, Inc., is prohibited.

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

Topic	Pages
Updated the Bill of Material.	6
Replaced the Electrical Schematic diagram.	8
Added a graphic that depicts the I/O configuration.	9
Replaced SISTEMA screen shots.	11...12

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 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 wire, configure, and program a GuardLogix® controller and POINT Guard I/O™ module to monitor a safety gate by using a SensaGuard safety switch. If the safety gate is opened, or if a fault is detected in the monitoring circuit, the GuardLogix controller de-energizes the final control device, in this case, a redundant pair of 100S contactors.

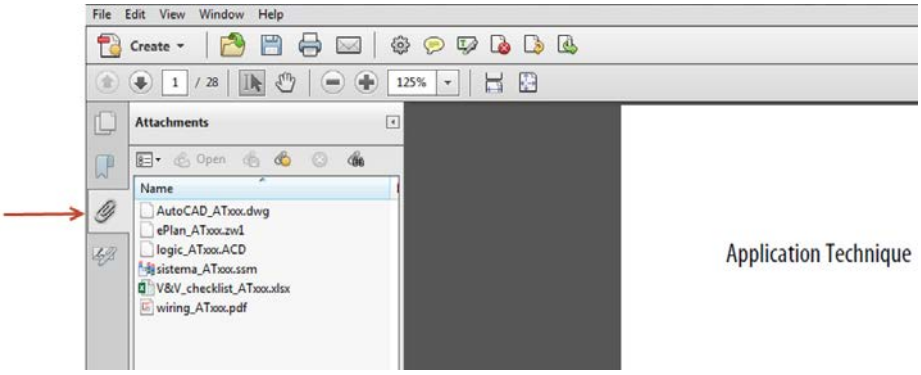
This example is applicable to any GuardLogix controller. The Safety Integrity Software Tool for the Evaluation of Machine Applications (SISTEMA) calculations that are shown later in this document must be recalculated if different products are used.

Use Sample Project Files

Sample project files (AutoCAD, EPLAN, ACD, SISTEMA, and Verification and Validation checklist) are attached to this document to help you implement this safety function.

To access these files, follow these steps.

1. If you are viewing the PDF file in a browser and do not see the Attachments link , download the PDF file and open it in the Adobe Acrobat Reader application.
2. Click the Attachments link .
3. Right-click and save the desired file.

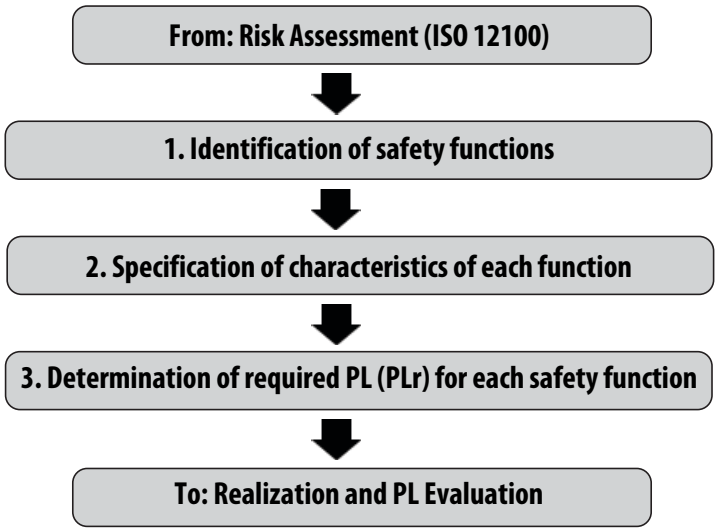


4. Open the file in the appropriate application.

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.



Door-monitoring Safety Function

This application technique includes one safety function: door-monitoring interlock.

Safety Function Requirements

Opening a guard door stops and prevents hazardous motion by removing power from the motor. When the door is closed, hazardous motion and power to the motor do not resume until a secondary action (pressing the Start button) occurs. Faults at the door interlock switch, wiring terminals, or safety controller are detected before the next safety demand.

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.

Functional Safety Description

This application technique uses a SensaGuard switch to monitor a safety gate. If the gate is opened, the output contactors are de-energized, and this event shuts down any associated machinery. The reset is manual.

The SensaGuard safety switch is connected to a pair of safety inputs of a 1734-IB8S module. The I/O module is connected via CIP Safety™ protocol over an EtherNet/IP™ network to the safety controller. The safety code in the safety processor monitors the status of the safety input by using a pre-certified safety instruction named Dual Channel Input Stop (DCS). The safety code is run in parallel in a 1oo2 processor configuration. When all conditions are satisfied, no faults are detected on the input modules, and the reset button is pressed, a second certified function block called Configurable Redundant Output (CROUT) checks the status of the final control devices, a pair of 100S redundant contactors. The controller then issues an output signal to the 1734-OB8S module to switch ON a pair of outputs to energize the safety contactors.

Bill of Material

This application technique uses these products.

Cat. No.	Description	Quantity
440N-Z21SS2A	SensaGuard switch, non-contact plastic RFP	1
800FM-G611MX10	800F Reset button - metal, guarded, blue, R, metal latch mount, one N.O. contact, standard	2
100S-C09EJ23C	Bulletin 100S-C - safety contactors	2
1734-AENT	24V DC Ethernet adapter	1
1734-TB	Module base with removable IEC screw terminals	4
1734-IB8S	POINT Guard I/O safety eight-point 24V DC sinking input module	1
1734-OB8S	POINT Guard I/O safety eight-point 24V DC output module	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, two-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
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 Compact GuardLogix processor, 2.0 MB standard memory,1.0 MB safety memory Compact GuardLogix processor, 3.0 MB standard memory, 1.5 MB safety memory Compact GuardLogix processor, 4.0 MB standard memory, 1.5 MB safety memory 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
	1769-ECR	Right-end cap and terminator	1
GuardLogix 5580	1756-L81ES 1756-L82ES 1756-L83ES 1756-L84ES	GuardLogix processor, 3 MB standard memory, 1.5 MB safety memory GuardLogix processor, 5 MB standard memory, 2.5 MB safety memory GuardLogix processor, 10 MB standard memory, 5 MB safety memory GuardLogix processor, 20 MB standard memory, 6 MB safety memory	1
	1756-L8SP	GuardLogix 5580 safety partner controller	1
	1756-PA72	Power supply, 120/240V AC input, 3.5 A @ 24V DC	1
	1756-A7	Seven-slot ControlLogix chassis	1
Compact GuardLogix 5380 - SIL 3	5069-L306ERMS3 5069-L310ERMS3 5069-L320ERMS3 5069-L330ERMS3 5069-L340ERMS3 5069-L350ERMS3 5069-L380ERMS3 5069-L3100ERMS3	Compact GuardLogix processor, 0.6 MB standard memory, 0.3 MB safety memory Compact GuardLogix processor, 1.0 MB standard memory, 0.5 MB safety memory Compact GuardLogix processor, 2.0 MB standard memory, 1.0 MB safety memory Compact GuardLogix processor, 3.0 MB standard memory, 1.5 MB safety memory Compact GuardLogix processor, 4.0 MB standard memory, 2.0 MB safety memory Compact GuardLogix processor, 5.0 MB standard memory, 2.5 MB safety memory Compact GuardLogix processor, 8.0 MB standard memory, 4.0 MB safety memory Compact GuardLogix processor, 10.0 MB standard memory, 5.0 MB safety memory	1
	5069-ECR	Right end cap and terminator	1

Setup and Wiring

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

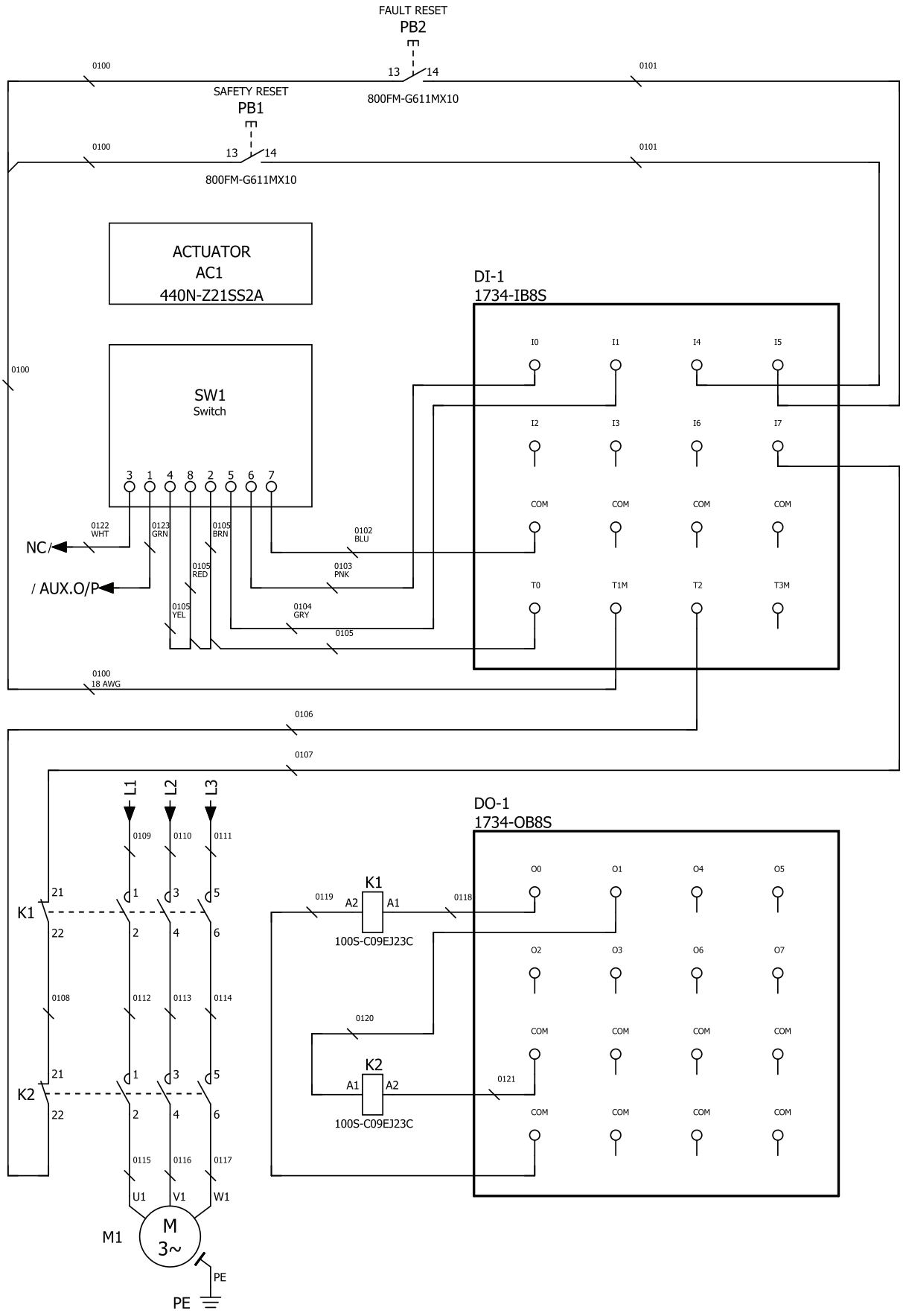
System Overview

The 1734-IB8S input module monitors the inputs from the SensaGuard switch.

The SensaGuard switch uses OSSD outputs that conduct periodic testing of the outputs. Thus, it is the OSSD outputs that test the integrity of the wiring between the SensaGuard switch and the safety inputs. The 1734-IB8S module test outputs are used as 24V sources.

The final control device is a pair of 100S safety contactors, K1 and K2. The contactors are controlled by the 1734-OB8S safety output module. The contactors are wired in a redundant configuration and are tested on start-up for faults. The start-up test is achieved by monitoring the feedback circuit into input 7 (I7) before the contactors are energized. This is accomplished by using a Configurable Redundant Output (CROUT) instruction. The system is reset by the momentary push button, PB1. Faults are reset by pressing PB2.

Electrical Schematic



For an electrical schematic in AutoCAD or EPLAN format, see the attached files.

Configuration

The safety controller is configured by using the Studio 5000 Logix Designer® application. You must create a project and add the POINT Guard I/O modules. A detailed description of each step is beyond the scope of this document. Knowledge of the Logix Designer application is assumed.

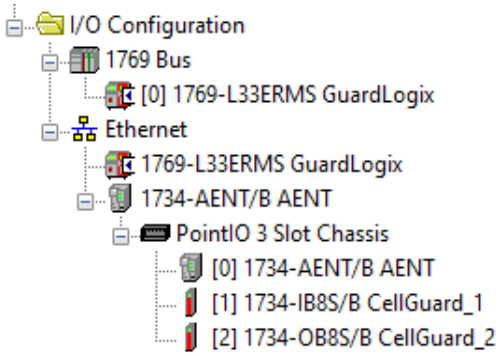
For a Studio 5000 Logix Designer project file that you can import into your own project, see the attached ACD file. The attached ACD file includes a GuardLogix 5370 controller, but if you choose a different controller, you can change the controller in the Logix Designer program. Make sure that the controller used in your safety function is the same controller used in your SISTEMA PL calculation.

Minimum Logix Designer Application Version	Product
20	GuardLogix 5570 controller
28	Compact GuardLogix 5370 controller (1769-L30ERMS, 1769-L33ERMS, 1769-L36ERMS)
31	Compact GuardLogix 5370 controller (1769-L37ERMS, 1769-L38ERMS)
31	GuardLogix 5580 or Compact GuardLogix 5380 controller

Create a Project with a GuardLogix Controller

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
   - GuardLogix 5580 and Compact GuardLogix 5370 and 5380 controllers have Ethernet ports
   - Time Synchronization enabled on the controller (5x70 series controllers) and any Ethernet communication modules, if used
2. Set the IP address for the controller or any Ethernet communication modules, if used.
3. Add a POINT I/O™ Ethernet adapter module to your project.
4. Add POINT Guard I/O modules to your project.
5. Configure the modules properly for your application.
   See Additional Resources for more information regarding I/O modules.



I/O Configuration from the Controller Organizer in the Logix Designer application

Programming

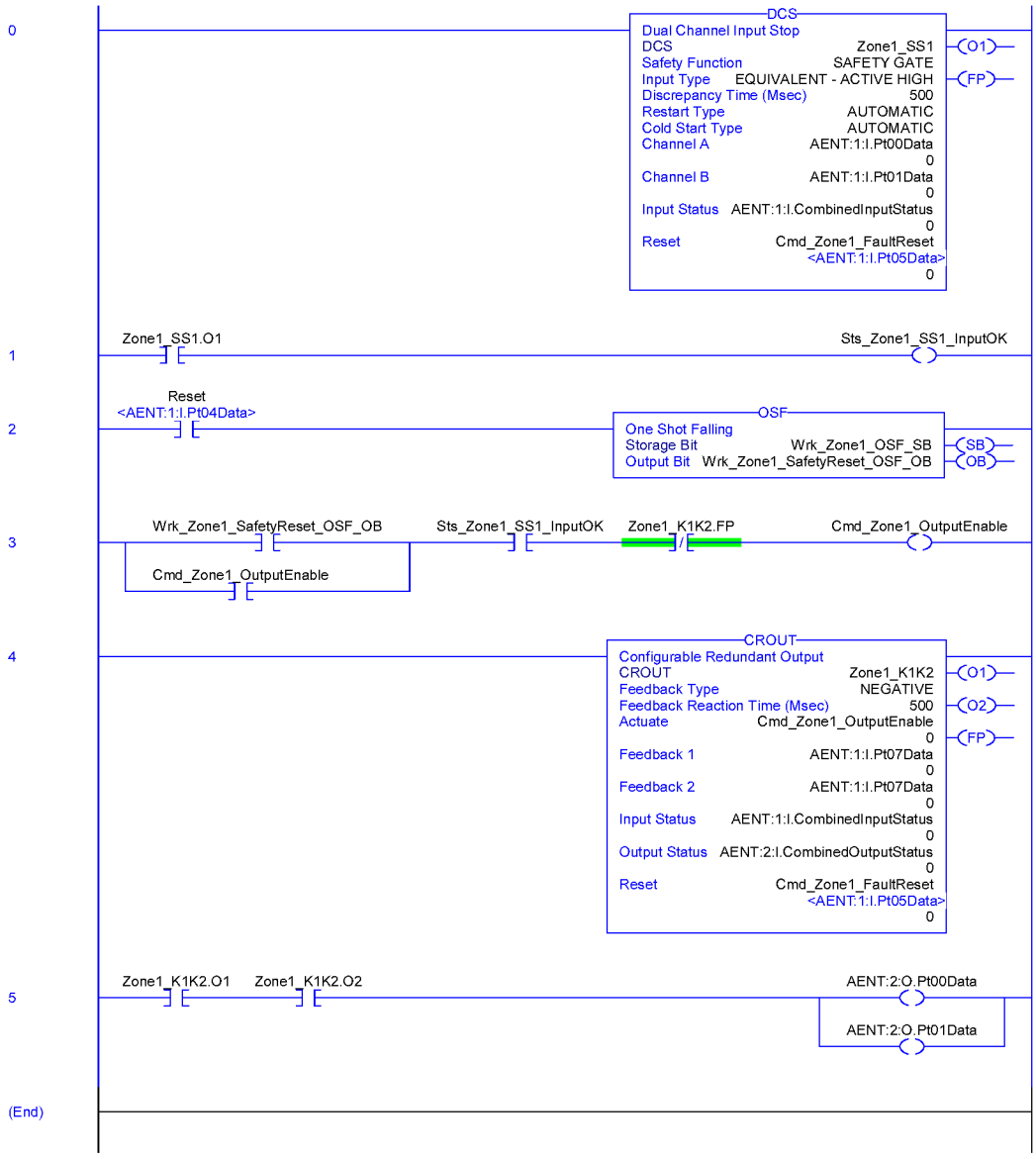
The Dual Channel Input Stop (DCS) instruction monitors dual-input safety devices whose main function is to stop a machine safely, for example, an E-stop, light curtain, or safety gate. This instruction can only energize Output 1 when both safety inputs, Channel A and Channel B, are in the active state as determined by the Input Type parameter, and the correct reset actions are conducted. The DCS

instruction monitors dual-input channels for consistency (Equivalent - Active High) and detects and traps faults when the inconsistency is detected for longer than the configured Discrepancy Time (ms).

The Configurable Redundant Output (CROUT) instruction controls and monitors redundant outputs. The reaction time for output feedback is configurable. The instruction supports positive and negative feedback signals.

The safety application code in the safety output routine prevents outputs from restarting if the input channel resets automatically, and this arrangement provides anti-tiedown functionality for the Circuit Reset.

The Input OK status (Sts_Zone1_SS1_InputOK) is used as a permissive in the safety output routines.



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

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 door-monitoring safety function can achieve a safety rating of category 4, Performance Level e (cat. 4, PLe), according to ISO 13849-1: 2015, as calculated by using the SISTEMA software PL calculation tool.

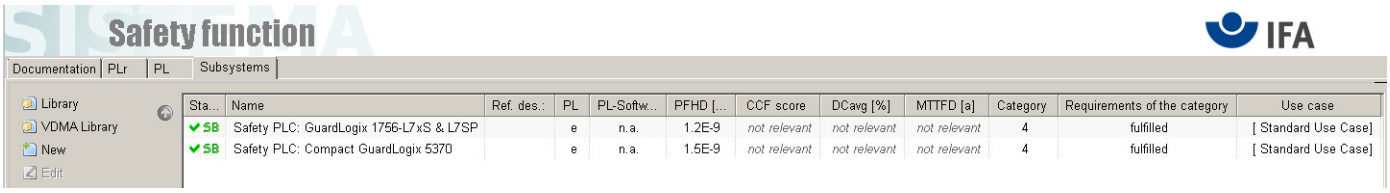
IMPORTANT To calculate the PL of your entire safety function, you must include the sensor subsystems along with the logic and actuator subsystems shown here. Depending on the sensor subsystems and devices you choose, the overall safety rating of your system could be reduced. An example that describes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

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

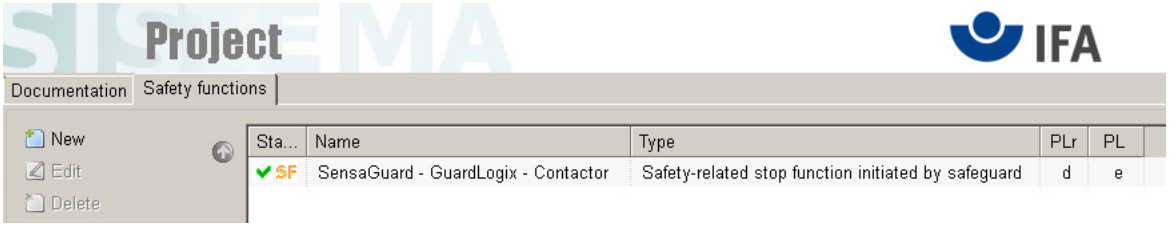
The average frequency of a dangerous failure per hour (PFH) for electromechanical systems may be calculated differently based on the version of ISO 13849 supported by SISTEMA. ISO 13849-1:2015, which changed the maximum MTTFd from 100...2500 years, is supported starting in version 2.0.3 of SISTEMA. As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

Calculations are based on operation 360 days per year for 16 hours per day with an actuation of the safety gate once every hour. This frequency equals 5760 operations per year.

The (logic) GuardLogix 5570 controller subsystem uses 1.2% of PLe bandwidth. The (logic) Compact GuardLogix 5370 controller subsystem uses 1.5% of PLe bandwidth.

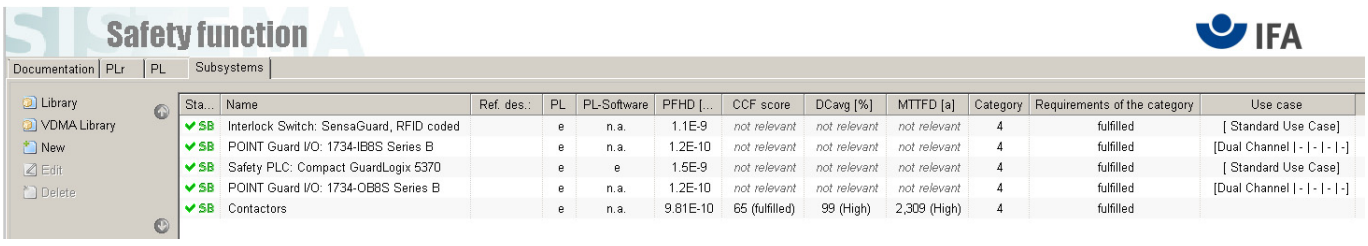


The minimum Performance Level required (PLr) from the risk assessment for this safety function is PLd.

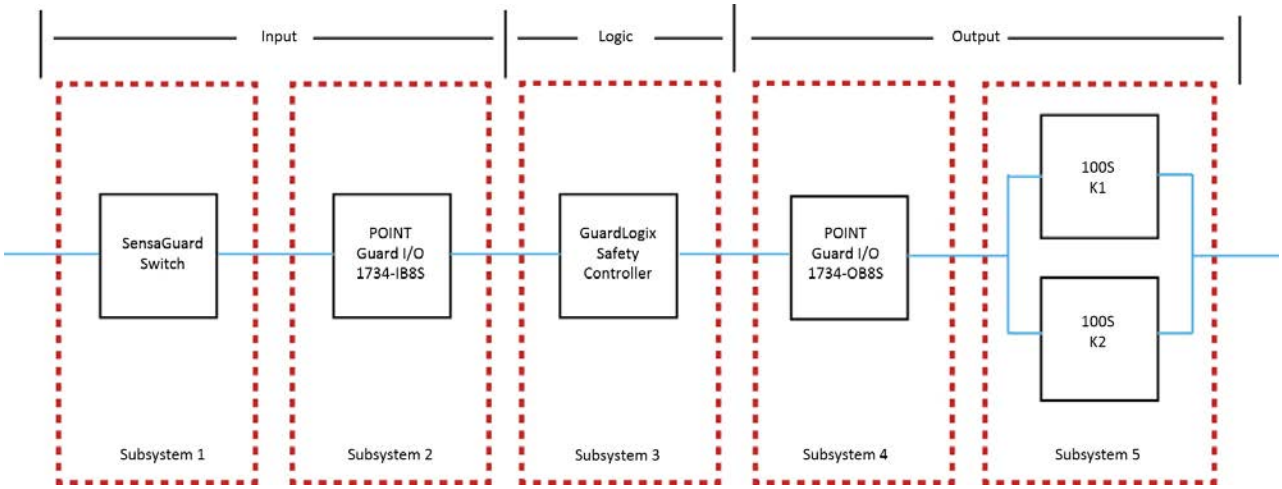


Complete Safety Function PL Calculation Example

Assuming the use of a Compact GuardLogix 5370 controller, here are all of the subsystems shown together. If you choose the GuardLogix 5570 controller, you need different calculations.



The door-monitoring safety function can be modeled as follows.



SensaGuard - GuardLogix - Contactor	
PLr	d
PL	e
PFHD [1/h]	3.82E-9

Because these devices are electromechanical devices, the functional safety data required for Performance Level calculation includes the following:

- Mean Time to Failure, dangerous (MTTFd)
- Diagnostic Coverage (DCavg)
- Common Cause Failure (CCF)

The functional safety evaluations of the electromechanical devices include the following:

- How frequently they are operated
- Whether they are effectively monitored for faults
- Whether they are properly specified and installed

SISTEMA calculates the MTTFd by using B10d data provided for the contactors along with the estimated frequency of use, entered during the creation of the SISTEMA project.

The DCavg (99%) for the contactors is selected from the Output Device table of ISO 13849-1 Annex E, Direct Monitoring.

The CCF value is generated by using the scoring process outlined in Annex F of ISO 13849-1. The complete CCF scoring process must be performed when actually implementing an application. A minimum score of 65 must be achieved.

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 validating the GuardLogix Safety System, confirm that the safety system and safety application program have been designed in accordance with the controller safety reference manuals listed in Additional Resources, and the GuardLogix Safety Application Instruction Set Reference Manual, publication 1756-RM095.

For a validation checklist, see the attached spreadsheet.

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 5580 and Compact GuardLogix 5380 Controller Systems SafetyReference Manual, publication 1756-RM012	Describes the GuardLogix 5580 and Compact GuardLogix 5380 controller system. Provides instructions on how to develop, operate, or maintain a controller-based safety system that uses the Studio 5000 Logix Designer application.
ControlLogix and GuardLogix 5580 Controllers User Manual, publication 1756-UM543	Provides information on how to install, configure, and program the GuardLogix 5580 controllers in the Logix Designer application.
CompactLogix and Compact GuardLogix Controllers User Manual, publication 5069-UM001	Provides information on how to install, configure, and program the Compact GuardLogix 5380 controllers in the Logix Designer application.
GuardLogix Safety Application Instruction Set 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.
POINT Guard I/O Safety Modules User Manual, publication 1734-UM013	Provides information on how to install, configure, and operate POINT Guard I/O modules.
SensaGuard Rectangular Flat Pack Installation Instructions, publication 440N-IN018	Provides information on how to install, wire, and troubleshoot the SensaGuard rectangular flat pack.
Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1	Provides general guidelines for installing a Rockwell Automation industrial system.
Product Certifications website, rok.auto/certifications.	Provides declarations of conformity, certificates, and other certification details.
Safety Automation Builder and SISTEMA Library website, rok.auto/sistema	Download the Safety Automation Builder© software to help simplify machine safety design and validation, and reduce time and costs. Integration with our risk assessment software provides you with consistent, reliable, and documented management of the Functional Safety Lifecycle. The SISTEMA tool, also available for download from the Safety Automation Builder page, automates calculation of the attained Performance Level from the safety-related parts of a machine's control system to (EN) ISO 13849-1.

You can view or download publications at rok.auto/literature.

Notes:

Rockwell Automation Support

Use these resources to access support information.

Technical Support Center	Find help with how-to videos, FAQs, chat, user forums, and product notification updates.	rok.auto/support
Knowledgebase	Access Knowledgebase articles.	rok.auto/knowledgebase
Local Technical Support Phone Numbers	Locate the telephone number for your country.	rok.auto/phonesupport
Literature Library	Find installation instructions, manuals, brochures, and technical data publications.	rok.auto/literature
Product Compatibility and Download Center (PCDC)	Get help determining how products interact, check features and capabilities, and find associated firmware.	rok.auto/pcdc

Documentation Feedback

Your comments help us serve your documentation needs better. If you have any suggestions on how to improve our content, complete the form at rok.auto/docfeedback.

Safety Function Capabilities

Visit rok.auto/safety for more information on our Safety System Development Tools, including Safety Functions.

Rockwell Automation maintains current product environmental information on its website at rok.auto/pec.

Rockwell Otomasyon Ticaret A.Ş. Kar Plaza İş Merkezi E Blok Kat:6 34752, İçerenköy, İstanbul, Tel: +90 (216) 5698400 EEE YÖnetmeliğine Uygundur

Connect with us.

rockwellautomation.com — expanding **human possibility**™

AMERICAS: Rockwell Automation, 1201 South Second Street, Milwaukee, WI 53204-2496 USA, Tel: (1) 414.382.2000, Fax: (1) 414.382.4444
EUROPE/MIDDLE EAST/AFRICA: Rockwell Automation NV, Pegasus Park, De Kleetlaan 12a, 1831 Diegem, Belgium, Tel: (32) 2 663 0600, Fax: (32) 2 663 0640
ASIA PACIFIC: Rockwell Automation, Level 14, Core F, Cyberport 3, 100 Cyberport Road, Hong Kong, Tel: (852) 2887 4788, Fax: (852) 2508 1846

Publication SAFETY-AT034C-EN-P - June 2021
Supersedes Publication SAFETY-AT034B-EN-P - November 2018