

**Original Instructions** 

# Safely-limited Speed and Guard Door Unlocking with Armor PowerFlex Safety Function

Products: Guardmaster 440G-MZ Interlocking Switch, GuardLogix 5580 or Compact GuardLogix 5380 Controller, Armor PowerFlex 35S Integrated Safety, 700S-C Relay

Safety Rating: Cat. 3, PLd to ISO 13849-1: 2023









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## **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).

## **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 help 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 13857:2019 (Safety of Machinery - Safety distances to help prevent hazardous zones being reached by upper and lower limbs) ANSI B11:19 2019 (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<sup>™</sup> 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 13857:2019 (Safety of Machinery – Safety distances to help prevent hazardous zones being reached by upper and lower limbs) ANSI B11:19 2019 (Machines – Performance Criteria for Safeguarding)

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

## Introduction

This safety function application technique explains how to wire, configure, and program a GuardLogix® controller to interface with an Armor™ PowerFlex® integrated safety AC drive to perform Safely-limited Speed (SLS) functions. The integrated safety Armor PowerFlex encoder feedback is used to bring velocity data into the GuardLogix safety task. The GuardLogix safety controller contains logic to monitor SLS. When the hazard is at a safe speed and an SLS request is made, safety logic unlocks the locking quard door. The Armor PowerFlex safety digital safety inputs are used to monitor the guard locking switch and safe speed selector switch. The safety outputs are used to control the lock function of the locking guard door switch.

The motion control actuator for the safety functions is the motor the Armor PowerFlex AC drive controls. Any malfunction the safety system detect results in a Safe Stop 1 (SS1) which is a safely monitored decel, followed by Safe Torque Off (STO).

This example uses a 1756-L84ES GuardLogix primary only controller, but you can substitute a Compact GuardLogix controller that supports the safety rating that is demonstrated in this safety function application technique. 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 *Q*, download the PDF file and open it in the Adobe Acrobat Reader application.
- 2. Click the Attachments link Ø.
- 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.



## **Safety Function**

This application technique includes three Safety Functions:

- 1. Guard Door Unlock at Safely-limited Speed (SLS)
- 2. Guard Door Unlock at standstill speed: Safe Stop 1 (SS1)
- 3. Prevention of an Unexpected Startup with guard door monitoring

## **Safety Function Requirements**

Guard door unlocking is a safety function when used to protect people. The guard door unlock is a safety output function that is based on safety inputs detection of safe-to-enter conditions. All safe entry conditions must be detected with safety integrity that meets the level of the unlock safety function.

When SLS is requested, the motor speed must go below the programmed speed limit before the SLS check time delay expires. After the delay expires, the speed must remain below the limit. After the delay expires, if motor speed is below the SLS, the gate is unlocked, and this action allows access to the hazardous area. You must perform a risk assessment to determine the SLS for the motor.

If the programmed speed limit is exceeded after the delay expires, a Safe Stop 1 (SS1) is generated to stop the motor, after which STO is activated, and this action causes the motor torque to be disabled.

A two-position maintained key selector switch is used to request SLS. When the key is in the SLS mode position, the key can be removed to preserve SLS mode while the task that requires SLS is performed.

If the door is unlocked or open, and the safety system is not in SLS or SS1 mode, then STO is activated.

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.

### **Guard Door Unlock at Safely-limited Speed**

For tasks that require motion, a safety function to limit and monitor the speed of the motor can be used so that harm can be avoided, or at least reduced, if motion occurs.

Normal operation with Automatic Restart is shown in the following diagram. After Check Delay expires, the speed must stay below the Active Limit, or the SLS Limit will be set to ON(1). The SLS Limit, once set, remains at ON(1) until the SLS function is reset. For automatic restart operation, the SLS function is reset when the request is removed OFF(0), provided no SLS faults have occurred.



Both the door and lock are monitored to help prevent an unexpected startup. Startup cannot occur until the door is closed and locked. After the door is closed, hazardous motion cannot resume until the door is locked via a lock request, and the STO condition is removed by using a manual action (Safety Circuit Reset) so the motor can be enabled.

The safety function meets the requirements for category 3, Performance Level d (cat. 3, PLd), per ISO 13849-1, and SIL 2 per IEC 62061, and control reliable operation per ANSI B11.19.

#### **IMPORTANT** Risk assessment is used to determine the SLS limits for the application.

#### SLS Operation

To operate the SLS function, follow these steps.

- While the motor is at speed, request SLS if there are no faults within the Safe Motion instructions (SFX/SS1/SLS). The SLS request must remain high (1) throughout the SLS procedure. After SLS is requested, the motion application is signaled to reduce the motor speed below the SLS Active Limit. SLS monitoring begins after a programmable time delay (7.3 seconds in this example) to verify that the motor speed is below the programmed SLS Active Limit. Once the monitoring begins, if the motor speed is below the limit, the gate is unlocked to allow access to the hazardous area.
- 2. When the task that requires access has been completed, close the monitored door.
- 3. To lock the door, remove the SLS request to initiate a lock request.
- 4. The SLS request is removed. The motor speed can now be increased above the SLS.

#### Recover from SS1 Due to Time Delay Expiration

If the speed does not go below the programmed speed limit before the delay expires, a Safe Stop 1(SS1) is requested. When the SS1 completes (standstill speed is reached), an STO request is made, which causes the motor torque to be disabled. With the motor disabled and speed below standstill, the gate is unlocked. To recover, follow these steps.

- 1. If the monitored door is open, close it.
- 2. Remove the SLS request.
- Press the Safety Reset to lock the guard door, and on the falling edge of the reset the STO is removed, which allows the motor to be enabled.

#### Recover from SS1 When SLS is Exceeded

The gate is assumed to be unlocked and open when the speed limit is exceeded.

If SLS is exceeded after the programmable delay expires, an SS1 request is generated. When the SS1 completes (standstill speed is reached), an ST0 request is made, which causes the motor torque to be disabled. To recover, follow these steps.

- 1. Close the monitored door.
- 2. Remove the SLS request.
- 3. Press the Safety Reset to lock the guard door, and on the falling edge of the reset the STO is removed, which allows the motor to be enabled.

### Guard Door Unlock at Zero Speed (Safe Stop 1 and Standstill Monitoring)

A guard door unlock condition for a properly executed SS1 with standstill monitoring allows entry when the actuator is in a standstill condition with STO activated. The safety function for SS1 standstill unlocking uses the same block diagram as SLS and is not analyzed separately in this example.



This example uses an operator interface to trigger the SS1 monitoring that is used to unlock the guard door when the actuator is within standstill speed limits. The triggering event is not considered part of the safety function for this application.

**IMPORTANT** Risk assessment is used to determine the conditions necessary for guard door unlock.

### Prevention of Unexpected Startup with Guard Door Monitoring

The guard door closed/locked status is the input of the subsystem. If the guard door is unlocked or opens when not commanded, or a safety fault is detected the actuator motor control executes an SS1. The SS1 monitors the encoder speed feedback to verify that the properly configured decel ramp is activated, followed by Safe Torque Off (STO) at standstill speed. The motor is prevented from resetting until a safe running condition is confirmed.

### **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 5580 and Compact GuardLogix 5380 Controller Systems Safety Reference Manual, publication 1756-RM012
- Machinery Safebook 5 Safety-related control systems for machinery, publication <u>SAFEBK-RM002</u>
- Safety Function: Light Curtain Products: Light Curtain GuardLogix Controller, publication <u>SAFETY-AT191</u>

**IMPORTANT** A risk assessment may require additional safeguarding methods such as hold-to-run devices and proximity to complementary safety functions such as E-stops and lifelines.

## **Bill of Materials**

This application technique uses these products.

Quantity	Cat. No. Description			
1	440G-MZS20SNRJ	Guard locking switch — 440G-MZ: OSSD, Power to Release, M12 5-pin QD connector		
1	889D-F5AC- <i>xx</i>	DC Micro (M12), female, straight, 5-pin, PVC cable, yellow, unshielded, IEC color coded, no connector, specify length		
1	800FM-KM22MX02	Two-position key selector switch, metal, maintained, right key removal, two N.C. contacts		
1	DSM9H/DSM9X	Incremental encoder. BEI Electronic Version 5G2, SIL 3 type. 2048PPR.		
1	700S-CF620EJBC	Safety control relay, 8 pole, 3 N.O./1 N.C. base, 3 N.O./1 N.C. auxiliary, bifurcated contact, 24V DC (with electric coil)		
1	1606-XLP72E	Compact power supply, 2428V DC, 72 W, 120/240V AC 1		

Choose one of the following safety-controller hardware groups.

Quantity	Controller	Cat. No.	Description		
		1756-L81ES	GuardLogix processor, 3 MB standard memory, 1.5 MB safety memory		
1		1756-L82ES	GuardLogix processor, 5 MB standard memory, 2.5 MB safety memory		
I		1756-L83ES	GuardLogix processor, 10 MB standard memory, 5 MB safety memory		
	GuaraLogix 5580."	1756-L84ES	GuardLogix processor, 20 MB standard memory, 6 MB safety memory		
1		1756-PA72	Power supply, 120/240V AC input, 3.5 A @ 24V DC		
1		1756-A7	Seven-slot ControlLogix® chassis		
		5069-L306ERS2	Compact Quard any processor 0.6 MD standard memory 0.7 MD sefety memory		
		5069-L306ERMS2	compact dualucoust processor, 0.0 nd standard memory, 0.5 nd safety memory		
		5069-L310ERMS	Compact Quardi asiy processor 10 MD standard memory 0 F MD sefety memory		
		5069-L310ERMS2	compact oual deographic processor, i.o no standard memory, o.o no safety memory		
		5069-L320ERS2	Compact Quardl agiv processor 2.0 MD standard memory 10 MD safety memory		
		5069-L320ERMS2	compact dual debyte processor, 2.0 mb standard memory, 1.0 mb safety memory		
		5069-L330ERS2	Compact Quardl agiv processor 7.0 MD standard memory 15 MD safety memory		
1		5069-L330ERMS2	Compact dualulugix processor, 5.0 mb standard memory, 1.5 mb safety memory		
I	Compact GuardLogix 5380- SIL 2	5069-L340ERS2	Compact Guardi agiy processor ( 0 MD standard memory 2.0 MD safety memory		
		5069-L340ERMS2	compact dual ucogix processor, 4.0 no standaru memory, 2.0 no safety memory		
		5069-L350ERS2	Compact Guardi agiy processor E 0 MD standard memory 2 E MD safety memory		
		5069-L350ERMS2	compact outractogic processor, 5.0 mb standard memory, 2.5 mb safety memory		
		5069-L380ERS2	Compact Guardiania processor 80 MD standard memory (0 MD sofety memory		
		5069-L380ERMS2	compact dual ucogix processor, 6.0 mb standard memory, 4.0 mb safety memory		
		5069-L3100ERS2	Compact Quard Logiv processor 10.0 MR standard memory 5.0 MP safety memory		
		5069-L3100ERMS2	compact obard Logix processor, io.0 mb standard memory, 5.0 mb Safety Memory		
1		1606-XLP72E	Compact power supply, 2428V DC, 72 W, 120/240V AC input		

<sup>(1)</sup> If your PLr is SIL 3/PLe, use a GuardLogix 5580 controller with a safety partner, cat. no. 1756-L8SP.

Choose an Armor PowerFlex 35S drive.

Quantity	Cat. No.	Description
1	35S-6 <i>xx-xxxx</i>	Safety Armor PowerFlex AC drive
3	889D-E5NC- <i>xx</i>	DC Micro (M12), female, straight, 5-pin, PVC cable, red, unshielded, IEC color coded, no connector, specify length
1	889D-F8FB- <i>xx</i>	DC Micro (M12), female, straight, 8-pin, PVC cable, black, braided shield, IEC color coded, no connector, specify length
1	AC Motor	Application dependent. Use the motor nameplate data to configure the Armor PowerFlex motor control.

## **Setup and Wiring**

For detailed information on how to install and wire the products in this application technique, refer to the publications that are listed in the <u>Additional Resources on page 29</u>.

### **System Overview**

The 440G-MZ guard locking switch is wired to the Safety Armor PowerFlex integrated safety IO. Guard door power is supplied from an external power supply. The dual-channel closed and locked signals are connected to safety inputs 0 and 1. Safety output 0 controls the guard door unlock via an interposing 700S-CF safety relay. The interposing relay is used to interface the bi-polar safety output to the guard door unlock signal.

An external power supply is connected to the 440G-MZ switch to provide solenoid power.

Safety speed feedback is supplied by one incremental encoder monitoring the AC motor actuator. The encoder is wired to the encoder input of the safety Armor PowerFlex 35S AC drive. The data for the encoder is passed internal to the drive to the internal safety speed-monitoring channel.

This example was tested using available components. An induction AC motor with dual-channel incremental encoder feedback that is compatible with the encoder input of the safety Armor PowerFlex AC drive was used for this example.

#### **Electrical Schematic**

For an electrical schematic in AutoCAD or EPLAN format, see the attached files. For instructions on how to access the attachments, see <u>Use</u> <u>Sample Project Files on page 4</u>.





#### **Network Architecture**

#### GuardLogix 5580 Controller

- I/O Configuration
   1756 Backplane, 1756-A7
  - [] [1] 1756-L84ES GuardLogix\_1
  - ▲ Lethernet I 1756-L84ES GuardLogix\_1
    - Armor PowerFlex 35x-6Dx-xxx1 Armor\_PF\_S

#### Compact GuardLogix 5380 Controller

- 🔺 🚄 I/O Configuration
  - ▲ 
    5069 Backplane

  - 5069-L3100ERMS2 GuardLogix Armor PowerFlex 35x-6Dx-xxx1 ArmorPF

## **Configuration**

The GuardLogix controller is configured by using the Studio 5000 Logix Designer<sup>®</sup> application, version 31 or later. You must create a project and add the Armor PowerFlex 35S AC drive. 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. For instructions on how to access the attachments, see <u>Use Sample Project Files on page 4</u>. The attached ACD file includes a GuardLogix 5580 controller, but if you choose a 5380 controller, you can change the controller in the Logix Designer application.

Product	Minimum Software Version
GuardLogix 5580 or Compact GuardLogix 5380 controller	31.0 or later
Studio 5000 Logix Designer	31.0 or later
FactoryTalk <sup>®</sup> Linx <sup>(1)</sup>	6.20 or later
Armor PowerFlex AC drive firmware	1.04 or later
Studio 5000 <sup>®</sup> Add-On-Profile (AOP) for Armor PowerFlex AC drive	1.1 or later

(1) Must be used as the Logix communication software. RSLinx<sup>®</sup> Classic does not allow connection to the Armor PowerFlex drive AOP.

**IMPORTANT** Only the safety-related programming and configuration are discussed in this document. Standard motion control required to satisfy the safety monitoring functions are out of scope of this document.

### Create a Project with a GuardLogix Controller

If you are not using the attached ACD file, follow these steps to create a project. For instructions on how to access the attachments, see <u>Use</u> Sample Project Files on page 4.

- 1. In the Logix Designer application, create a project with a GuardLogix controller.
  - IMPORTANT If you use a GuardLogix 5580 controller, you must configure the safety level of the controller on the Safety tab of the Module Properties dialog box. The default setting is SIL 2, PLd. For SIL 3, PLe operation, you must install a 1756-L8SP Safety Partner to the right of the primary controller.
- 2. Set the IP address for the controller and the Armor PowerFlex 35S.

Armor PowerFlex 35S Configuration - Device Definition

1. Create an Armor PowerFlex Drive via Ethernet to the project I/O Configuration.

amo	or powerflex		Cle	r Filte	5	Hide Filt	ers 🛠
AGAG A	Module Type Category Filters 20 - Comm-ER Analog CIP Motion Safety Track Section Communication		>	<pre>&gt; SSSS </pre>	Module Type Vendor Filters Advanced Energy Industries, In Bray International, Inc Buerkert Fluid Control Systems Dialight	c.	^ ~
Cat	alog Number Amor PowerFlex 35x-6Dx-xxx1	Description Armor PowerFle	x Drive	via Eth	ernet	Vendor Rockwell Autom	Catego Drive
<							>

- 2. Identity configure Connection, Safety Variant, and Safety Instance.
  - a. Variant is product-dependent; you must use a 35S catalog number. Set to Safety (S).
  - b. EM Brake is product-dependent; must be set to match the catalog number specified.
  - c. Connection set to Standard and Safety
  - d. Safety Instance set to Single Feedback Monitoring. Even though we are using controller-based safety functions, not drive-based, the safety instance must be set to feedback monitoring to enable encoder connection to the Logix safety tasks.
  - e. Select the drive rating and 24V power supply source that matches your equipment.

evice Definition			
Type Armor PowerFlex	Catalog Number 35S-6D1-P001	Revision 1	. 001
Name ArmorPF		Electronic Keying Compatible Keying	(001 - 255)
Product Armor PowerFlex		Connection Standard and Safety	<u> </u>
Description		Safety Instance Single Feedback Mon	itoring 🗸
Max. 50 characters	Drive Rating	Ethernet Address	
Variant Safety (S)	1 HP (0.75 kW) 🗸	Private Network	

Armor PowerFlex 35S Configuration - Initial Safety Configuration

- 1. Input Configuration:
  - a. Point Mode 0,1 Single-channel, which is used without Test Output (Safety, not pulse test). Safety input device (440G-MZ) wired to points 0 and 1 is an Output Signal Switching Device (OSSD). Set the Input Delay Time for these inputs to 1 ms.
  - b. Point Mode 2,3 Single-channel equivalent, which is used with Test Output. Safety input device (SLS Keyswitch) wired to points 2 and 3 is a standard contact device.

Armor PowerFlex Device ×										-
Armor_PF_S										
IP Address: 192.168.1.69										
Controller State: Offline	ontroller State Offline Device Connection: Standby Drive State: Offline					ve State: Offline				
INFORMATION	-									
Overview		11	nput C	onngu	ration					
MONITOR					Point Operation				Input Delay	Time (ms)
Date and Time					r on operation				input being	Time (mo)
Faults and Alarms				Point	Туре	Discrepancy Time (ms)	Point Mode	Test Source	$Off \rightarrow On$	$On \rightarrow Off$
Predictive Maintenance	0		0	0	0. 1.01		Used without Test Output 🔎	None	0	1
SAFETY			0	1	Single Channel •	U	Used without Test Output 🔎	None	0	1
Safety Configuration				2			Used with Test Output 🔹	0	0	1
Safety Feedback				3	Single Channel 🔹	0	Lised with Test Output	1	0	1
Scaling		Ľ	B Tost	Sourcov	alue corresponde to the Point v	aluo on Tost Outr	ut page		U	
Safe Torque Off (STO)		1.1	J Teats	Source v	alue corresponds to the Follit v	alde on rest outp	ut page.			
Safe Brake Control (SBC)										
Safe Stop 1 (SS1)			1000	or Latch Tin	ms					
Test Output			(0 - 6553)	5)						
Input Configuration										

2. Output Configuration: Type - Dual Channel, Point Mode - Safety Pulse Test. To control guard door solenoid interposing safety relay.



3. Test Output: Point Mode - Test Pulse Output. Used for pulse testing the SLS Keyswitch input.



- 4. Safety Feedback: The motor actuator drives the encoder, which wired to the Armor PowerFlex encoder input.
  - a. Per the encoder specifications, the cycle resolution is a dual channel incremental type.
  - b. The encoder is powered by 12V DC from the Armor PowerFlex drive.
  - c. The encoder cycle resolution is 1024 cycles/rev.
  - d. The encoder input circuits detect the rising and falling edges of the encoder pulse out for 4 counts/cycle.
  - e. Leave all other settings at default values. The Logix safety instructions are used for the SLS and SS1 safety functions.
  - The Effective Resolution (4096 count/rev) is required to configure the GuardLogix SFX instruction.

Armor_PF_S							
IP Address: 192.168.1.69							
Controller State: Offline	Device Conn	nection: Standby					Drive State: Offlin
INFORMATION Overview MONITOR Date and Time Faults and Alarms Predictive Maintenance	0	Safety Feedback Electrical Interface Type Digital Incremental, Do	ual Cha 🗸	Voltage Monitor			
Safety Configuration Safety Feedback Scaling Safe Torque Off (STO)		Cycle Resolution 1024 (0 - 999999999)	• Cycles/Rev	Cycle Interpolation	• Counts/Cycle	Effective Resolution 4096	Counts/Rev
Safe Brake Control (SBC) Safe Stop 1 (SS1) Test Output		Velocity Average Time 10 (0 - 65535)	ms	Maximum Speed 0.000 (0 - 999999999.000)	Rev/s	Standstill Speed 1.000 (0 - 999999999.000)	Rev/s
Output Configuration Actions		Acceleration Average Time	ms	Maximum Acceleration 0.000	Rev/s2		
MOTOR Motor Control Encoder Feedback		(0 - 65535)		(0 - 999999999.000)			
	*					OK Apply	Cancel

5. Scaling: For this example, we are not using position feedback, leave values at default.



6. Motor Encoder Feedback: Set to match encoder specifications. These settings must match the Safety Feedback configuration (<u>step 4</u>).

Armor PowerFlex Device ×		Ŧ
Armor_PF_S		
IP Address: 192.168.1.69		
Controller State: Offline	Device Connection: Standby	Drive State: Offline
INFORMATION	Encoder Ecodbook	
Overview	Elicouel Feeuback	
MONITOR	Electrical Interface Type	
Date and Time	O Disabled Encoder Feedback	
Faults and Alarms	Digital Incremental Single Channel Single Ended	
Predictive Maintenance	Digital Incremental Single Channel Differential	
SAFETY	O Digital Incientental, Single Channel, Direcental	
Safety Configuration	O Digital Incremental, Dual Channel, Single Ended	
Safety Feedback	Digital Incremental, Dual Channel, Differential	
Scaling	O Generic Sine/Cosine	
Safe Torque Off (STO)		
Safe Brake Control (SBC)	Polarity	
Safe Stop 1 (SS1)	Normai	
Test Output		
Input Configuration	Cycle Resolution Cycle Interpolation Effective Resolution	
Output Configuration	1024 Cycles/Rev 4 Counts/Cycle 4096	Counts/Rev
Actions	(1 - 20000)	
MOTOR	Enable Velocity Comparison Diagnostic	
Motor Control		
Encoder Feedback		

Safety: Configure drive-based Safe Stop 1 (SS1) for Monitored SS1. Configure these settings to the same values as the corresponding settings in the Logix SS1 instruction. This setting is the action that the drive takes when a communication loss or communication timeout occurs. Safe Brake Control (SBC) is not used. The communication connection loss and connection idle action is set to drive 7. based SS1.

Armor PowerFlex Device ×		상가 전화 가지 않는 것 같아.	이상에 전 것이 있어요?		
Armor_PF_S					
IP Address: 192.168.1.69					
Controller State: Offline Device	e Connection: Standby				
INFORMATION	Safe Stop 1 (SS1)				
Overview	Sale Stop 1 (SST)				
MONITOR	Mode	<ol> <li>It initiates and more</li> </ol>	nitors the motor deceleratio	n rate within selecter	d limits to stop the motor
Date and Time	Monitored SS1	deceleration are m	ionitored, Safety Feedback E	or speed is below a s Encoder is required.	pecified limit. Speed and
Faults and Alarms		)			
Predictive Maintenance 🔹	Class Dalau	Ctop Meniter Delay		May Clan Time	
SAFETY	10000 ms	200	ms	10200	ms
Safety Configuration	(1 - 999999999)	(0 - 65535)		(1 - 999999999)	
Safety Feedback					
Scaling	30.000	Position Units/s	2.500		Position Units/s
Safe Torque Off (STO)	(0.000 - 999999999.000)		(0.000 - 9999999999.00)	0)	
Safe Brake Control (SBC)				-,	
Safe Stop 1 (SS1)	Standstill Speed		Decel Reference Rate		
Test Output	0.300	Position Units/s	3.000		Position Units/s/s
Input Configuration	(0.000 - 99999999.000)		(0.000 - 9999999999.00)	0)	
Armor PowerFlex Device ×					
Armor_PF_S					
IP Address: 192.168.1.69					
Controller State: Offline Device	e Connection: Standby				Drive State: Offline
INFORMATION	Safe Brake Control (SBC)				
Overview	Suite Braile Control (CDC)				
MONITOR	SBC Mode	STO Activates SBC		STO to SBC Delay	
Date and Time	Not Used 🗸	Not Linked	-	0	ms
Faults and Alarms		,		(-32768 - 32767)	
Predictive Maintenance					
SAFETY					
Safety Configuration					
Safety Feedback					
Scaling					
Safe Torque Off (STO)					
Safe Brake Control (SBC)					
Armor PowerFlex Device ×			•		
Armor_PF_S					
IP Address: 192.168.1.69					
Controller State: Offline Device	e Connection: Standby		Drive State: Offline		
INFORMATION	Actions to Take Upon Conditi	ons			
Overview					
MONITOR	Connection Loss Action	Connection Idle Actio	in		
Date and Time	Safe Stop 1 (SS1)	Safe Stop 1 (SS1	) -		
Faults and Alarms					
Predictive Maintenance 0	Restart Type	Cold Start Type			
SAFETY	Automatic -	Automatic	•		
Safety Configuration					
Safety Feedback					
Scaling					
Safe Torque Off (STO)					
Safe Brake Control (SBC)					
Safe Stop 1 (SS1)					
Test Output					
Input Configuration					
Output Configuration					
Actions					

## Programming

4

For controller logic that you can download to your controller, see the attached ACD file. For instructions on how to access the attachments, see <u>Use Sample Project Files on page 4</u>.

### **General Safety Task Configuration**

1. For modularity, and following application software guidance from safety standards, the safety zone program has been broken into routines for input, logic, and output. Be sure to call all routines from the MainRoutine.

SafetyTask (20 ms)	Input: Safety Mapped
<ul> <li>SafetyProgram</li> <li>Parameters and Local Tags</li> <li>MainRoutine</li> <li>100_MappedTags</li> </ul>	Iags JSR Routine Name 100_MappedTags
= 101_SLS = 102_GuardDoor	JSR Routine Name 101_SLS
UU_Logic O01_GuardDoor_Unlock O10_Ax1_SS1 O20_STO	JSR Routine Name 102_GuardDoor

- 2. Map safety tags with the user-defined data type (UDT)
  - a. Create Standard and Safety tags of the same Data Type.

Controller Tags - GuardLogix_1(controller)	×		
Scope: GuardLogix_1 ~ Show: All Tag	<b>3</b> 8		
Name ==	Style	Data Type	Class
▲ Safety_From_Standard	Decimal	DINT[4]	Safety
Safety_From_Standard[0]	Decimal	DINT	Safety
Safety_From_Standard[1]	Decimal	DINT	Safety
<ul> <li>Safety_From_Standard[2]</li> </ul>	Decimal	DINT	Safety
Safety_From_Standard[3]	Decimal	DINT	Safety
▲ Standard_to_Safety	Decimal	DINT[4]	Standard
Standard_to_Safety[0]	Decimal	DINT	Standard
Standard_to_Safety[1]	Decimal	DINT	Standard
Standard_to_Safety[2]	Decimal	DINT	Standard
Standard_to_Safety[3]	Decimal	DINT	Standard



A best practice is to map a UDT of information.

b. In the Safety Tag Mapping dialog box, enter the tag names, click Close.

5	afet	ty Tag Mapping		
		Standard Tag Name	Safety Tag Name 🔶	Close
	►	Standard_to_Safety 🗸	Safety_From_Standard	
	*			Help

3. The Reset and Safe Stop 1 (SS1) signals for safety logic are mapped from the standard logic with the mapped alias.

×

#### Figure 1 - Standard Program, Any Routine

Reset_Input	Armor_PF_S:O.ClearFault	Standard_to_Safety[0].0
SS1 Input		Standard to Safetvi01.3
ī ;		

Figure 2 - Safety Program, IOO\_MappedTags Routine



#### 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.

Risk Assessment and Safety Standards shall determine the location and specific requirements for safety reset.

#### Figure 3 - Safety Routine L10\_Logic

Safety Reset		
(Mapped)	Zone Reset Timer	
SafetyReset	TOF	
	Timer ResetTmr	-(EN)
	Preset 50	(DN)-
	Accum 60	
	Zone Reset	
	Storage Bit	
	OSF	
	Storage Bit ResetSB	
	Output Bit ResetOB	-(SB)
	Zone	Reset Guard
Zone Reset Timer	De	oor Lock
ResetTmr.DN	Reset_0	GuardDoor_Lk
		$\sim$
Zone Reset Falling		
Edge Output Bit		Zone Reset
		_

### Input Safely-limited Speed (SLS) Selector Switch – Safety Routine I01\_SLS

Monitor SLS selector switch status inputs.

Tag	Description
InputStatus	Combine the input status of the inputs before the DCS.
DSC	Dual Channel Stop instruction for monitoring two inputs and associated I/O status.
raC_Dvc_DCS	The optional raC_Dvc_DCS Add-On Instruction (AOI) connects DCS to the HMI faceplate. (ME, SE, PV5000) To find this information, go to the <u>Product Compatibility Download Center</u> website, and search for Safety Device Library.

		O
	Safe Speed Selector	DCS Safety Device Objects
	DCS	raC_Dvc_DCS
L	DCS         SLS1           Safety Function         USER DEFINED           Input Type         EQUIVALENT - ACTIVE HIGH           Discrepancy Time (Msec)         500           Restart Type         AUTOMATIC           Cold Start Type         AUTOMATIC	rac_Dvc_DCS         SLS1         Dvc         SLS1           Out_Ctrl_inf         SLS1         SLS1         SLS1           Out_Ctrl_ist         SLS1         SLS1         SLS1           Out_Ctrl_ists         SLS1         SLS1         SLS1           Inp_Suspend         0+         Cts_DispositicPresent)
	Channel B Armor_F_S:SLIN930ata Channel B Armor_PF_S:SLIN930ata Input Status Reset ResetSB	
Safe Speed Selector SLS1.01	440G-MZ has 2.5s dwell time between subseq Timer prevents rapid SLS request that caus	uent locking and unlocking. se GD_Unlock CROUT.FP Zone Safe Limited Speec Request Initiate SLS_Reqint
		<b></b>

### Input Guard Door Closed and Locked – Safety Routine IO2\_GuardDoor

Monitor guard door lock status inputs.

Tag	Description
InputStatus	Combine the input status of the inputs before the DCS.
DSC	Dual Channel Stop instruction for monitoring two inputs and associated I/O status.
raC_Dvc_DCS	The optional raC_Dvc_DCS A0I connects DCS to the HMI faceplate. (ME, SE, PV5000) To find this information, go to the <u>Product Compatibility Download Center</u> website, and search for Safety Device Library.

Arr	nor_PF_S:SI.In00Status Armor_PF_S:SI.In0	1Status			Zone Guard Door 1 Closed GuardDoor_CIs1.InputStatus
	Zone Guard Door 1 Closed			DCS Safety Device Objects	
	DCS GuardDoor_Cls1 DCS GuardDoor_Cls1 Safety Function SAFETY GATE Input Type EOUVALENT - ACTIVE HIGH Discrepancy Time (Msec) 250 Restart Type AUTOMATIC Cold Start Type AUTOMATIC Cold Start Type AUTOMATIC Channel A Armor_PF_S:SI.In00Data Channel B Armor_PF_S:SI.In01Data 0 Input Status GuardDoor_Cls1.InputStatus 1 Reset ResetSB	-(01) -(FP)	raC_Dvc_DCS -raC_Dvc_DCS Inp_DCS Out_Ctrl_Inf Out_Ctrl_Sts Inp_Suspend	GuardDoor_Cls1_Dvc GuardDoor_Cls1 GuardDoor_Cls1_Inf GuardDoor_Cls1_Sts 0	(Sts_DeviceSuspended)— (Sts_SafelyDemand) (Sts_RestRequired)— (Sts_DiagnosticPresent)— (Sts_FaultPresent)—
Zone Guard Door 1 Closed GuardDoor_Cls1.01		l Zone Guard D	oor Summary		Zone Guard Door Closed GuardDoor_Cls

## Input SFX — Safety Routine I03\_Ax1\_SFX

The Input SFX routine brings safe speed and velocity feedback into the safety task. Primary feedback scaling and home proximity switch (not used).

Tag	Description		
DIV	Feedback resolution is taken directly from the Armor PowerFlex module feedback properties. PositionUnitsPerMtrRev: Application scaling factor. This example, 4096 count/rev. Position Scaling: Counts/rev		
SFX	Safe Feedback Interface Monitors safety position, velocity, and feedback status Scales position and velocity to proper units. SFX.ActualSpeed is used by the SLS and SS1 instructions to monitor actual motor velocity.		
The SFX inst For this example, ArmorPF enc. Feedback effective resolution = SFX.FeedbackResolution = 4096, SFX I SFX.I Zone DV Source A Ax Source B At Dest	ruction is configured using your application feedback specifications. def redeback device is 1024PPR AdB incremental encoder with x4 cycle interpolation. def redeback device is 1024PPR AdB incremental encoder with x4 cycle interpolation. def redeback device is 1024PPR AdB incremental encoder with x4 cycle interpolation. def redeback device is 1024PPR AdB incremental encoder with x4 cycle interpolation. def redeback device is 1024PPR AdB incremental encoder with x4 cycle interpolation. def redeback device is 1024PPR AdB incremental encoder with x4 cycle interpolation. def redeback device is 1024PPR AdB incremental encoder with x4 cycle interpolation. def redeback device is 1024PPR AdB incremental encoder with x4 cycle interpolation. def redeback device is 1024PPR AdB incremental encoder with x4 cycle interpolation. def redeback device is 1024PPR AdB incremental encoder with x4 cycle interpolation. def redeback device is 1024PPR AdB incremental encoder with x4 cycle interpolation. def redeback device is 1024PPR AdB incremental encoder with x4 cycle interpolation. def redeback device is 1024PPR AdB incremental encoder with x4 cycle interpolation. def redeback device is 1024PPR AdB incremental encoder with x4 cycle interpolation. def redeback device is 1024PPR AdB incremental encoder with x4 cycle interpolation. def redeback device is 1024PPR AdB incremental encoder encod		
	SFX Fault Armor_PF_S:S0.SFXFault Actual Postion 29935:S0. Actual Cycles 0 Actual Speed 0.0 Fault Type 1 Diagnostic Code 0		

### Logic SLS — Safety Routine LO1\_Ax1\_SLS

The Logic SLS routine performs the Safely-limited Speed (SLS) logic. SLS is used for guard door unlocking. When the SLS request is removed the timer allows time for the Guard Door to lock before stopping SLS monitoring. The timer preset value is dependent upon the guard locking device lock and feedback response time.

The 440G-MZ lock feedback from Armor PowerFlex output through 700S safety relays trends about 500 ms.



#### **Table 1 - SLS Instruction**

Tag	Description
MOV	Actual velocity visual for the programmer to see what speed the SLS is monitoring.
SLS	Safely-limited Speed instruction Velocity Active Limit is the maximum velocity. Can be programmatically changed. Feedback SFX is the SFX being monitored. SLS Active, Limit, Fault values sent to the drive for pass through standard tags.



Zone Axis1 Safe Limited Speed Axis1.SLS.SLS.FP

#### Table 2 - SLS Output Status

Tag	Description
SLS_0k	IF SLS is Active, check-delay expired, not over speed limit, no SLS fault THEN SLS is OK. SLS Limit is the key variable for SLS out of Active Limit. SLS does not fault when exceeding the active limit.
StopReq	IF SLS is Active, check-delay expired, and (limit or SLS fault) THEN SLS Stop Request. Safe stop the application due to SLS malfunction or overspeed limit. In this example, initiate Safe Stop 1 (SS1).
Zone Axis 1 S Limited Spe Armor_PF_S:S0 SLSActive Axis1.SLS.SLS.Check	afe Zone Axis1 Safe Zone Axis1 At Safe ed Limited Speed Limited Speed DelayActive Armor_PF_S:S0.SLSLimit Axis1.SLS.SLS_PP Axis1.SLS.SLS_Ok Zone Axis1 SLS_SLS_P Zone Axis1 Stop Reguest Axis1 StopRep

#### Example of Safely-limited Speed Monitoring

This trend example shows the key elements for normal (no faults) operation of Safely-limited Speed monitoring for guard door unlock control. This trend file, Axis1\_SLS, is available within the attached Logix project file under >Assets>Trends.



ltem	Description
1	Motor running at normal speed.
2	With an SLS_Req, the SLS instruction initiates. SLS.CheckDelayActive goes true. The Armor PowerFlex passthrough tag SLSActive goes true and is used to select the Safely-limited Speed in the standard task.
3	When the SLS.CheckDelay time has expired SLS.CheckDelayActive goes false, the SFX.ActualSpeed is compared to the SLS.ActiveLimit speed. If the Armor PowerFlex tag SO.SLSLimit is false, the SFX.ActualSpeed is less than the SLS.ActiveLimit speed. If the SLSLimit tag is true, the SFX.ActualSpeed is greater than the SLS.ActiveLimit speed.
4	If the SO.SLSLimit tag is false, SLS.SLS_Ok goes true and initiates a GuardDoor_Unlk_Cmd, unlocking the guard door. If the SO.SLSLimit tag is true, SLS.SLS_Ok is false, the guard door does not unlock and the SLS instruction, SAF_RunPerm goes false and initiates a Safe Stop 1 (SS1).
5	Exit SLS, tag SLS_ReqInit goes false, the GuardDoor_UnIk_Cmd goes false locking the guard door.
6	SLS_TMR provides time for the guard door to lock and the closed/locked feedback to be received before the SLS_Req tag goes false.
7	Armor PowerFlex tag SO.SLSActive goes false and the speed resumes to normal running speed.

A trend can be used to verify the timing of the safety functions. Understanding sequential logic timing is important to allow time for a system to respond and help prevent nuisance tripping.

### Logic Main — Safety Routine L10\_Logic

The main safety logic contains reset logic, device status summary, and the main run permissive. Table 3 - Zone Safety Motion Ready and Safety Reset Required

Tag	Description
Axis1.SFX.SFX.01 Axis1.SS1.SS1.01 Axis1.SLS.SLS.01	Safety instructions monitoring and ready.
SAF_RunPerm	On loss of safe run permissive, a Safe Stop 1(SS1) is executed.
STO_ResetReq	Safe Torque Off (STO) requesting reset.
SafeMotion_Rdy	Safety instructions ready. Important for fault recovery.

Zone Axis1 Safe Feedback Axis1.SFX.SFX.01	Zone Axis1 Safe Stop 1 Axis1.SS1.SS1.01	Safe motion monitoring ready Zone Axis1 Safe Limited Speed Axis1 SLS,SLS,01	Zone Safe Motion Ready SafeMotion_Rdy
Zone Safety Run Permissive SAF_RunPerm		Indicate to machine safety requires a reset	Safety Reset Required SafetyReset_REQD
Zone STO Reset Required STO_ResetReq			
Zone Safe Motio Ready SafeMotion_Rd	n Y		

#### **Table 4 - Safety Input Summary**

Tag	Description
GuardDoor_Cls	Guard Door Closed Status
GuardDoor_Lk	Guard Door Locked Status
SLS_0k	SLS actively monitoring allows the guard door to be unlocked and open.
Zone Guard Doors Zone Guard Door Closed Locked GuardDoor_Cls GuardDoor_Lk Zone Axis1 At Safe Limited Speed Axis1.SLS SLS_0k	Safety input Summary Rung Zone Safety Inputs Ok SafetyIn_Ok

#### Table 5 - Drive Run Permissive

Tag	Description
SafetyIn_Ok	Input summary from previous rung.
SS1_Req	Safe Speed 1 (SS1) request mapped from standard.
SLS.StopReq	SLS malfunction or velocity over limit removes run permissive.
SAF_RunPerm	On loss of safe run permissive, a Safe Stop 1 (SS1) is executed

Zone Reset	Zone Safety Inputs Ok	Zone Safe Stop 1 Request (Mapped)	Zone Axis1 Stop Request	Zone Safet Run Permiss
Reset	Safetyin_Ok	SS1_Req	Axis1.SLS.StopReq	SAF_RunPe
		/	/ [	
Zone Safety				
Run Permissive				

### Output Guard Door Unlock — Safety Routine 001\_GuardDoor\_Unlock

The output guard door unlock routine contains the logic that controls the guard door lock and unlock function.

Guard door unlock permissive is based on SS1 at standstill or SLS monitoring velocity is below limit:

	SS1 When SLS is no longer requested, the g	Zone hazard safe summary standstill or Safe Limited Speed uard doors are locked immediately, then SLS monitoring is stopped.	
Zone Axis1 Standstill Ok Axis1.SS1.StandStill		Zi Ur Guai	one Guard Door nlock Permissive rdDoor_Unlk_Perm
Zone Axis1 At Safe Limited Speed Axis1.SLS.SLS_Ok	Zone Safe Limited Speed Request Initiate SLS_Reginit		-0

Guard door unlock command requires the unlock permissive, no unlock faults, and is removed on a safety reset to allow restart:

	OR branch prevents t	Guard Door Unlock Command OR branch prevents trying to lock an open door he the GD trying to lock when reset PB is pressed, ui	niess all conditions are met.
Zone Guard Door Unlock Permissive GuardDoor_Unlk_Perm	Zone Guard Door 1 Unlock GuardDoor_Unlk1.FP	Zone Reset Guard Door Lock Reset_GuardDoor_Lk	Zone Guard Door Unlock Command GuardDoor_Unlk_Cmd
]		Zone Safe Limited Speed Request Initiate SLS_Reginit	

Table 6 - Guard Door Solenoid and Lock Monitoring

Tag	Description
InputStatus	Combine the input status of the inputs before the CROUT.
CROUT	Configurable Redundant Output instruction for controlling the locking outputs and monitoring two locked feedback inputs and associated I/O status. Provides continuous monitoring of locked feedback relationship to commanded unlock output.
raC_Dvc_CROUT	The optional raC_Dvc_CROUT AOI connects CROUT to the HMI faceplate. (ME, SE, PV5000) To find this information, go to the <u>Product Compatibility Download Center</u> website, and search for Safety Device Library.

		Zone Guard Door 1 Unlock
Armor_PF_S:SI.In00Status Armor_PF_S:SI.In01Status		GuardDoor_Unlk1.InputStatu
Zone Guard Door 1 Unlock	CROUT Safety Device Objects	2.6 1
CROUT	raC_Dvc_CROUT	
CROUT GuardDoor_Unik1 Feedback Type NEGATIVE a: 01)= Feedback Reaction Time (Msec) 1000 Actuate GuardDoor_Unik_Cmd =: 02)= 1000	raC_Dvc_CROUT GuardDoor_Unik1_Dvc [ Inp_CROUT GuardDoor_Unik1 Out_Ctrl_Inf GuardDoor_Unik1_Inf Out_Ctrl_Sts GuardDoor_Unik1_Sts	(Sts_SafetyDemand)(Sts_ResetRequired)
Feedback 1 Armor_PF_S:SLIn00Data (FP)- Feedback 2 Armor_PF_S:SLIn01Data 0 +		
Input Status GuardDoor_Unik1.InputStatus		
Reset ResetSB		

#### Table 7 - Solenoid Output

Tag	Description	
GuardDoor_Unlk1.01	CROUT output actuates the interposing relay controlling guard door unlock solenoid	
GuardDoor_Lk	Status of guard door lock for other safety task routines.	
Zone Guard Door 1 Unlock GuardDoor_Unk1.01 Cone Reset Zone Guard Door Z Storage Bit Unlock Permissive ResetSB GuardDoor_Unk_Perm G	ArmorPF safety output (00). For output (01). For Gate Unlock Command Gate Unlock Command CHA CHA Armor_PF_S:S0.Out0100tput Armor_PF_S:S0.Out0100tput Armor_PF_S:S0.Out0100tput J	
Zone Guard Door 1 Zone Guard Door 1 Unlock Unlock GuardDoor_Unlk1.01 GuardDoor_Unlk1.FP	Zone Guard Door Locked GuardDoor_Lk	

### Output SS1 – Safety Routine O10\_Ax1\_SS1

The Output SS1 routine performs the Safe Stop 1 (SS1) safety function.

SS1 Request on loss of run permissive and no SS1 fault.



#### Table 8 - SS1 Instruction

Tag	Description
MOV	Actual Speed visual for the programmer to see what speed the SS1 is monitoring.
SS1	<ul> <li>Safe Stop 1 instruction.</li> <li>Stop Monitor Delay; time after request to start monitor decel ramp.</li> <li>Stop Delay; used to build X-axis of decel monitor ramp, and maximum allowed time to reach standstill. The deceleration time from maximum speed to zero in ms.</li> <li>Decel Ref Speed; used to build Y-axis of decel monitor ramp. Typically the maximum speed reference.</li> <li>Standstill Speed; is the speed that standstill is declared and STO request is made.</li> <li>Decel Speed Tolerance is the tolerance shift between actual ramp and fault point. Typically set to 10% or less of the maximum speed reference. Experiment with setting this value as low as possible. Too low a value can cause nuisance faulting of the SS1 instruction so include some tolerance for varying operating conditions.</li> <li>Feedback SFX is the SFX being monitored.</li> <li>SS1 Active, Fault values sent to the drive for pass through standard tags.</li> </ul>
Standstill	When SS1.01 goes off and there is no SS1 fault, SS1 has passed through standstill. This standstill is based on STO, which results in no additional motion. Not valid for overdriving loads or gravitational loads that can move after motor torque has been removed. For these applications, use other forms of stop monitoring such as Safe Operating Stop.
STO_Req	This bit is used to have the SS1 instruction initiate the drive STO.
Deceleration rate is c After	SS1 Req, then Montor Delay, then Stop Delay. computed: Decel Ref Speed(y) / Stop Delay/X). The deceleration rate is used to compute the decel ramp speed after the Stop Monitor Delay time expires. Stop Monitor Delay a 2010 must be connected to STO outside of natruction. Stop Monitor Delay a 2000 mis how fast tendedack reacts to SS1 cont mis and the tendedack reacts to SS1 cont must be connected to STO outside of natruction. Stop Monitor Delay a 2000 mis how fast tendedack reacts to SS1 cont must be connected to STO outside of natruction. Stop Monitor Delay a 2000 mis how fast tendedack reacts to SS1 contrand. Stop Monitor Delay a 2000 mis how fast tendedack reacts to SS1 contrand. Stop Monitor Delay a 2000 mis how fast tendedack reacts to SS1 contrand. Stop Monitor Delay a 2000 mis how fast tendedack reacts to SS1 contrand. Stop Monitor PF AOP settings for default Preset 1 ramp times): Decel Ref Speed = 30rev/s. Including tolerance. Stop Delay=decel ramp time = 10000ms. Decel Stop Delay decel ramp times = 10000ms. Decel Stop Monitor Delay = 4000 MATC Col Standstill Speed = 0.000 mis Mov fast STX SFX ActualSpeed 0.00 mis Nov fast SFX SFX ActualSpeed 0.00 mis Nov fast SFX SFX ActualSpeed Stop Delay Axist SS1 StopDelay (FP)- 1000 Standstill Speed = 0.000 mis StandstillSpeed 0.00 mis Nov fast SFX SFX ActualSpeed Stop Delay Axist SS1 StopDelay (FP)- 1000 Standstill Speed Axist SS1 Req Reset ResetSB SS1 Active Armor_PF_S:S0 SS1 Fault Reset ResetSB SS1 Active Armor_PF_S:S0 SS1 Fault Pagnostic Code 0 mis Nov fast SFX SFX Active SS1 fault Reset ResetSB SS1 Active Armor_PF_S:S0 SS1 Fault Pagnostic Code 0 mis SS1 SFX SFX Active SS1 fault Pagnostic Code 0 mis SS1 fault Armor_PF_S:S0 SS1 Fault Pagnostic Code 0 mis SS1 Active SS1 fault Pagnostic Code 0 mis SS1 fault Armor_PF_S:S0 SS1 Fault Pagnostic Code 0 mis SS1 fault Armor_PF_S:S0 SS1 Fault Pagnostic Code 0 mis SS1 fault Armor_PF_S:S0 SS1 Fault Pagnostic Code 0 mis Pagnostic Code 0 mis Pagnostic Code 0 mis Pagnostic Code 0 mis Pagnostic Code

Zone Axis1 Safe Stop

Axis1.SS1.SS1.01

Zone Axis1 Standstill Ok

Axis1.SS1.StandStill

Zone Axis1 Safe Torque Off Request Axis1.SS1.STO\_Req

Zone Axis1 Safe Stop

Axis1.SS1.SS1.FP

#### Example of Safe Stop 1

This trend example shows the key elements for an SLS instruction detecting safe speed limit exceeded safety function, initiating Safe Stop 1 with STO and guard door unlock at standstill speed. This trend file, Axis1\_SS1, is available within the attached Logix project file under >Assets>Trends.



ltem	Description
1	SLS is initiated. The drive speed reference is changed to the SLS velocity.
2	When SLS.CheckDelay time expires, the SLS instruction is monitoring SFX.ActualSpeed versus SLS.ActiveLimit speed. The SLS instruction finds the SFX.ActualSpeed is greater than SLS.ActiveLimit speed, Armor PowerFlex passthrough tag SLSLimit and SLS.StopReq are set true. This setting causes SAF_RunPerm to go false, which then triggers an SS1.Req and a drive normal stop via the Armor PowerFlex passthrough tag SS1Active going true.
3	SS1.StopMonDelay provides time for the drive to begin deceleration repeatably. When the SS1.StopMonDelayActive goes false, the SS1 instruction monitors SFX.ActualSpeed versus SS1.SpeedLimit during the ramp deceleration. If the SFX.ActualSpeed is less than the SS1.SpeedLimit speed the drive follows the normal deceleration during the SS1.StopDelay. If the SFX.ActualSpeed is greater than the SS1.SpeedLimit speed or SS1.StopDelay times out before standstill speed, the SS1 instruction faults initiating an immediate SS1.STO_Req.
4	When SFX.ActualSpeed is less than the SS1.StandstillSpd, SS1.STO_Req is set true, and the guard door is unlocked. To resume operation a Reset is required.

Safe Stop 1 must be configured for the application. A trend can be used to verify the load deceleration response and timing that is required for the safety function. The system dynamics must be understood to configure the SS1 to monitor deceleration repeatably without nuisance faulting.

### Output STO — Safety Routine O20\_STO

The output STO routine contains drive safety reset logic, device status summary, and the main run permissive. Table 9 - Drive Safety Reset Request

Tag	Description	
STOOutput	Must be on to reset drive safety	
	SAFE TORQUE OFF (STO) RESET The PowerFlex Safe Torque Off requires the STOOutput ON to reset	
Armor_PF_S:SO.STOOutput Armor_PF_S:S	SI.TorqueDisabled Armor_PF_S:SI.SafetyFault	Armor_PF_S:SO.ResetRequest

Table 10 - STO Output - True is Drive Enabled, False is Drive Disabled

Tag	Description						
No Safety Fault							
Safety Fault	Turn on STO when reset and all interlock conditions are met.						
	SAFE TORQUE OFF (STO) Axis 1	Zona Aviel Safa					
Armor_PF_S:SI.SafetyFault		Torque Off Request Axis1.SS1.STO_Req					
Zone Reset Storage Bit							
Armor_PF_S:SI.SafetyFault ResetSB	Armor_PF_S:SI.TorqueDisabled Armor_PF_S:SI.RestartRequired	Ĵ					
Armor_PF_S:SI.ConnectionFaulted	$-\!$	Armor_PF_S:SO.STOOutput					
]/[							

#### STO reset required indication:

Armor\_PF\_S:SO.SLSActive

Fault summary	
	Zone STO Reset Required
Armor_PF_S:SI.SafetyFault	STO_ResetReq
Armor_PF_S:SIRestartRequired	

### Standard Task Drive Control – R01\_StartStopReset

The drive control routine provides drive speed reference selection for SLS. Table 11 - Drive Safely-limited Speed Reference Request

Tag	Description
SLSActive	Armor PowerFlex safety output tag, indicates that SLS is requested and is used to select the drive SLS reference during SLS monitoring.
MOV	Move instructions transfer the drive speed reference between normal and safe speed references. The safe speed reference must be less than the SLS instruction Active Limit value.
Armor_PF_S:SO.SLSActive	MOV     Source     Normal_Speed_Setpoint_RPS       25.0 ←       Dest     Armor_PF_S:O.CommandedVelocity       10.0 ←

MOV	
Source	Safe_Speed_Setpoint_RPS
	10.0 🖛
Doot Armo	DE S:O CommandedValaath

10.0 +

## **Calculation of the Performance Level**

When properly implemented, these safety functions can achieve a safety rating of category 3, Performance Level d (cat. 3, PLd), 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 specific subsystems that you chose. Depending on the devices you choose, the overall safety rating of your system is different.

The SISTEMA file that is referenced in this safety function application technique is attached to this publication. For instructions on how to access the attachments, see <u>Use Sample Project Files on page 4</u>.

The PFH for electromechanical systems may be calculated differently based on the version of ISO 13849 supported by SISTEMA. The maximum MTTFd of 2500 years is supported starting in version 2.0.3 of SISTEMA. As a result, the same SISTEMA data file that is opened in different versions of SISTEMA can yield different calculated results.

Status	Name	PL	PL-Software	PFHD [1/h]	Category 🔺	Requirements of the category	Use case
<b>✓</b> SB	Safety PLC: GuardLogix 1756-L8xES	d	d	6.4E-9	3	fulfilled	[Standard Use Case]
✓ SB	Compact GuardLogix 5380, SIL 2, Category 3	d	d	7.2E-9	3	fulfilled	[Standard Use Case]

### **Guard Door Unlock at Safely-limited Speed**

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

Status	Name	Ref. des .:	PL	PL-Software	PFHD [1/h]	CCF score	DCavg [%]	MTTFD [a]	Category	Requirements of the category
¥ SB	SLS Mode Select Key Swi	01	e	n.a.	2.5E-8	80 (fulfilled)	99 (High)	100 (High)	3	fulfilled
¥ SB	Incremental Encoder	02	e	n.a.	1.1E-9	not relevant	not relevant	not relevant	4	fulfilled
¥ SB	AC Drive: Armor PowerFle	03	d	d	3.3E-10	not relevant	not relevant	not relevant	3	fulfilled
¥ SB	Safety PLC: GuardLogix 1	04	d	d	6.4E-9	not relevant	not relevant	not relevant	3	fulfilled
¥ SB	AC Drive: Armor PowerFle	05	d	d	1.8E-9	not relevant	not relevant	not relevant	3	fulfilled
✓ SB	AC Drive: Armor PowerFle	06	d	d	1.3E-9	not relevant	not relevant	not relevant	4	fulfilled
¥ SB	700SCF_Relay	07	d	n.a.	2.3E-7	65 (fulfilled)	99 (High)	100 (High)	2	fulfilled
¥ SB	Guardmaster 440G-MZ Int	08	е	n.a.	3.2E-9	not relevant	not relevant	not relevant	4	fulfilled

The Guard Door Unlock at Safely-limited Speed safety function can be modeled as follows:



# **IMPORTANT** The PFH for this complete safety function, with the sensor, logic, and actuator subsystems, is 2.7E-7. The PL for the complete safety function is PLd.

	Sal	fety	function		
Documentation	PLr	PL	Subsystems		
Oetermine P	L from	subsyste	ms		
Performance	Level	(PL):	d	PFHD [1/h]:	2.7E-7

### Guard Door Unlock at Zero Speed (SS1 and Standstill Monitoring)

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

Status	Name	Ref. des .:	PL	PL-Software	PFHD [1/h]	CCF score	DCavg [%]	MTTFD [a]	Category	Requirements of the category
¥ SB	Incremental Encoder	01	e	n.a.	1.1E-9	not relevant	not relevant	not relevant	4	fulfilled
✓ SB	AC Drive: Armor PowerFlex 35S Encoder Feedback	02	d	d	3.3E-10	not relevant	not relevant	not relevant	3	fulfilled
✓ SB	Safety PLC: GuardLogix 1756-L8xES	03	d	d	6.4E-9	not relevant	not relevant	not relevant	3	fulfilled
✓ SB	AC Drive: Armor PowerFlex 35S Network STO/Timed SS1	04	d	d	1.8E-9	not relevant	not relevant	not relevant	3	fulfilled
¥ SB	AC Drive: Armor PowerFlex 35S Safety IO	05	d	d	1.3E-9	not relevant	not relevant	not relevant	4	fulfilled
✓ SB	700SCF_Relay	06	d	n.a.	2.3E-7	65 (fulfilled)	99 (High)	100 (High)	2	fulfilled
¥ SB	Guardmaster 440G-MZ Interlocking Device with Guard Locking	07	е	n.a.	3.2E-9	not relevant	not relevant	not relevant	4	fulfilled



The Guard Door Unlock at Safely-limited Speed safety function can be modeled as follows:

**IMPORTANT** The PFH for this complete safety function, with the sensor, logic, and actuator subsystems, is 2.4E-7. The PL for the complete safety function is PLd.

	Sal	fety	function	
Documentation	PLr	PL	Subsystems	
Oetermine P	L from	subsyste	ms	
Performance	Level (	(PL):	d	PFHD [1/h]: 2.4E-7

### **Prevention of Hazardous Motion using Guard Door Switch**

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

Status	Name	Ref. des.:	PL	PL-Software	PFHD [1/h]	CCF score	DCavg [%]	MTTFD [a]	Category	Requirements of the category
¥ SB	Guardmaster 440G-MZ Interlocking Device with Guard Locking	01	е	n.a.	3.2E-9	not relevant	not relevant	not relevant	4	fulfilled
✓ SB	AC Drive: Armor PowerFlex 35S Safety IO	02	d	d	1.3E-9	not relevant	not relevant	not relevant	4	fulfilled
¥ SB	Safety PLC: GuardLogix 1756-L8xES	03	d	d	6.4E-9	not relevant	not relevant	not relevant	3	fulfilled
✓ SB	AC Drive: Armor PowerFlex 35S Network STO/Timed SS1	04	d	d	1.8E-9	not relevant	not relevant	not relevant	3	fulfilled

The prevention of hazardous motion with the guard door switch safety function can be modeled as follows:



**IMPORTANT** The PFH for this complete safety function, with the sensor, logic, and actuator subsystems, is 1.3E-8. The PL for the complete safety function is PLd.

	Sal	fety	function	
Documentation	PLr	PL	Subsystems	
Oetermine P	L from	subsyste	ms	
Performance	Level (	(PL):	d	PFHD [1/h]:

## **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 that are listed in the <u>Additional Resources on page 29</u> and the GuardLogix Safety Application Instruction Set Reference Manual, publication <u>1756-RM095</u>.

For a validation checklist, see the attached spreadsheet. For instructions on how to access the attachments, see <u>Use Sample Project Files on</u> page 4.

## **Additional Resources**

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

Resource	Description	
GuardLogix 5580 and Compact GuardLogix 5380 Controller Systems Safety Reference Manual, publication <u>1756-RM012</u>	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 <u>1756-UM543</u>	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 <u>5069-UM001</u>	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 <u>1756-RM095</u>	ty Application Instruction Set Reference Manual, - <u>RM095</u> Describes the Rockwell Automation GuardLogix Safety Application Instruction Set. - <u>RM095</u> use GuardLogix controllers.	
Rockwell Automation Functional Safety Data Sheet, publication <u>SAFETY-SR001</u>	Provides functional safety data for Rockwell Automation® products.	
440G-MZ Guardmaster <sup>®</sup> Guard Locking Switch User Manual, publication <u>440G-UM004</u>	Provides information on how to install and operate the 440G-MZ guard locking switch.	
Armor PowerFlex AC Drive User Manual, publication <u>35-UM001</u>	Provides information on how to install, configure, and program the Armor PowerFlex AC drive.	
Armor PowerFlex AC Drive Technical Data Manual, publication <u>35-TD001</u>	Provides specifications and technical details of the Armor PowerFlex AC drive.	
Bulletin 700 Relay and Timer Specifications Technical Data, publication 700-TD552	Provides technical documentation about the 700S-CF safety relays.	
Industrial Automation Wiring and Grounding Guidelines, publication <u>1770-4.1</u>	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.	

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

## **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

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## **Safety Function Capabilities**

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

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