



# ArmorKinetix System Safe Monitor Functions

Catalog Numbers 2198-DSDxxxx-ERS2, 2198-DSDxxxx-ERS5,  
2198-DSMxxxx-ERS2, 2198-DSMxxxx-ERS5



**Allen-Bradley**

by ROCKWELL AUTOMATION

Safety Reference

Original Instructions

# Important User Information

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

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

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

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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.

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



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



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



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

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



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

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**Notes:**

This publication explains how the ArmorKinetix® system can be used in up to Safety Integrity Level (SIL 3), Performance Level (PLe) applications. It describes the safety requirements, including PFH values and application verification information, and provides information to configure and troubleshoot the ArmorKinetix modules with safe-stopping and safe-monitoring functions.

Use this publication if you are responsible for designing, configuring, or troubleshooting safety applications that use the ArmorKinetix modules. You must have a basic understanding of electrical circuitry and familiarity with Kinetix 5700 drives and ArmorKinetix modules.



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

To install, configure, startup, and troubleshoot your ArmorKinetix system, refer to the ArmorKinetix System User Manual, publication [2198-UM006](#). For Kinetix 5700 drive specifications, see the Kinetix 5700, 5500, 5300, and 5100 Servo Drives Specifications Technical Data, publication [KNX-TD003](#).

## Conventions

These conventions are used throughout this publication:

- Bulleted lists, such as this one, provide information, not procedural steps
- Numbered lists provide sequential steps or hierarchical information
- When the phrase ‘GuardLogix® controller’ is used in this publication, it refers to either of the following controller families:
  - GuardLogix 5580
  - Compact GuardLogix 5380
- When the phrase ‘Logix 5000™ controller’ is used in this publication, it refers to any of the following controller families:
  - ControlLogix® 5570, CompactLogix™ 5370, or GuardLogix 5570
  - ControlLogix 5580 or GuardLogix 5580
  - CompactLogix 5380 or Compact GuardLogix 5380

## Terminology

This table defines the abbreviations that are used in this manual.

**Table 1 - Abbreviations and Definitions**

Abbreviation	Full Term	Definition
Timed SS1	Timed Safe Stop 1	Timed SS1 and Safe Stop 1 time-controlled (SS1-t) are synonymous. Both mean safe stop where the motor speed is decelerated to zero and once the maximum stop-time elapses, torque is removed from the motor. Safe Stop 1 time-controlled (SS1-t) is according to IEC 61800-5-2.
SS1-t	Safe Stop 1 time-controlled	
Monitored SS1	Monitored Safe Stop 1	Monitored SS1 and Safe Stop 1 ramp-monitored (SS1-r) are synonymous. Both mean a safe stop where the motor speed is reduced to standstill within deceleration limits and once standstill speed is reached or the maximum stop-time elapses, torque is removed from the motor. Safe Stop 1 ramp-monitored (SS1-r) is according to IEC 61800-5-2.
SS1-r	Safe Stop 1 ramp-monitored	
Integrated STO	Integrated Safe Torque Off	Safe Torque Off safety function activated over the network.
-	Control application	Program that is designed using Studio 5000 Logix Designer® and downloaded to the controller.
-	Safety control application	Safety program that is designed using Studio 5000 Logix Designer and downloaded to the GuardLogix controller for functional safety.
-	Safe motion monitoring drive	A drive that supports safety feedback and communicates safety function status or control over the EtherNet/IP™ network.
DSL	Digital Servo Link	HIPERFACE DSL is a digital protocol that is trademarked by SICK AG.
CIP™	Common Industrial Protocol	Protocol for industrial automation applications and trademarked by ODVA, Inc.
1oo2	One out of Two	Refers to the behavioral design of a dual-channel safety system.
CAT	Category	ISO 13849-1 safety category.
IEC	International Electrotechnical Commission	Non-profit, non-governmental international standards organization that prepares and publishes international standards for all electrical, electronic, and related technologies, collectively known as electrotechnology.

Table 1 - Abbreviations and Definitions (Continued)

Abbreviation	Full Term	Definition
EN	European Norm	European Standards (EN specifications) developed by the European Committee for Standardization for the European Union.
IGBT	Insulated Gate Bi-polar Transistors	Typical power switch used to control main current.
ISO	International Organization for Standardization	Voluntary organization whose members are recognized authorities on standards, each one representing another country.
PES	Programmable Electronic Systems	System for control, protection, or monitoring based on one or more programmable electronic devices, including all elements of the system such as power supplies, sensors and other input devices, data highways and other communication paths, and actuators and other output devices.
PFH	Average Frequency of a Dangerous Failure	The average frequency of a system to have a dangerous failure occur.
HFT	Hardware Fault Tolerance	Hardware fault tolerance is the minimum number of faults that can cause a loss of the safety function as defined by IEC 61508-2.
PL	Performance Level	ISO 13849-1 safety category.
SIL	Safety Integrity Level	A measure of a products ability to lower the risk that a dangerous failure could occur.
DSD	Distributed Servo Drive	The Distributed Servo Drive (DSD) is an electronic drive that can be mounted on machine to control a servo or induction motor.
DSM	Distributed Servo Motor	The Distributed Servo Motor (DSM) combines an electronic servo drive with a servo motor resulting in a hybrid unit.
DSx		A DSx module, refers to either a distributed servo drive (DSD) module or a distributed servo motor (DSM) module.
PIM	Power Interface Module	The Power Interface Module is an in-cabinet module that takes 24V DC input and provides 58V output with 4A rating, to provide control power to DSD/DSM modules.

## Additional Resources

These documents contain additional information concerning related products from Rockwell Automation. You can view or download publications at [rok.auto/literature](http://rok.auto/literature).

Resource	Description
Kinetix Rotary Motion Specifications Technical Data, publication <a href="#">KNX-TD001</a>	Product specifications for Kinetix® VPL, VPC, VPF, VPH, VPS, Kinetix MPL, MPM, MPF, MPS; Kinetix TL and TLY, Kinetix RDB, Kinetix MMA, and Kinetix HPK rotary motors.
Kinetix Linear Motion Specifications Technical Data, publication <a href="#">KNX-TD002</a>	Provides product specifications for Kinetix MPAS and MPMA linear stages, Kinetix VPAR, MPAR, and MPAL electric cylinders, Kinetix LDAT linear thrusters, and Kinetix LDC linear motors.
Kinetix 5700, 5500, 5300, and 5100 Servo Drives Specifications Technical Data, publication <a href="#">KNX-TD003</a>	Provides product specifications for Kinetix Integrated Motion over the EtherNet/IP network and EtherNet/IP networking servo drive families.
Kinetix Rotary and Linear Motion Cable Specifications Technical Data, publication <a href="#">KNX-TD004</a>	Product specifications for Kinetix 2090 motor and interface cables.
Kinetix Servo Drive Performance Specifications per Ecodesign Regulation (EU) 2019/1781 Technical Data, publication <a href="#">KNX-TD006</a>	Provides energy efficiency performance data for Rockwell Automation Kinetix servo drives. This data supports IE2 compliance of Kinetix servo drives per EU 2019/1781.
ArmorKinetix System User Manual, publication <a href="#">2198-UM006</a>	Provides information to install, configure, startup, and troubleshoot your ArmorKinetix system.
ArmorKinetix 2090 Cables and Connectors Installation Instructions, publication <a href="#">2090-IN053</a>	Provides information for the ArmorKinetix 2090 cables.
Vertical Load and Holding Brake Management Application Technique, publication <a href="#">MOTION-AT003</a>	Provides information on vertical loads and how the servo motor holding-brake option can be used to help keep a load from falling.
GuardLogix 5580 and Compact GuardLogix 5380 Controller Systems Safety Reference Manual, publication <a href="#">1756-RM012</a>	Provides information for development, operation, or maintenance of a GuardLogix or Compact GuardLogix controller-based safety system that uses the Studio 5000 Logix Designer application.
GuardLogix Safety Application Instruction Set Reference Manual, publication <a href="#">1756-RM095</a>	Provides information that describes the GuardLogix Safety Application Instruction Set.
Industrial Automation Wiring and Grounding Guidelines, publication <a href="#">1770-4.1</a>	Provides general guidelines for installing a Rockwell Automation industrial system.
Product Certifications website, <a href="http://rok.auto/certifications">rok.auto/certifications</a>	Provides declarations of conformity, certificates, and other certification details.



## About Safe Stop and Safe Monitor Functions

Use this chapter to become familiar with the safe stop and safe monitor functions that are built into ArmorKinetic<sup>®</sup> Distributed Servo Drive (DSD) and Distributed Servo Motor (DSM) (inverter/motor).

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The ArmorKinetic DSD and DSM inverters are equipped for integrated (drive-based) Monitored SS1 and Timed SS1 stopping functions over the EtherNet/IP™ network. Drive-based safety functions operate in the drive and are activated through the network safety connection.

The ArmorKinetic DSx inverters also support controller-based monitoring functions. Controller-based safety functions operate in the GuardLogix<sup>®</sup> 5580 or Compact GuardLogix 5380 controllers and use the EtherNet/IP network to communicate with the safety I/O. This includes the safety functions provided by the Drive Safety tab of your Studio 5000 Logix Designer<sup>®</sup> project.

- The drive-based (Monitored SS1) stopping functions and controller-based monitoring functions apply to the 2198-DSD and 2198-DSM ERS5 modules

**Table 2 - Integrated Functional Safety Support**

Integrated Safety Over the EtherNet/IP Network	Safety Function	Distributed Servo Motor Cat. No.	Distributed Servo Drive Cat. No.
Drive-based stopping functions	Timed Safe Stop 1 (SS1)	<ul style="list-style-type: none"> <li>• 2198-DSMxxx-ERS2</li> <li>• 2198-DSMxxx-ERS5</li> </ul>	<ul style="list-style-type: none"> <li>• 2198-DSDxxx-ERS2</li> <li>• 2198-DSDxxx-ERS5</li> </ul>
	Monitored Safe Stop 1 (SS1)	2198-DSMxxx-ERS5	2198-DSMxxx-ERS5
Controller-based stopping functions	<ul style="list-style-type: none"> <li>• Monitored Safe Stop 1 (SS1)</li> <li>• Safe Stop 2 (SS2)</li> </ul>		
Controller-based monitoring functions	<ul style="list-style-type: none"> <li>• Safe Operational Stop (SOS)</li> <li>• Safely-limited Speed (SLS)</li> <li>• Safely-limited position (SLP)</li> <li>• Safe Direction (SDI)</li> </ul>		
Safety feedback function	Safety Feedback Interface (SFX)		
Integrated STO mode	Safe Torque-off (STO)	<ul style="list-style-type: none"> <li>• 2198-DSMxxx-ERS2</li> <li>• 2198-DSMxxx-ERS5</li> </ul>	<ul style="list-style-type: none"> <li>• 2198-DSDxxx-ERS2</li> <li>• 2198-DSDxxx-ERS5</li> </ul>

The 2198-DSD-ERS5 and 2198-DSM-ERS5 modules also support the safety feedback (SFX) instruction that provides safety position and velocity data to a GuardLogix safety controller for use in controller-based monitoring functions.

The ArmorKinetic DSD/DSM ERS2/ERS5 inverters/motor are only equipped for integrated Safe Torque Off (STO). See the ArmorKinetic System User Manual, publication [2198-UM006](#).



The Kinetix 5700 family contains ERS3 and ERS4 drives, which support both Hardwire and Integrated STO for information. See the Kinetix 5700 Servo Drives User Manual, publication [2198-UM002](#) and Kinetix 5700 Safe Monitor Functions Safety Reference Manual, publication [2198-RM001](#) for more information.

**Table 3 - Achievable Safety Function Ratings**

Function	Mode	Achievable Safety Rating <sup>(1)</sup>
SS1 <sup>(2)</sup>	Monitored	SIL 3, PL <sub>e</sub>
SS2 <sup>(2)</sup>	Velocity check	SIL 3, PL <sub>e</sub>
SOS <sup>(2)</sup>	Velocity check	SIL 3, PL <sub>e</sub>
SLS <sup>(2)</sup>	-	SIL 3, PL <sub>e</sub>
SS2	Position check	SIL 2, PL <sub>d</sub>
SOS	Position check	SIL 2, PL <sub>d</sub>
SDI	-	SIL 2, PL <sub>d</sub>
SLP	-	SIL 2, PL <sub>d</sub>

(1) Achievable safety rating depends on each system component. Performance level (PL) per ISO 13849-1 and safety integrity level (SIL) per IEC 61508, IEC 61800-5-2, and IEC 62061.

(2) SIL 3, PL<sub>e</sub> rating requires the use of two encoders.

The safe motion-monitoring drives can be configured for single feedback or dual feedback per axis to achieve the following safety rating:

- Single feedback configurations provide up to SIL 2 (PL<sub>d</sub>) capability.
- Dual feedback configurations provide up to SIL 3 (PL<sub>e</sub>) capability using velocity discrepancy checking. Safety functions that use position check with dual feedback have up to SIL 2 (PL<sub>d</sub>) capability.

## Safety Concept

This section introduces you to the functional safety specifications and how the ArmorKinetix DSx modules meet those requirements.

### Certification

The TÜV Rheinland group has approved the ArmorKinetix DSM ERS5 modules with support for Stopping Function SS1-r and DSM Monitoring Functions.

The TÜV Rheinland group has approved the ArmorKinetix DSx ERS2/ERS5 modules with support for Stopping Function ST0/SS1-t and DSD ERS5 Stopping Function SS1-r and DSD Monitoring Functions.

These safety functions are for use in safety-related applications up to:

- Performance Level e (PL<sub>e</sub>), Category 3 per ISO 13849-1.
- SIL CL 3 per IEC 61508, IEC 61800-5-2, and IEC 62061.

Removing the motion producing power is considered to be the safe state.

See the GuardLogix Safety Application Instruction Set Reference Manual, publication [1756-RM095](#), for more information on safe motion-monitoring instructions.

For product certifications currently available from Rockwell Automation, go to [rok.auto/certifications](http://rok.auto/certifications).

### Important Safety Considerations

The system user is responsible for the following:

- Validation of any sensors or actuators that are connected to the system
- Completing a machine-level risk assessment
- Certification of the machine to the desired ISO 13849 Performance Level or IEC 62061 SIL level
- Project management and proof testing in accordance with ISO 13849

## Stop Category Definition

You must use a risk assessment to determine the selection of a stop category for each stop function.

- Stop Category 0, as defined in IEC 60204, or Safe Torque-off as defined by IEC 61800-5-2, is achieved with immediate removal of power to the actuator, which results in an uncontrolled coast-to-stop.
- Stop Category 1, as defined in IEC 60204, or Safe Stop 1 (Monitored SS1 and Timed SS1), as defined by IEC 61800-5-2, is achieved with power available to the machine actuators to achieve the stop. Power is removed from the actuators when the configured stop is achieved.

## Performance Level (PL) and Safety Integrity Level (SIL)

For safety-related control systems, Performance Level (PL), according to ISO 13849-1, and SIL levels, according to IEC 61800-5-2, IEC 61508, and IEC 62061, include a rating of the systems ability to perform its safety-related functions. All safety-related components of the control system must be included in both a risk assessment and the determination of the achieved levels.

See the ISO 13849-1, IEC 61508, and IEC 62061 standards for complete information on requirements for PL and SIL determination.

## Average Frequency of a Dangerous Failure

Safety-related systems are classified as operating in a High-demand/continuous mode. The SIL value for a High-demand/continuous mode safety-related system is directly related to the average frequency of a dangerous failure per hour (PFH). PFH calculation is based on the equations from IEC 61508 and show worst-case values. [Table 4](#) demonstrates the worst-case effect of various configuration changes on the data.

**IMPORTANT** Determination of safety parameters is based on the assumptions that the system operates in High-demand mode and that the safety function is requested at least once every three months.

**Table 4 - PFH for 20-year Proof Test Interval - DSD Modules**

Attribute	2198-DSx-ERS2 Single-axis Inverters	2198-DSx-ERS5 Single-axis Inverters
PFH (1e-9) (under worst case conditions)	3.38	3.38
HFT (hardware fault tolerance) <sup>(1)</sup>	1	1
Proof test (years)	20	20
MTTFd (Mean Time to Failure) years	128	128
DC avg (Diagnostic Coverage) %	90	90
Category	3	3
PL (Performance Level)	e - for support of the safety stopping functions d - for support of monitoring functions	e - for support of the safety stopping functions
SIL (Safety Integrity Level)	3 - for support of the stopping functions 2 - for support of monitoring functions	up to 3
SFF (Safe Failure Fraction) %	95	95

(1) A hardware fault tolerance of N means that N+1 is the minimum number of faults that can cause a loss of the safety function as defined by IEC 61508-2.

The DSM module is equipped with a Hiperface DSL functional safety-rated feedback sensor, which is designed to maintain the functional safety rating of the feedback sensor attached.

**Table 5 - PFH for 20-year Proof Test Interval - DSM Module Encoder Reliability Data**

Attribute	2198-DSM0xx-ERSx-x075xx-W	2198-DSM0xx-ERSx-x1xxxx-T
Probability of a Dangerous Failure per Hour (PFH)	350.0 x 10 <sup>-9</sup> at 115 °C (239 °F) ambient temperature	370.0 x 10 <sup>-9</sup> at 115 °C (239 °F) ambient temperature

## Kinetix Safe Motion-monitoring Operation

In safe motion-monitoring applications, the 2198-DSDxx-ERS5 and the 2198-DSMxxx-ERS5 inverter/motors provide safety position and velocity information over the EtherNet/IP network.

The following components are included in typical safe motion-monitoring drive systems.

**Table 6 - Safe Motion-monitoring System Components**

Safety System Component	Bulletin/Cat. No.	Description
ArmorKinetix modules	2198-DSDxx-ERS5	Distributed Servo Drive with Safe motion monitoring support.
	2198-DSMxx-ERS5	Distributed Servo Motor with safe motion monitoring support.
Compact GuardLogix controller	5380	Safety controllers required for use in safe motion-monitoring applications with 2198-xxxx-ERS5 distributed servo motor/inverter
GuardLogix controller	5580	Safety controllers required for use in safe motion-monitoring applications with 2198-xxxx-ERS5 distributed servo motor/inverter
Studio 5000 Logix Designer	Version 35.00 or later	Application environment
External SIN/COS encoder	842HR	Used in Dual Feedback Monitoring applications on the Distributed Servo drive/inverter only when using VPx SIL2 motor configurations.
Kinetix VP rotary motors <sup>(1)</sup>	<ul style="list-style-type: none"> <li>• VPL-Bxxxx-W, VPL-Bxxxx-Q</li> <li>• VPF-Bxxxx-W, VPF-Bxxxx-Q</li> <li>• VPH-Bxxxx-W, VPH-Bxxxx-Q</li> </ul>	Kinetix VPL, VPF, or VPH servo motors with SIL 2 (PLd) rated (-W or -Q) encoders.
Kinetix VP electric cylinders	VPAR-Bxxxx-W, VPAR-Bxxxx-Q	Kinetix VPAR electric cylinder with SIL 2 (PLd) rated (-W or -Q) encoders
MP-Series™ rotary motors <sup>(1) (2)</sup>	<ul style="list-style-type: none"> <li>• MPL-Bxxxx-S, MPL-Bxxxx-M</li> <li>• MPF-Bxxxx-S, MPF-Bxxxx-M</li> <li>• MPM-Bxxxx-S, MPM-Bxxxx-M</li> </ul>	Kinetix MP servo motors with single-turn (-S) and multi-turn (-M) encoders.

(1) SIL and PL rating is dependent on the motor encoder, the external encoder (if present), and how they are used in the safety application.

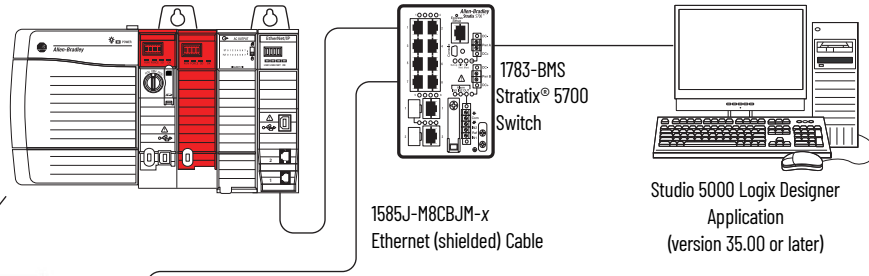
(2) Kinetix MP motors can only be used for single channel feedback purposes to a 2198-DSDxx-ERS5 because there is a single power and feedback connection.

In this example, the components that are described in [Table 6](#) are used in a motion and safety control system with dual-feedback monitoring.



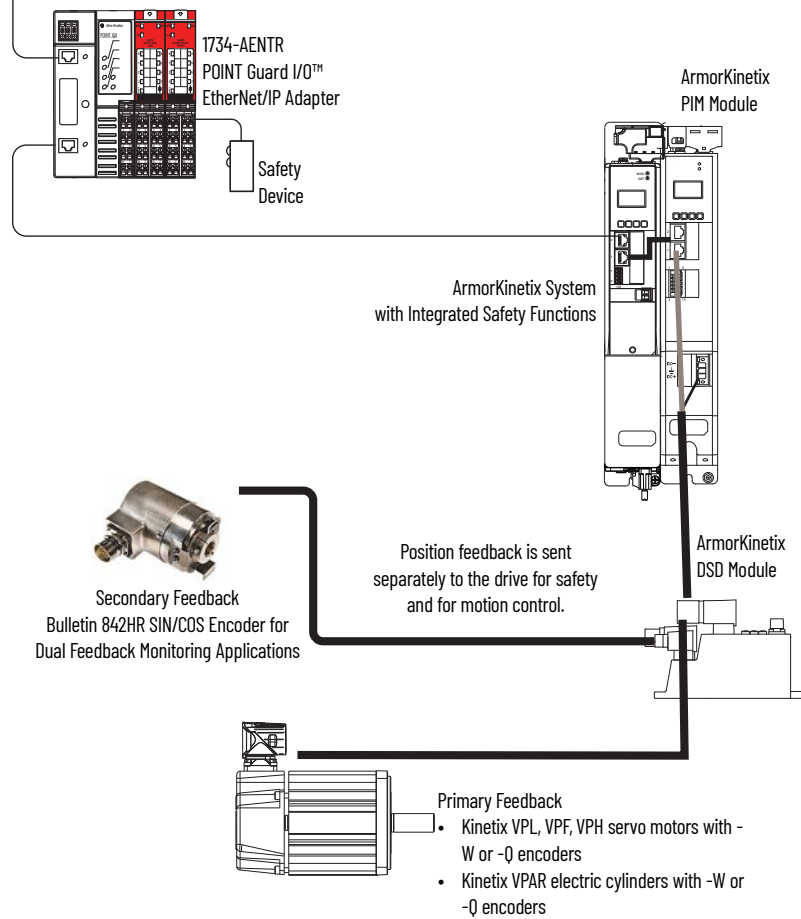
Figure 1 - Safe Motion-monitoring Configuration

Compact GuardLogix 5380 or  
GuardLogix 5580 Safety Controller  
(GuardLogix 5580 Safety Controller is shown)



SS1	
Safe Stop 1	
Safety Control	SS1_Control_SA1
Restart Type	AUTOMATIC
Cold Start Type	AUTOMATIC
Stop Monitor Delay	50
Stop Delay	500
Standstill Speed	0.05
Decel Ref Speed	25.0
Decel Speed Tolerance	5.0
Feedback SFX Request	SFX_Control_SA1 SS1_Request_SA1
Reset	SS1_Reset_SA1
SS1 Active	SDA1:SO.SS1Active1
SS1 Fault	SDA1:SO.SS1Fault1
Fault Type	0+
Diagnostic Code	0+

Controller-based Instruction Example



## Compatible Safety Controllers

A GuardLogix 5580 or Compact GuardLogix 5380 safety controller is required for integrated safety control of the ArmorKinetix module stopping and monitoring functions.

The Studio 5000 Logix Designer application, version 35 or later, supports programming, commissioning, and maintaining GuardLogix safety controllers with ArmorKinetix systems.

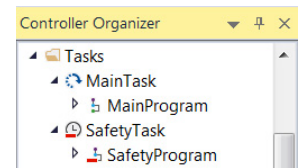
The safety connection can originate from either of these GuardLogix controllers:

- A GuardLogix 5580 or Compact GuardLogix 5380 safety controller that provides both safety and motion control
- A GuardLogix 5580 or Compact GuardLogix 5380 safety controller that controls only the safety connection, while a separate ControlLogix® 5570, ControlLogix 5580, CompactLogix™ 5370, or CompactLogix 5380 controller that controls the motion connection

## Motion and Safety Tasks

Motion systems that are built using Rockwell Automation® Integrated Architecture® components have separate motion and safety functions. In a typical control application with motion and safety connections, motion and safety tasks run in the following Logix 5000™ controllers:

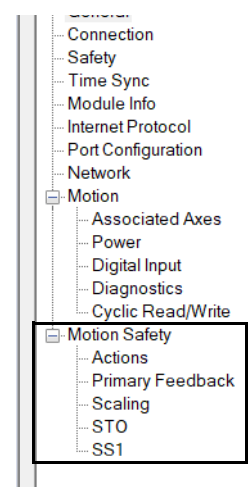
- Motion functions operate in a motion task of any ControlLogix or CompactLogix (Logix 5000) controller
- Safety functions operate in a safety task of only GuardLogix 5580 or Compact GuardLogix 5380 controllers
- Motion tasks and safety tasks can operate in the same GuardLogix controller or in separate controllers
- The safety task, operating in a GuardLogix controller, communicates with the drive module with a safety connection over the EtherNet/IP network. See Safety Task in [Figure 3 on page 17](#).
- The motion task, operating in any of these controllers, communicates with the drive module Associated Axes with a motion connection over the EtherNet/IP network. See Motion Task in [Figure 3 on page 17](#).
- Feedback from position encoders, supplied to the motion tasks, is also associated with the axis.



## Motion Safety Instances

The ArmorKinetix (2198-xxx-ERS5) modules also contain a motion safety instance to provide integrated safety functions. The safety instances operate independently of the inverters and feedback that is used for motion. The drive module safety instances receive encoder safety feedback for use with the integrated safety functions. The safety feedback is also supplied to the controller safety task over the safety connection, for use with controller-based safety functions that may operate in the controller.

A motion and safety system can be configured so that a safety function operates in the controller. This type of configuration is referred to as a controller-based safety function. The system can also be configured so that the safety function operates in the drive module, with the initiation and monitoring of the function in the safety task. This type of safety function is referred to as drive-based safety. A motion system can have both controller-based and drive-based safety functions.



## Safety Function Operation

In this example, we describe how a motion and safety control system operates and how motion and safety tasks are coordinated. In typical motion and safety system applications, an E-stop switch is used to stop the system. In the following example, the switch is used to initiate the process that brings the axis to a controlled stop before removing power. This type of stop is called Stop Category 1. The motion task and drive inverter are responsible for bringing the axis to a Category 1 stop. Simultaneously, to make sure that the Stop Category 1 is correctly executed by the motion system, the safety task initiates a Monitored SS1 safety function. The SS1 safety function can be configured to use the drive-based SS1 function or it can be configured to use the controller-based SS1 function.

This sequence of events represents the steps that are required for a Monitored SS1 drive-based safety function.



The words *module* and *axis* (italic) in these steps represent the module and axis name assigned in the Studio 5000 Logix Designer application.

1. The safety task reads the E-stop input and detects the switch actuation.
2. The safety task communicates an SS1 request by setting the bit: *module*:SO.SS1Request tag of the drive (inverter) motion-safety instance.
3. The motion-safety instance in the drive communicates to the drive motion core of the Axis Safety Status.
4. The motion core communicates with the motion controller running the motion task by updating the motion axis tag *axis*.SS1ActiveStatus.
5. The motion task controls the axis to bring the motor to a stop within the Monitored SS1 limits for speed and time.
6. While the axis is stopping, the SS1 function (in the motion-safety instance) monitors the axis speed to make sure it remains below the speed limit and maximum stopping time.
7. When the axis reaches standstill speed, the motion-safety core activates the Safe Torque-off function.

This sequence of events represents the steps that are required for a Monitored SS1 controller-based safety function.

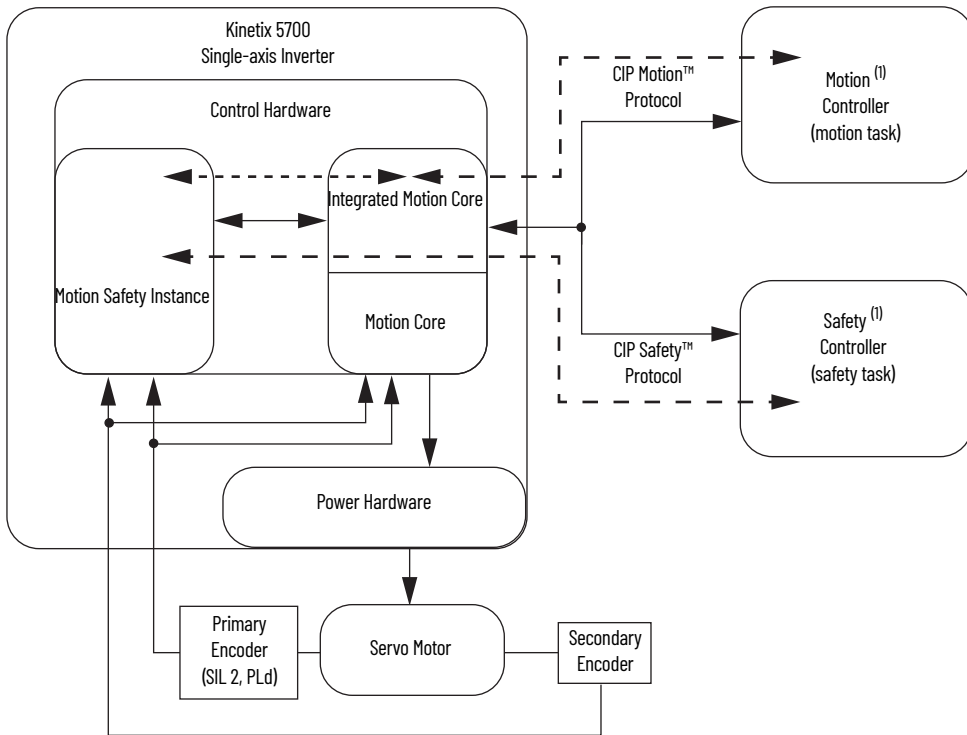


The words *module* and *axis* (italic) in these steps represent the module and axis name assigned in the Studio 5000 Logix Designer application.

1. The safety task reads the E-stop input and detects the switch actuation.
2. The safety task activates the SS1 safety instruction running in the safety task.
3. The SS1 instruction communicates an SS1 active by setting the bit: *module*:SO.SS1Active tag of the drive (inverter) motion-safety instance.
4. The motion-safety instance in the drive communicates to the drive motion core of the Axis Safety Status.
5. The motion core communicates with the motion controller running the motion task, by updating the motion axis tag *axis*.SS1ActiveStatus.
6. The motion task controls the axis to bring the motor to a stop within the Monitored SS1 limits for speed and time.
7. While all events are occurring, the motion-safety instance updates the Feedback Velocity tag, *module*:SI.FeedbackVelocity, in the safety controller. The SS1 function running in the safety task receives the speed that is scaled by the SFX safety instruction and makes sure that the axis remains below the speed limit and maximum stopping time.
8. When the axis reaches standstill speed the SS1 safety instruction outputs SS1 complete.
9. The safety task communicates to the drive motion safety instance to activate STO by clearing the bit: *module*:SO.STOOutput tag of the drive motion-safety instance.

This figure shows how the safety task and motion tasks communicate with the drive.

Figure 2 - Safe Monitor System Communication



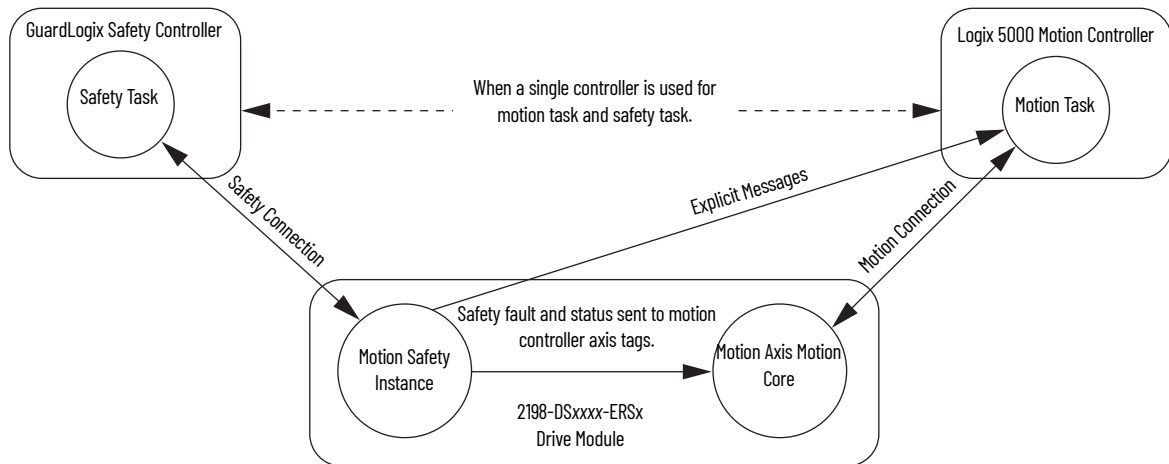
- (1) Motion and Safety connections can be made from a single Safety controller or two separate Motion and Safety controllers.
- (2) The secondary encoder is required to meet a SIL 3 system rating.



## Safe Monitor Network Communication

The safe monitor network executes motion and safety tasks by using CIP™ protocol.

Figure 3 - Motion and Safety Connections



### Motion Connection

The motion connection communicates drive motion and safety status to the motion task. The motion connection also receives motion commands from the motion task in the motion controller. Data is exchanged at a periodic rate over the connection. To configure the drive-module motion connection Axis Properties in the Studio 5000 Logix Designer application, see the ArmorKinetic System User Manual, publication [2198-UM006](#).

Some of the axis tags are updated from fault and safety status provided by the safety instance in the drive module. The safety instance sends this status to the motion core and then on to the motion controller. Axis tags show the updated status. See [Figure 3 - Motion and Safety Connections](#) for an illustration on how status is sent to the motion controller.

**IMPORTANT** Axis tags are for status only and are not used by the safety function.

Table 7 - Motion Connection Axis Tags

Axis Tag Name (motion controller)	Motion Connection Attribute #	Data Type	Description	Safety Output Assembly Tag Name (safety controller)
Axis.AxisSafetyState	760	DINT	Drive module Safety Supervisor state. See the <a href="#">Safety Supervisor State</a> on <a href="#">page 19</a> for more details.	None
Axis.AxisSafetyDataA	986	DINT	32-bit data container holding general purpose safety-data passed from the safety controller.	module:S0:PassThruDataA
Axis.AxisSafetyDataB	987	DINT	32-bit data container holding general purpose safety-data passed from the safety controller.	module:S0:PassThruDataB
Axis.AxisSafetyStatus	761	DINT	Collection of bits indicating the status of the standard safety functions for the axis as reported by Drive Safety Instance.	See individual bits in <a href="#">Table 37</a> on <a href="#">page 95</a> .
Axis.AxisSafetyStatusRA	762	DINT	Collection of bits indicating the status of Rockwell Automation specific safety functions for the axis as reported by Drive Safety Instance.	See individual bits in <a href="#">Table 37</a> on <a href="#">page 95</a> .
Axis.AxisSafetyFaults	763	DINT	Collection of bits indicating the Safety Fault status of the drive-module safety instances and integrated safety functions.	See individual bits in <a href="#">Table 37</a> on <a href="#">page 95</a> .
Axis.AxisSafetyFaultsRA	764	DINT	Collection of bits indicating the safety fault status of Rockwell Automation safety functions.	See individual bits in <a href="#">Table 37</a> on <a href="#">page 95</a> .
Axis.AxisSafetyAlarms	753	DINT	Reserved for future use.	—

### Pass-through Data

Some of the Motion Connection axis tags are updated from information received from the Safety Connection. This data originates in the safety controller as Safety Output assembly tags and are passed through the drive and on to the motion controller where the corresponding axis tag is updated. These data are called pass-through data. The pass-through data includes items such as status and faults for controller-based safety functions. Two general purpose 32-bit words are provided in the output assembly from the safety controller and appear as AxisSafetyDataA and Axis SafetyDataB in the motion controller associated axis. Safety Data A and B are provided for the safety and motion application for additional safety program status. A typical use of Safety Data A and Safety Data B can be to indicate the value of a safety limit that is currently in effect for the motion application to accordingly control the motion.

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**IMPORTANT** Axis tags are for status only and are not used by the safety function. For more information on pass-through data, see See [Pass-through Data on page 84](#).

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### Safety Connection

The safety controller communicates with the safety instances in the drive module over the safety connection. Cyclic data are passed in each direction over the safety connection that appears in Safety Controller tag structures called input and output assemblies. The safety connection cyclic rate is configured in the Studio 5000 Logix Designer application. The Safety Input Assembly tag structure is data from the drive module safety instances to the safety controller. The Safety Output Assembly tag structure is data from the safety controller to the drive module safety instances.

**Table 8 - Safety Input Assembly Tags**

Safety Input Assembly Tag Name (input to safety controller)	Type/[bit]	Description
module:SI.ConnectionStatus	SINT	See individual bits in <a href="#">Table 38 on page 98</a> .
module:SI.FeedbackPosition	DINT	Primary Feedback Position from drive-module safety instance. Value is in feedback counts.
module:SI.FeedbackVelocity	REAL	Primary Feedback Velocity from drive-module safety instance. Value is in revolutions/second.
module:SI.SecondaryFeedbackPosition	DINT	Secondary Feedback Position from drive-module safety instance. Value is in position counts.
module:SI.SecondaryFeedbackVelocity	REAL	Secondary Feedback Velocity from drive-module safety instance. Value is in revolutions/second.
module:SI.StopStatus	SINT	See individual bits in <a href="#">Table 38 on page 98</a> .
module:SI.SafeStatus	SINT	See individual bits in <a href="#">Table 38 on page 98</a> .
module:SI.FunctionSupport	SINT	See individual bits in <a href="#">Table 38 on page 98</a> .

**Table 9 - Safety Output Assembly Tags**

Safety Output Assembly Tag Name (output to safety controller)	Type/[bit]	Description
module:SO.PassThruDataA	DINT	32-bit data container holding general purpose safety data passed from the safety controller.
module:SO.PassThruDataB	DINT	32-bit data container holding general purpose safety data passed from the safety controller.
module:SO.PassThruStopStatus	SINT	Collection of Safe Stop Function Status bits.
module:SO.PassThruSpeedLimitStatus	SINT	Collection of Limit Function Status bits.
module:SO.PassThruPositionLimitStatus	SINT	Collection of bits indicating the Monitoring Function Limit status of controller-based functions. See individual bits in <a href="#">Table 39 on page 98</a> .
module:SO.PassThruStopFaults	SINT	Collection of bits indicating the Safety Fault status of controller-based safety functions. See individual bits in <a href="#">Table 39 on page 98</a> .
module:SO.PassThruLimitFaults	SINT	Collection of bits indicating the Safety Fault status of controller-based safety functions. See individual bits in <a href="#">Table 39 on page 98</a> .
module:SO.SafetyStopFunctions	SINT	A collection of bits used to activate (request) safety functions as in <a href="#">Table 39 on page 98</a> .

## Explicit Messages

Use explicit messages to communicate with a drive and obtain additional fault, status, or configuration information that is not available in the Safety I/O Tag structure. Attribute data is useful for additional diagnostic information. An explicit message can be sent by any controller on the network and used to read any drive module attribute. See [Motion Connection Axis Tags on page 95](#) for the drive-module safety attribute names, and numbers to read the attribute values by using an MSG instruction. Refer to [Figure 3 on page 17](#) to see how explicit messages are part of motion and safety communication.

When an explicit message is used, a class ID must be specified. The class ID identifies the safety object type in the drive module that is accessed.

**Table 10 - Object Classes Available in Motion Safety Instances**

Object Class	Motion Safety Instances
	Single-axis Inverters
Safety Supervisor	1
Safe Stop Functions	1
Safety Feedback	2
Dual-channel Safety Feedback	1

**IMPORTANT** Explicit messages must not be used for any safety related function.

### *Safety Supervisor State*

In the drive module, the connection to the safety instance or instances is controlled by a safety supervisor. The supervisor status can be read by the motion controller through the motion connection and the safety controller through the Safety Input Assembly or by an explicit message.

The safety supervisor state provides information on the state of the integrated safety connection and the mode of operation. There is only one safety supervisor object per drive module.

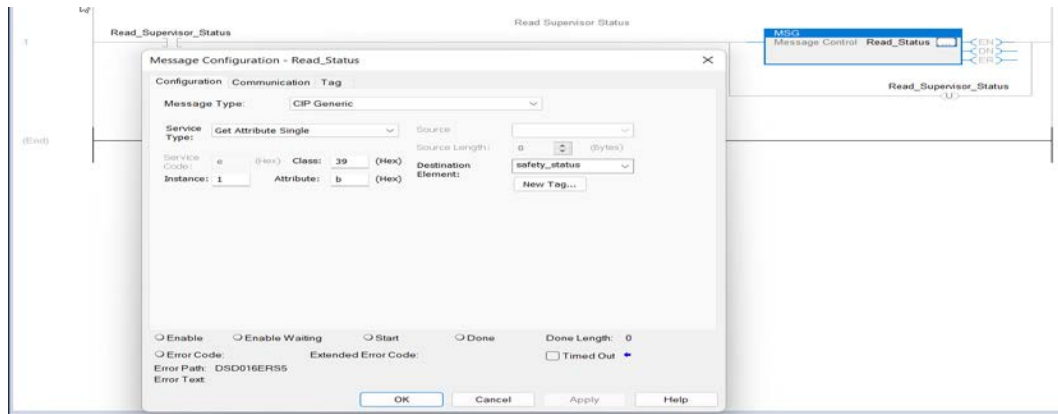
**Table 11 - Safety Supervisor State: MSG**

Parameter	Value	Description
Service Code	0x0E	Get attribute single
Class	0x39	Safety supervisor
Instance	1	Drive-module safety instance associated with an axis
Attribute	0x0B	Device status
Data Type	SINT	Short integer

**Table 12 - Safety Supervisor States**

Value	Safety Supervisor State	Definition	Safety Mode
2	Configured (no safety connection)	No active connections	Integrated
4	Running	Normal running state	Integrated
7	Configuring	Transition state	Integrated
8	Not Configured	Torque disabled	Out of the box
51	Not Configured (torque permitted)	Out of box state with torque permitted	Out of box state, safety bypassed
52	Running (torque permitted)	STO bypass state	Integrated

Figure 4 - Explicit Message Example



### Safe Torque-off Mode

You can use the attribute STO Mode to check if the ArmorKinetic DSx module is in STO Bypass mode. STO Bypass mode is used to allow motion while commissioning or troubleshooting a system when Motion Direct Commands (MDC) are needed. See the ArmorKinetic System User Manual, publication [2198-UM006](#), for more about Safety Bypass and MDC commands.

Table 13 - Safe Torque-off Mode: MSG

Parameter	Value	Description
Service Code	0x0E	Get attribute single
Class	0x5A	Safety stop functions
Instance	1	Drive-module safety instance associated with an axis
Attribute	0x104	STO mode
Data Type	SINT	Short integer

Table 14 - Safe Torque-off Mode: Values

Value	Definition
1	Normal operation
2	STO bypass mode

## Out of Box State

**IMPORTANT** For procedures to restore the modules to the out-of-box state, see the ArmorKinetic System User Manual, publication [2198-UM006](#).



## Safe Stop Functions

Use this chapter to learn more about the Monitored SS1 and Timed SS1 stopping functions that are built into ArmorKinetix<sup>®</sup> DSD or DSM modules.

Topic	Page
Timed SS1 (drive-based) Stopping Function	21
Monitored SS1 (drive-based) Stopping Function	22
Safe Torque-off Function	27
Safe Stop Functions (drive-based) Assembly Tags	27
Drive-based Safe Stopping Application Requirements	29

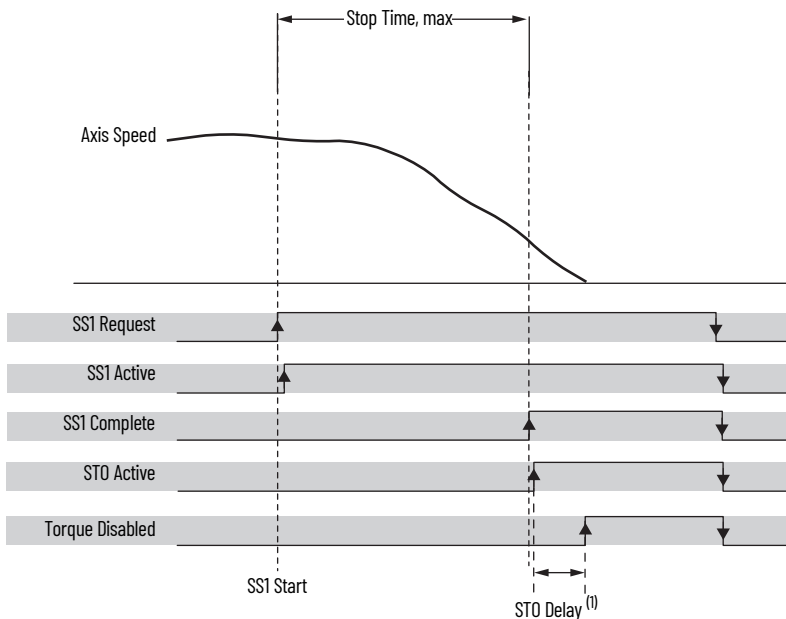
Monitored SS1 and Timed SS1 meet the requirements of Performance Level e (PL e) per ISO 13849-1 and SIL CL 3 per IEC 61508, IEC 61800-5-2, and IEC 62061.

In drive-based SS1 mode, the GuardLogix<sup>®</sup> 5580 or Compact GuardLogix 5380 safety controller issues the SS1 command over the EtherNet/IP<sup>™</sup> network and the 2198-DSDxxx-ERS5 inverter or 2198-DSM-ERS5-xxx inverter/motor combination and execute the SS1 command.

### Timed SS1 (drive-based) Stopping Function

Timed SS1 is a safe stop function where a fixed amount of time is given for the drive to stop. Timed SS1 does not monitor the speed of the drive or detect standstill. Timed SS1 is initiated by setting the SS1 Request tag in the Safety Output Assembly for the drive module. When SS1 Request is received by the drive, the axis safety status is updated with SS1 Active. Once SS1 Active is set high (1), either the motion controller or the drive itself must stop the axis within the SS1 Max Stop Time. When Max Stop Time expires, SS1 Complete transitions to high (1), which activates STO. Once activated, STO operates as described in the section on STO Stop Function.

Figure 5 - Timed SS1 Normal Operation



(1) For more information on STO Delay, see [STO Category on page 51](#).

Attribute Name	Tag Name	Description	Value
SS1 Request	<i>module</i> :S0.SS1Request	An Output Assembly member that requests the drive to initiate it's Safe Stop 1 function.	0 – No Request 1 – Request
SS1 Active	<i>module</i> :S0.SS1Active	The SS1 Active attribute is set to Active when any bit in SS1 Activation is set.	0 – Not Active 1 – Active
SS1 Complete	Tag Name does not apply. See <a href="#">Safe Stop Function Attributes on page 101</a> .	When using SS1-Timed, the STO Activation Bit SS1-Complete is set when the SS1 Timer expires, setting STO Active to Disable Torque.	0 – Not Active 1 – Active
STO Active	<i>module</i> :SI.STOActive	When using SS1-Timed, the STO Activation Bit SS1-Complete is set when the SS1 Timer expires, setting STO Active to Disable Torque.	0 – Not Active 1 – Active
Torque Disabled	<i>module</i> :SI.TorqueDisabled	Output status of the Safe Torque Off control.	0 – Torque Permitted 1 – Torque Disabled

Both elements of the Timed SS1 safety function design have SIL 3/PL e (Cat 3) rating.



The word *module* (italic) in these tag names represent the module name assigned in the Studio 5000 Logix Designer® application.

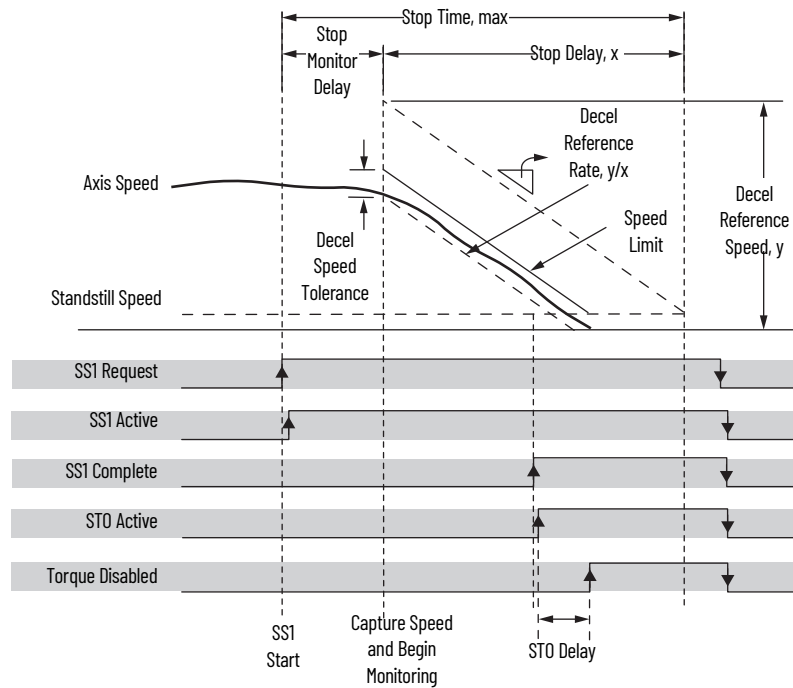
## Monitored SS1 (drive-based) Stopping Function

Monitored SS1 is a ramped safe-stop where the motion safety instance monitors the speed ramp to standstill speed, while either the motion task or the drive itself controls the deceleration to standstill speed. When standstill is reached, then the motion safety instance removes torque from the motor.

**IMPORTANT** In the event of a malfunction, the most likely stop category is Stop Category 0. When designing the machine application, timing and distance must be considered for a coast to stop. For more information regarding stop categories, refer to IEC 60204-1.

When active, the Axis Speed is monitored and must remain below the Speed Limit ramp shown in [Figure 6](#). The axis motion control application must be coordinated with the SS1 activation to bring the axis to Standstill Speed, also known as a Stop Category 1. This section explains several ways to configure the drive and controller for a Monitored SS1 safety function.

Figure 6 - Monitored SS1 Normal Operation



Attribute Name	Tag Name	Description	Value
SS1 Request	<i>module</i> :S0.SS1Request	An Output Assembly member that requests the drive to initiate it's Safe Stop 1 function.	0 - No Request 1 - Request
SS1 Active	<i>module</i> :S0.SS1Active	The SS1 Active attribute is set to Active when any bit in SS1 Activation is set.	0 - Not Active 1 - Active
SS1 Complete	Tag Name does not apply. See <a href="#">Safe Stop Function Attributes (Class 0x5A) on page 101</a> .	When the drive speed is at or below SS1Standstill Speed, the STO Activation bit SS1 Complete is set, setting STO Active to Disable Torque.	0 - Not Active 1 - Active
STO Active	<i>module</i> :SI.STOActive	When the drive speed is at or below SS1Standstill Speed, the STO Activation bit SS1 Complete is set, setting STO Active to Disable Torque.	0 - Not Active 1 - Active
Torque Disabled	<i>module</i> :SI.TorqueDisabled	Output status of the Safe Torque Off control.	0 - Torque Permitted 1 - Torque Disabled

## Ramp Monitored Function

The Monitored SS1 (ramp monitored) function is the ramped deceleration of the axis. A ramp function represents the maximum speed while the axis is stopping as a function of time (t).

The ramp function depends on several variables as stated in this equation:

$$\text{Speed}(t) = \text{Speed}_0 - (D_R \cdot t) + S_{tol}$$

- $\text{Speed}_0$  is the actual speed captured at the end of the monitoring delay in rev/s.
- $S_{tol}$  is a speed tolerance that is added to account for instantaneous speed variations as the actual speed ramps down to standstill.
- $D_R$  is the slope (deceleration) of the ramp function in  $\text{rev/s}^2$ . The slope is calculated by entering the Decel Reference speed and the Stop Delay.

You enter the Decel Reference Speed and the Stop Delay while configuring SS1 in the Logix Designer application to calculate  $D_R$  and display the value.

When choosing a value for  $S_{tol}$  there are several considerations that depend on the velocity average time. If the velocity average time is too small, the instantaneous speed calculated by the motion safety instance can exceed the ramped speed-limit function. If the velocity average time is too large, the result can be more delay in the speed calculated and compared to the ramped speed-limit function. Refer to Instantaneous Velocity in [Figure 17 on page 45](#).



Use your maximum axis speed for the Decel Reference Speed and the maximum time to bring the axis to Standstill Speed for the Stop Delay.



For more information see the Actions Definitions table in the ArmorKinetix System User Manual, publication [2198-UM006](#).

### Monitored SS1 Example

In this example, an axis is running at 1200 rpm when SS1 Request goes high (1), which sets SS1 Active high (1). SS1 Active is read by the Main task and prepares to decelerate the axis. At the end of Stop Monitor Delay, the axis speed is 1200 rpm.

Data summary for this Monitored SS1 example:

- The Deceleration Reference Speed is 2400 rpm because the original application sizing calculated this value as the maximum axis speed.
- A 10 second Stop Delay value is used, based on the control system ability and the safety evaluation.
- Stop Monitor Delay is set to 2 seconds. At the end of the Stop Monitor Delay, the motor speed is measured at 1200 rpm.
- Deceleration Speed Tolerance is set to 240 rpm, based on machine characteristics and safety evaluation.

At the end of Stop Monitor Delay and the beginning of Stop Delay time,  $t = 0$  for the ramp function. [Figure 7](#) shows the data summary values inserted into the equation.

**Figure 7 - Monitored SS1 Example**

$$\text{Speed}(t) = \text{Speed}_0 - (D_R \cdot t) + S_{tol}$$

$$S_{tol} = \left( \frac{240 \text{ Revolutions}}{\text{Minutes}} \right) \cdot \left( \frac{1 \text{ Minute}}{60 \text{ Seconds}} \right) = \left( \frac{4 \text{ Revolutions}}{\text{Seconds}} \right)$$

$$D_R = \left( \frac{2400 \text{ Revolutions}}{\text{Minutes}} \right) \cdot \left( \frac{1 \text{ Minute}}{60 \text{ Seconds}} \right) \cdot \left( \frac{1 \text{ Minute}}{10 \text{ Seconds}} \right) = \left( \frac{4 \text{ Revolutions}}{\text{Seconds}^2} \right)$$

$$\text{Speed}_0 = 1200_{\text{rpm}} \cdot \left( \frac{1 \text{ Minute}}{60 \text{ Seconds}} \right) = \left( \frac{20 \text{ Revolutions}}{\text{Seconds}} \right)$$

Values of  $t$  in the equation are only valid during the Stop Delay where  $t$  starts at 0 and increases to a maximum of Stop Delay.

**Figure 8 - Final Monitored SS1 Example**

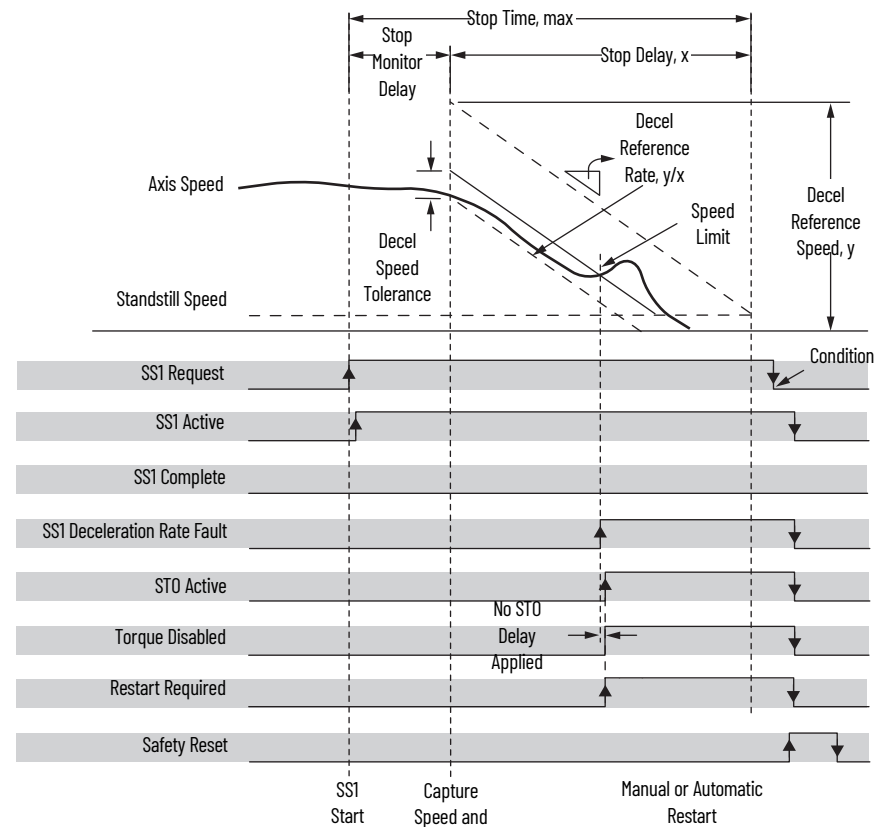
$$\text{Speed}(t) = \left( \frac{24 \text{ Revolutions}}{\text{Second}} \right) - \left( \frac{4 \text{ Revolutions}}{\text{Seconds}^2} \right) \cdot t$$

For any value of  $t$  between 0...5 seconds, if the actual speed exceeds  $\text{Speed}(t)$ , a Deceleration Rate fault is set by the SS1 function.

## Monitored SS1 With Fault

This figure shows how the Monitored SS1 behaves when the axis speed does not stay below the ramp function limit.

Figure 9 - Deceleration Rate Fault



Attribute Name	Tag Name	Description	Value
SS1 Request	<i>module</i> :S0.SS1Request	An Output Assembly member that requests the drive to initiate it's Safe Stop 1 function.	0 - No Request 1 - Request
SS1 Active	<i>module</i> :S0.SS1Active	The SS1 Active attribute is set to Active when any bit in SS1 Activation is set.	0 - Not Active 1 - Active
SS1 Complete	Tag Name does not apply. See <a href="#">Safe Stop Function Attributes (Class 0x5A) on page 101</a> .	When the drive speed is at or below SS1Standstill Speed, the STO Activation bit SS1 Complete is set, setting STO Active to Disable Torque.	0 - Not Active 1 - Active
SS1 Deceleration Rate Fault	Tag Name does not apply. See <a href="#">Safe Stop Function Attributes (Class 0x5A) on page 101</a> .	Describes detailed information about the fault.	1 = No Fault 3 = Deceleration Rate
STO Active	<i>module</i> :SI.STOActive	When the drive speed is at or below SS1Standstill Speed, the STO Activation bit SS1 Complete is set, setting STO Active to Disable Torque.	0 - Not Active 1 - Active
Torque Disabled	<i>module</i> :SI.TorqueDisabled	Output status of the Safe Torque Off control.	0 - Torque Permitted 1 - Torque Disabled
Restart Required	<i>module</i> :SI.RestartRequired	Performs restart of safety instance attribute.	0 - Restart Not Required 1 - Restart Required
Safety Reset	<i>module</i> :S0.ResetRequest	Performs reset of safety instance attribute.	0 - No Restart 1 - Restart

Series of events when a Monitored SS1 fault occurs.

1. If an SS1 fault occurs, STO Active goes high (1), and Torque Disabled goes high (1) immediately and ignores STO Delay.

The safety instance detects a fault and activates the STO function within 6.0 ms of when the fault condition occurred.

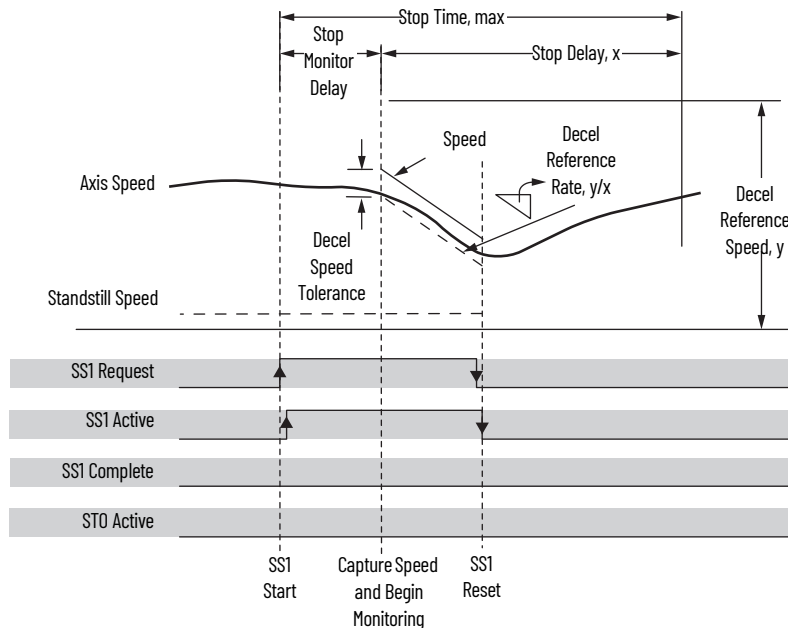
**IMPORTANT** The fault condition for a deceleration fault is measured after velocity averaging. Velocity averaging adds additional delay before STO activation in this case.

2. Restart Required goes high (1) whenever an SS1 fault is present.
3. To reset the SS1 fault, SS1 Request must go low (0), followed by Reset (0-1 transition).

### Monitored SS1 Request Removed

This figure shows what happens when SS1 Request goes low (0) before completion.

**Figure 10 - Monitored SS1 Request Removed Before Completion**



Attribute Name	Tag Name	Description	Value
SS1 Request	<i>module</i> :SO.SS1Request	An Output Assembly member that requests the drive to initiate it's Safe Stop 1 function.	0 - No Request 1 - Request
SS1 Active	<i>module</i> :SO.SS1Active	The SS1 Active attribute is set to Active when any bit in SS1 Activation is set.	0 - Not Active 1 - Active
SS1 Complete	Tag Name does not apply. See <a href="#">Safe Stop Function Attributes (Class 0x5A) on page 101</a> .	When the drive speed is at or below SS1Standstill Speed, the STO Activation bit SS1 Complete is set, setting STO Active to Disable Torque.	0 - Not Active 1 - Active
STO Active	<i>module</i> :SI.STOActive	When the drive speed is at or below SS1Standstill Speed, the STO Activation bit SS1 Complete is set, setting STO Active to Disable Torque.	0 - Not Active 1 - Active



The word *module* (italic) in these tag names represent the module name assigned in the Studio 5000 Logix Designer application.

Series of events when SS1 Request is removed before completion.

1. When SS1 Request goes low (0) before completion, SS1 function is reset and ready for another operation.
2. Main task reads the SS1 Active axis tag and resumes normal operation.

## Safe Torque-off Function

The safe torque-off (STO) function provides a method, with sufficiently low probability of failure, to force the power-transistor control signals to a disabled state. When the command to execute the STO function is received from the GuardLogix controller, all of the drive output-power transistors are released from the ON-state. This results in a condition where the motor is coasting. Disabling the power transistor output does not provide isolation of the electrical output that is required for some applications.



**ATTENTION:** The STO function removes motion-producing power from the motor and must be considered in vertical load applications.

These conditions must be met for integrated control of the STO function:

- The ArmorKinetix module must be added to the GuardLogix or Compact GuardLogix controller I/O Configuration.
- The module must be configured for either:
  - Safety Only
  - Motion and Safety connections

Response times are listed in [Table 15](#). Response time for the drive is the delay between the time the drive STO command receives the CIP Safety™ packet with an STO request and the time when motion producing power is removed from the motor.

**Table 15 - Safe Torque-off Specifications**

Attribute	Value
STO function response time	10 ms, max
Safety connection RPI, min	6 ms
Input assembly connections <sup>(1)</sup>	1
Output assembly connections <sup>(1)</sup>	1
Integrated safety open request support	Type 1 and Type 2 requests

(1) Motion and Safety and Safety-only connections with the DSD or DSM modules use 1 input assembly connection and 1 output assembly connection.

## Safe Stop Functions (drive-based) Assembly Tags

In Integrated safe torque-off (STO) mode, a GuardLogix or Compact GuardLogix safety controller controls the safe torque-off function through the SO.STOOutput tag in the safety output assembly.

**Table 16 - Safety Output Assembly Tag Name Description**

Tag Name <sup>(1)</sup>	Value
<i>module:SO.STOOutput</i>	0 = Activate STO Function 1 = Permit Torque
<i>module:SO.SS1Request</i>	0 = Remove SS1 Request 1 = Activate Drive Based SS1 Function
<i>module:SO.ResetRequest</i>	0 = One transition resets drive-based Safe Stop function
<i>module:SI.TorqueDisabled</i>	0 = Torque Permitted 1 = Torque Disabled

(1) Output assembly tag name from safety controller.

The SO.Command tags are sent from the GuardLogix safety output assembly to the drive safety output assembly to control the safe torque-off function.

The SI.Status tags are sent from the drive to the GuardLogix safety input assembly and indicate the drive safety control status.

**Table 17 - Safety Input Assembly Tag Name Description**

Tag Name <sup>(1)</sup>	Value
<i>module</i> :SI.SafetyFault	0 = Safety fault not present 1 = Safety fault present
<i>module</i> :SI.RestartRequired	0 = Reset is not required 1 = Reset is required
<i>module</i> :SI.STOActive	Indicates STO function status 0 = STO function not active 1 = STO function active
<i>module</i> :SI.SS1Active	Indicates drive-based SS1 active status 0 = SS1 function not active 1 = SS1 function active
<i>module</i> :SI.SS1Ready	0 = Drive-based SS1 function is not configured or faulted 1 = Drive-based SS1 function is configured and ready for operation

(1) Input assembly tag name from safety controller.

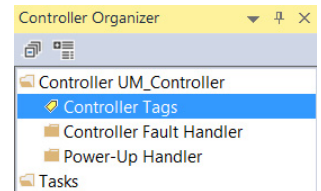
The SI.ConnectionStatus tags indicate the safety input connection status.



The word *module* (italic) in these tag names represent the module name assigned in the Studio 5000 Logix Designer application.

### Controller Tags in Studio 5000 Logix Designer Application

Double-click Controller Tags in the Controller Organizer to see the Safety Assembly controller tags.



The controller tags created for your drive configuration appears.

Name	Value	Force Mask	Style	Data Type	Class	Description	Constant
UM_D006:S	{...}	{...}	{...}	AB:Motion_Diagnostics:S:1	Standard		<input type="checkbox"/>
UM_D006:SI	{...}	{...}	{...}	AB:CIP_Motion_Device_Safety2:SI:0	Safety		<input type="checkbox"/>
UM_D006:SO	{...}	{...}	{...}	AB:CIP_Motion_Device_Safety2:SO:0	Safety		<input type="checkbox"/>

[Safety Assembly Tags](#) on [page 98](#) list the safety tags added to the controller tags when an ArmorKinetix module is added to a GuardLogix I/O configuration and the connection is configured for Safety Only.

In this example, the SO.STOOutput bit permits torque when the bit is high.

**Figure 11 - Safe Torque-off Function Safety Logic Example**





## Drive-based Safe Stopping Application Requirements

This section describes some of the safety information required to design your safety application.

Table 18 - Achievable Safety Ratings

Safety Function	Achievable Functional Safety Rating <sup>(1)</sup>
STO	SIL 3, PL e
Timed SS1	SIL 3, PL e
Monitored SS1	<ul style="list-style-type: none"> <li>SIL 2, PL d in a single feedback sensor configuration when used with SIL 2, PL d compliant feedback sensor</li> <li>SIL 3, PL e in a dual feedback sensor configuration when primary feedback sensor is SIL 2, PL d compliant</li> </ul>

(1) Rating according to IEC 61508 and ISO 13849.

The 2198-xxxx-ERS5 STO circuit is designed to turn off all of the output-power transistors when the STO function is requested. You can use the STO circuit in combination with other safety devices to achieve the Stop Category 0 as described in [Stop Category Definition on page 13](#), and protection-against-restart as specified in IEC 60204-1.



**ATTENTION:** The safe torque-off (STO) feature is suitable only for performing mechanical work on the drive system or affected area of a machine. It does not provide electrical safety.



**SHOCK HAZARD:** In Safe Torque-off mode, hazardous voltages can still be present at the drive. To avoid an electric shock hazard, disconnect power to the system and verify that the voltage is zero before performing any work on the drive.



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

## Safety Application Requirements

Safety application requirements include evaluating probability of failure rates (PFH), system reaction time settings, and functional verification tests that fulfill your required SIL level criteria. See [Average Frequency of a Dangerous Failure on page 11](#) for more PFH information.

Creating, recording, and verifying the safety signature is also a required part of the safety application development process. Safety signatures are created by the safety controller. The safety signature consists of an identification number, date, and time that uniquely identifies the safety portion of a project. This includes all safety logic, data, and safety I/O configuration.

For safety system requirements, including information on the safety network number (SNN), verifying the safety signature, and functional verification tests refer to the appropriate GuardLogix controller publication as defined in [Additional Resources on page 8](#).

**IMPORTANT** You must read, understand, and fulfill the requirements detailed in the GuardLogix controller systems safety reference manual prior to operating a safety system that uses a GuardLogix controller and ArmorKinetix module.

## System Safety Reaction Time

System safety reaction time is the sum of sensor reaction time, GuardLogix controller system reaction time and actuator reaction time. GuardLogix controller system reaction time is estimated based on a number of factors that include:

- Fixed delay time per selected Input/Output module
- Non-configurable variables that are determined by the amount of network communication traffic and the EMC environment
- Configurable values for your specific settings (for example, Safety Input RPI and Safety Task Period)

For a complete list of the factors that affect GuardLogix controller reaction time, refer to the appropriate GuardLogix controller publication as defined in [Additional Resources on page 8](#).

To optimize the configurable factors and minimize the safety reaction time, the GuardLogix Safety Estimator tool can be used to determine the reaction time under these three conditions:

- If there are no faults or errors, the safety function is demanded under normal operation
- Considering a Single Fault (Max) - Safety function is demanded when there is a single delay in the system (for example, loss of a packet)
- Considering Multiple Faults (Max) - Safety function is demanded when there are multiple delays in the system

The GuardLogix Safety Estimator tool, in Microsoft Excel format, is available from the Product Compatibility Download Center (PCDC) to help you determine the reaction time of your particular control loop. Go to website: at [rok.auto/pcdc](http://rok.auto/pcdc) click Find Downloads and, in the Search PCDC box under Compatibility and Downloads, search for GLX Safety Tools.

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**IMPORTANT** Using this tool does not substitute for taking proper validation and verification measures. See [Appendix B on page 107](#) for more information.

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## Configure the Motion Safety Instances

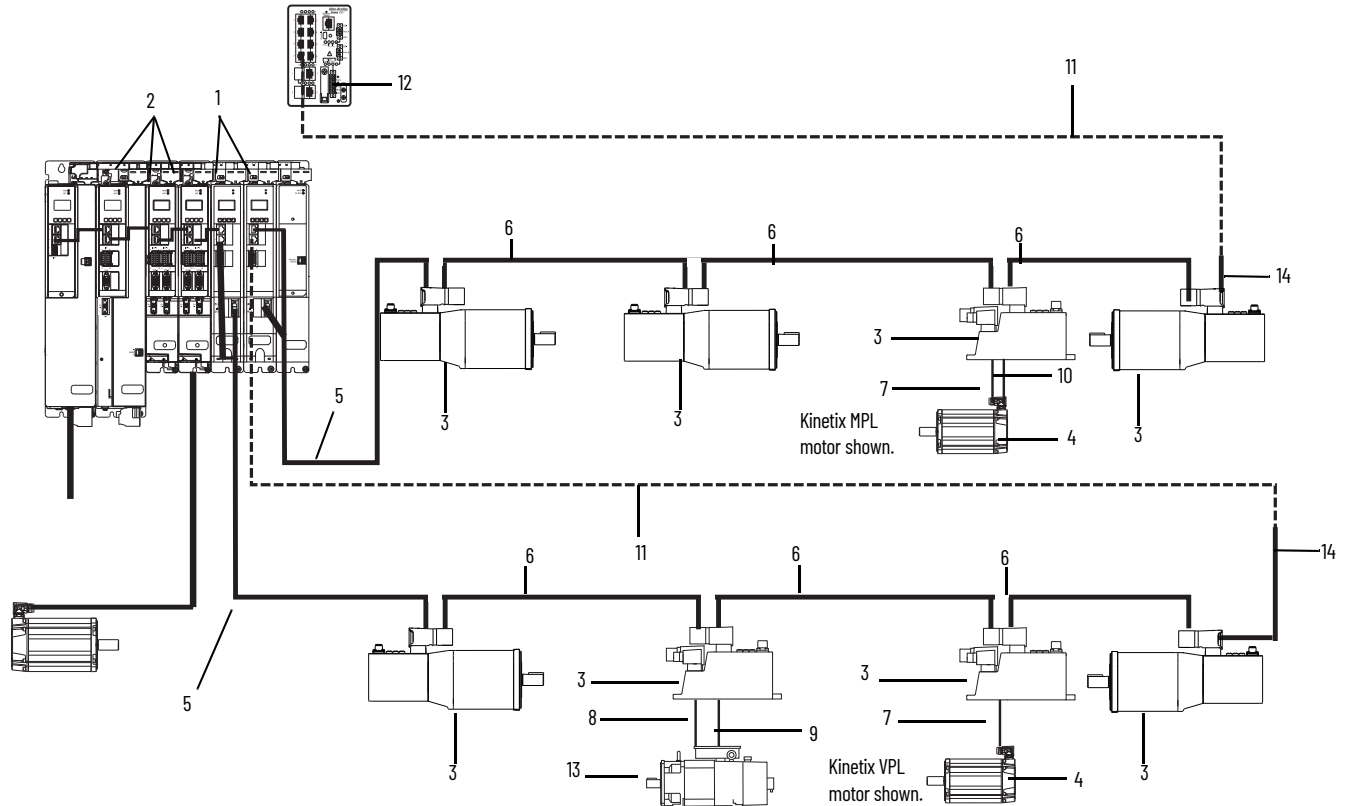
Use this chapter to configure ArmorKinetix® DSD or DSM modules for safety applications with Allen-Bradley® servo motors. This chapter covers these items:

- Understand Module Properties Categories
- Configuring the Module
- Module Properties
- Motion Safety
- Axis Properties Safety Actions
- Safety Connection Examples
  - ArmorKinetix DSD module connected to induction motor, safe stop only, no feedback
  - ArmorKinetix DSD module to Kinetix VPL motor with Q encoder single feedback monitoring
  - ArmorKinetix DSD module to Kinetix VPL motor with Q encoder and 842 HR encoder for dual feedback monitoring
  - ArmorKinetix DSD module to Kinetix MPL motor with M encoder single feedback monitoring
  - ArmorKinetix DSM module for single feedback monitoring
- Encoder Types and SIL Ratings

## Understand Module Properties Categories

We recommend that you layout your Armorkinetic 5700 System with use of the Armorkinetic System User Manual, publication [2198-UM006](#).

If an existing Kinetix 5700 inverter systems is used, see the Kinetix 5700 Servo Drives User Manual, publication [2198-UM002](#) for layout and configuration information as well.



Item	Description	Item	Description
1	Armorkinetic PIM Modules	8	Armorkinetic DSD to Induction Motor Power Cable (2090-CPWFLP7-14AFxx) 1...4 m (3.28...13.12 ft)
2	Kinetix 5700 Servo Drives	9	Armorkinetic DSD to Induction Motor Feedback or Stand-alone Feedback Cable (2090-CFBFLS7-CDAFxx) 1...4 m (3.28...13.12 ft)
3	Armorkinetic DSD or DSM Module	10	Armorkinetic DSD to Kinetix Motor Feedback Cable (2090-CFBM7S7-CDAFxx) 1...4 m (3.28...13.12 ft)
4	Kinetix VPL or Kinetix MPL Motor	11	Ethernet patchcord, 1 Gigabit with hybrid connector to connect to communication extension 85 m (278 ft) max. (1585D-M8UGDM, 1585D-M8TGDE, or 1585D-E8TGDE)
5	Armorkinetic PIM to DSx Hybrid Cable (2090-CDHIFS-12AFxxxx) 3...50 m (9.8...164 ft)	12	Managed Ethernet Switch
6	Armorkinetic DSx to DSx Hybrid Cable (2090-CDHP1S-12AFxxxx) 0.5...30 m (1.64...98.4 ft)	13	Induction Motor
7	Armorkinetic DSD to Kinetix Motor Power/Feedback Cable (2090-CSBM1P7-14AFxx) 1...4 m (3.28...13.12 ft)	14	Communication Extension Jumper Cable (2090-CDET)

See the Armorkinetix 5700 System with use of the Armorkinetix System User Manual, publication [2198-UM006](#) for more information about these module definitions.

**Table 19 - Module Definitions**

Module Definition	DSD Module		DSM Module	
	-ERS2	-ERS5	-ERS2	-ERS5
Firmware Revision	14.000 or later			
Electronic Keying	<ul style="list-style-type: none"> <li>• Disable Keying</li> <li>• Compatible Module</li> <li>• Exact Match</li> </ul>			
Power Structure	2198-DSM016-ERS2 as an example			
Verify Power Rating on Connection				
Safety Application	Networked - used for Safety Only OR Motion And Safety connections.			
	No Safety - used for Motion Only connections. Module must be in out of box state.			
Connection	Motion Only - for motion instructions only.			
	Safety Only - safety controller separate from motion controller.			
	Motion and Safety - both safety and motion in this controller control.			
Motion Safety	<ul style="list-style-type: none"> <li>• Safe Stop - No Feedback</li> </ul>	<ul style="list-style-type: none"> <li>• Safe Stop - No Feedback</li> <li>• Single Feedback</li> <li>• Dual Feedback</li> </ul>	<ul style="list-style-type: none"> <li>• Safe Stop - No Feedback</li> </ul>	<ul style="list-style-type: none"> <li>• Safe Stop - No Feedback</li> <li>• Single Feedback</li> </ul>

- Safe Stop Only-No Feedback - indicates ERS2 or ERS5 are in Integrated STO/SS1 Timed Mode Only.
- Single Feedback Monitoring - indicates the safety function can monitor the main DSD/DSM encoder signal for SFX, SLS and other advanced safety functions.
- Dual Feedback - indicates the safety function can monitor the main DSD (VPx Only) encoder signal and second encoder for SFX, SLS, dual checking and other advanced safety functions.

Safety Configurations of the 2198-DSD and 2198-DSM modules are limited to specific functions.

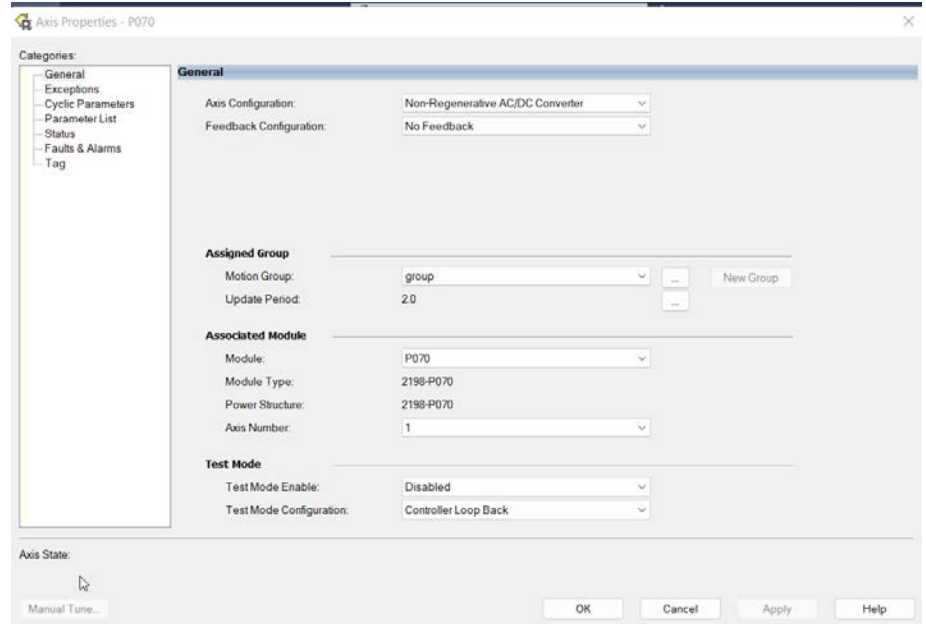
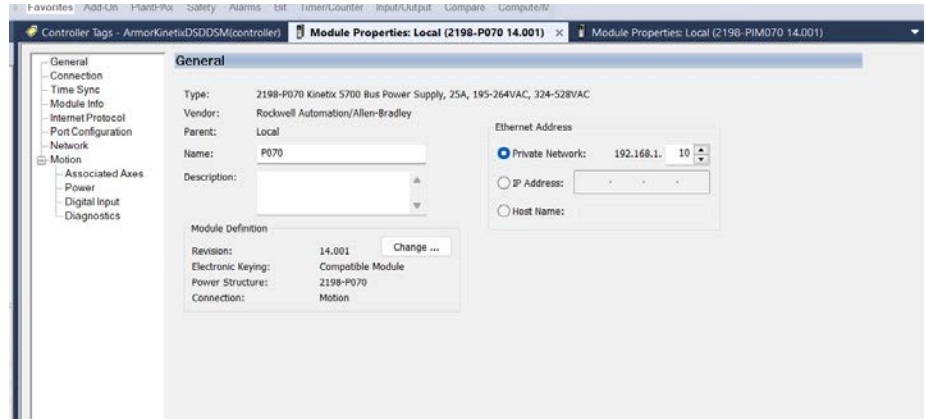
**Table 20 - ERS2 vs ERS5 Safety Capability**

Drive/Motor	Safe Stop No Feedback	Primary Feedback	Secondary Feedback
2198-DSDxxx-ERS2	Yes	–	–
2198-DSDxxx-ERS5	Yes	Yes	Yes
2198-DSMxxx-ERS2	Yes	–	–
2198-DSMxxx-ERS5	Yes	Yes	–

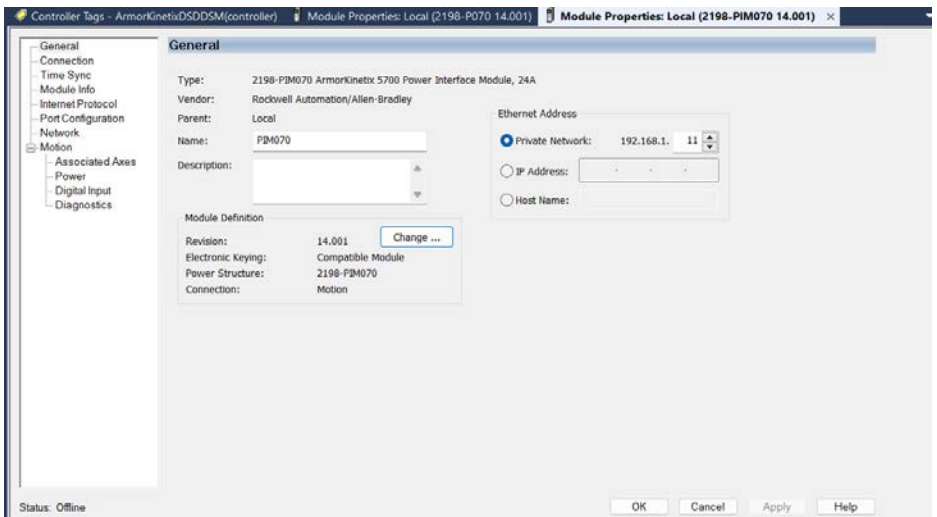
- 2198-DSxxx-ERS2 or 2198-DSxxx-ERS5 contain integrated STO and SS1 timed function. Armorkinetix modules do not support Hardwire STO.
- 2198-DSxxx-ERS2 cannot do Safely-limited Speed functions such as SFX and SLS.
- 2198-DSDxx-ERS5 can do Primary Feedback to the following motors:
  - Kinetix VPL, VPH, VPF, or VPAR with Q or W encoders only
  - Kinetix MPL, MPF, MPS, MPM, or MPAR with M or S encoders only
  - Induction Motors with Hiperface/Sin, Cos encoders only
- 2198-DSDxx-ERS5 can do Secondary Feedback to ONLY the Kinetix VPL, VPH, and VPS with Q or W encoders because these motors use a single cable for power/feedback for the main connection, then an alternate 2090-C cable for the secondary feedback.
- 2198-DSMxx-ERS5 module supports Primary Feedback only to all DSM module listed encoders. The 2198-DSMxx-ERS5 module does not support Secondary Feedback because there are no external feedback terminations for that distributed servo motor control physical device.

The sizing of the 2198-Pxxx Non-Regenerative Converter Power Supply must be able to handle all existing or new inverters (such as 2198-D020-ERS4, if used) along with the 2198-PIM070 connected to a bus group configured with the 2198-DSD drive to external motor and 2198-DSM distributed servo motors.

Thus, the 2198-Pxxx Non-Regenerative Converter must be sized to handle the entire kW continuous and peak needs of all DC power for all modules. It must also be configured in the IO tree and added as a Non-Regenerative converter as shown.

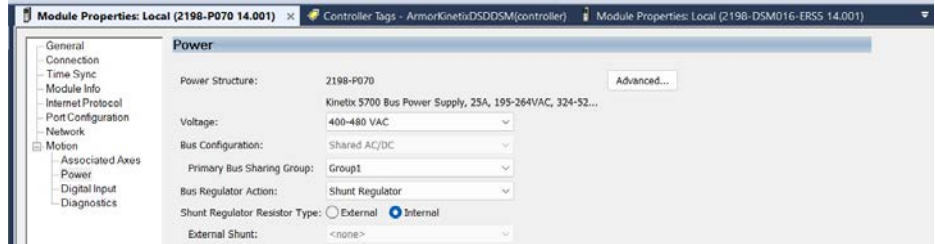


Once the 2198-P is configured or already maybe configured, the 2198-PIM070 can be configured for a primary and secondary bus sharing group.



If the 2198-Pxxx is controlling 2198-D or S-ERSx modules already OR if there are higher power modules or units configured for use, then it is best to configure the 2198-Pxxx primary bus sharing group with these modules and then configure the 2198-PIM070 primary bus sharing group with the ArmorKinetix module bus sharing.

For example, the system uses 2198-S086-ERS4 and 2198-D012-ERS4 and keeps these modules with group 1 primary group.

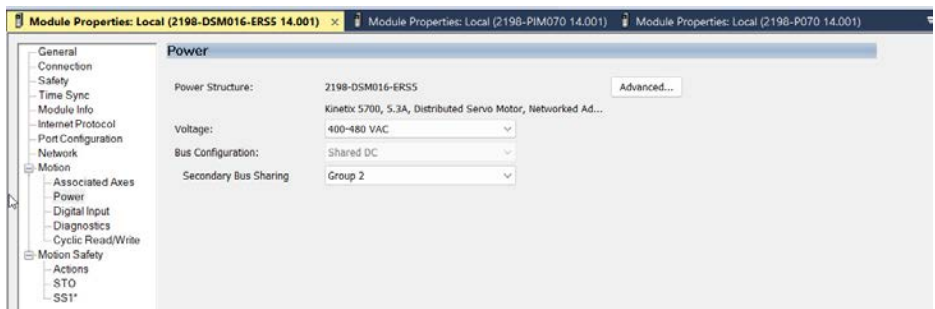


Then, use the 2198-DSD or DSM module with the 2198-PIM070 module and add these modules in group 2 or the secondary bus sharing group as shown. The primary reason for adding the 2198-PIM070 with the DSD/DSM module is that the converter output power and current from the 2198-PIM070 can be monitored to evaluate if high power draw and current is being seen and to take some type of action to remedy based on application needs.

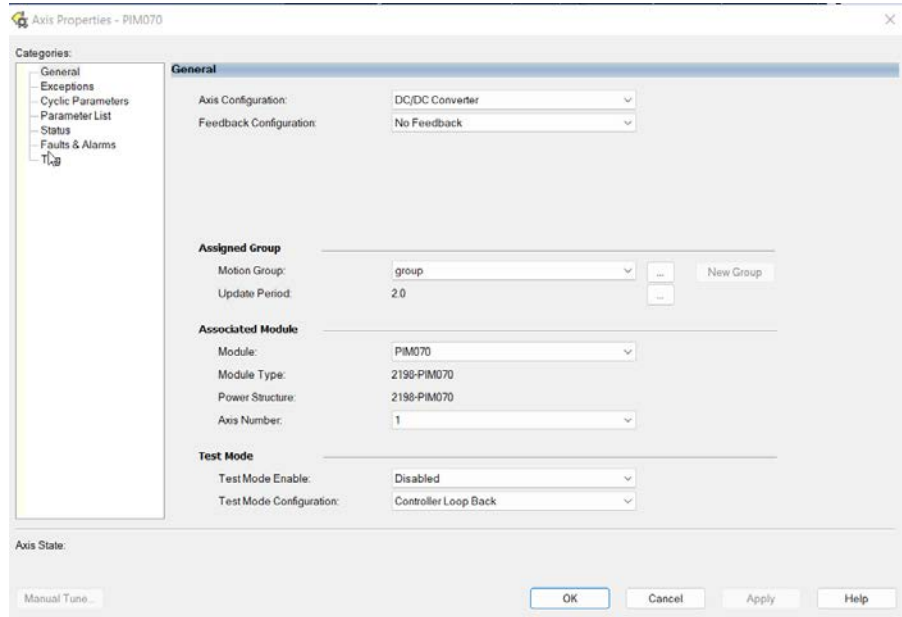


#### Configuration considerations:

- The 2198-Pxxx still supplies rectified AC to DC for the 2198-S/D modules and the 2198-PIM070. Thus, kW output RMS and peak must be sized not to exceed.
- 2198-PIM070 converter output and capacity to all ArmorKinetix DSD/DSM modules can be monitored for overload and other power conditions more accurately because they are in the same bus sharing group.
- If a 2198-Pxxx converter and multiple 2198-PIM070 modules are used:
  - Do not exceed 2198-Pxxx kW output draw continuous and peak
  - Each 2198-PIM070 can support multiple 2198-DSD or DSM modules in separate bus sharing groups and thus monitored for converter metrics to each module, even from the same non-regenerative converter module.



The 2198-PIM070 configures a DC/DC Converter that basically transfers the 2198-Pxxx Non-Regenerative Converter Module power to one or more 2198-DSDxxx-ERS5 or 2198-DSMxxx-ERS5-xx modules.



See *ArmorKinetic System User Manual*, publication [2198-UM006](#) and other tools for the configuration and sizing of the 2198-Pxxx and 2198-PIM070 modules in a Kinetix cluster.

Each 2198-DSD/DSM module has these module property categories:

- Motion Only
- Safety Only
- Motion and Safety

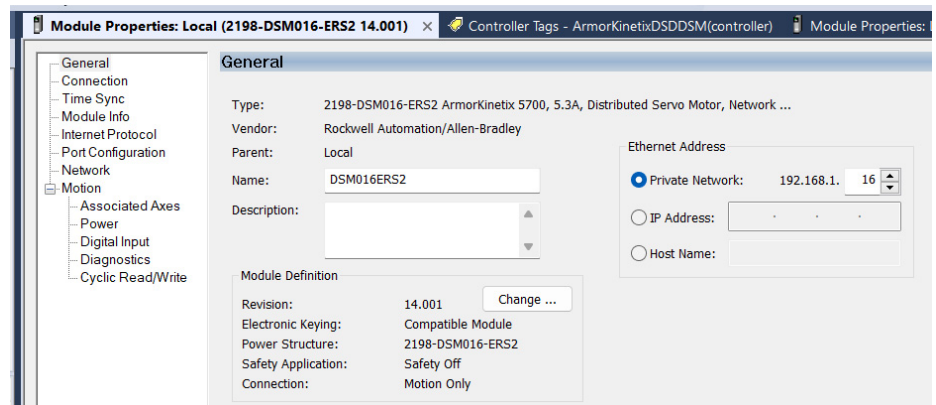
These categories are discussed in the next sections along with what selections are available and tags associated in the GuardLogix controller.

This Category List changes based on which connection that you use; Motion Only, Safety Only, or Motion and Safety, as well if you use Safe Stop Only No Feedback, Primary Feedback, or Secondary Feedback. [Table 20](#) outlines the various selections in each module.

## Motion Only

The Motion Only category has Safety Application options of Safety Off or Networked and no Motion Safety configuration options.

Figure 12 - General Tab - Motion Only



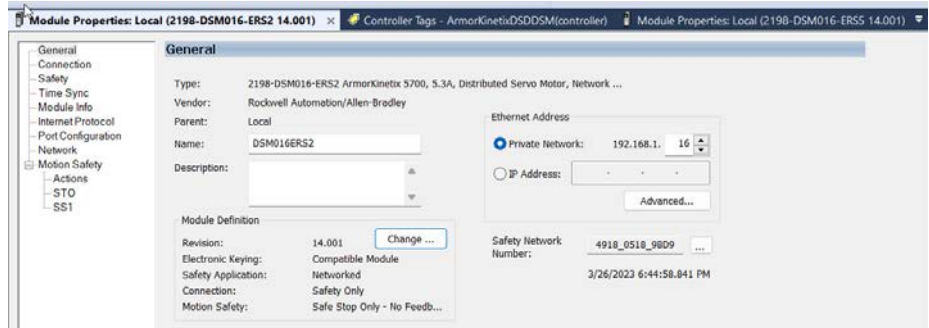


## Safety Only

The Safety Only category has a Safety Application configuration of Networked and Motion Safety configuration options.

When Safety Only is selected in a project, no motion control planner functions, such as Motion Servo On and Motion Axis Move, are allowed. In the Categories, there are no associated axis that tie the Motion group to the axis. Only Motion Safety appears with the selections.

Figure 13 - General Tab - Safety Only

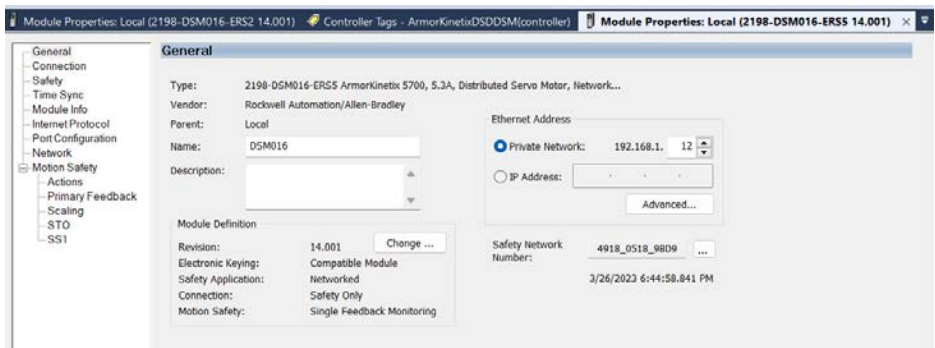


When Safety Only is selected in a project, no motion control planner functions, such as Motion Servo On and Motion Axis Move, are allowed. In the Categories, there are no associated axis that tie the Motion group to the axis. Only Motion Safety appears with the selections.



Safety IO data does not use CIP Sync.

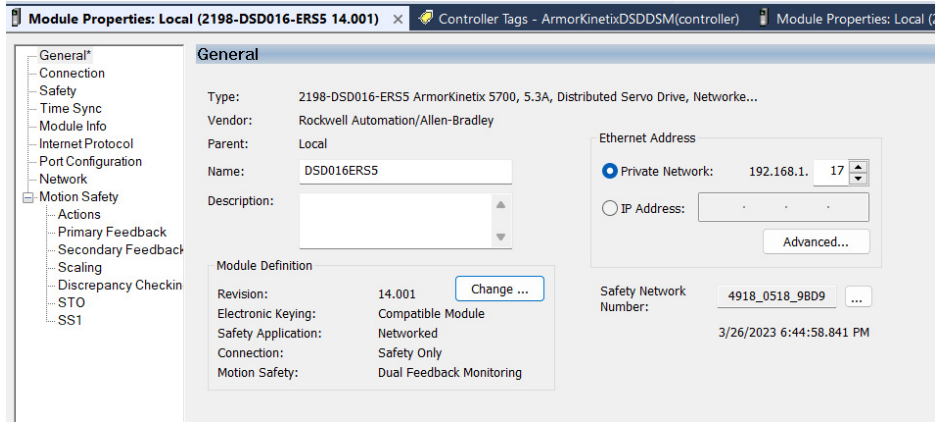
Figure 14 - General Tab - Safety Only, Single Feedback



Primary Feedback and Scaling are now added to the Category List. Both the DSD and DSM modules support this function, see [Table 20](#). The associated tags don't change, just the enabled function to allow safe monitoring position functions (primary and secondary).

The 2198-DSD-ERS5 adds in the ability, when using a Kinetix VPx motor, per the above chart, to do secondary feedback monitoring functions, basically, velocity discrepancy checking. In this case, the Add On Profile adds the secondary feedback and discrepancy checking functions to the functions listed in [Figure 14](#).

Figure 15 - General Tab - Safety Only, Dual Feedback

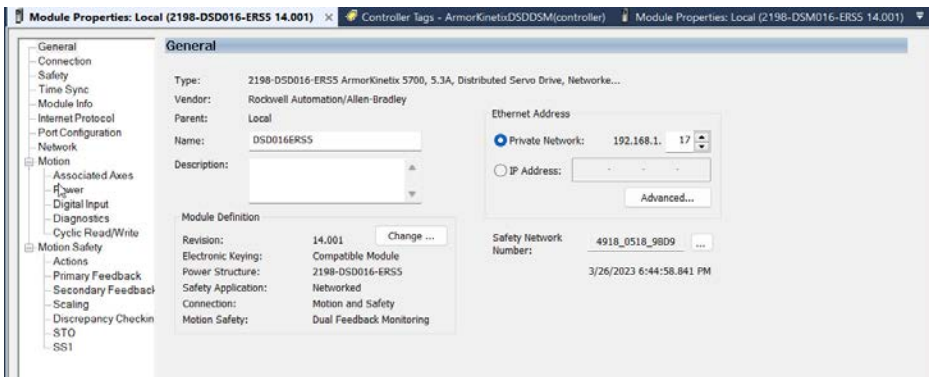


The 2198-DSD-ERS5 is the only module with the ability to add a feedback configuration if the primary motor used is a Kinetix VPx motor with single power/feedback combination. The 2198-DSM-ERS5 module has no external feedback port to accommodate a secondary feedback.

### Motion and Safety

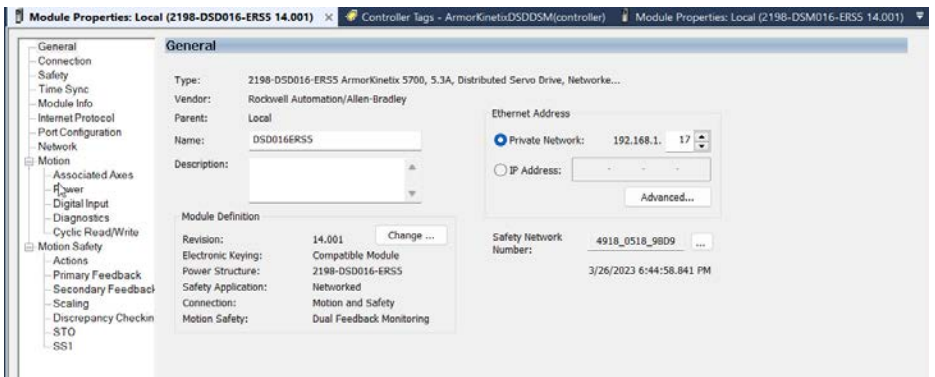
The Motion and Safety category combines both the Motion and the Safety functions and have both Motion associated selections as well as combinations of the selected safety configuration, see [Safety Only on page 37](#). The 2198-DSD-ERS5 module with dual feedback monitoring is used for example.

Figure 16 - General Tab - Motion and Safety



### Configuring the Module

The configuration for the ERS5 module primarily takes place in the AOP.



## Ethernet Address

- Private Network selected at 192.168.1.xxx where xxx is 1 to 254 valid fourth octet
- IP address selected as something specific to system network
- IP address is unique to each PIM, DSD, and DSM module. See the ArmorKinex System User Manual, publication [2198-UM006](#) for proper configuration.

## Advanced Tab

The Advanced tab lets you use a Network Address Translation configuration. Network Address Translation (NAT) enables the reuse of IP addressing without introducing a duplicate IP address error into your application architecture. See Deploying Network Address Translation within a Converged Plantwide Ethernet Architecture, publication [ENET-TD007](#).

## Safety Network Number

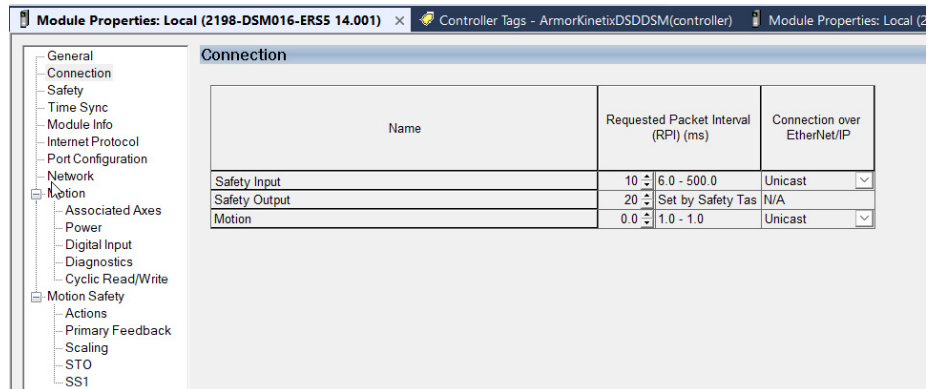
The document purpose is not to describe how or what to set the SNN, but to give you the ability to evaluate and change how the GuardLogix controllers recommend for the SNN. See publication [1756-UM543](#).

## Module Properties

### Connection and Safety Categories

Follow these steps to configure the Safety Output and Safety Input values.

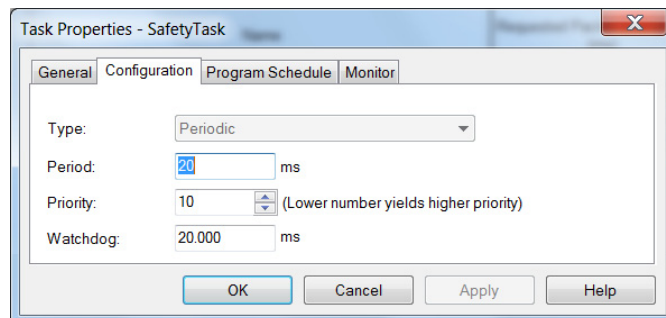
1. Select the Connection category.



From the Connection category you can observe the status of the Safety Output and Safety Input requested packet interval (RPI) values. The default values are shown.

**IMPORTANT** The Safety Output and Safety Input values, when viewed from the Connection category, is for status only. To set the Safety Output and Safety Input values, continue with [step 2](#) through [step 6](#).

2. To set the Safety Output value, right-click SafetyTask in the Controller Organizer and select Properties.



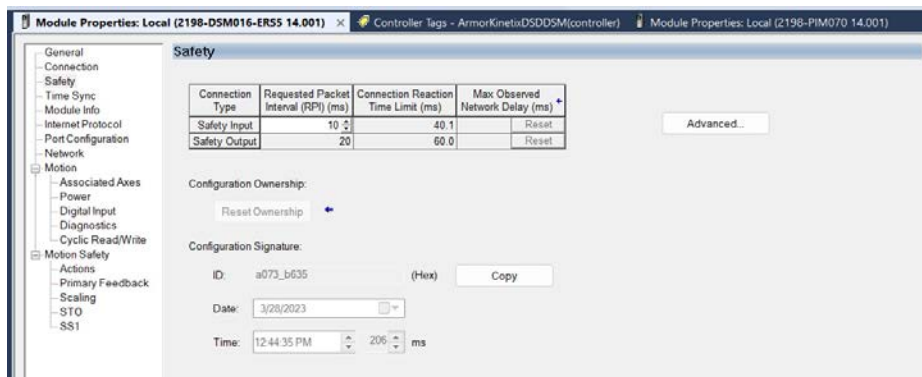
3. Select the Configuration tab.

The default safety task Period value (and output RPI) is 20 ms.

**IMPORTANT** The period is the interval at which the safety task executes. The watch dog must be less than the period.

For more safety task information, see the GuardLogix 5580 and Compact GuardLogix 5380 Controller Systems Safety Reference Manual, publication [1756-RM012](#).

4. Select OK.
5. To set the Safety Input value, select the Safety category.



The default Safety Input RPI value is 10 ms. Edit as appropriate for your application.

Configuration Ownership shows the upper level GuardLogix device that 'owns' this module safety function. If the configuration needs to reset ownership it is best to either inhibit this module from the owner or use the Kinetix HMI to do the reset. The ownership reset is explained in the Armorkinetix System User Manual, publication [2198-UM006](#).

Configuration Signature can apply a unique ID for use for configuring safety zones and organization. See the GuardLogix 5580 and Compact GuardLogix 5380 Controller Systems Safety Reference Manual, publication [1756-RM012](#) to review such requirements based on application needs.

6. Select Apply.

### Additional Categories

Time Sync, Module Info, Internet Protocol, Port Configuration, and Network are all fields for standard CIP Sync Motion functions.

References to each function can be found in documents from Rockwell Automation such as the Converged Plantwide Ethernet (CPwE) Design and Implementation Guide, publication [ENET-TD001](#).

### Motion Category

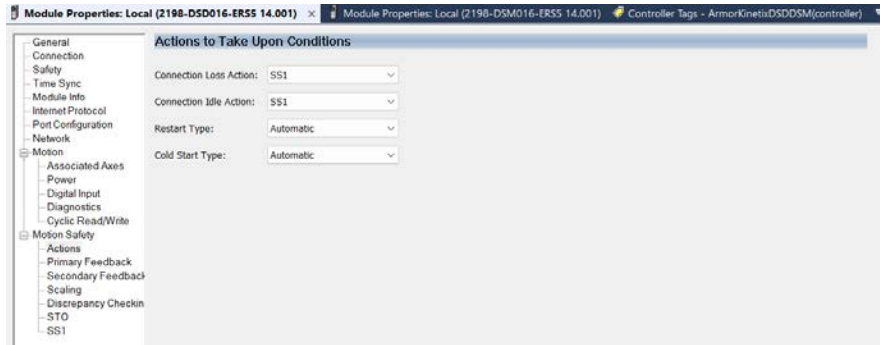
The Motion Category appears when Motion Only or Motion and Safety Connections are used. This document refers more to the Safety Configuration, thus the Motion Category is further expanded on in the Armorkinetix System User Manual, publication [2198-UM006](#).

## Actions Category

The Actions category provides fault behavior options. Determine the preferred machine function when a connection loss or connection idle condition occurs. Safe Torque-off (STO) means that the drive immediately disables the motor power outputs causing a coast condition for the motor and load. Safe Stop 1 (SS1) means that the drive decelerates the load to zero speed before removing the motor power outputs causing a controlled stop for the motor and load.

Follow these steps to configure the Actions to Take Upon Conditions dialog box.

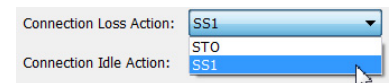
1. Select the Motion Safety 1>Actions category.



**Table 21 - Motion Safety Actions**

Attribute	Description	Values	Description
Connection Loss Action	<ul style="list-style-type: none"> <li>• Connection Loss is caused by a failure or disconnection of the Ethernet cable to the drive.</li> <li>• The loss could also be an indication of excessive traffic causing the drive to lose synchronization to the grandmaster clock/motion controller.</li> </ul>	SS1	Drive-based Safe Stop 1 instruction is initiated and operates according to the SS1 configuration for each motion safety instance.
		STO	Torque is removed from the associated axis according to the STO configuration of each motion safety instance.
Connection Idle Action	Connection Idle is caused by the safety output task becoming disabled because the controller is in Remote Program mode.	SS1	Drive-based Safe Stop 1 instruction is initiated and operates according to the SS1 configuration for each motion safety instance.
		STO	Torque is removed from the associated axis according to the STO configuration of each motion safety instance.
Restart Type	Restart type means that the safety function resets and will be ready for subsequent operation when the request is removed. See specific function for more detail.	Automatic	Automatic is the only choice.
Cold Start Type	Cold start type means that the configured safety function is ready for operation immediately after the controller enters run mode.	Automatic	Automatic is the only choice.

2. From the Connection Loss Action and Connection Idle Action dropdown menus, choose SS1 or STO as required for your application.
3. Select Apply.



# Motion Safety

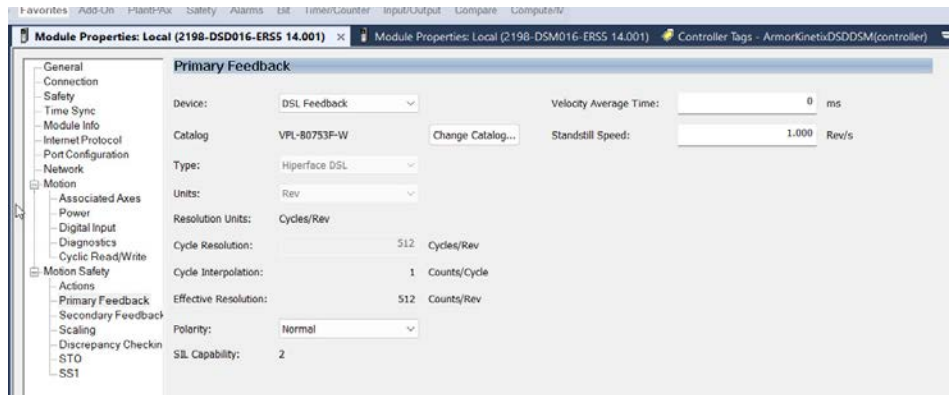
## Primary Feedback Category

Configure primary feedback if you intend to use any drive-based or controller-based safety function that monitors motion. There are many different combinations of feedback for motion control and safety that can be configured. See [Table 24](#) on [page 79](#) for single feedback instances where only primary feedback is configured. See [Table 25](#) on [page 79](#) for dual feedback instances that require a primary and secondary feedback configuration.

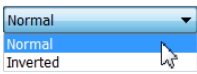
Follow these steps to configure the Primary Feedback dialog box.

1. Select the Motion Safety>Primary Feedback category.

**IMPORTANT** Only Kinetix VPL, VPF, and VPH motors or Kinetix VPAR electric cylinders, with -Q or -W encoder options are SIL 2 rated. Other motors can be selected, but do not support the SIL 2 rating.



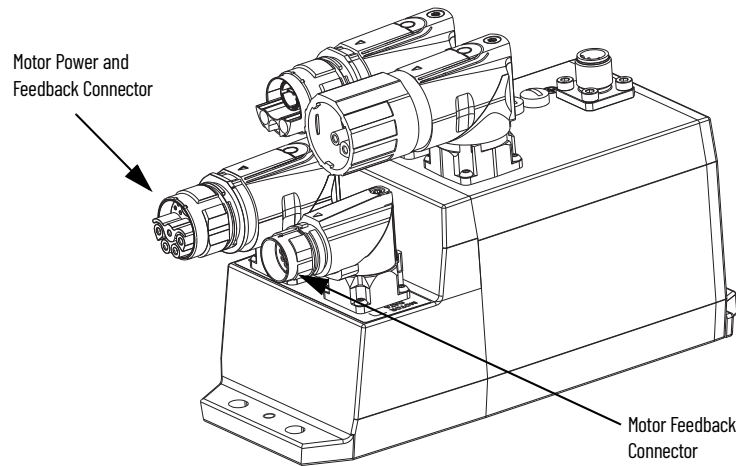
2. Set the remaining Primary Feedback attributes.

Attribute	Description
Units	Default value is revolutions (Rev) that supports rotary motors.
Resolution Units	Default value is Cycles/Revolution (Rev).
Cycle Resolution	Used in the Effective Resolution calculation. The actual motor encoder cycle resolution. This is the raw encoder cycle resolution of the motor or encoder device type. For example, when DSL Hiperface (VPL-Bxxxx-Q motors) is the chosen primary feedback Type, the value is 4096 cycles/rev. VPL-B063xxx and VPL-B075xxx motors have 512 cycle resolution.
Cycle Interpolation	Used in the Effective Resolution calculation. The safety primary-feedback that is interpolated counts as opposed to the motion axis-feedback interpolated counts. For DSL encoders this value is 1. For sin/cos encoders this value is 4.
Effective Resolution	The product of cycle resolution and cycle interpolation for the primary safety function evaluation.
Polarity	Based on encoder rotation and evaluation requirements. Choose between Normal (default) or Inverted as appropriate for your application. 
SIL Capability	Kinetix VP motors with -Q or -W, and Kinetix MMA motors with -S2 or -M2 types are SIL 2 capable and 2 is shown. For non SIL-rated motor or encoder, this field indicates Unknown.
Velocity Average Time	The velocity average time attribute is a moving-average window of time for which the velocity samples are averaged. A small value results in more deviation in the velocity evaluation. A large value results in less deviation in the velocity evaluation, but also adds more delay to the resulting evaluation. This delay should be considered with system requirements for over-speed response. See <a href="#">Velocity Average Time Parameter</a> on <a href="#">page 43</a> for more information.
Standstill Speed	Used in the safe-monitoring process to indicate to the safety controller that the motor has stopped rotating. The system is at standstill when the speed detected is less than or equal to the configured Standstill Speed. This parameter sets the speed at which <i>module:SI.MotionPositive</i> or <i>module:SI.MotionNegative</i> tags are set in the safety input assembly.

3. Select Apply.



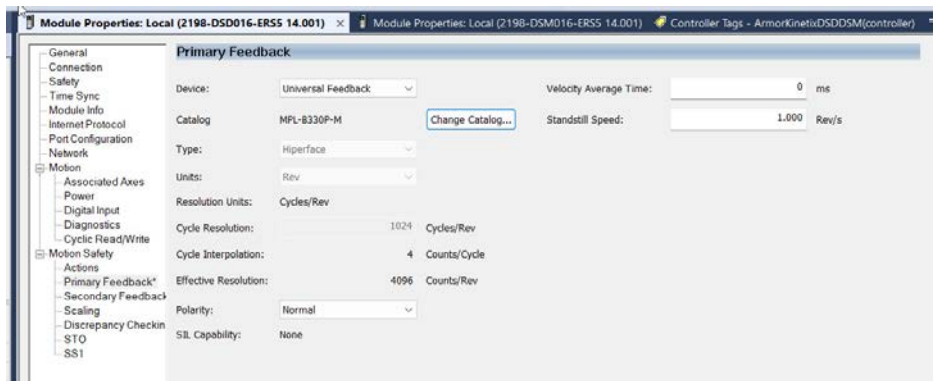
For the DSD modules, feedback is connected to these connectors on the module.



Kinetix VPx motors connect to the motor power and feedback connector by using the single Armorkinetix 2090 motor power and feedback cable.

**IMPORTANT** A 2198-DSDxxx-ERS5 module supports Kinetix VPF, VPL, VPH, and VPAR motors with Q or W feedback based on power density and selection. The Primary Feedback is always mapped to the DSL Feedback Connector on the 2198-DSD module.

**IMPORTANT** A 2198-DSDxxx-ERS5 module can connect to an induction motor with or without feedback OR a Kinetix MPAR, MPF, MPL, MPM, or MPS motor with M or S Feedback. The Primary Feedback is always mapped to the Motor Feedback Connector termed the Universal Feedback Connector.



### Velocity Average Time Parameter

The Velocity Average Time parameter sets the time period for a moving average filter that is applied to velocity samples reported in Velocity Feedback.

The Velocity Average Time is important for three reasons:

- For low resolution encoders there is not enough shaft movement between position samples to allow for a smooth velocity signal. Instead it will jump between zero and a higher value than the actual velocity. This determines the minimum velocity that can be resolved and used in the safety application.
- The safety input connection cycle time or input RPI may be slow compared to changes in the velocity signal. If the velocity changes several times between these Input Assembly updates to the drive, then all of the changes will not be seen at the safety controller. This is known as aliasing. Aliasing has the potential to report velocities that are different from the actual velocity. To avoid aliasing set Velocity Average Time parameter to greater than the safety input connection RPI time.

- Value that is chosen for velocity average time affects the Response time of the safety monitoring function. Higher values result in slower response time.

The motion safety instance of the drive calculates velocity by taking the differences in position count samples that are divided by the sample period. The safety feedback position and velocity, in the motion safety instance, are updated every 3 ms.

Velocity average time determines the number of most recent velocity samples that are averaged. The number of samples averaged is given by the Velocity Average Time/3 ms. Any remainder is truncated. At low velocities with low-resolution encoders, the encoder shaft position does not have enough movement for a change in the encoder output with each sample. This results in delta positions of zero followed by a position increment of one count. The reported velocity in this case jumps between zero and a large value. On average, the velocity is correct.

Large velocity fluctuations are avoided by averaging velocity samples. [Figure 17](#) on [page 45](#) shows the relationships between the encoder cycles, counts, sample points, velocity with no averaging, and averaging. The figure also shows that as the averaging time is increased, the effective velocity resolution is improved. However, with higher resolution comes a longer delay in reporting the velocity due to the N point average. To determine the Velocity Average Time for a given encoder and Velocity Resolution, use the following equation.

$$\text{Velocity Average Time} = \left( \frac{60}{\text{Velocity Resolution} \cdot \text{Encoder Cycle Count} \cdot \text{Cycle Interpolation}} \right)$$

Where:

- Velocity Average Time is in seconds.
- Velocity Resolution is in RPM (Revolutions Per Minute).
- Encoder Cycle Count is the number of cycles per revolution.
  - For motors with Q type feedback, the count is 4096 cycles.
  - For motors with W type feedback, the count is 512 cycles.
  - For motors with sin/cos feedback the number of sinusoidal cycles per revolution. For example:
    - For Kinetix MPL motors with M type feedback, the count is 1024 cycles.
- Encoder interpolation is either 4 or 1.
  - For motors with Q or W type feedback, the value is 1.
  - For motors with Sin/Cos feedback, the value is 4 ([Figure 17](#) shows interpolation with Sin/Cos signals).

For velocity average time in the equation, use the following conversion for the value entered:

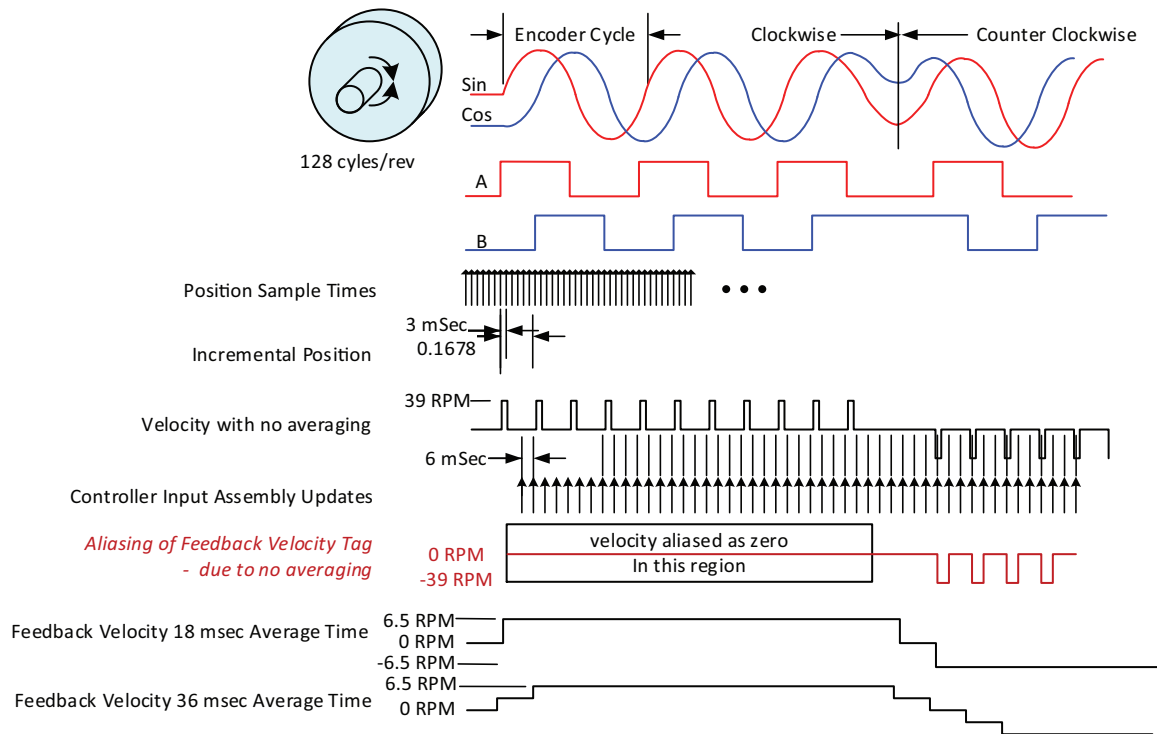
Average Time Setting in Studio 5000 Logix Designer	Effective Value
0...5 ms	3 ms
6...8 ms	6 ms
9...11 ms	9 ms
12...14 ms	12 ms

and continuing to ...<sup>(1)</sup>

(1) Effective Value = (floor(Average Time Setting ÷ 3 ms)) • 3 ms. Floor(x) is the greatest integer ≤ x.



Figure 17 - Encoder Sampling and Velocity



This table shows different values of velocity resolution based on the encoder cycle count and the velocity average time.

Table 22 - Velocity Resolution vs Velocity Average Time for Different Interpolated Encoder Cycle Counts

Interpolated Count	Velocity Resolution		
	Velocity Average Time 100 ms	Velocity Average Time 500 ms	Velocity Average Time 1000 ms
64	9.375 rpm	1.875 rpm	0.9375 rpm
512	1.171875 rpm	0.234375 rpm	0.117188 rpm
2048	0.292969 rpm	0.058594 rpm	0.029297 rpm
4096	0.146484 rpm	0.029297 rpm	0.014648 rpm

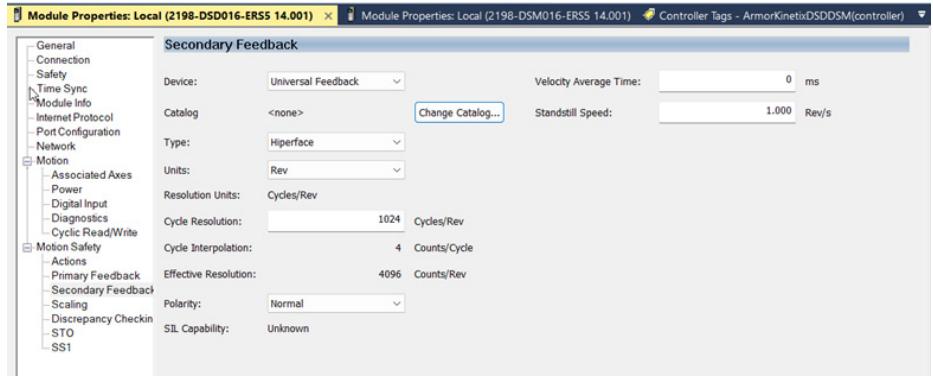
## Secondary Feedback Category

Configure secondary feedback for your motion monitoring application that requires SIL 3 or PL e for drive-based or controller-based safety functions.

**IMPORTANT** For Motion Safety Dual Channel Feedback configurations, the primary feedback must be a SIL 2 rated encoder.

Secondary feedback device can only be used as follows:

- A DSDxx-ERS5 module with a VPxx-Q/W primary motor.
- A DSM module does not allow a secondary feedback device. Consider using a 843ES when configuring such a requirement.
- The motor feedback connector, shown in [Primary Feedback Category on page 42](#) and in the ArmorKinetic System User Manual, publication [2198-UM006](#), is the only place to connect a secondary feedback device to the DSDxxx-ERS5 module.
- ArmorKinetic ERS2 modules are Safe Stop Only-No Feedback and not applicable.



Configure polarity so that when the primary encoder position increments positive , the secondary encoder position increments positive too.

To configure the Secondary Feedback dialog box, see [Primary Feedback Category on page 42](#). Secondary feedback module properties have the same attributes and drop-down menus as the primary feedback category.

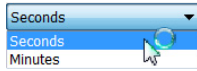
### Scaling Category

The Primary Feedback category provides safety resolution in terms of counts per revolution. The Scaling category configures the position and time to be used in terms of counts per position unit in the safe monitoring functions.

Figure 18 - Scaling Category (default settings)



Table 23 - Scaling Category Attributes

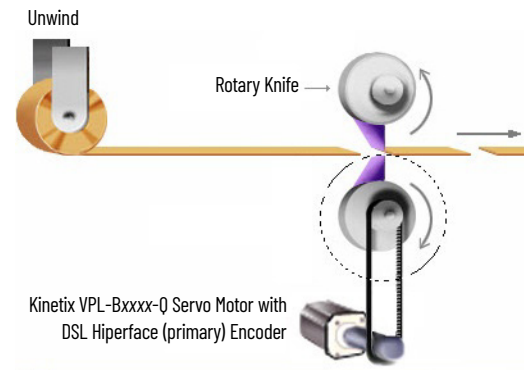
Attribute	Description
Feedback Resolution	The number of counts per motor revolution, which is determined by the Primary Feedback category.
Position Units	The position units for this safety application. Enter text for the name of your units.
Time	The evaluation of position per unit of time for a velocity evaluation. Choose between Seconds (default) and Minutes as appropriate for your application. 
Position	The conversion constant showing the counts per position units. This is the number of counts for one of your position units.

Refer to [Scaling Example 1 on page 47](#) and [Scaling Example 2 on page 48](#) to see how scaling is configured for two rotary knife applications.

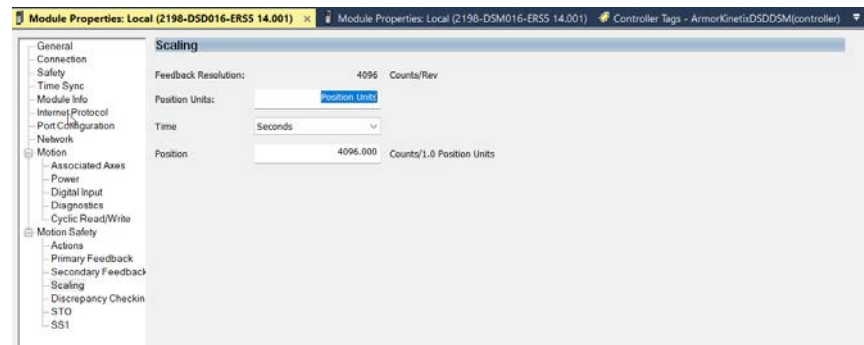
### Scaling Example 1

In the following example, a rotary knife with one blade is directly coupled to the motor. The servo motor is a Kinetix VPL-B1306C-Q with SIL 2 encoder that generates 4096 counts per revolution.

**Figure 19 - Rotary Knife with One Blade**



**Figure 20 - Scaling Example 1 Dialog Box**



Data summary for this scaling example:

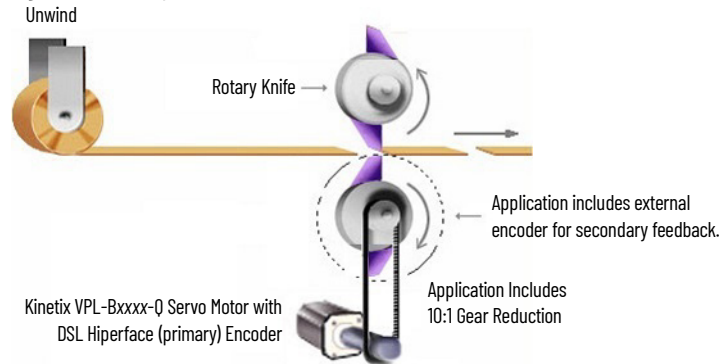
- VPL-B1306C-Q motor with DSL Hiperface encoder that generates 4096 counts per revolution
- Units = Knife Revolutions (one revolution evaluated in seconds)

$$\left( \frac{4096 \text{ Counts}}{\text{Motor Revolution}} \right) \cdot \left( \frac{1 \text{ Motor Revolution}}{1 \text{ Knife Revolution}} \right) = \frac{4096 \text{ Counts}}{\text{Knife Revolution}}$$

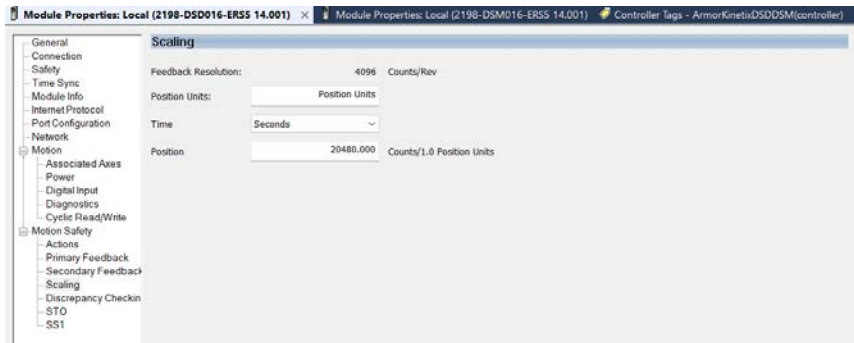
### Scaling Example 2

In this example, a rotary knife with two blades is driven by a 10:1 gear reduction and servo motor. The servo motor is a VPL-B1306C-Q with SIL 2 encoder that generates 4096 counts per revolution

**Figure 21 - Rotary Knife with Two Blades**



**Figure 22 - Scaling Example 2 Dialog Box**



Data summary for this scaling example:

- VPL-B1152C-Q motor with DSL Hiperface encoder that generates 4096 counts per revolution
- Motor connects with a 10:1 gear reduction to drive the knife blades
- Units = Knife Cuts (two cuts per load revolution evaluated in seconds)
- Secondary encoder used to improve safety rating

$$\left( \frac{4096 \text{ Counts}}{\text{Motor Revolution}} \right) \cdot \left( \frac{10 \text{ Motor Revolution}}{1 \text{ Load Revolution}} \right) \cdot \left( \frac{1 \text{ Load Revolution}}{2 \text{ Knife Cuts}} \right) = \frac{20480 \text{ Counts}}{\text{Knife Cut}}$$

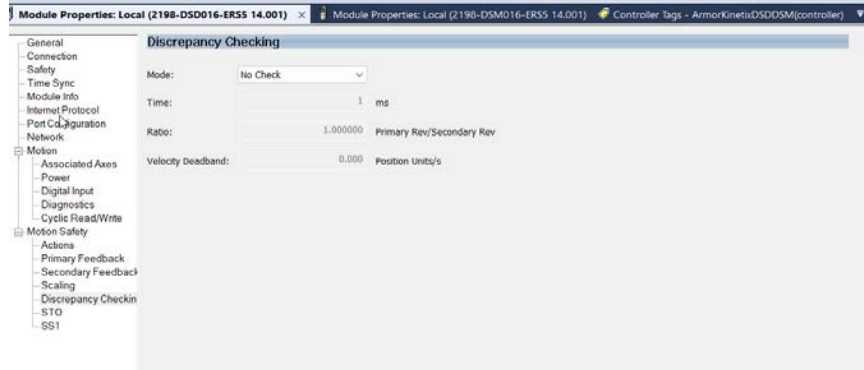
**IMPORTANT** Scaling for the GuardLogix Motion Function, the Guardlogix Safety Function, and the Integral Safety Function all can have different scaling and cause confusion. See Knowledgebase article [How to scale the SFX instruction to meet the Motion/IO mode and safety configuration units](#) for help with all three functions based on various configuration examples.

## Discrepancy Checking Category

Discrepancy checking is only used in applications where the Module Definition>Safety Instance is configured for Dual Feedback Monitoring. Its purpose is to perform an evaluation of the speed discrepancy between primary and secondary feedback. Primary Feedback is used for safe monitoring functions. Secondary feedback is used for fault diagnostics.

If primary feedback and secondary feedback differ in the velocity deadband value for longer than the time entry, a velocity discrepancy fault occurs.

**Figure 23 - Discrepancy Checking Dialog Box (default attributes)**

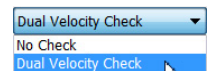


**IMPORTANT** When setting discrepancy tolerances in terms of the velocity deadband attribute, consider that configuring a high gear-ratio between primary feedback and secondary feedback can lead to unexpected dual-feedback position faults. This is because a very large primary feedback movement translates into very small secondary feedback increments.

When Module Definition>Safety Instance is configured for Single Feedback Monitoring, use the No Check (default) setting.

Follow these steps to configure the Discrepancy Checking attribute.

1. From the Mode pull-down menu, choose Dual Velocity Check.



Use Dual Velocity Check to measure the difference between primary feedback speed and secondary feedback speed to see if that tolerance is greater than the velocity deadband for more than the time tolerance.

2. Set the remaining Discrepancy Checking attributes.

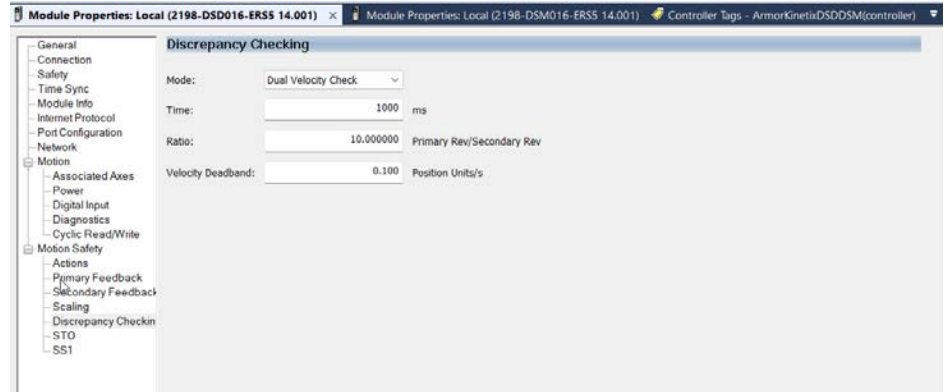
Attribute	Description
Time	The amount of time (ms) specified for velocity deadband to be evaluated and trigger a safety fault condition.
Ratio	The gear ratio of one primary feedback revolution to one secondary feedback revolution.
Velocity Deadband	The velocity units of the difference between primary and secondary feedback speed for the discrepancy check.

3. Select Apply.

### Discrepancy Checking Example

This example uses [Scaling Example 2](#) on [page 48](#) to show how discrepancy checking is used to measure the speed discrepancy between primary and secondary feedback and avoid dual-feedback position faults.

**Figure 24 - Discrepancy Checking Example**



Data summary for this scaling example:

- The primary feedback encoder is rotating at 600 rpm
- Hence, the secondary feedback encoder is rotating at 60 rpm (10:1 gear reduction)
- Time = 1000 ms

To calculate the secondary feedback speed:

$$\left( \frac{600 \text{ Motor Revolutions}}{\text{Minute}} \right) \cdot \left( \frac{1 \text{ Minute}}{60 \text{ Seconds}} \right) \cdot \left( \frac{1 \text{ Load Revolution}}{10 \text{ Motor Revolutions}} \right) \cdot \left( \frac{2 \text{ Knife Cuts}}{1 \text{ Load Revolution}} \right) = \frac{2 \text{ Knife Cuts}}{\text{Second}}$$

Primary encoder feedback speed is calculated in the same safety units, but rotating at 20 knife cuts/s.

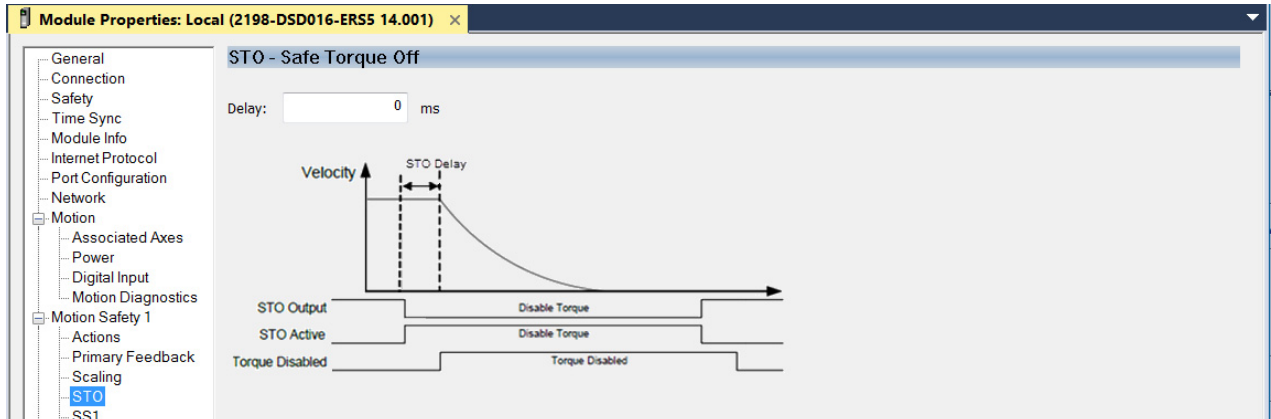
If primary versus secondary feedback speed differs by more than the Velocity Deadband value (0.1 knife cuts/s), for the Time (1000 ms) duration, a velocity discrepancy fault occurs.

## STO Category

The STO category provides a disable and coast fault action. However, if a torque disable delay is needed following STO Active, you can enter a value in the Delay field.

STO Output is a tag in the safety output assembly, which is used to activate the STO function, and is written by the GuardLogix controller. When any source for STO is asserted, STO Active becomes high to indicate that the STO function is operating.

Figure 25 - Motion Safety STO



STO becomes active if any of the following inputs to STO are asserted:

- STO Output = 0
- Safety Connection Loss and Connection Loss Action = STO
- Safety Connection is Idle and Connection Idle Action = STO
- Drive-based SS1 Function is Complete (= 1)
- Safety Stop Fault = 1
- Critical Safety fault occurs

See Safe Stop Function attribute 265 (STO Activation) on [page 103](#).

STO Delay follows this sequence of events.

1. STO becomes active and the STO delay timer begins.
2. The STO delay timer expires.

Torque producing power is removed from the inverter output.

- If STO is activated by a Safety Stop fault or Critical Safety fault, torque is removed immediately without the STO delay.
- If STO is reset by removing all inputs, torque is immediately permitted without delay.

## SS1 Category

The Motion Safety>SS1 category is configured when a Timed or Monitored Safe Stop 1 (SS1) function is desired.

Timed SS1 mode is the default setting. Monitored SS1 and Not Used are also available.

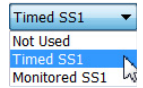
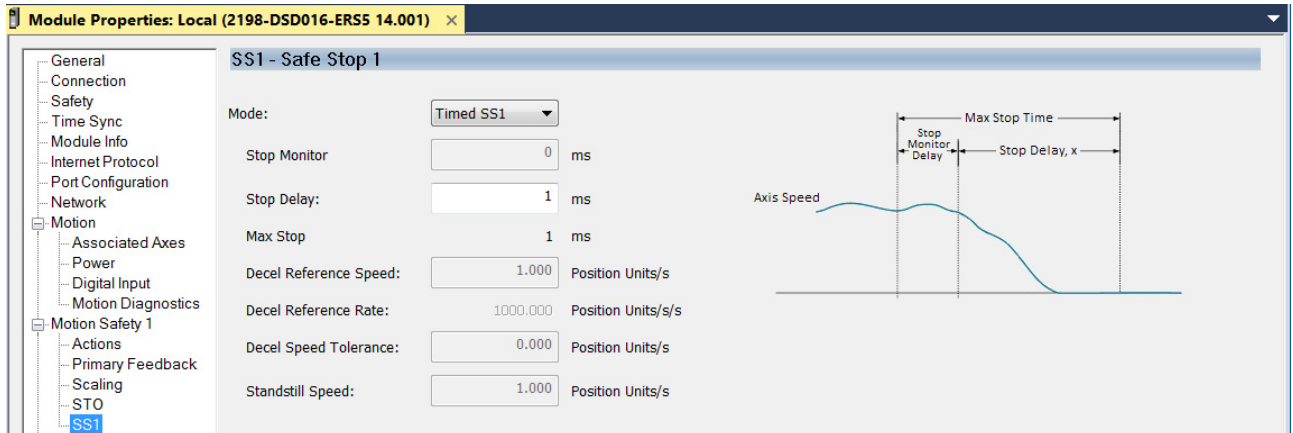
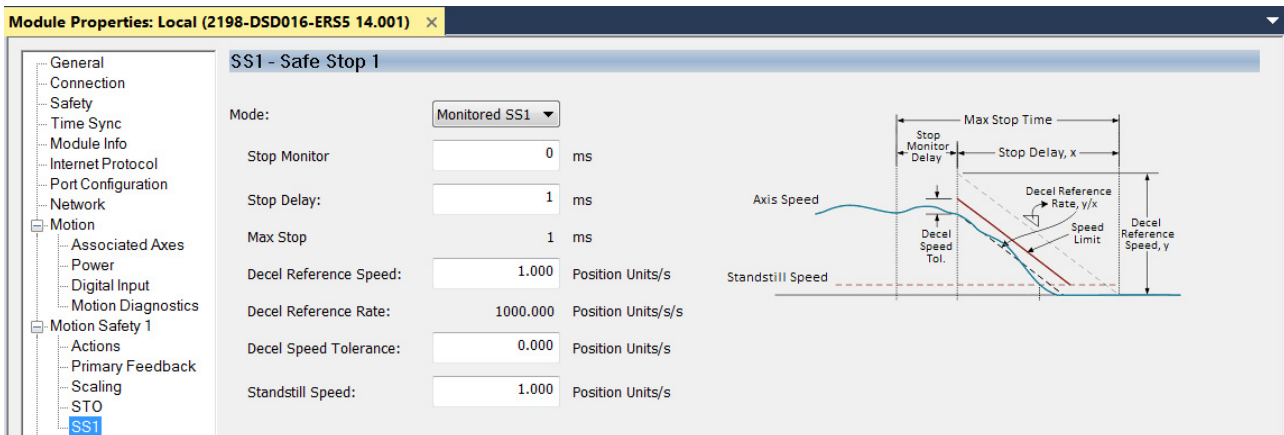


Figure 26 – SS1 Dialog Box (Timed SS1, default)



Timed SS1 is a fixed time for the motor to stop before removing torque. Motor feedback is not monitored. Stop Delay is the only parameter used for Timed SS1 and determines the Max Stop Time.

Figure 27 – SS1 Dialog Box (Monitored SS1)



Monitored SS1 is a ramped safe-stop where the motion safety instance monitors the speed ramp to standstill speed, while either the motion task or the drive controls the deceleration to standstill speed. When standstill is reached, the motion safety instance removes torque from the motor.



## Axis Properties Safety Actions

The drive and controller combination supports multiple stopping functions:

- STO with optional STO Delay
- Timed Safe Stop 1 (drive-based)
- Monitored Safe Stop 1 (drive-based or controller-based)
- Monitored Safe Stop 2 (controller-based)

The motion control of the drive does not have a safety performance rating, but often must control the motor in coordination with the safety stopping functions. For example, the Monitored Safe Stop 1 function monitors the deceleration of the motor and maintains a disabled state for the torque producing output, while the motion control executes the deceleration of the motor, engages the brake (if applicable), and disables the motion control torque. Proper coordination of the safety and motion control of the drive is, therefore, necessary to achieve the expected and optimal behavior. The Safety Actions configurations, in the Axis Properties, are to assist in the coordination of the motion control with the safety stopping functions while also meeting the needs of the application.

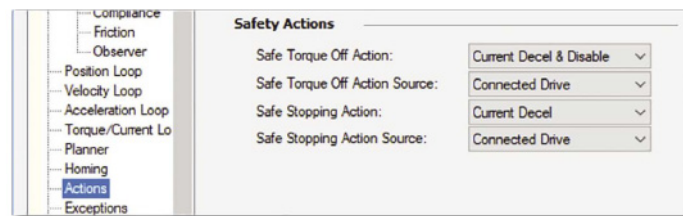
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**IMPORTANT** The Safety Actions are part of the drive's motion control and are not included as a part of the safety performance level of the safety function. Failures in the motion control system should be considered as a part of a worst-case fault reaction analysis of the safety functions.

---

### Safety Actions Parameters

The Safety Actions parameters, located in the Axis Properties on the Actions tab, determine if the drive or the user motion control program initiates the stopping sequence in response to an STO or SS1.



The selection options for both Safe Torque Off Action Source and Safe Stopping Action Source are the following:

- Connected Drive - the drive initiates the Safe Torque Off Action stopping sequence upon detection of the Safe Torque Off function activation
- Running Controller - requires the user motion control program to monitor the Axis.SafeTorqueOffActiveStatus tag and initiate a stopping action

If the drive is initiating the stopping sequence, the stopping method is based off the Action parameter selection. The Safe Torque Off Action and/or Safe Stopping Action are ignored when Running Controller is selected because the motion control program performs the stopping sequence. The Safe Torque Off Action parameters are dependent on the axis configuration setting.

Available options are the following:

- Disable and Coast
- Current Decel and Disable
- Ramped Decel and Disable (Velocity Mode, Frequency Mode only)

The Safe Stopping Action parameter options are dependent on the axis configuration setting. Available options are the following:

- Current Decel (Disable implied)
- Ramped Decel (Velocity Mode, Frequency Mode only)

### Initiate Safety Function Execution

When you use networked safety, the Guardlogix controller initiates the safety function request. Initiation is done by controlling bits in the Safety Output Assembly of the drive module. The safety program logic is used to execute the drive-based safety functions.

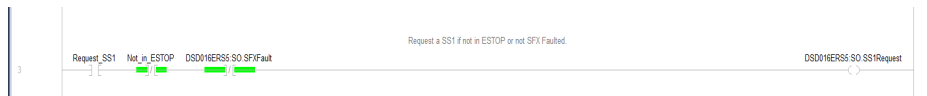
### Initiating STO

The STO safety function is controlled by the drive module tag Module:SO.STOOutput tag. During normal operation the Module:SO.STOOutput tag would be ON. To initiate the STO, the Module:SO.STOOutput tag would need to transition to OFF. Below is an example of controlling the Module:SO.STOOutput bit.



### Initiating SS1

The SS1 safety function is controlled by the drive module tag Module:SO.SS1Request tag. To initiate the SS1, the Module:SO.SS1Request tag needs to transition to ON. Below is an example of controlling the SS1Request bit.



## Safe Torque Off Actions

The STO drive safety function is in both ArmorKinetix ERS2 and ERS5 modules.

The STO safety function has some added functionality due to the IEC61800-5-2 change that was mentioned and previous drive network STO solutions. This STO configuration allows better coordination of STO with engaging a brake prior. The STO Delay starts timing when the Axis.SafeTorqueOffActiveStatus bit is set (ON). This delay is used to allow time for the motor to decelerate to zero speed, engage a holding brake, and disable the motor before removing torque producing ability when the STO Delay time expires.

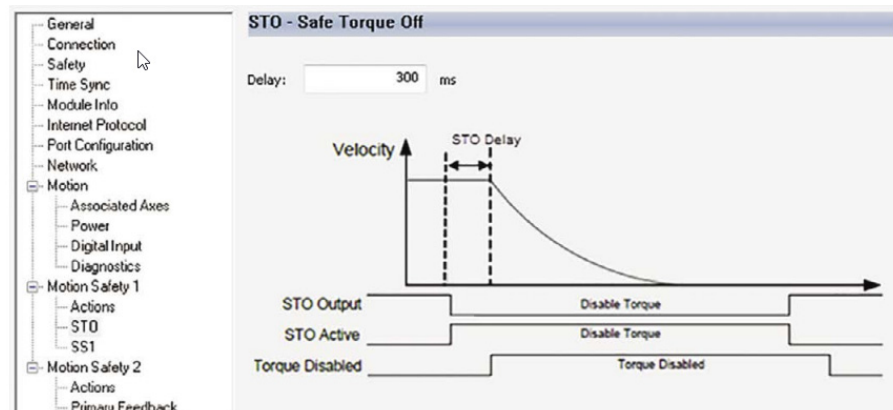
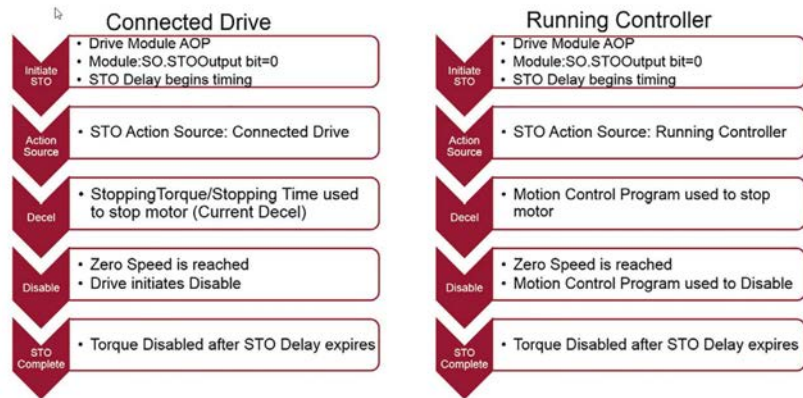


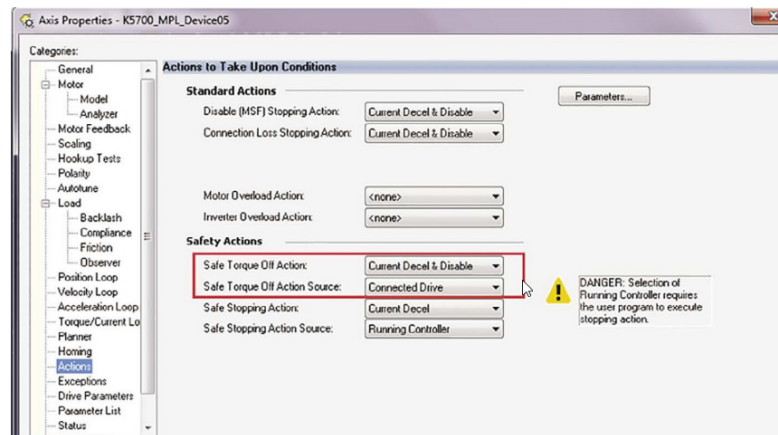
Figure 28 – STO Execution with Different Action Sources



Both the STO and SS1 examples can use the Zero Speed value as an indicator that the motor has reached zero speed. Zero Speed is an Axis parameter that can be modified and lets you manually set the zero-speed condition that is used by the Studio 5000 Logix Designer application to indicate the motor is at zero speed. This value is used together with a disabling operation to determine when the holding brake output is applied in a Category 0 and Category 1 Stop and is a percentage of the motor rated speed. Once the motor speed is less than the Zero Speed value, a timer begins timing (Zero Speed Time) which, upon expiring, is meant to indicate a true zero-speed condition of the motor.

Safe Torque Off - Connected Drive

When the Safe Torque Off Action Source is set to Connected Drive, the drive performs the Safe Torque Off Action before removing torque producing ability and completing the STO request.



MechanicalBrakeControl	Automatic
MechanicalBrakeEngageDelay	1.0 s
MechanicalBrakeReleaseDelay	1.0 s

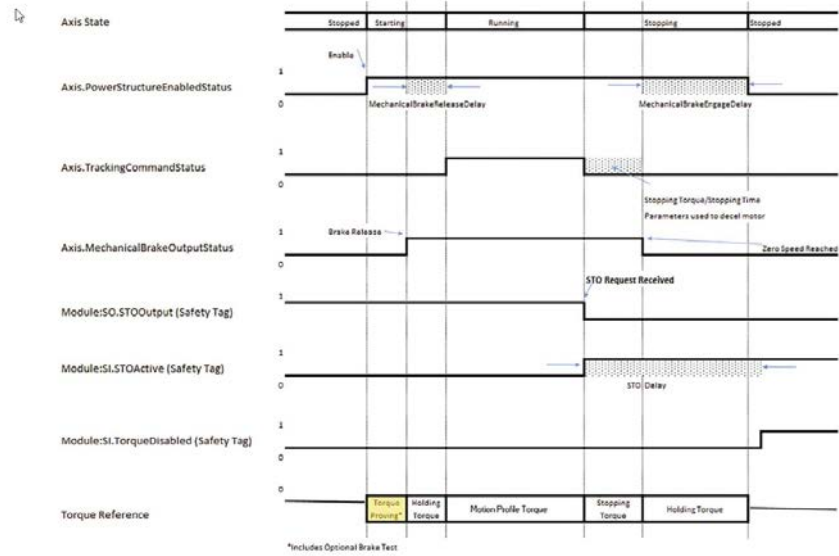
StoppingTimeLimit	1.0 s
StoppingTorque	295.2941 % Motor Rated

ZeroSpeed	1.0 % Motor Rated
ZeroSpeedTime	0.2 s

- In the Safety Program, Module:SO.STOOutput is cleared (OFF) to initiate the STO Request.
- The drive sets Module:SI.STOActive (ON) and STO Delay begins timing.
- Current Decel & Disable: The drive uses the Stopping Torque to bring the motor to zero speed. (Current Decel & Disable is shown - Disable and Coast is also available. When Disable & Coast is used, be sure the STO Delay is large enough so the motor can reach zero speed).

- At zero speed, the drive disabling begins, the Mechanical Brake Output is cleared (OFF) and MechanicalBrakeEngageDelay begins timing.
- PowerStructureEnabled is cleared (OFF) once the MechanicalBrakeEngageDelay time expires.
- STO Delay timer expires and torque producing ability is removed.
- STO Request is complete.

Figure 29 - Timing Chart Showing the STO Action Source Connected Drive (Current Decel & Disable)

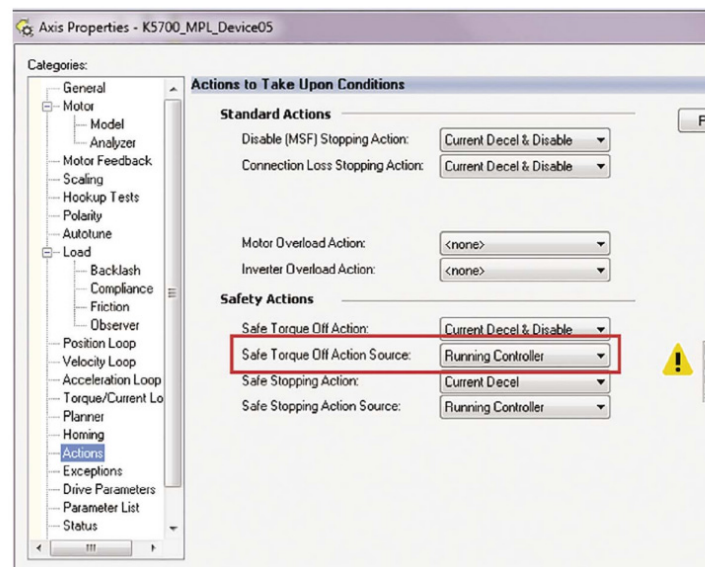


**IMPORTANT** Vertical Load application techniques are used commonly. See the Vertical Load and Holding Brake Management Application Technique, publication [MOTION-AT003](#) to help supplement the timing diagram in [Figure 29](#).

### Safe Torque Off - Running Controller

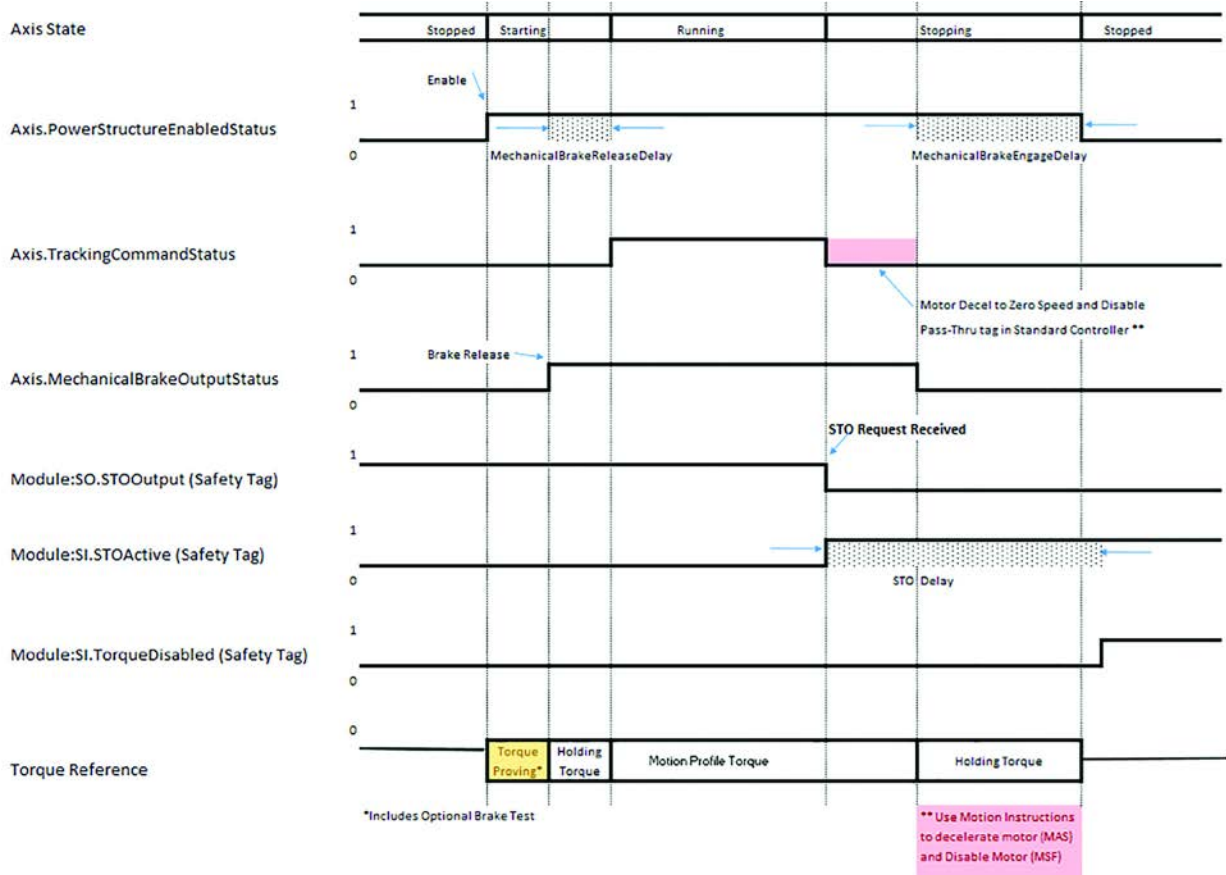
When the Safe Torque Off Action Source is set to Running Controller, the motion control program executes the stopping action and performs any additional control including disabling of the motor. Once the Safe Torque Off delay expires, torque producing ability is removed and the STO Request is complete. Safe Torque Off Action is ignored in this configuration.

Figure 30 - Safety Actions>Safe Torque Off Action Source - Running Controller



- In the Safety Program, Module:SO.STOOutput is cleared (OFF) to initiate the STO Request.
- The drive sets Module:SI.STOActive (ON) and STO Delay begins timing.
- The motion control program uses the pass-through axis tag Axis.SafeTorqueOffActiveStatus as a condition to initiate the stopping of the motor to zero speed.
- At zero speed, a disable is executed by the motion control program, Axis.MechanicalBrakeOutputStatus is cleared (OFF) and MechanicalBrakeEngageDelay begins timing.
- Axis.PowerStructureEnabledStatus is cleared (OFF) once the MechanicalBrakeEngageDelay time expires.
- STO Delay timer expires and torque producing ability is removed.
- STO Request is complete.

Figure 31 - Timing Chart Showing the STO Action Source - Running Controller



**Safety Actions**

Safe Torque Off Action:	Current Decel & Disable	<b>DANGER:</b> Selection of Running Controller requires the user program to execute stopping action.
Safe Torque Off Action Source:	Running Controller	
Safe Stopping Action:	Current Decel	
Safe Stopping Action Source:	Connected Drive	

**IMPORTANT** In the Axis Properties, when the STO Action Source is set to Running Controller, the DANGER note implies the user created logic monitors for a Safe Torque Off Active Status and executes a stopping action in the standard user task.

**IMPORTANT** If STO is activated by a Safety Stop fault or Critical Safety fault, torque is removed immediately without the STO delay.

### Safe Stop Actions

The SS1 (Safe Stop 1) is designed to perform in combination with a Category 1 stop. There are two different modes of the SS1, Timed and Monitored. The modes are selected in the Drive AOP Properties.

- Armorkinetix ERS2 modules can only execute a SS1-t (timed) because there is no monitored feedback.
- Armorkinetix ERS5 modules can execute both SS1-t (timed) or SS1-r (monitored).

**Figure 32 - SS1 Mode Selection from Drive Properties - SS1/Motion Safety Category**



Similar to the STO safety function, the Action Source of the SS1 is selected as Connected Drive or Running Controller. Either of these selections take different monitoring and execution paths, but have the same result. The SS1 examples can use the Zero Speed or Standstill Speed value as an indicator that the motor has reached zero speed. Standstill speed is a parameter that can be modified either by the SS1 instruction or in the drive module AOP and lets you manually set a zero-speed condition that is in user units. Once the motor speed is below the Standstill Speed value, the 'standstill' condition is met. Standstill speed is used with the Monitored SS1 function only. When the Standstill Speed condition is met, the STO request is initiated. It is typical for the Standstill Speed and Zero Speed to be similar values.

One way to think about Zero/Standstill speed and their use is the following:

- Zero Speed is used in the Standard environment as a permissive to disable the motor.
- Standstill Speed is used by the Safety environment to initiate an STO request.

These figures show the execution for both of the SS1 functions when using different Safe Stopping Action Sources.

**Figure 33 - SS1 - Timed Sequence Execution with Different Safe Stopping Action Sources**

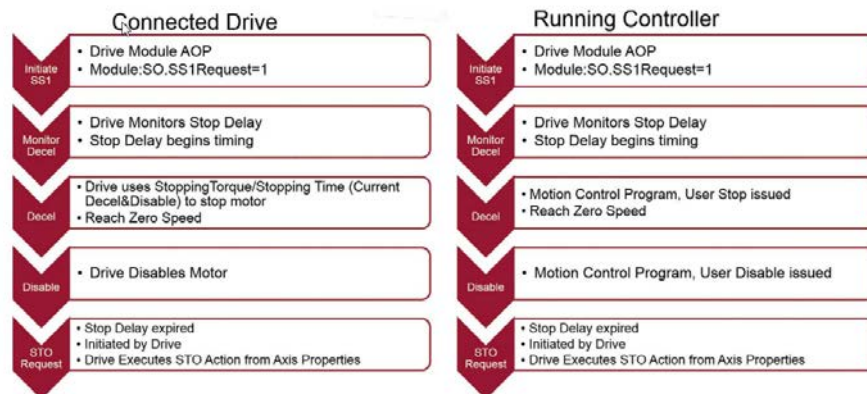
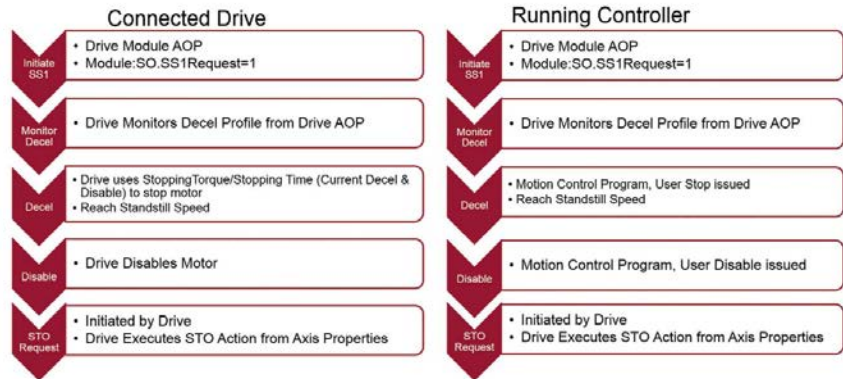




Figure 34 - SS1 - Monitored Sequence Execution with Different Safe Stopping Action Sources

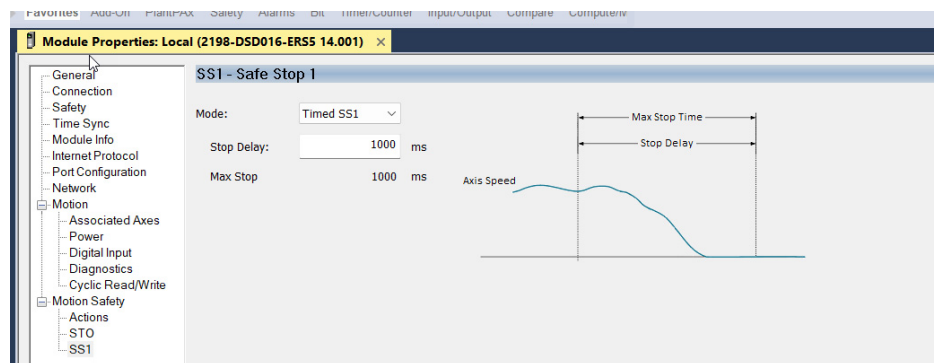


**IMPORTANT** The Safe Stopping Action configuration in the Axis Properties shows the Action of Current Decel. This setting is not changeable. SS1 is a Current Decel & Disable (Cat 1 Stop), SS2 is a Current Decel & Hold (Cat 2 Stop). The reason Current Decel is the selection is because it is common to both SS1 and SS2. At this time, the Current Decel selection implies a Disable to fulfill the SS1 condition.

### Timed SS1 - Connected Drive

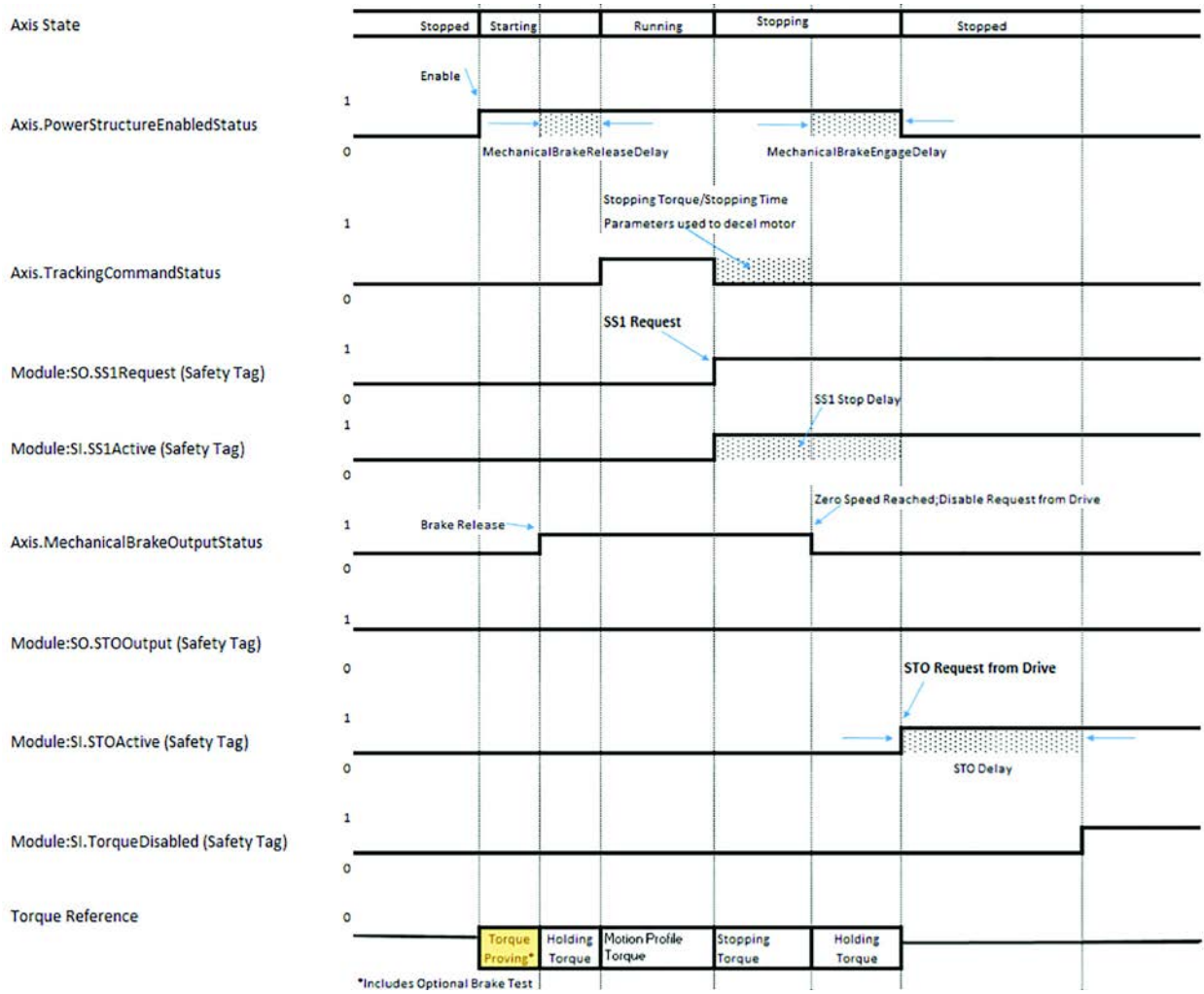
Timed SS1 is available in both the ArmorKinetix -ERS2 and -ERS5 modules. The timed SS1 is a basic function and used as a drive-based safety function. The timed SS1 uses the Stop Delay time and does not monitor the deceleration of the motor. Once the Stop Delay expires, the STO Request is made from the drive. The motor is decelerated by the drive using the Stopping Torque and Stopping Time to reach zero speed. At zero speed, the motor is disabled by the drive.

Figure 35 -



- The SS1 Request function (drive based safety function) is initiated by setting the SS1Request bit ON (drive safety output tag - Module:SO.SS1Request = 1).
- SS1 Stop Delay begins timing.
- Stopping Torque/Stopping Time is used to decelerate the motor to reach zero speed.
- At zero speed, the drive disabling begins, the mechanical brake output is cleared (OFF) and BrakeEngageDelay begins timing.
- PowerStructureEnabled bit is cleared (OFF) once the BrakeEngageDelay time expires.
- SS1 Stop Delay expires and STO Request is made by the drive and the STO Action defined by the Axis Properties is initiated.
- STO Delay timer begins.
- STO Delay timer expires and torque producing ability is removed.
- STO Request is complete.

Figure 36 - Timed SS1 Action Source - Connected Drive



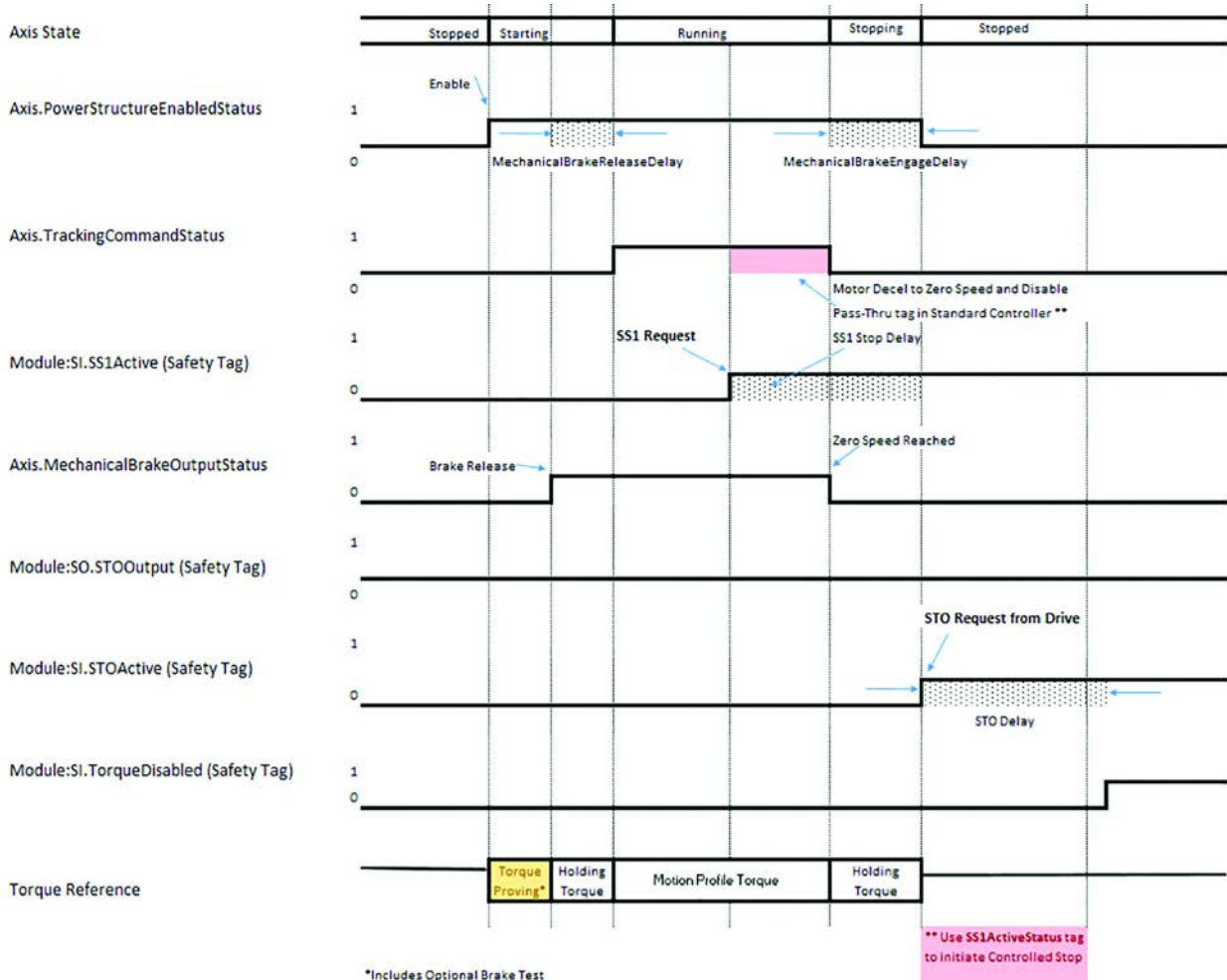


### Timed SS1 - Running Controller

Timed SS1 is available in the both the ArmorKinetix -ERS2 and -ERS5 modules. Timed SS1 is used as a drive based safety function. The Timed SS1 uses the Stop Delay Time and does not monitor the deceleration of the motor. Once the Stop Delay expires, the STO Request is made from the drive. The motor is decelerated by the motion control program to reach zero speed. At zero speed, the motor is disabled by the motion control program.

- The SS1 Request function (drive based safety function) is initiated by setting the SS1Request bit ON (drive safety output tag - Module:SO.SS1Request = 1).
- SS1 Stop Delay begins timing.
- Motion control program is used (based on pass-through axis tag SS1ActiveStatus) to decelerate the motor to zero speed.
- At zero speed, the motor is disabled by the motion control program, the mechanical brake output is cleared (OFF) and MechanicalBrakeEngageDelay begins timing.
- PowerStructureEnabled bit is cleared (OFF) once the MechanicalBrakeEngageDelay time expires.
- SS1 Stop Delay expires and STO Request is made by the drive and the STO Action defined by the Axis Properties is initiated.
- STO Delay timer begins.
- STO Delay timer expires and torque producing ability is removed.
- STO Request is complete.

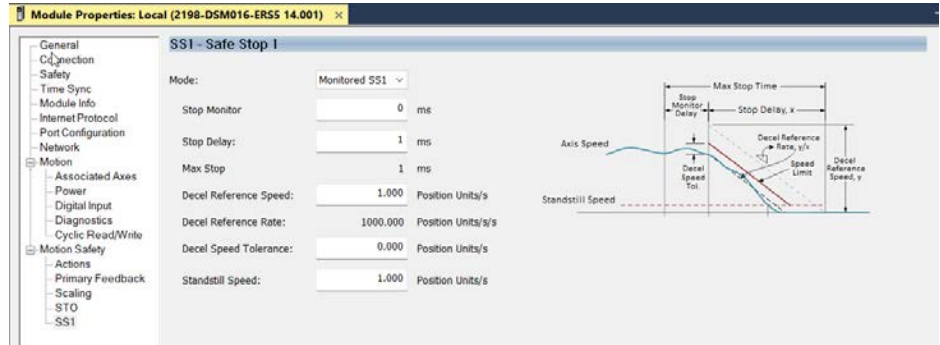
Figure 37 - Timed SS1 Action Source - Running Controller



### Monitored SS1 - Connected Drive

Monitored SS1 is only available in the ArmorKinetix -ERS5 module. When Monitored SS1 is used with Connected Drive as the Action Source, the drive receives the SS1 Request from the safety program. The drive uses the Stop Delay Time and the Safety defined primary feedback device to monitor the deceleration of the motor. The motor is decelerated by the drive by using the Stopping Torque and Stopping Time to reach zero speed. At zero speed, the motor is disabled by the drive. Once the Stop Delay expires, or the Standstill Speed is reached, the STO Request comes from the drive and the STO Action, as defined in the Axis Properties, is performed.

**Figure 38 - Monitored SS1 Safety AOP Configuration**



**IMPORTANT** Monitored SS1 is available with a Ramped Decel Safe Stopping Action when the axis is configured for Velocity Loop, or Frequency Control. Position Loop uses Current Decel as the Safe Stopping Action.

## Safety Connection Examples

The following are examples of each of the Safety Connection available when using ArmorKinetix ERS2 and ERS5 based on allowed function.

For these examples not all safety monitoring functions are shown because many are user specific. For instance, showing of the Motion Safety Actions (when communications are interrupted) or STO.

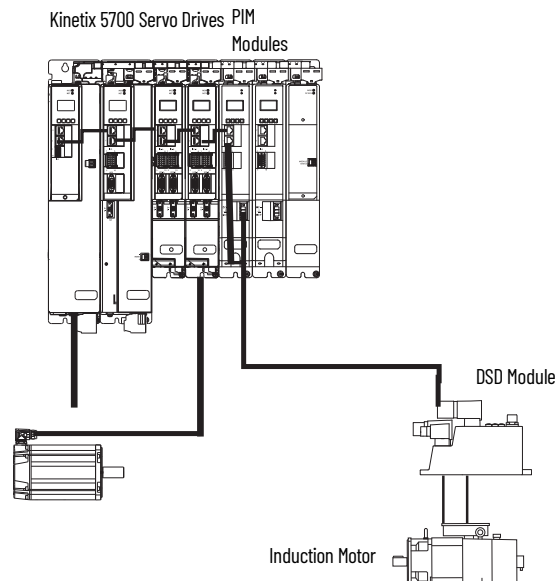
- ArmorKinetix DSD module to induction motor, safe stop only, no feedback
- ArmorKinetix DSD module to Kinetix VPL Q motor single feedback monitoring
- ArmorKinetix DSD module to Kinetix VPL Q motor with 842 HR for dual feedback monitoring
- ArmorKinetix DSD module to Kinetix MPL M motor with single feedback monitoring
- ArmorKinetix DSM module for single feedback monitoring

### Safe Stop Only-No Feedback - ArmorKinetix DSD Module to Induction Motor

The motion instance has been configured to run an asynchronous induction motor.

Example of a configuration layout when Safe Stop Only-No Feedback is used on the ERS5 module to induction motor.

**Figure 39 - 2198-DSDxxx-ERS5 Module to Induction Motor**

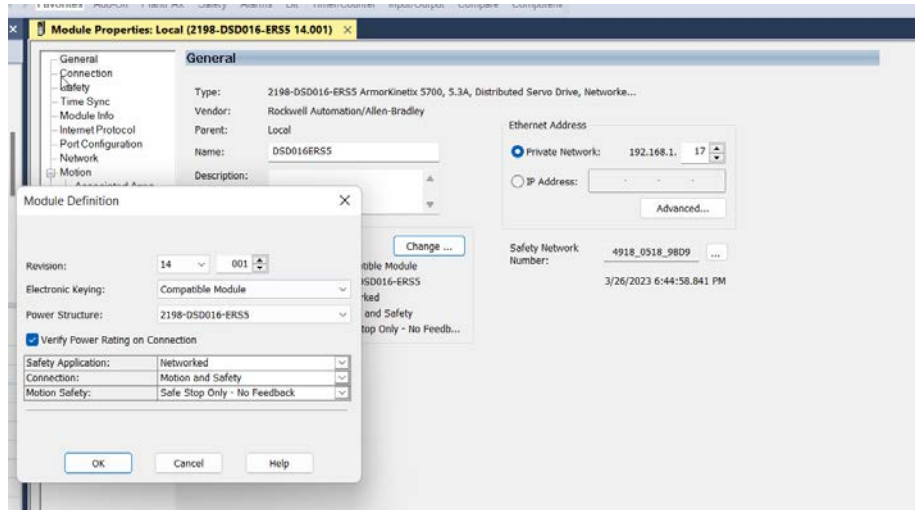


In this example, the 2198-DSDxxx-ERS5 module is used, but an ERS2 module supports Safe Stop Only-No Feedback as well.

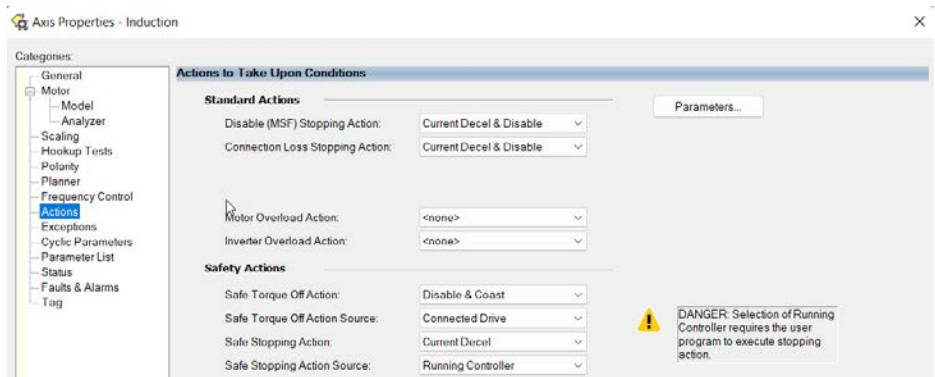
1. To select the module properties, select Change.

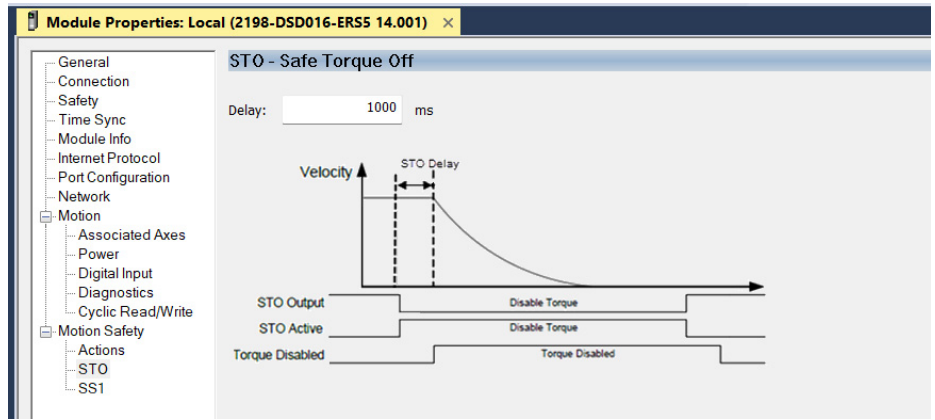
2. Make these selections for the module definitions:
  - Safety Application - Networked
  - Connection - Motion and Safety
  - Motion Safety - Safe Stop Only - No Feedback

A reason for using Safe Stop Only - No Feedback for a 2198-DSDxxx-ERS2/5 module is to control an induction motor open loop, in frequency control. Because both VHz and SVC modes do not have current loops, the current decel type of stopping actions are not real stopping types. We recommend you use this configuration for STO and SS1 as shown.

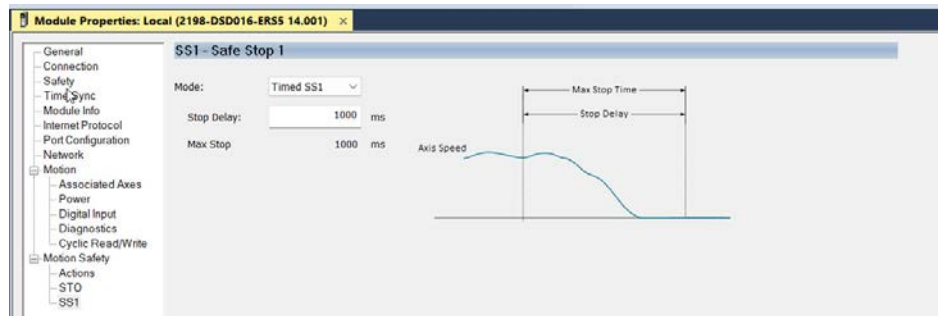


3. From the Actions tab, set the Safety Actions.
  - a. For a Safe Torque Off Action for frequency control, we recommend the following actions:
    - If the Safe Torque Off Action Source is set to Connected Drive, the drive accepts the Module:SO.STOOutput and after the Delay, if used, disables the drive modulation and lets the motor to coast-to-stop due to friction/losses.
    - If the Safe Torque Off Action Source is set to Running Controller and uses the Module:SO.STOOutput pass through to the controller, the controller uses Axis.SafeTorqueOffActiveStatus to control the motor to a stop. Then, the controller removes the Module:SO.STOOutput OTE, which sets the motor in a Safe Torque Off Condition.
  - b. For a Safe Stopping Action for frequency control, we recommend the following action:
    - If the Safe Stopping Action Source is set to Running Controller and uses the SS1Request bit ON (Drive Safety Output tag - Module:SO.SS1Request = 1) pass through to the controller, the controller uses of the SS1ActiveStatus tag to control the motor to a stop.



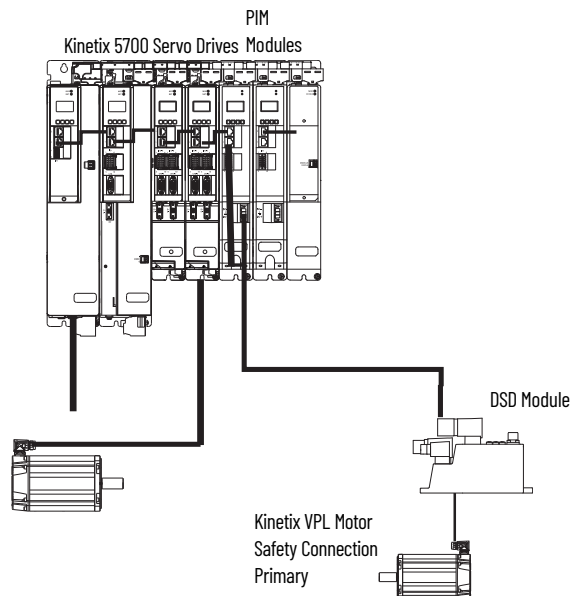


**IMPORTANT** The only drive selection for SS1 is timed (or none). Note this is the drive safety planner but the running controller won't be affected unless the SS1-t stop time is exceeded. When the SS1-t stop time is reached in the safety planner, the drive will automatically initiate a Safe Torque Off, regardless of the motor's speed at the time of expiration.



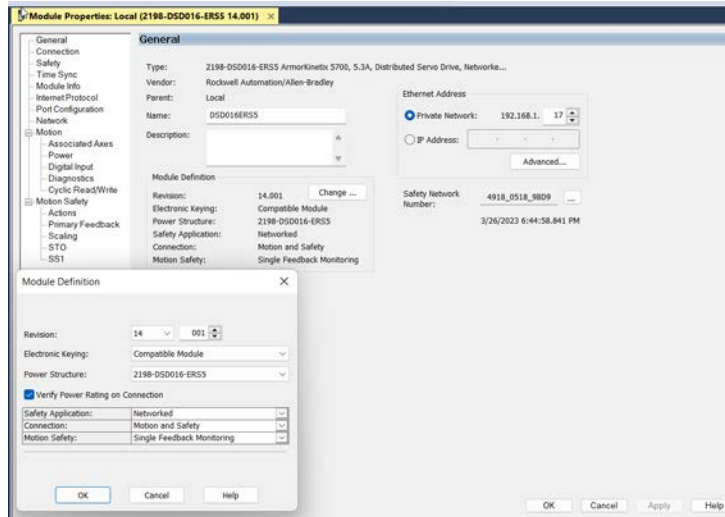
### Single Feedback Monitoring Armorkinetic DSD Module to Kinetix VPL Motor with SIL2 Encoder

Figure 40 - 2198-DSDxxx-ERS5 Module to Kinetix VPL Motor with SIL2 Encoder



The single feedback monitoring, along with the Kinetix VPx SIL2 encoder is the most common application type for an Armorkinetix ERS5 drive. For example, you can use this application type in a Safely-limited Speed application to know when a specific speed is controlled/monitored.

1. To select the module properties, from the General tab, select Change.
2. Make these selections for the module definitions, then select OK:
  - Safety Application - Networked
  - Connection - Motion and Safety
  - Motion Safety - Single Feedback Monitoring

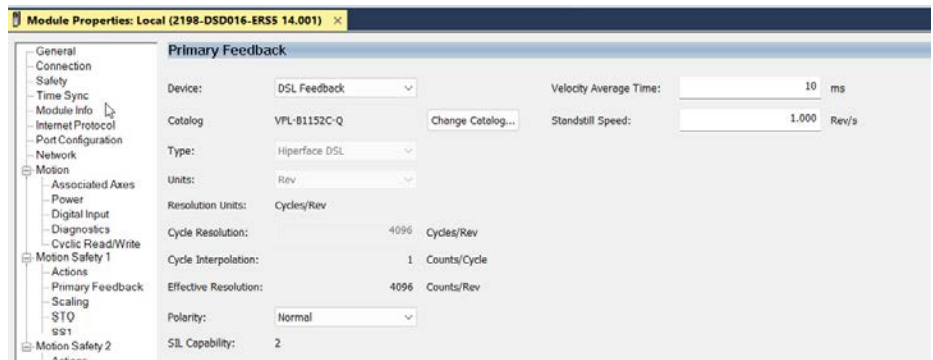


Compared to Safe Stop Only - No Feedback, you can select both Primary Feedback and Scaling for feedback monitoring functions.

3. Configure the following items in the Primary Feedback.
  - Device - Select DSL Feedback for device type. Kinetix VPL motors can use either the Q or W SIL2 encoder based on current density.
  - Catalog - Change value to the correct motor catalog number.
  - Polarity - Select the safety encoder count direction.
  - Velocity Average Time - Set this value based on previous analysis for speed accuracy and safety monitoring function response time.

**IMPORTANT** This setting is an important requirement for maintaining proper safety monitoring, such as the accuracy and response time of the Safely-limited Speed functions.

- Standstill Speed - Set this value to know when the Deceleration of a Monitored Safe Stop 1 is complete.

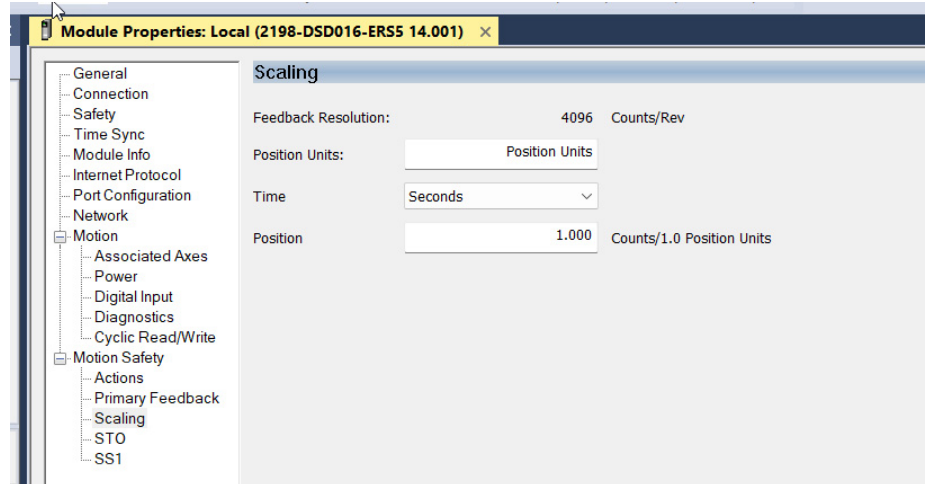


## 4. Configure the Scaling.



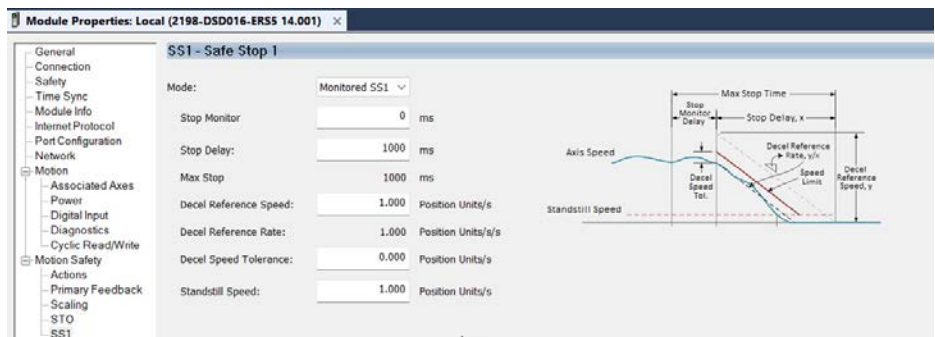
This section can be quite complex based on your machine code. We recommend that you see Knowledgebase article [How to scale the SFX instruction to meet the Motion/IQ mode and safety configuration units](#) to use good engineering practices to program similar units.

- The Motion Safety Scaling
  - The GuardLogix Safety Task Scaling from the SFX to the Safety instructions
  - The Motion Planner Scaling for use of Motion Axis Moves
- The encoder counts are the resolution of the safety encoder, therefore, 12 bit or  $2^{12} = 4096$  counts per motor revolution.
- There also are evaluations of machine transmissions that alter motor speed at the load due to use of gearbox or other such devices.



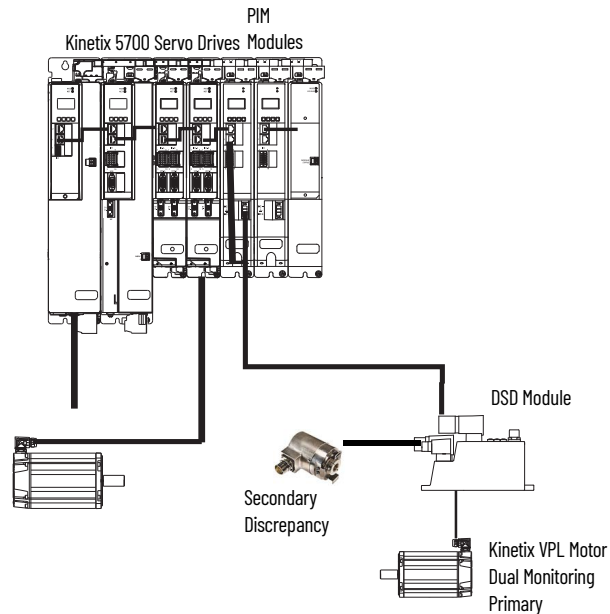
## 5. Configure the SS1 function.

- When using an encoder in the drive safety configuration the use of SS1-monitoring can be used for controlled deceleration.
- SS1-timed can be used but the deceleration rate and standstill speed is not monitored.



## Dual Feedback Monitoring ArmorKinetix DSD Module to Kinetix VPL Motor with SIL2 Encoder and using an 842HR for Discrepancy Encoder Checking

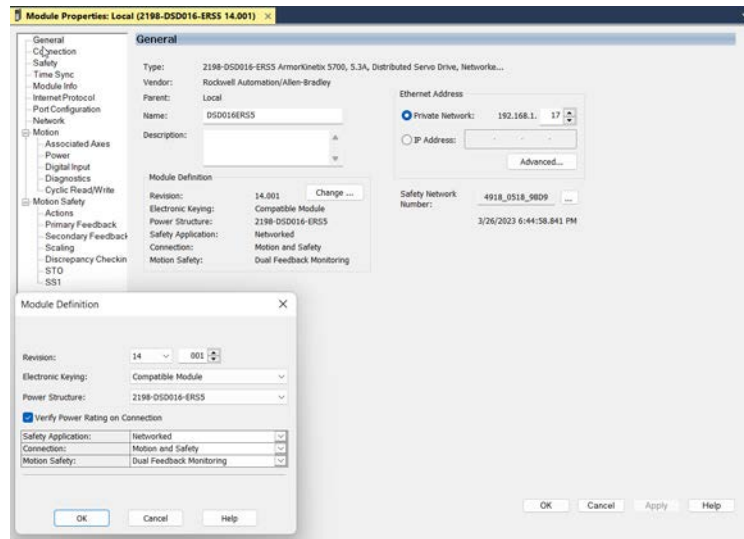
Figure 41 - 2198-DSDxxx-ERS5 Module to Kinetix VPL Motor and 842 Encoder



By using a SIL 2 rated Kinetix VP encoder with an external secondary encoder lets you achieve the use of the speed in safety speed monitoring functions with a performance level up to SIL3 PL<sub>e</sub>, Category 3. See [Table 24](#) and [Table 25](#) for details.

The configuration uses the following:

- ArmorKinetix DSD ERS5 module
  - Kinetix VPx SIL 2 encoder for single feedback monitoring function
  - 842HR to allow for discrepancy checking of the Kinetix VP motor speed
1. To select the module properties, from the General tab, select Change.
  2. Make these selections for the module definitions, then select OK:
    - Safety Application - Networked
    - Connection - Motion and Safety
    - Motion Safety - Dual Feedback Monitoring







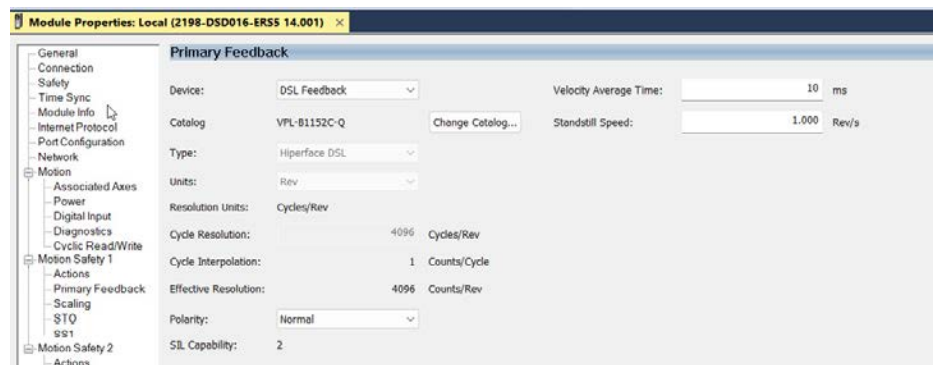
Compared to Single Feedback Monitoring, you have the ability to select both Secondary Feedback and Discrepancy Checking for dual feedback monitoring functions

### 3. Configure the following items in Primary Feedback.

- Device - Select DSL Feedback for device type. Kinetix VPL motors can use either the Q or W SIL2 encoder based on current density.
- Catalog - Change value to the correct motor catalog number.
- Polarity - Select the safety encoder direction count.
- Velocity Average Time - Set this value based on previous analysis for speed accuracy and safety speed monitoring function response time.

**IMPORTANT** This setting is an important requirement for maintaining proper safety monitoring, such as the accuracy and response time of the Safely-limited Speed functions.

- Standstill Speed - Set this value to know when the Deceleration of a Monitored Safe Stop 1 is complete.



### 4. Configure the Scaling.

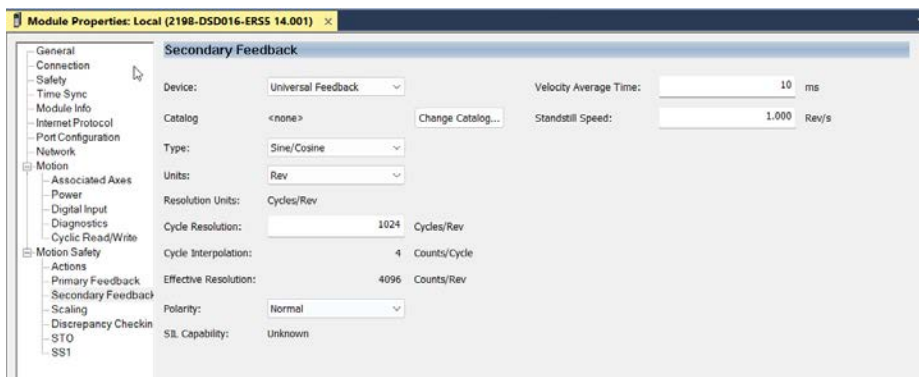


This section can be quite complex based on your machine code. We recommend that you see Knowledgebase article [How to scale the SFX instruction to meet the Motion/I/O mode and safety configuration units](#) to use good engineering practices to program similar units.

- The Motion Safety Scaling
- The GuardLogix Safety Task Scaling from the SFX to the Safety instructions
- The Motion Planner Scaling for use of Motion Axis Moves
- The encoder counts are the resolution of the safety encoder, therefore, 12 bit or  $2^{12} = 4096$  counts per motor revolution.
- There also are evaluations of machine transmissions that alter motor speed at the load due to use of gearbox or other such devices.



5. Configure the following items in Secondary Feedback.
  - Device - Select Universal Feedback for device type. As with the DSL Feedback, the Universal Feedback is geared more toward a Hiperface/SIN/COS device. The Safety AOP of the drive keeps the same feedback configuration nomenclature as the Axis Properties, but it is important to note that these two configurations are separate and isolated.
  - Catalog - Change value to NONE as there is no motor connected to this port.
  - Polarity - Select the safety encoder count direction.
  - Velocity Average Time - Set this value based on previous analysis for speed accuracy.
    - This function must consider now the Discrepancy Checking algorithm such that a wider speed variance of the secondary encoder versus the primary Kinetix VPx motor can be misleading.
    - It is recommended to make sure that resolutions are comparable and velocity average time to be comparable.
  - Standstill Speed - Set this value to know when the Deceleration of a Monitored Safe Stop 1 is complete.



6. Configure the Discrepancy Checking.

### IMPORTANT

Confirm the ratio of primary to secondary is accurate, based on encoder resolution and gearing. Differences in encoder resolutions and velocity average times can impact the velocity discrepancy.

We recommend that you see Knowledgebase article [How to scale the SFX instruction to meet the Motion/IO mode and safety configuration units](#) due to the complexity of the configuration.

- Mode - supports Dual Velocity Check for comparison of the encoder feedback devices. If no feedback comparison is needed, then Not Used would be selected.
- Ratio - sets the ratio between the primary and secondary feedback for the speed comparison. In this example the Kinetix VPx Q/W encoder rotates 1 revolution and the 842HR rotates 1 revolution. This establishes the gear ratio in the drive safety planner.
- Velocity deadband - set to 0.1 position units/second. Both the primary and secondary encoders use the same position units to evaluate the actual discrepancy.
- Time - set to 100 ms. This value indicates that the monitoring of the Kinetix VPx Q/W encoder position units/sec cannot differ from the 842HR secondary position units/sec more than the Velocity Deadband for 100 ms, lest the drive safety planner posts a fault and takes specific fault action (coast to stop are typical safety fault actions).

- In this example, both the VPL-B1152C-Q encoder and 842HR encoder are 4096 counts per motor revolution in the Scaling tab. The ideal configuration has two similar count encoders. If, for instance, a mandatory use of a VPL-B1152C-Q of 4096 counts per motor were directly coupled to a line shaft with encoder 2048 counts per motor, the scaling can't change but the discrepancy ratio can change to one primary revolution to two secondary revolution, which could satisfy a gear ratio configuration.

The screenshot shows the 'Discrepancy Checking' configuration window. The left sidebar lists various configuration categories, with 'Motion Safety' expanded to show 'Discrepancy Checkin'. The main window contains the following settings:

- Mode: Dual Velocity Check
- Time: 100 ms
- Ratio: 1.000000 Primary Rev/Secondary Rev
- Velocity Deadband: 0.100 Position Units/s

#### 7. Configure the SS1 function.

- When using an encoder in the drive safety configuration the use of SS1-monitoring can be used for controlled deceleration.
- SS1-timed can be used but the deceleration rate and standstill speed is not monitored.

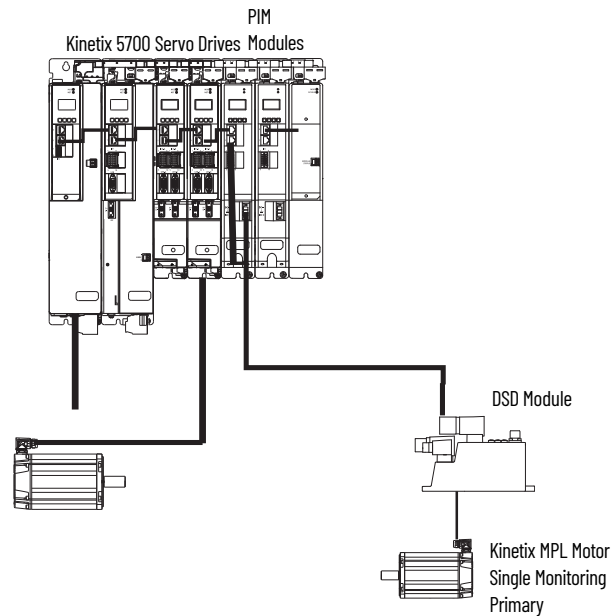
The screenshot shows the 'SS1 - Safe Stop 1' configuration window. The left sidebar lists various configuration categories, with 'Motion Safety' expanded to show 'SS1'. The main window contains the following settings:

- Mode: Monitored SS1
- Stop Monitor: 0 ms
- Stop Delay: 1000 ms
- Max Stop: 1000 ms
- Decel Reference Speed: 1.000 Position Units/s
- Decel Reference Rate: 1.000 Position Units/s
- Decel Speed Tolerance: 0.000 Position Units/s
- Standstill Speed: 1.000 Position Units/s

To the right of the settings is a graph titled 'Axis Speed' showing the deceleration profile. The graph plots speed against time, illustrating the 'Decel Speed Tol.' (Deceleration Speed Tolerance) and 'Decel Reference Rate' (Deceleration Reference Rate) parameters. Key points on the graph include 'Stop Monitor Delay', 'Stop Delay, x', 'Decel Reference Rate, y/s', 'Speed Limit', and 'Decel Reference Speed, y'. The total duration of the stop is labeled as 'Max Stop Time'.

## Single Feedback Monitoring ArmorKinetix DSD Module to Kinetix MPL Motor with Hiperface, non-rated Safety Encoder

Figure 42 - 2198-DSDxxx-ERS5 Module to Kinetix MPL Motor with non-rated Encoder



This example shows single feedback monitoring for ArmorKinetix DSD ERS5 module that is connected to a Kinetix MPL Hiperface. This example shows another common application type.

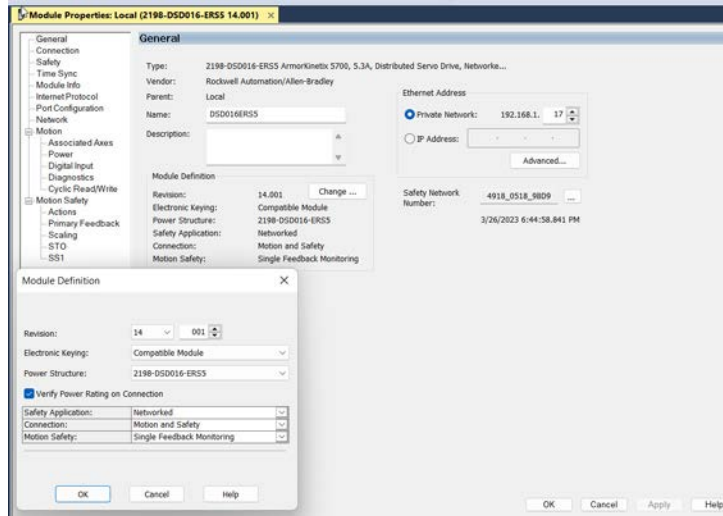


This application is similar to the Kinetix VPx SIL 2 encoder for single feedback monitoring applications. For instance, in the use of a Safely-limited Speed application, to know when a specific speed is controlled/monitored.

The hybrid cable connection from the DSD module has one motor power cable to the Kinetix MPL motor power connector and an auxiliary encoder cable to the Kinetix MPL motor feedback connector. In this case, the use of Dual Feedback Monitoring cannot be used because only one feedback device is being used.

1. To select the module properties, from the General tab, select Change.

2. Make these selections for the module definitions, then select OK:
  - Safety Application - Networked
  - Connection - Motion and Safety
  - Motion Safety - Single Feedback Monitoring



Compared to Safe Stop Only - No Feedback, you can select both Primary Feedback and Scaling for feedback monitoring functions.

3. Configure the following items in Primary Feedback.
  - Device - Select Universal Feedback for device type. The catalog numbers for the non-rated SIL encoders or the Kinetix MPx with S or M designation are then available. Kinetix MPx motors must use the S (single turn) or M (multi-turn) type encoder. The H (incremental) or R (resolver) are not compatible. The MPL-B420P-M motor is shown here, for example.
  - Catalog - Change value to the correct motor catalog number.
  - Polarity - Select the safety encoder count direction.
  - Velocity Average Time - Set this value based on previous analysis for speed accuracy and safety speed monitoring function response time.

---

**IMPORTANT** This setting is an important requirement for maintaining proper safety monitoring, such as the accuracy and response time of the Safely-limited Speed functions.

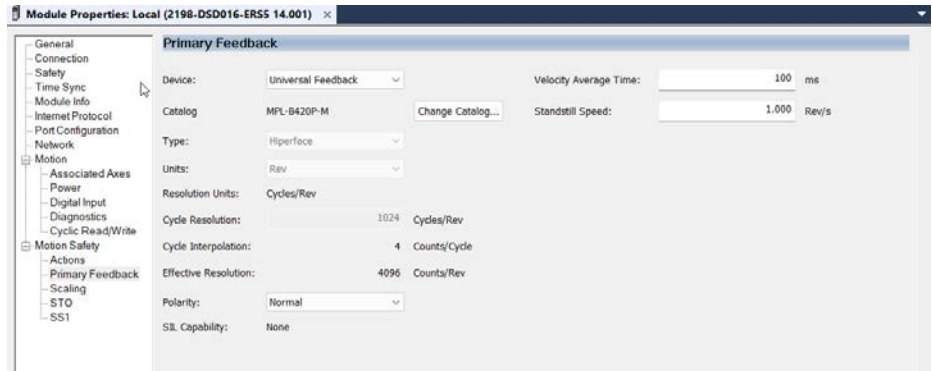
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- Standstill Speed - Set this value to know when the Deceleration of a Monitored Safe Stop 1 is complete.

- SIL Capability - For Kinetix MPx motors with S/M encoders, the designation is None because these motors do not have safety rated encoders. Contact the Rockwell Technical Consultant/Safety Engineers to discuss system safety performance level (PL) with the MPx with S/M encoders.



For Kinetix VPx with Q or W encoders, the SIL 2 is shown because the encoder itself meets that designation per the encoder manufacturer.

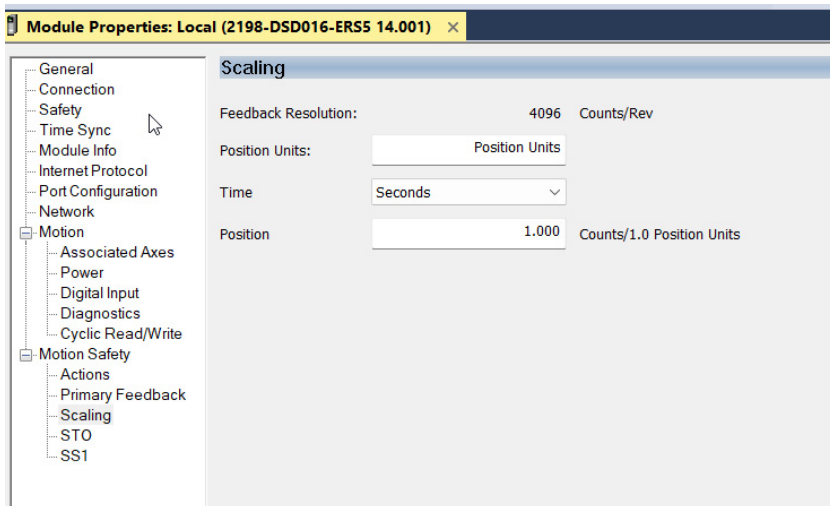


#### 4. Configure the Scaling.

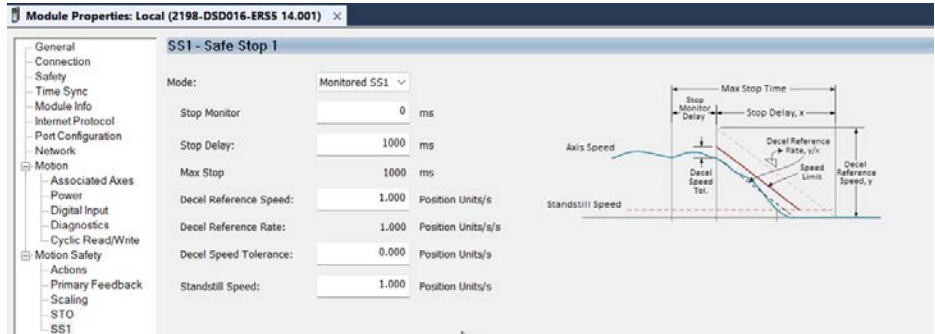


This section can be quite complex based on your machine code. We recommend that you see Knowledgebase article [How to scale the SFX instruction to meet the Motion/IQ mode and safety configuration units](#) to use good engineering practices to program similar units.

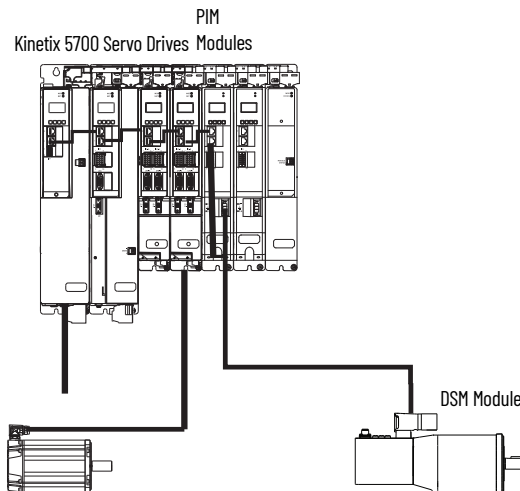
- The Motion Safety Scaling
  - The GuardLogix Safety Task Scaling from the SFX to the Safety instructions
  - The Motion Planner Scaling for use of Motion Axis Moves
- Kinetix MPx motors with S/M encoders do not have a safety configured encoder but the standard channel is evaluated with 1024 lines per revolution x 4 or 4096 counts per motor revolution. This is used in the safety channel for monitoring functionality.
  - There also are evaluations of machine transmissions that can alter the scaling of the encoder feedback, due to the use of a gearbox or other such device.



5. Configure the SS1 function.
  - When using an encoder in the drive safety configuration the use of SS1-monitoring can be used for controlled deceleration.
  - SS1-timed can be used but the deceleration rate and standstill speed is not monitored.



## Single Feedback Monitoring of ArmorKinetix DSM Module with Integrated Safety Encoder



This example is single feedback monitoring for a drive/motor 2198-DSMxxx-ERS5 module with Safety Encoder. This configuration does not require drive to motor wiring and allows for single feedback monitoring applications. For example, in use of a Safely-limited Speed application, to know when a specific speed is controlled/monitored.

1. To select the module properties, from the General tab, select Change.

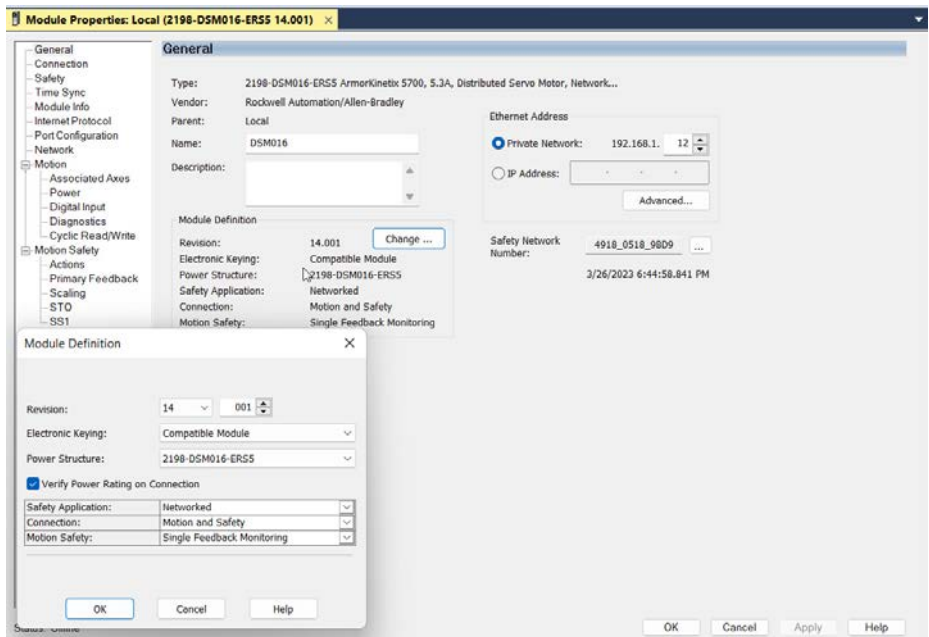
2. Make these selections for the module definitions, then select OK:
  - Safety Application - Networked
  - Connection - Motion and Safety
  - Motion Safety - Single Feedback Monitoring



Compared to Safe Stop Only - No Feedback, you can select both Primary Feedback and Scaling for feedback monitoring functions.



Dual feedback monitoring is not available because the DSM module has the motor and encoder feedback integrated with the drive and the connector available for a secondary encoder connection.



3. Configure the following items in Primary Feedback.
  - Device - Select DSL Feedback for device type. The DSM modules use the -W or -T Safety Encoders based on current density/encoder dimensions. The ArmorKineticx ERS5 to the 2198-DSMxxx-B1152F-T is shown here for example.



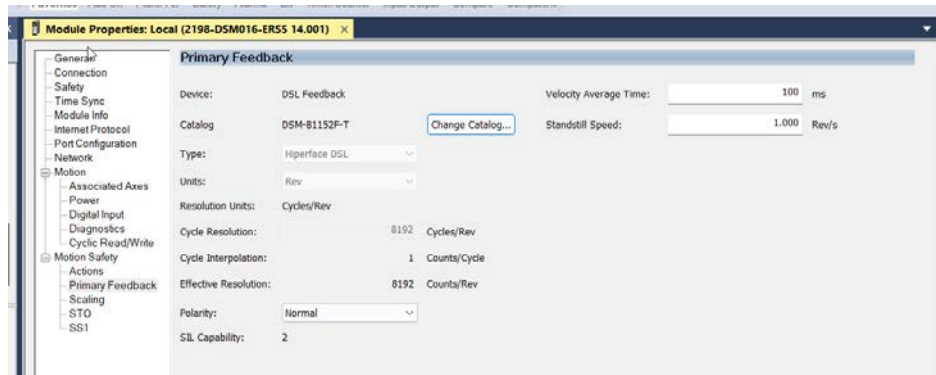
The DSM module catalog numbers that use safety encoders use W or T for the encoder type. For comparison purposes, Kinetix VPx motors use W or Q encoder types.

- Catalog - Change value to the correct motor catalog number.
- Polarity - Select the safety encoder count direction.
- Velocity Average Time - Set this value based on previous analysis for speed accuracy and safety speed monitoring function response time.



**IMPORTANT** This setting is an important requirement for maintaining proper safety monitoring, such as the accuracy and response time of the Safely-limited Speed functions.

- Standstill Speed - Set this value to know when the Deceleration of a Monitored Safe Stop 1 is complete.

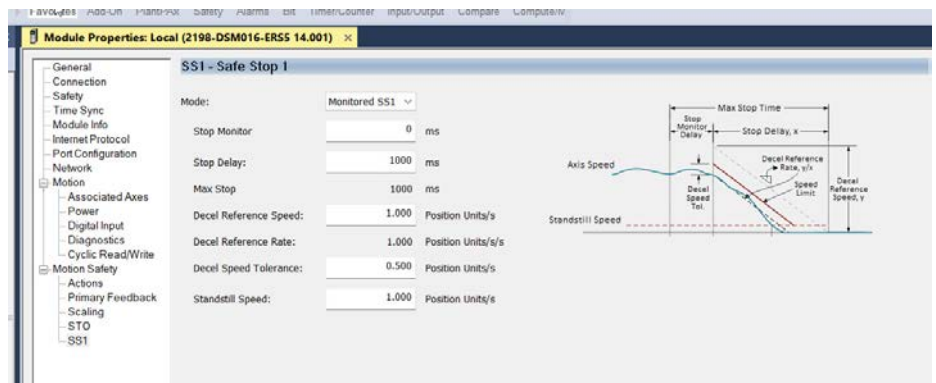


#### 4. Configure the Scaling.



This section can be quite complex based on your machine code. We recommend that you see Knowledgebase article [How to scale the SFX instruction to meet the Motion/I/O mode and safety configuration units](#) to use good engineering practices to program similar units.

- The Motion Safety Scaling
  - The GuardLogix Safety Task Scaling from the SFX to the Safety instructions
  - The Motion Planner Scaling for use of Motion Axis Moves
- The encoder counts are the resolution of the safety encoder, 13 bit or  $2^{13} = 8192$  counts per motor revolution
  - There also are evaluations of machine transmissions that can alter the scaling of the encoder feedback, due to the use of a gearbox or other such device.



5. Configure the SS1 function.
  - When using an encoder in the drive safety configuration the use of SS1-monitoring can be used for controlled deceleration.
  - SS1-timed can be used but the deceleration rate and standstill speed is not monitored.



## Encoder Types and SIL Ratings

Encoder feedback is used for motion control, safety motion monitoring, or both. The drive must be configured to use a feedback device for motion and/or for safety. The motion and safety functions in the drive are independent regarding the encoder feedback. For SIL 2 PLd safety applications, one encoder can be used. The encoder for SIL 2 applications has restrictions. [Table 24](#) and [Table 25](#) show how different feedback types can be used with a drive to achieve the desired motion control and safety for SIL 2 PLd applications.

For SIL 3 PLe applications, two encoders must be used. One of the encoders must be a SIL 2 rated Hiperface DSL encoder that is provided in a Kinetix VP (VPL, VPF, VPH, or VPS motors) servo motor. The secondary encoder must be a Sin/Cos type that meets specific requirements for diagnostic coverage.

Table 24 - Feedback Types Assigned to Feedback Ports for SIL 2 and PL d Applications

Motor Power/Feedback (MF) Connector <sup>(1)</sup>			Motor Feedback (UFB) Connector <sup>(1)</sup>			Achievable System Safety Rating
Encoder Source	Encoder Safety Function	Encoder Motion Function	Encoder Source	Encoder Safety Function	Encoder Motion Function	
VPL-Bxxxxx-Q VPL-Bxxxxx-W VPF-Bxxxxx-Q VPF-Bxxxxx-W VPH-Bxxxxx-Q VPH-Bxxxxx-W VPAR-Bxxxxx-Q VPAR-Bxxxxx-W	Primary	Motor feedback	<ul style="list-style-type: none"> <li>No encoder</li> <li>Any encoder supported by the drive</li> </ul>	Not used	<ul style="list-style-type: none"> <li>None</li> <li>1/2 axis</li> <li>Dual-loop load feedback</li> </ul>	Single Channel SIL 2/PL d
VPL-Bxxxxx-C VPL-Bxxxxx-P VPF-Bxxxxx-C VPF-Bxxxxx-P VPH-Bxxxxx-C VPAR-Bxxxxx-C	Not used	Motor feedback	Any Sin/Cos encoder compatible with drive	Primary	<ul style="list-style-type: none"> <li>None</li> <li>1/2 axis</li> <li>Dual-loop load feedback</li> </ul>	<ul style="list-style-type: none"> <li>Single Channel SIL 2/PL d for rated encoders.</li> <li>PLd according to machinery safety standard and additional (customer-supplied) safety measures. <sup>(2)</sup></li> </ul>
No encoder	Not used	Not used	<ul style="list-style-type: none"> <li>SIL 2 Safety rated Sin/Cos encoder compatible with drive <sup>(2) (3) (4)</sup></li> </ul>	Primary	Motor Feedback	<ul style="list-style-type: none"> <li>Single Channel SIL 2/PL d for rated encoders according to machinery safety standard and additional (customer supplied) safety measures. <sup>(5)</sup></li> </ul>
No encoder	Not used	Not used	<ul style="list-style-type: none"> <li>Any Sin/Cos encoder compatible with driver <sup>(2) (3) (4) (6)</sup></li> </ul>	Primary	Motor Feedback	<ul style="list-style-type: none"> <li>PL d according to machinery safety standard and additional (customer-supplied) safety measures. <sup>(5)</sup></li> <li>Applies for Kinetix MP motors with -M and -S encoder options.</li> </ul>

(1) The motor power/feedback connector and motor feedback connector appear on 2198-DSD modules.

(2) Applies to generic sin/cos and Hiperface with Sin/Cos.

(3) Does not support absolute position.

(4) Hiperface encoders must be programmed with the Rockwell Automation Encoder Data format to be compatible with the drive.

(5) Encoder diagnostics for SIN/COS encoders provided by the drive include: 5V encoder power supply monitoring, 9V encoder power supply monitoring, and SIN<sup>2</sup> and COS<sup>2</sup> (vector length) test. You must determine the suitability of the encoder and the system safety rating. Determine encoder suitability from the failure rate provided by the encoder manufacturer.

(6) You must determine if the encoder is suitable for the application according to reliability data obtained from manufacturer.

Table 25 - Feedback Types Assigned to Feedback Ports for SIL 3/PL e Applications

Motor Feedback (MF) Connector <sup>(1)</sup>			Universal Feedback (UFB) Connector <sup>(1)</sup>			Achievable System Safety Rating
Encoder Source	Encoder Safety Function	Encoder Motion Function	Encoder Source	Encoder Safety Function	Encoder Motion Function	
VPL-Bxxxxx-Q VPL-Bxxxxx-W VPF-Bxxxxx-Q VPF-Bxxxxx-W VPH-Bxxxxx-Q VPH-Bxxxxx-W VPAR-Bxxxxx-Q VPAR-Bxxxxx-W	Primary	Motor Feedback	Any Sin/Cos encoder compatible with drive (includes Hiperface <sup>(2)</sup> )	Secondary	<ul style="list-style-type: none"> <li>None</li> <li>1/2 axis</li> <li>Dual-loop load feedback</li> </ul>	Dual Channel SIL 3/PL e <sup>(3)</sup>

(1) The motor power/feedback connector and motor feedback connector appear on 2198-DSD modules.

(2) Secondary sin/cos encoders do not need to have a SIL rating, however, you must determine the suitability of the encoder for the safety application. Encoder diagnostics for SIN/COS encoders provided by the drive include: 5V encoder power supply monitoring, 9V encoder power supply monitoring, and SIN<sup>2</sup> and COS<sup>2</sup> (vector length) test.

(3) Dual-channel SIL 3 (PL e) applies only to velocity discrepancy checking and functions that use velocity (or speed) checking. The SLP and SDI safety functions use position checking. SS2 and SOS can also be configured for position checking. The 2198-DSD module does not perform position discrepancy checking in the drive, limiting position safety functions to SIL 2 (PL d). Position checking safety functions requiring SIL 3 (PL e) require dual-channel position discrepancy checking in the GuardLogix controller with user defined safety logic.

**IMPORTANT** Due to complexity of application of encoder types and the many combinations, final system reliability calculation is the responsibility of the system designer.

**Notes:**

## Controller-based Safety Functions

Use this chapter to become familiar with the GuardLogix® controller-based Drive Safety instructions and how they interact with the ArmorKinetix® system ERS5 DSD inverter and DSM motor/inverter.

Topic	Page
Drive Safety Instructions	81
Pass-through Data	84
SFX Instruction	86

- See the GuardLogix Safety Application Instruction Set Reference Manual, publication [1756-RM095](#), for more information on the Drive Safety instructions and TÜV Rheinland certification.
- See Safe Monitoring Solutions for Drives Application Note, publication [SAFETY-AT175](#).
- See Knowledgebase article [How to scale the SFX instruction to meet the Motion/IO mode and safety configuration units](#).

### Drive Safety Instructions

The Drive Safety instructions are designed to work with the 2198-DSDxxx-ERS5 inverters and 2198-DSMxxx-ERS5 motor/inverter. They are available in the Studio 5000 Logix Designer® application, version 35.00 or later, under the Drive Safety tab when a Safety Task routine is active.

Controller-based safety functions operate in GuardLogix 5580 or Compact GuardLogix 5380 controllers and use the EtherNet/IP™ network to communicate with the safety I/O. Drive Safety instructions use safety feedback, provided by ArmorKinetix modules in the Safety Task of the controller, to perform safe monitoring functions.

**IMPORTANT** Each machine axis used with safety functions must be verified each time a motor, drive, cable or encoder is installed or replaced to verify that the safety instruction operates as intended. See [Appendix B Safety Function Validation Checklist](#).

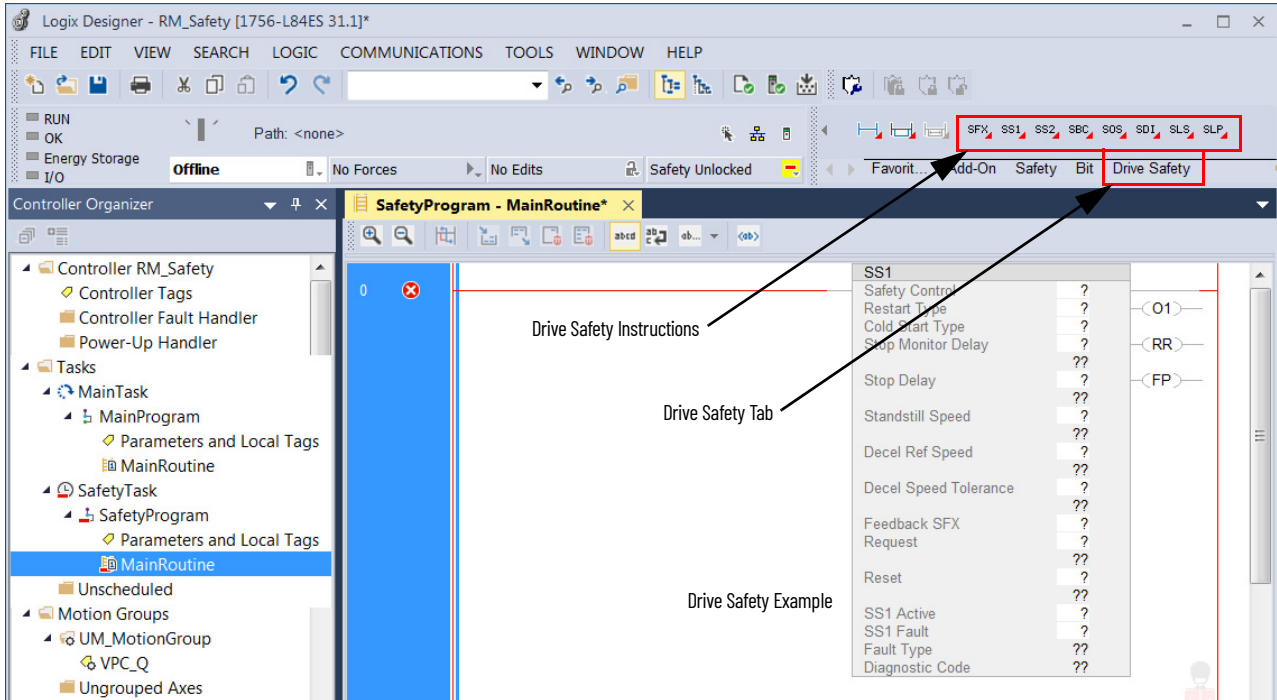
**Table 26 - Drive Safety Instructions**

Safety Instruction		Description
Safety Feedback Interface	SFX	The SFX function scales feedback position into position units and feedback velocity into position units per time unit. SFX is used with other Drive Safety instructions. SFX also provides unwind for rotary applications and position homing.
Safe Stop 1	SS1	The SS1 function monitors the motor deceleration rate within set limits during motor stopping and provides an indication to initiate safe torque-off (STO) function when the motor speed is below the specified limit.
Safe Stop 2	SS2	The SS2 function monitors the motor deceleration rate within set limits during motor stopping and initiates the safe operating stop (SOS) function when the motor speed is below the specified limit.
Safe Operational Stop	SOS	The SOS function prevents the motor from deviating more than a defined amount from the stopped position.
Safely Limited Speed	SLS	The SLS function prevents the motor from exceeding the specified speed limit.

**Table 26 - Drive Safety Instructions (Continued)**

Safety Instruction		Description
Safely Limited Position	SLP	The SLP function prevents the motor shaft from exceeding the specified position limits.
Safe Direction	SDI	The SDI function prevents the motor shaft from moving in the unintended direction.
Safe Brake Control	SBC	The SBC function provides safe output signals to control an external brake.

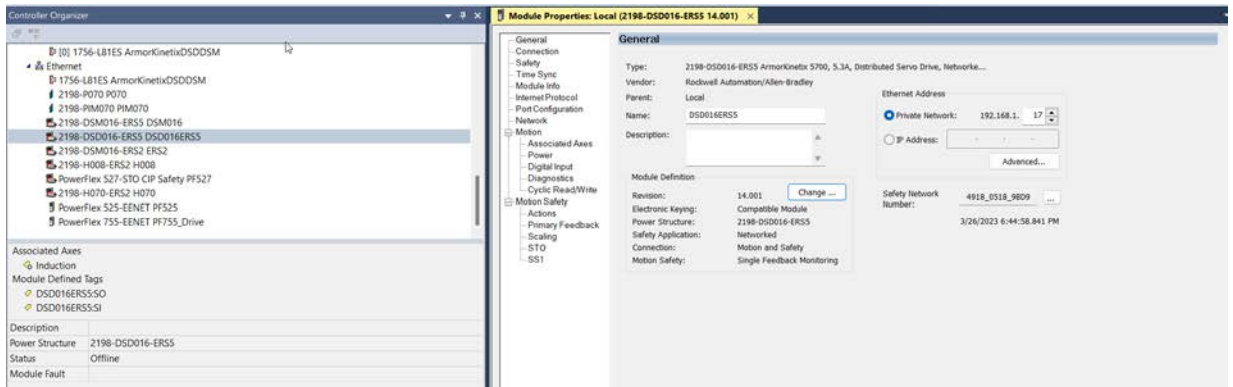
**Figure 43 - Drive Safety Tab and Instructions**



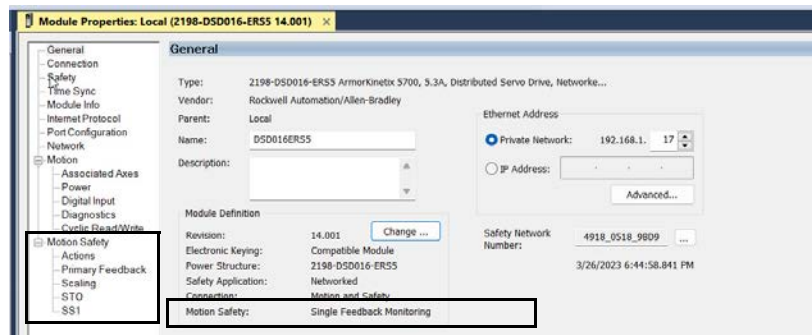
### Before Adding the Safety Instructions

Before adding Drive Safety instructions to your Studio 5000 Logix Designer application, you must perform the following:

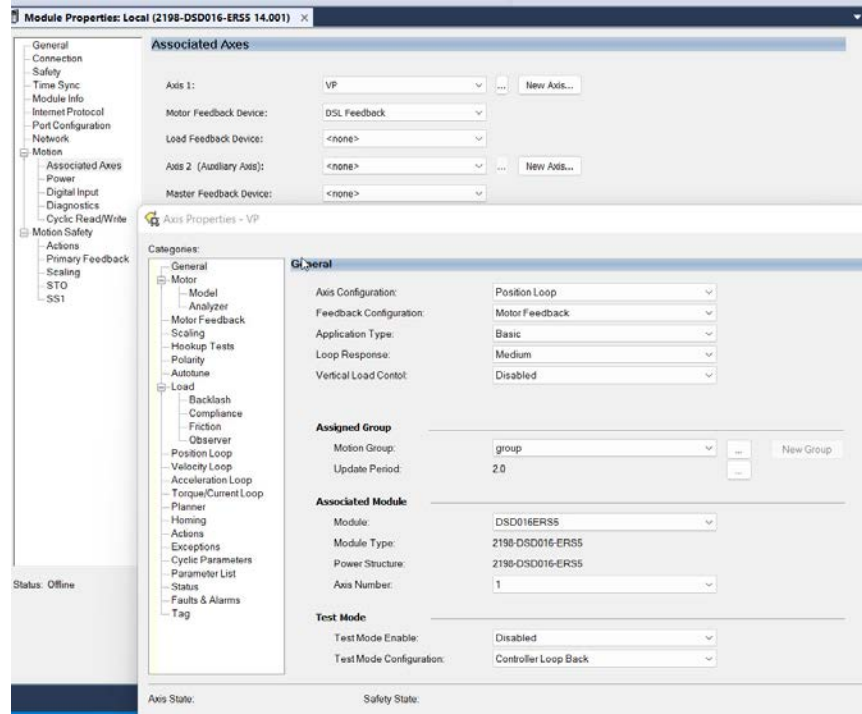
1. Add the 2198-DSD-ERS5 distributed servo drive module to the I/O Configuration folder, set Safety Application as Networked, set Connection as either Motion and Safety or Safety Only and set Motion Safety Feedback as required for your application.



2. Configure drive module Motion Safety instance.



### 3. Add and configure an axis in the Motion Group.



For help with these Studio 5000 Logix Designer configuration examples see the Armorkinetix System User Manual, publication [2198-UM006](#).

4. Configure the Safety Actions in the axis property action tab.
5. Add Drive Safety instructions to your Safety Task safety program.

## Drive Safety Instruction Example

Drive Safety instructions provide the following information. In this example, the Safely Limited Speed (SLS) instruction is shown.

Figure 44 - SLS Drive Safety Instruction

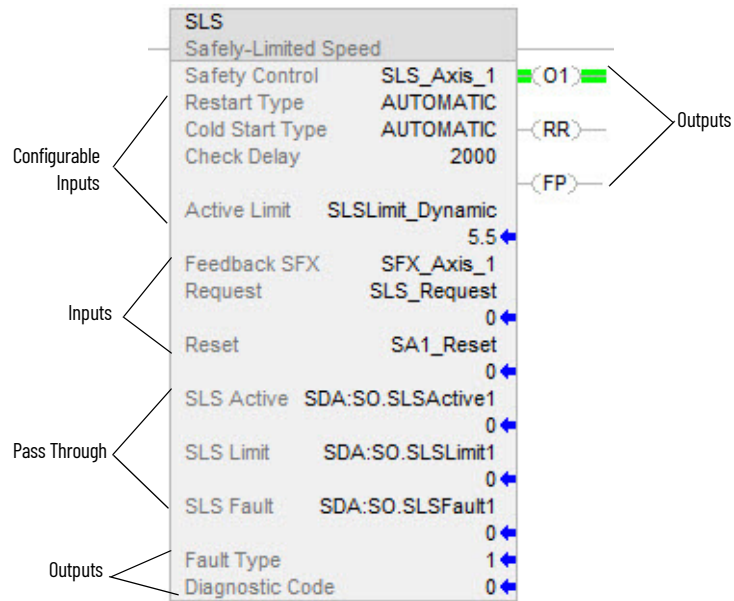


Table 27 - Drive Safety Instruction Definitions

Instruction Information	Description
Configurable Inputs	Safety function parameters used to define how the safety function operates.
Inputs	<ul style="list-style-type: none"> <li>Feedback SFX is the link to the SFX instruction for an axis.</li> <li>Request initiates the safe monitoring function.</li> <li>Reset initiates a safety instruction reset.</li> </ul>
Pass Through	Safety Output assembly object tags pass safety function status information from the Safety Task of the safety controller to the safety instance of the drive module. The status is made available to the motion controller.
Outputs	<ul style="list-style-type: none"> <li>Fault Type is the instruction fault code that indicates the type of fault that occurred.</li> <li>Diagnostic Code provides additional details on the fault.</li> <li>O1 - Output 1 indicates the status of the instruction. When ON (1), it indicates that the input conditions are satisfied.</li> <li>RR- Reset Required indicates when a reset is needed to restart the instruction or to clear faults.</li> <li>FP - Fault Present indicates whether a fault is present in the instruction.</li> </ul>

## Pass-through Data

The Drive Safety instructions provide safety function monitoring in the Safety Task of the controller. Control of the drive is done in the motion programming within the Standard Task of the controller. For the motion program to receive status information from the Drive Safety instruction, tag data in the output assembly for the drive module (Safety Task) are passed to the drive and then to the corresponding tag in the axis structure (Standard Task).

This is especially useful when the motion program is in a separate controller from the safety program that is in a safety controller. [Figure 45](#) shows how this works for the SLS instruction.

**IMPORTANT** Pass-through data is for status information only and does not impact configured safety functions.



**ATTENTION:** Tags used for the safety pass through attributes of instructions should only be used once. Re-use of the pass through tag in other instructions can cause unintended operation. This may result in damage to equipment or personal injury.



Figure 45 - Pass Through Data Path

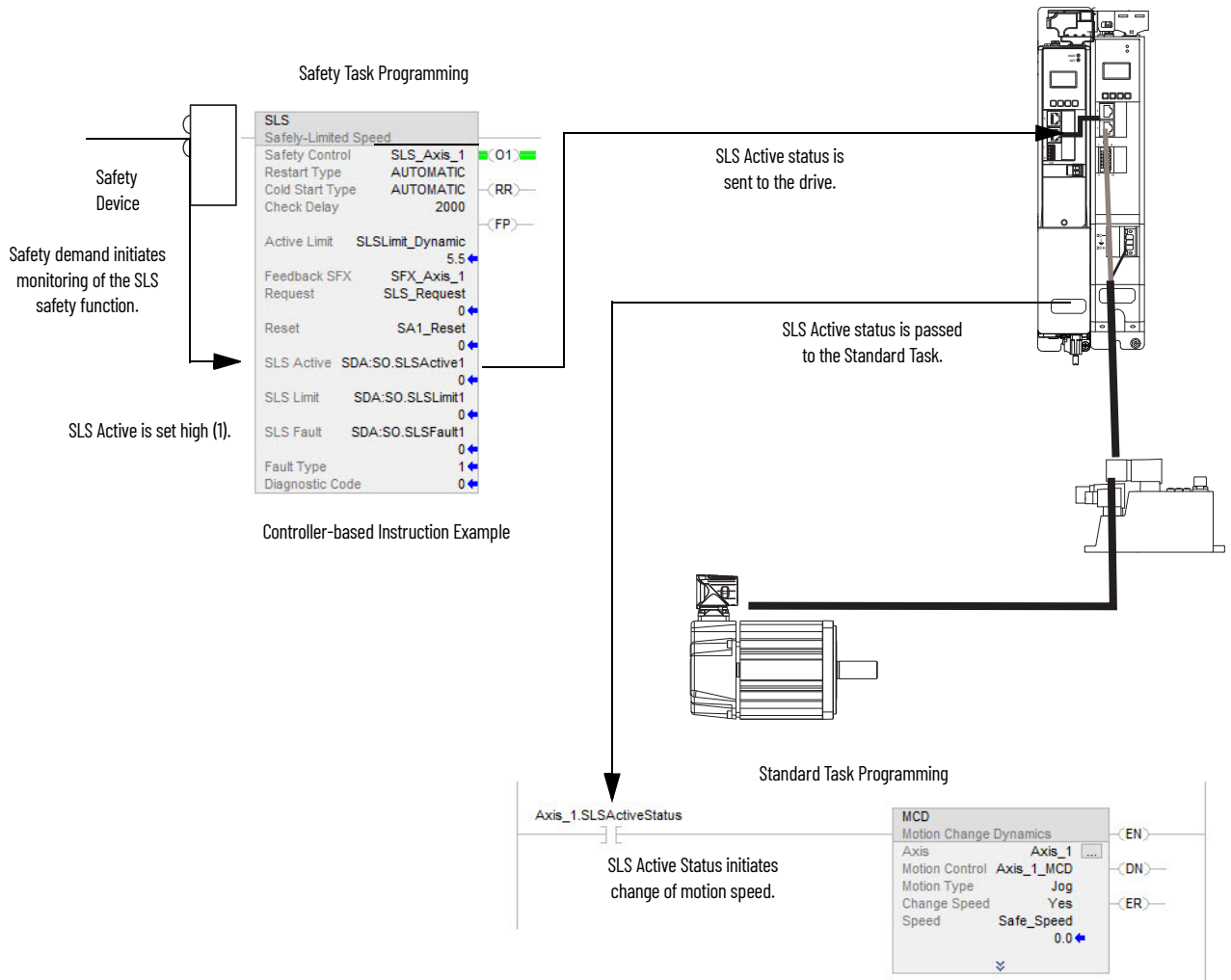


Table 28 - SLS Tag Information

Safety Output Assembly Tag	Axis Tag
<i>module:SO.SLSActive</i>	<i>Axis.SLSActiveStatus</i>
<i>module:SO.SLSLimit</i>	<i>Axis.SLSLimitStatus</i>
<i>module:SO.SLSFault</i>	<i>Axis.SLSFault</i>



The words *module* and *axis* (italic) in these tag names represent the module and axis name assigned in the Studio 5000 Logix Designer application.

The following steps correspond to the activity in [Figure 45](#).

- Safety device reports a request to the safety zone. Initiates monitoring by the SLS instruction (Safety Task).
- SLS Active status is passed to the motion program (Safety Task to Standard Task via the drive).
- The motion program adjusts the speed of the drive to below the SLS Active Limit during the Check Delay (Standard Task).
- If the drive speed exceeds the SLS Active Limit (Safety Task) during SLS monitoring, the SLS Limit output is set.
  - Optionally, a stopping safety function can be initiated within the safety program.

## SFX Instruction

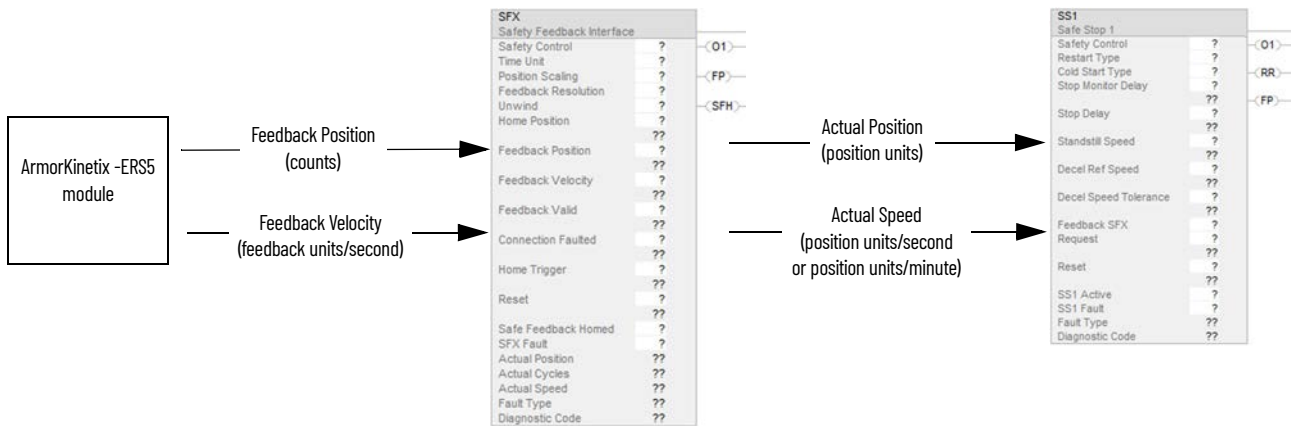
The Safety Feedback Interface (SFX) instruction scales feedback position into position units and feedback velocity into speed units per unit of time. Feedback position and velocity are read from the safety input assembly and become inputs to the instruction. The SFX instruction also sets a reference position from a home input and performs position unwind in rotary applications.

The 2198-DSD-ERS5 module and 2198-DSM-ERS5 drive/motor module safe motion-monitoring drive provides safe position and velocity feedback. Up to SIL 3 PL e safety rating can be achieved by using dual feedback with velocity discrepancy checking. Up to SIL 2 PL d safety rating can be achieved by using single or dual feedback for functions that require position checking.

The outputs of the SFX instruction are used as inputs to other Drive Safety instructions. For any safe motion-monitoring drive to execute a controller-based safety function, an SFX instruction is required. Although the SFX instruction is a safety instruction, it alone does not perform a safety function.

In [Figure 46](#), the SS1 instruction uses the Actual Speed output from the SFX instruction during execution of the SS1 safety function.

**Figure 46 - SFX Instruction Feeds Data to SS1 Instruction**



## SFX Instruction Example

In this SFX example, a VPL-B1152C-Q motor is used in the safety function. The motor has 4096 feedback counts per motor revolution and is scaled for position to have 4096 counts per motor revolution.

The SFX instruction scales the applicable safety instructions with feedback position units from the safety encoder/motor, into position feedback units used in applicable safety instructions. It also scales feedback velocity units from the safety encoder/motor into position feedback units per time unit.

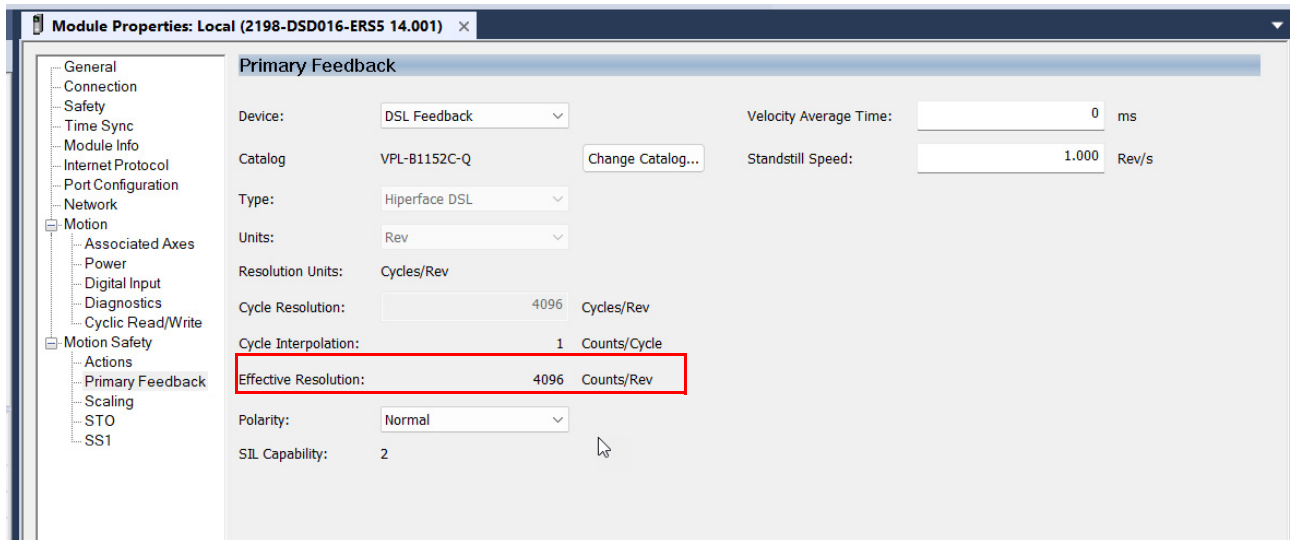
### Scaling Setup

When configuring the SFX instruction, calculate the value for Position Scaling so that the Actual Position and Actual Speed output from the instruction matches the Actual Position and Actual Velocity in the motion controller.

Values from Axis Properties>Scaling and Motion Safety>Primary Feedback are required to calculate the instruction input.

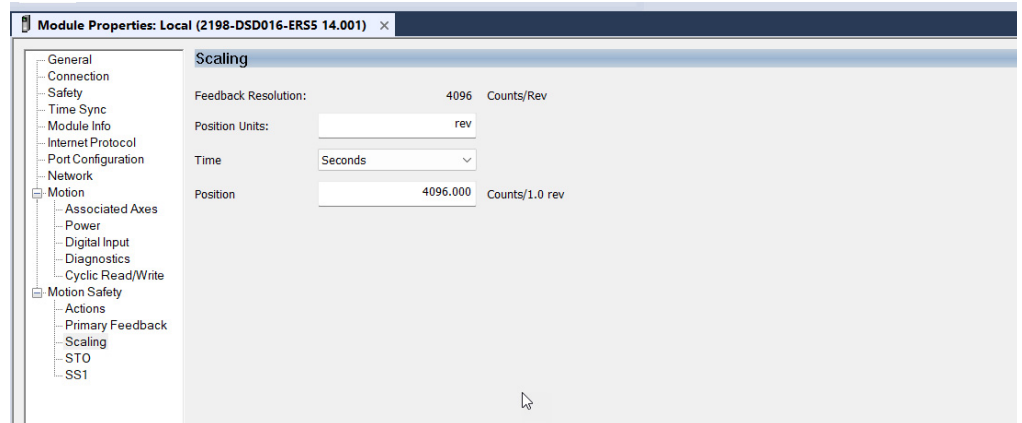
The Feedback Resolution is determined based on the feedback device and the Effective Resolution of the feedback. This information is configured on the Module Properties>Motion Safety>Primary Feedback category.

Figure 47 - Effective Resolution Parameter



The VPL-B1152C-Q motor is used in a rotary application where the unwind is set to rollover each motor revolution. Therefore, the unwind of 4096 counts/ rev was added in the SFX instruction appropriately.

Figure 48 - Scaling



### Homing

Setting the Actual Position output to the Home Position input (homing) of the instruction is required if using a position-based drive safety instruction like Safely-limited Position (SLP). If a position-based drive safety instruction is not being used on an axis, homing the SFX instruction is not required.

**IMPORTANT** Homing as described here is for the safety position and is not related to axis homing on the Motion Redefine Position (MRP) instruction.

The data in the Primary Feedback category, Scaling category, and motor unwind value is used to populate the SFX instruction.

Figure 49 - SFX Instruction Example

6

Parameter	Value
Position Scaling	4096.0
Feedback Resolution	4096
Unwind	4096
Home Position	0.0
Feedback Position	SDA:SI.FeedbackPosition1 621748
Feedback Velocity	SDA:SI.FeedbackVelocity1 29.997238
Feedback Valid	SDA:SI.PrimaryFeedbackValid1 1
Connection Faulted	SDA:SI.ConnectionFaulted 0
Home Trigger	SA1_HomeTrigger 0
Reset	SA1_Reset 0
Safe Feedback Homed	SDA:SO.SFHomed1
SFX Fault	SDA:SO.SFXFault1
Actual Position	0.3515625
Actual Cycles	1214
Actual Speed	29.997238
Fault Type	1
Diagnostic Code	0

Position Scaling value from [Figure 48](#).

Feedback Resolution value from [Figure 47](#).

Unwind value as specified for the VPL-B1152C-0 rotary motor used in this example.

Used only with position-based drive safety instructions

Refer to the GuardLogix Safety Application Instruction Set Reference Manual, publication [1756-RM095](#)

See the GuardLogix Safety Application Instruction Set Reference Manual, publication [1756-RM095](#), for more information on the Drive Safety instructions.

## Troubleshoot Safety Faults

This chapter provides troubleshooting tables and related information for ArmorKinetix® systems that include 2198-DSDxxx-ERS5 or 2198-DSMxxx-ERS5 modules.

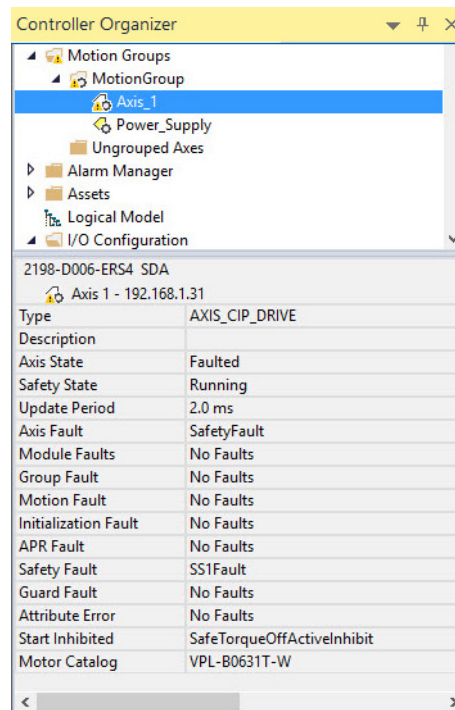
Topic	Page
Safety Fault Names	89
Understand Safety Faults	90

### Safety Fault Names

The Motion Safety instance in the drive reports faults to the drive through the AxisSafetyFaults and AxisSafetyFaultsRA tags. Each bit in these tags indicates a specific fault. This information is used by the drive to log and display faults.

The Studio 5000 Logix Designer® application displays axis faults and status. When an axis is selected in the Controller Organizer, axis faults and status are displayed in the quick-view window.

Figure 50 - Axis Faults and Status



The safety faults named in [Table 29](#) appear as Safety Faults when they occur. In addition, if any of these faults are present, a safety fault appears under the axis fault. Corresponding axis tags are set with any of the faults.

Table 29 - Safety Fault Names

Fault Name	Description
SafetyCoreFault	Internal fault in the drive's safety processor
STOFault	A fault was detected by the Safe Torque-off function
SS1Fault <sup>(1)</sup>	A fault was detected by the Safe Stop 1 function
SS2Fault	A fault was detected by the Safe Stop 2 function
SOSFault	A fault was detected by the Safe Operating Stop function
SBCFault	A fault was detected by the Safe Brake Control function
SLSFault	A fault was detected by the Safely-limited Speed function
SDIFault	A fault was detected by the Safe Direction function
SLPFault	A fault was detected by the Safe Limited Position function
SafetyFeedbackFault	The Safety processor has detected a problem with one or more of the safety feedback devices associated with the axis.

(1) The SS1 fault bit can be set because the SS1 fault was detected by the drive internal SS1 safety function (if it is configured), or by the connected safety controller. Read the SS1 Fault attribute from the drive to determine if the fault was generated by the drive or received from the safety controller.

## Understand Safety Faults

To obtain more detailed information about any faults that are detected, most faults have a corresponding fault-type attribute. These attributes are read by using an MSG instruction in the ladder program to read the specific attribute information. Details of the various fault-type attributes are described in the following sections.

See [Explicit Messages](#) on [page 19](#) for an example of using the MSG instruction to read status. See [Motion Connection Axis Tags](#) on [page 95](#) for a list of attributes including fault information that can be read by using a MSG instruction.

### Safety Core Fault

The Motion Safety instance has detected a non-recoverable fault or internal error. When this happens, the Motion Safety instance reboots itself and attempts to re-establish normal operation.

### Safe Torque-off Fault

The safe torque-off (STO) function detected a fault. The safe stop function in the Motion Safety instance records the specific fault type in the attribute. Explicit messaging can be used to read the fault type information from the drive. For example, for STO Fault Type (Safe Stop Function [class code 0x5A], attribute ID 0x108). The drive immediately disables torque if an STO fault is detected.

Table 30 - Safe Torque-off Fault Type: MSG

Parameter	Value	Description
Service Code	0x0E	Get attribute single
Class	0x5A	Safety stop functions
Instance	1 or 2	Drive-module safety instance associated with an axis
Attribute	0x108	STO fault type
Data Type	SINT	Short integer

Table 31 - STO Fault Types

STO Fault Type Value	STO Fault Type Name	Description
0	Reserved	Not used
1	No Fault	No Fault is present
2	Invalid Configuration	A safe stop function has been requested when it is not in the Ready state.
3	Circuit Error	Safety diagnostics have detected an error in the STO circuits.

## Safe Stop 1 Fault

The safe stop 1 (SS1) function detected a fault. The safe stop function in the Motion Safety instance records the specific fault type in the attribute. Explicit messaging can be used to read the fault type information from the drive. For example, for SS1 Fault Type (Safe Stop Function object [class code 0x5A], safety instance 1 or 2, attribute ID 0x11C). The drive immediately disables torque, ignoring STO delay, if an SS1 fault is detected. If the SS1 Fault Type is reported as 1 (no fault), the SS1 fault was generated by the connected safety controller and reported to the drive over the safety connection.

**Table 32 - SS1 Fault Types**

SS1 Fault Type Value	SS1 Fault Type Name	Description
0	Reserved	Not used
1	No Fault	No Fault is present
2	Invalid Configuration	The SS1 function has been requested when it has been configured as 'not used'.
3	Decel Rate error	Applies only when SS1 is configured for Monitored SS1 mode. The SS1 function has detected that the feedback speed is not decelerating as fast as expected.
4	Maximum Time exceeded	Applies only when SS1 is configured for Monitored SS1 mode. The SS1 function has detected that the device has not reached standstill speed within the maximum stopping time.
100	STO Request Received	An STO request was received during execution of the SS1 function.
101	Feedback Invalid	The Monitored SS1 function was requested when the associated safety feedback is not valid.

## SS2, SOS, SBC, SLS, SLP, and SDI Faults

The Motion Safety instance in the drive does not support the SS2, SOS, SBC, SLS, SLP, and SDI safe stop/safety limit functions. If the drive reports one of these faults, then the fault was detected by the safety controller and reported to the drive over the safety output connection. Additional information for these faults must be obtained from the safety controller associated with the drive. In addition, the safety controller is responsible for issuing a torque disable request.

## Safety Feedback Faults

When configured for safety feedback, the Motion Safety instance performs periodic diagnostics to make sure that the feedback device is operating correctly. Explicit messaging can be used to read the fault type information from the drive. For example, if an error is detected, the Safe Feedback object (class code 0x58) updates the Safe Feedback Fault Type attribute (attribute ID 0x09) with the reason for the fault. A safety feedback fault does not immediately result in torque disable of the drive. A safety feedback fault only causes a torque disable under these two conditions:

- SS1 is configured for Monitored SS1 mode
- SS1 request is received from the safety controller

**Table 33 - Safety Feedback Faults**

Safe Feedback Fault Type Value	Safe Feedback Fault Type Name	Description	Duplicated to Other Axis?
0	Reserved	Not used	-
1	No Fault	No Fault is present	-
2	Invalid Configuration	The DSL safety feedback diagnostics have detected that the actual resolution of the connected DSL feedback device does not match the configured resolution of the corresponding Motion Safety instance.	No
5	$\text{Sin}^2 + \text{Cos}^2$ Error	Analog signal diagnostics for Sin/Cos feedback have detected an error in the signal levels. This could indicate an open or short circuit in the Sin/Cos feedback wiring, or device failure.	Yes
7	Discrepancy Error	Safety Dual Channel Feedback has detected a discrepancy in the velocity reported by the two monitored feedback devices.	No
8	Partner Faulted	Safety Dual Channel Feedback has detected a safety feedback fault with the partner feedback device.	No

Table 33 - Safety Feedback Faults (Continued)

Safe Feedback Fault Type Value	Safe Feedback Fault Type Name	Description	Duplicated to Other Axis?
9	Supply Voltage Error	Safety diagnostics have detected that the power supply for the configured safety feedback device is out of range. This can indicate a problem in feedback wiring or internal failure of the drive circuits.	Yes
11	Feedback Signal Lost	The safety diagnostics for Sin/Cos feedback have detected loss of signal (below the minimum level) from the Sin/Cos encoder. This can indicate open or short circuit in the feedback device connection, or feedback device failure.	Yes
12	Feedback Data Loss	The safety diagnostics for DSL feedback have detected loss of data from the DSL encoder. This can indicate an open circuit in the feedback connections or feedback device failure.	No
13	Feedback Device Failure	<ul style="list-style-type: none"> <li>The safety diagnostics for Sin/Cos feedback have detected an internal error with the feedback interface.</li> <li>The safety diagnostics for DSL feedback have detected an internal data error with the encoder.</li> </ul>	Yes
100	Unsupported DSL Device	The safety diagnostics for DSL feedback have detected that the connected DSL feedback device is not supported by the drive.	No
101	DSL Unexpected UEI	The safety diagnostics for DSL feedback have detected that the device for one axis is connected to the other axis. Occurs only during startup or re-configuration. This applies to only dual-axis inverters.	Yes
102	DSL Position Comparison Failure	The safety diagnostics for DSL feedback have detected an error with the reported position from the DSL encoder. This can be an indication of encoder failure.	No
103	DSL Position Checksum Error	The safety diagnostics for DSL feedback have detected an error with the data received from the DSL encoder. This can indicate noise on the DSL signals or an encoder failure.	No
104	DSL Multi Implementation error	The safety diagnostics have detected that the feedback device for one axis is connected to the other axis. This applies to only dual-axis inverters.	Yes
105	DSL Test Message error	The safety diagnostics for DSL feedback have detected an error with the DSL encoder. This indicates an encoder failure.	No
106	DSL Power On Self-Test failure	The safety diagnostics for DSL feedback have detected that the DSL encoder did not complete its internal power-on self-test diagnostics. Repeated occurrence of this error likely indicates an encoder failure.	No

### Troubleshoot the Safety Function

Table 34 - Safe FLT Sxx Fault Codes

Exception Code on Drive Display	Fault Message Logix Designer	Problem	Possible Solutions
SAFE FLT S01 - Safety Core Internal Fault	SafetyFault	Drive safety diagnostic detected internal STO design failure.	<ul style="list-style-type: none"> <li>Cycle control power</li> <li>Return drive for repair if fault continues</li> </ul>
SAFE FLT S02 - Safety Feedback Fault	SafetyFeedbackFault	Safety feedback has detected a fault.	Use explicit messages to read the fault reason from the primary feedback device. See <a href="#">Safety Feedback Attributes</a> on <a href="#">page 100</a> for fault reasons.
SAFE FLT S03 - Safe Torque Off Fault	SafeTorqueOffFault <sup>(1)</sup>	Drive safety diagnostic detected internal STO design failure or hardwired input received while in integrated safety mode.	<ul style="list-style-type: none"> <li>Check the cause of the fault using a Safe Torque-off faults explicit message. Refer to <a href="#">Explicit Messages</a> on <a href="#">page 21</a>.</li> <li>Execute STO function.</li> <li>Return drive for repair if fault continues.</li> </ul>
SAFE FLT S04 - Safe Stop 1 Fault	SS1Fault	SS1 safety function has detected a fault.	<ul style="list-style-type: none"> <li>If a controller-based SS1 function has faulted, check the SS1 controller instruction fault code and diagnostic codes for more information in the controller help or the GuardLogix® Safety Application Instruction Set Reference Manual, publication <a href="#">1756-RM095</a>.</li> <li>If the drive-based SS1 function has faulted, check attribute 284 (SS1 Fault Type) by using explicit messaging to the drive module safety instance operating the SS1 function. See <a href="#">Safe Stop Function Attributes</a> on <a href="#">page 102</a>.</li> </ul>
SAFE FLT S05 - Safe Stop 2 Fault	SS2Fault	Controller-based SS2 instruction has detected a fault.	Check the controller instruction fault code and diagnostic codes for more information in the controller help or the GuardLogix Safety Application Instruction Set Reference Manual, publication <a href="#">1756-RM095</a> .
SAFE FLT S06 - Safe Operating Stop Fault	SOSFault	Controller-based SOS instruction has detected a fault.	
SAFE FLT S07 - Safe Brake Fault	SBCFault	Controller-based SBC instruction has detected a fault.	
SAFE FLT S16 - Safe Speed Monitor Fault	SSMFault	Controller-based SSM instruction has detected a fault.	This fault is not used. Check your application program for correct tag values.



Table 34 - Safe FLT Sxx Fault Codes (Continued)

Exception Code on Drive Display	Fault Message Logix Designer	Problem	Possible Solutions
SAFE FLT S17 - Safe Limited Speed Fault	SLSFault	Controller-based SLS instruction has detected a fault.	Check the controller instruction fault code and diagnostic codes for more information in the controller help or the GuardLogix Safety Application Instruction Set Reference Manual, publication <a href="#">1756-RM095</a> .
SAFE FLT S19 - Safe Limited Direction Fault	SDIFault	Controller-based SDI instruction has detected a fault.	
SAFE FLT S20 - Safe CAM Fault	SCAFault	Controller-based SCA instruction has detected a fault.	This fault is not used. Check your application program for correct tag values.
SAFE FLT S21 - Safe Limited Position Fault	SLPFault	Controller-based SLP instruction has detected a fault.	Check the controller instruction fault code and diagnostic codes for more information in the controller help or the GuardLogix Safety Application Instruction Set Reference Manual, publication <a href="#">1756-RM095</a> .

(1) Displayed in the Quick View Pane as Safety Fault.

Table 35 - Init FLT Invalid Safety Firmware Fault Code

Exception Code on Drive Display	Fault Message Logix Designer	Problem	Possible Solutions
INIT FLT M14 - Safety Firmware	InvalidSafetyFirmwareFault <sup>(1)</sup>	Invalid safety firmware.	<ul style="list-style-type: none"> <li>• Cycle control power.</li> <li>• Upgrade the drive firmware.</li> <li>• Call Technical Support.</li> <li>• Return drive for repair if fault continues.</li> </ul>

(1) Displayed in the Quick View Pane as Initialization Fault.

Table 36 - SAFE FLT SFX Fault Code

Exception Code on Drive Display	Fault Message Logix Designer	Problem	Possible Solutions
SAFE FLT M01 - Safety Feedback Interface Fault	SFXFault	Controller-based SFX instruction has detected a fault.	Check the controller instruction fault code and diagnostic codes for more information in the controller help or the GuardLogix Safety Application Instruction Set Reference Manual, publication <a href="#">1756-RM095</a> .

## Safety Fault Reset

If the drive motion safety instance detects a fault, the input assembly tag *module:SI.SafetyFault* is set to 1. The associated *axis.SafetyFault* tag is also set to 1.



The word *module* (italic) in these tag names represent the module name assigned in the Studio 5000 Logix Designer application.

A SafetyFault can result from the SS1 stopping function, STO function, safety feedback, or other safety diagnostics.

To clear (reset) the SafetyFault, the fault conditions must be removed first and then a transition from logic 0 to 1 of the *module:SO.ResetRequest* tag is required. It is only the 0 to 1 transition that clears the fault.

To clear an axis fault associated with a SafetyFault, first clear the SafetyFault from the safety task of your application, then clear the axis fault using the MAFR command from the motion application.

### Faults after Download

Whenever an axis is configured with Hiperface DSL feedback and the motion connection is closed, a SafetyFeedbackFault is generated.

When a single controller is used for motion and safety connections, and Hiperface DSL is the configured feedback type, a SafetyFeedbackFault is generated after program download due to DSL feedback signal loss. To clear the SafetyFeedbackFault, first clear the fault and then use the MAFR command to clear the axis fault.

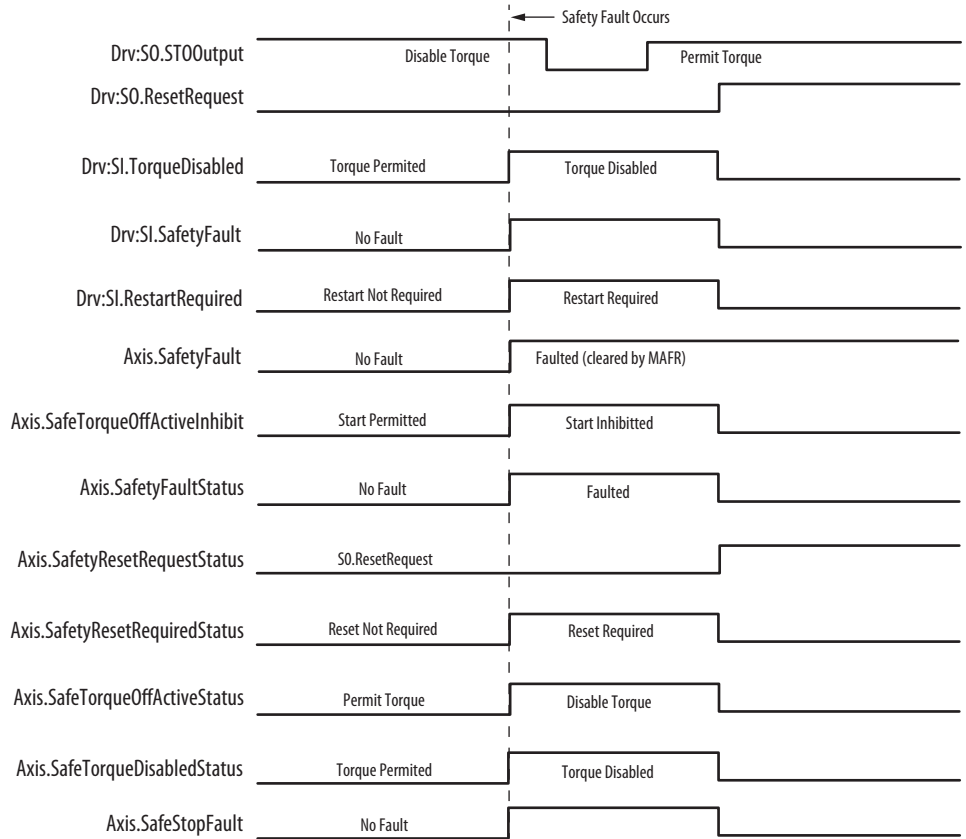
When separate controllers are used for motion and safety connections, a SafetyFeedbackFault is generated after program download to the controller that manages the motion connection.

**IMPORTANT** Transition of the SO.STOOutput tag to logic 1 must always be executed prior to transition of the SO.ResetRequest tag to logic 1.

**IMPORTANT** All ArmorKinetic inverter axes enter the faulted state if any STO function fault is detected. Refer to [Table 34](#) on [page 92](#) for integrated safety troubleshooting.

Refer to [Figure 51](#) on [page 94](#) for an understanding of the drive STO state restart function.

**Figure 51 - Reset Safe Stop Fault Diagram**



## Controller Tags and Safety Attributes

Controller axis tags are used by the motion controller motion task to read the status of safety functions and coordinate motion. This appendix lists the motion controller tags that are associated with the safety instances and with safety functions operating in the safety task of the controller.

Topic	Page
Motion Connection Axis Tags	95
Safety Assembly Tags	97
Safety Feedback Attributes	100
Safe Stop Function Attributes	101
Dual Channel Feedback Attributes	105

Safety attributes provide additional information not available through the tag structure. Attributes are read using explicit messages.

**IMPORTANT** The controller axis tags and the safety attributes read by using explicit messages must not be used in the operation of a safety function.

### Motion Connection Axis Tags

This table provides motion-connection axis tag names that are updated to show safety instance status or controller-based safety function status.



The words *module*, *instance*, and *axis* (italic) in these tag names represent the module, instance, and axis name assigned in the Studio 5000 Logix Designer® application.

**Table 37 - Motion Connection Axis Tags**

Axis Tag Name (motion controller)	Motion Connection Attribute Number	Data Type	Description	Safety Output Assembly Tag Name (safety controller)
Axis.AxisSafetyState	760	DINT	Drive module Safety Supervisor state. See the <a href="#">Safety Supervisor State</a> on <a href="#">page 19</a> for more details.	None
Axis.AxisSafetyDataA	986	DINT	32-bit data container holding general purpose safety-data passed from the safety controller.	<i>module</i> :S0:PassThruDataA
Axis.AxisSafetyDataB	987	DINT	32-bit data container holding general purpose safety-data passed from the safety controller.	<i>module</i> :S0:PassThruDataB
Axis.AxisSafetyStatus	761	DINT	Collection of bits indicating the status of the standard safety functions for the axis as reported by Drive Safety Instance.	See individual bits below.
Axis.SafetyFaultStatus	[0]	BOOL	Any Safe Stop Fault occurring in the Safety Instance. 0 = Not Faulted 1 = Safety Fault	None
Axis.SafetyResetRequestStatus	[1]	BOOL	Indicates that the state of the reset request output from the safety controller (in the safety output assembly) connected with the drive safety instance. This is the reset input to the safety instance in the drive module. 0 = Reset Request OFF 1 = Reset Request ON	<i>module</i> :S0:ResetRequest
Axis.SafetyResetRequiredStatus	[2]	BOOL	Indicates that the drive-module safety instance associated with this Axis requires a reset of the safety function. 0 = Normal 1 = Reset Required	None

Table 37 - Motion Connection Axis Tags (Continued)

Axis Tag Name (motion controller)	Motion Connection Attribute Number	Data Type	Description	Safety Output Assembly Tag Name (safety controller)
Axis.SafeTorqueOffActiveStatus	[3]	BOOL	Indicates that the state of the STO output from the safety controller, which is the STO input to the drive-module safety instance associated with this axis. 0 = STO Output Is active 1 = STO is not active, STO is not requested	module:SO.STOOutput
Axis.SafeTorqueDisabledStatus	[4]	BOOL	Indicates that the drive-module safety instance Torque Disabled Status. 0 = Axis power structure is not inhibited by the safety instance 1 = Axis power structure is inhibited	None
Axis.SBCActiveStatus	[5]	BOOL	Indicates that the SBC function is active and the sequence to set the Safety Brake has started. This function is only available as a controller-based function. 0 = SBC Function is not Active 1 = SBC Function is Active	module:SO.SBCActive
Axis.SBCEngagedStatus	[6]	BOOL	Indicates that the External Safety Brake is engaged by the controller-based SBC function. 0 = Brake is Engaged 1 = Brake is Released	module:SO.SBCBrakeEngaged
Axis.SS1ActiveStatus	[7]	BOOL	Indicates that the controller-based or the drive-based SS1 function is active. 0 = SS1 Function is not Active 1 = SS1 Function is Active	module:SO.SSActive
Axis.SS2ActiveStatus	[8]	BOOL	Indicated that the controller-based SS2 function is active. 0 = SS2 Function is not Active 1 = SS2 Function is Active	module:SO.SSActive
Axis.SOSActiveStatus	[9]	BOOL	Indicates that the controller-based SOS function is active. 0 = SOS Function is not Active 1 = SOS Function is Active	module:SO.SOSActive
Axis.SOSStandstillStatus	[10]	BOOL	Indicates that the controller-based SOS function has detected standstill according to the function configuration. 0 = monitored axis is not at Standstill 1 = monitored axis is at standstill	module:SO.SOSLimit
Axis.SMTActiveStatus	[11]	BOOL	Always 0. This function is not available	None
Axis.SMTOvertemperatureStatus	[12]	BOOL	Always 0. This function is not available.	None
Axis.SSMActiveStatus	[16]	BOOL	For use with a controller-based SSM function.	module:SO.SSMActive
Axis.SSMStatus	[17]	BOOL	For use with a controller-based SSM function.	module:SO.SSMStatus
Axis.SLSActiveStatus	[18]	BOOL	Indicates that the controller-based SLS function is active. 0 = SLS Function is not Active 1 = SLS Function is Active	module:SO.SLSActive
Axis.SLSLimitStatus	[19]	BOOL	Indicates that the controller-based SLS function has detected the monitored axis speed above the limit set-point. 0 = axis is below set-point speed 1 = axis is greater than or equal to the set-point speed	module:SO.SLSLimit
Axis.SLAAActiveStatus	[20]	BOOL	Always 0. This function is not available.	None
Axis.SLALimitStatus	[21]	BOOL	Always 0. This function is not available.	None
Axis.SDIActiveStatus	[22]	BOOL	Indicates that the controller-based SDI function is active. 0 = SDI Function is not Active 1 = SDI Function is Active	module:SO.SDIActive
Axis.SDILimitStatus	[23]	BOOL	Indicates that the controller-based SDI function detected motion greater than the limit in the unintended direction. 0 = Limit not reached 1 = Unintended motion	module:SO.SDILimit
Axis.SafePositiveMotionStatus	[24]	BOOL	Always 0. This function is not available.	None
Axis.SafeNegativeMotionStatus	[25]	BOOL	Always 0. This function is not available.	None
Axis.SCAActiveStatus	[26]	BOOL	For use with a controller-based SCA function.	module:SO.SCAActive
Axis.SCAStatus	[27]	BOOL	For use with a controller-based SCA function.	module:SO.SCAStatus
Axis.SLPActiveStatus	[28]	BOOL	Indicates that the controller-based SLP function is active. 0 = SLP Function is not Active 1 = SLP Function is Active	module:SO.SLPActive
Axis.SLPLimitStatus	[29]	BOOL	Indicates that the controller-based SLP function has detected the monitored axis position outside of the set-point limits. 0 = axis position is within the limits 1 = axis position is outside of the limits	module:SO.SLPLimit
Axis.SafetyOutputConnectionClosedStatus	[30]	BOOL	Indicates the safety connection status from the controller to the drive module. 0 = connection open 1 = connection closed	None

Table 37 - Motion Connection Axis Tags (Continued)

Axis Tag Name (motion controller)	Motion Connection Attribute Number	Data Type	Description	Safety Output Assembly Tag Name (safety controller)
Axis.SafetyOutputConnectionIdleStatus	[31]	BOOL	Indicates the safety connection status from the controller to the drive module. 0 = connection active 1 = connection idle	None
Axis.AxisSafetyStatusRA	762	DINT	Collection of bits indicating the status of Rockwell Automation specific safety functions for the axis as reported by Drive Safety Instance.	See individual bits below.
Axis.SafeBrakeIntegrityStatus	[0]	BOOL	Status of an external safety brake controlled by SBC instruction. The brake status, released or engaged, is undetermined. 0 = SBC fault 1 = No faults detected	module:SO.SBCIntegrity
Axis.SafeFeedbackHomedStatus	[1]	BOOL	Status of the controller-based SFX position homing function.	module:SO.SFHome
Axis.AxisSafetyFaults	763	DINT	Collection of bits indicating the Safety Fault status of the drive-module safety instances and integrated safety functions.	See individual bits below.
Axis.SafetyCoreFault	[0]	BOOL	Indicates an internal fault occurred within the drive-module safety instance. 0 = Normal Operation 1 = Fault	None (use explicit message)
Axis.SafetyFeedbackFault	[2]	BOOL	Indicates a fault occurred with the safety feedback or with the safety dual-channel feedback. 0 = Normal Operation 1 = Fault	None (use explicit message)
Axis.SafeTorqueOffFault	[3]	BOOL	Indicates a fault occurred within the STO function of the drive-module safety instance. 0 = Normal Operation 1 = Fault	None (use explicit message)
Axis.SS1Fault	[4]	BOOL	Indicates that a fault occurred with the drive-based or a controller-based SS1 function. 0 = Normal Operation 1 = Fault	module:SO.SS1Fault
Axis.SS2Fault	[5]	BOOL	Indicates that a fault occurred with the drive-based SS2 function. 0 = Normal Operation 1 = Fault	module:SO.SS2Fault
Axis.SOSFault	[6]	BOOL	Indicates that a fault occurred with the drive-based SOS function. 0 = Normal Operation 1 = Fault	module:SO.SOSFault
Axis.SBCFault	[7]	BOOL	Indicates that a fault occurred with the controller-based SS2 function. 0 = Normal Operation 1 = Fault	module:SO.SBCFault
Axis.SMTFault	[8]	BOOL	Always 0. This function is not available.	-
Axis.SSMFault	[16]	BOOL	Controller-based SSM fault. 0 = Normal Operation 1 = Fault	module:SO.SSMFault
Axis.SLSFault	[17]	BOOL	Controller-based SLS fault. 0 = Normal Operation 1 = Fault	module:SO.SLSFault
Axis.SLAFault	[18]	BOOL	Always 0. This function is not available.	-
Axis.SDIFault	[19]	BOOL	Controller-based SDI fault. 0 = Normal Operation 1 = Fault	module:SO.SDIFault
Axis.SCAFault	[20]	BOOL	Controller-based SCA fault. 0 = Normal Operation 1 = Fault	module:SO.SCAFault
Axis.SLPFault	[21]	BOOL	Controller-based SLP fault. 0 = Normal Operation 1 = Fault	module:SO.SLPFault
Axis.SafetyValidatorFault	[30]	BOOL	Always 0. This function is not available.	-
Axis.SafetyUNIDFault	[31]	BOOL	Always 0. This function is not available.	-
Axis.AxisSafetyFaultsRA	764	DINT	Collection of bits indicating the safety fault status of Rockwell Automation safety functions.	See individual bits below.
Axis.SFXFault	[1]	BOOL	Controller-based SFX fault. 0 = Normal Operation 1 = Fault	module:SO.SFXFault
Axis.AxisSafetyAlarms	753	DINT	Reserved for future use.	-

## Safety Assembly Tags

Safety assembly tags are associated with a safety connection from a safety controller to a drive module. The data in these tags are communicated at the configured connection rate.



The word *module* (italic) in these tag names represent the module name assigned in the Studio 5000 Logix Designer application.

Data from the drive module to the safety controller is in the safety input assembly. Data from the safety controller to the drive module is in the safety output assembly.

**Table 38 - Safety Input Assembly Tags**

Safety Input Assembly Tag Name (input to safety controller)	Type/ [bit]	Description
<i>module:SI.ConnectionStatus</i>	SINT	Collection of bits listed below.
<i>module:SI.RunMode</i>	[0]	Safety Connection 0= idle 1 = Run
<i>module:SI.ConnectionFaulted</i>	[1]	Safety Connection 0=normal 1= Faulted
<i>module:SI.FeedbackPosition</i>	DINT	Primary Feedback Position from drive-module safety instance. Value is in feedback counts.
<i>module:SI.FeedbackVelocity</i>	REAL	Primary Feedback Velocity from drive-module safety instance. Value is in revolutions/second.
<i>module:SI.SecondaryFeedbackPosition</i>	DINT	Secondary Feedback Position from drive-module safety instance. Value is in position counts.
<i>module:SI.SecondaryFeedbackVelocity</i>	REAL	Secondary Feedback Velocity from drive-module safety instance. Value is in revolutions/second.
<i>module:SI.StopStatus</i>	SINT	Collection of bits listed below.
<i>module:SI.STOActive</i>	[0]	Indicates STO function status. 0 = STO function not active 1 = STO function active
<i>module:SI.SBCActive</i>	[1]	Always 0
<i>module:SI.SS1Active</i>	[2]	Indicates drive-based SS1 active status. 0 = SS1 function not active 1 = SS1 function active
<i>module:SI.SS2Active</i>	[3]	Always 0
<i>module:SI.SOSStandstill</i>	[4]	Always 0
<i>module:SI.SafetyFault</i>	[6]	1 = Safe Stop Fault present
<i>module:SI.RestartRequired</i>	[7]	1 = Reset is required
<i>module:SI.SafeStatus</i>	SINT	Collection of bits listed below.
<i>module:SI.TorqueDisabled</i>	[0]	0 = Torque Permitted 1 = Torque Disabled
<i>module:SI.BrakeEngaged</i>	[1]	Always 0
<i>module:SI.MotionStatus</i>	SINT	Collection of bits listed below.
<i>module:SI.MotionPositive</i>	[0]	0 = no positive motion 1 = motion in positive direction
<i>module:SI.MotionNegative</i>	[1]	0 = no negative motion 1 = motion in negative direction
<i>module:SI.FunctionSupport</i>	SINT	Collection of bits listed below.
<i>module:SI.PrimaryFeedbackValid</i>	[0]	0 = Primary Feedback not configured or Faulted 1 = Primary Feedback Value is valid
<i>module:SI.SecondaryFeedbackValid</i>	[1]	Collection of bits listed below.
<i>module:SI.DiscrepancyCheckingActive</i>	[2]	1 = Feedback Velocity Discrepancy checking is active
<i>module:SI.SBCReady</i>	[3]	Always 0
<i>module:SI.SS1Ready</i>	[4]	0 = Drive-based SS1 function is not configured or faulted 1 = Drive-based SS1 function is configured and ready for operation
<i>module:SI.SS2Ready</i>	[5]	Always 0
<i>module:SI.SOSReady</i>	[6]	Always 0

**Table 39 - Safety Output Assembly Tags**

Safety Output Assembly Tag Name (output to safety controller)	Type/ [bit]	Description
<i>module:SO.PassThruDataA</i>	DINT	32-bit data container holding general purpose safety data passed from the safety controller.
<i>module:SO.PassThruDataB</i>	DINT	32-bit data container holding general purpose safety data passed from the safety controller.
<i>module:SO.PassThruStopStatus</i>	SINT	Collection of Safe Stop Function Status bits.
<i>module:SO.SBCIntegrity</i>	[0]	Status of an external Safety Brake controlled by SBC function. 0 = SBC fault. The brake status, released or engaged, is undetermined. 1 = No faults detected.
<i>module:SO.SBCActive</i>	[1]	Indicates that the SBC function is active and the sequence to set the Safety Brake has started. This function is only available as a controller-based function. 0 = SBC Function is not Active 1 = SBC Function is Active

Table 39 - Safety Output Assembly Tags (Continued)

Safety Output Assembly Tag Name (output to safety controller)	Type/ [bit]	Description
<i>module:SO.SBCBrakeEngaged</i>	[2]	Indicates that the External Safety Brake is engaged by the controller-based SBC function. 0 = Brake is Engaged 1 = Brake is Released
<i>module:SO.SS1Active</i>	[3]	Indicates that the controller-based SS1 function is active. 0 = SS1 Function is not Active 1 = SS1 Function is Active
<i>module:SO.SS2Active</i>	[4]	Indicates that the controller-based SS2 function is active. 0 = SS2 Function is not Active 1 = SS2 Function is Active
<i>module:SO.SOSActive</i>	[5]	Indicates that the controller-based SOS function is active. 0 = SOS Function is not Active 1 = SOS Function is Active
<i>module:SO.SOSStandstill</i>	[6]	Indicates that the controller-based SOS function has detected Standstill according to the function configuration. 0 = Monitored axis is not at Standstill 1 = Monitored axis is at Standstill
<i>module:SO.PassThruSpeedLimitStatus</i>	SINT	Collection of Limit Function Status bits.
<i>module:SO.SLSActive</i>	[2]	Indicates that the controller-based SLS function is active. 0 = SLS Function is not active 1 = SLS Function is active
<i>module:SO.SLSLimit</i>	[3]	Indicates that the controller-based SLS function has detected the monitored axis speed above the limit set-point. 0 = axis is below set-point speed 1 = axis is greater than or equal to the set-point speed
<i>module:SO.SDIActive</i>	[6]	Indicates that the controller-based SDI function is active. 0 = SDI Function is not active 1 = SDI Function is active
<i>module:SO.SDILimit</i>	[7]	Indicates that the controller-based SDI function detected motion greater than the limit in the unintended direction. 0 = Limit not reached 1 = Unintended motion
<i>module:SO.PassThruPositionLimitStatus</i>	SINT	Collection of bits indicating the Monitoring Function Limit status of controller-based functions. The bits are listed below.
<i>module:SO.SLPActive</i>	[2]	Indicates that the controller-based SLP function is active. 0 = SLP Function is not active 1 = SLP Function is active
<i>module:SO.SLPLimit</i>	[3]	Indicates that the controller-based SLP function has detected the monitored axis position outside of the set-point limits. 0 = axis position is within the limits 1 = axis position is outside of the limits
<i>module:SO.SFHomed</i>	[7]	Status of the controller-based SFX position homing function. 1 = SFX Homed
<i>module:SO.PassThruStopFaults</i>	SINT	Collection of bits indicating the Safety Fault status of controller-based safety functions. The bits are listed below.
<i>module:SO.SFXFault</i>	[0]	Indicates that a fault occurred with the controller-based SFX function. 0 = Normal Operation 1 = Fault
<i>module:SO.SBCFault</i>	[1]	Indicates that a fault occurred with the controller-based SBC function. 0 = Normal Operation 1 = Fault
<i>module:SO.SS1Fault</i>	[2]	Indicates that a fault occurred with the controller-based SS1 function. 0 = Normal Operation 1 = Fault
<i>module:SO.SS2Fault</i>	[3]	Indicates that a fault occurred with the controller-based SS2 function. 0 = Normal Operation 1 = Fault
<i>module:SO.SOSFault</i>	[4]	Indicates that a fault occurred with the controller-based SOS function. 0 = Normal Operation 1 = Fault
<i>module:SO.PassThruLimitFaults</i>	SINT	Collection of bits indicating the Safety Fault status of controller-based safety functions. The bits are listed below.
<i>module:SO.SLSFault</i>	[1]	Controller-based SLS fault. 0 = Normal Operation 1 = Fault
<i>module:SO.SDIFault</i>	[2]	Controller-based SDI fault. 0 = Normal Operation 1 = Fault
<i>module:SO.SLPFault</i>	[4]	Controller-based SLP fault. 0 = Normal Operation 1 = Fault

Table 39 - Safety Output Assembly Tags (Continued)

Safety Output Assembly Tag Name (output to safety controller)	Type/[bit]	Description
module:SO.SafetyStopFunctions	SINT	A collection of bits used to activate (request) safety functions as listed below.
module:SO.STOOutput	[0]	0 = Activate STO Function 1 = Permit Torque
module:SO.SBCOutput	[1]	Drive-based function not available.
module:SO.SS1Request	[2]	0 = Remove SS1 Request 1 = Activate Drive-based SS1 Function
module:SO.SS2Request	[3]	Drive-based function not available.
module:SO.SOSRequest	[4]	Drive-based function not available.
module:SO.ResetRequest	[7]	0 -> 1 transition resets drive-based Safe Stop function.

## Safety Feedback Attributes

Safety feedback attributes provide configuration and status information for safety feedback. Single-axis drives (inverters) have two safety feedback instances. Safety feedback attributes provide status and configuration data. All attributes can be read by using explicit messages. Attributes that can be written are indicated in [Table 41](#). Configuration attributes can only be read using explicit messages.

Table 40 - Safety Feedback Instance Numbers

Safety Feedback Instance	ArmorKinetix DSD/DSM	Motion Safety Category	Feedback
1	Single-axis inverters	Motion Safety	DSL Hiperface
2	Single-axis inverters	Motion Safety	Sin/Cos or Hiperface

Table 41 - Safety Feedback Attributes (Class 0x58)

Attribute ID Decimal (Hex)	Attribute Name	Attribute Description	Values
1 (0x1)	Velocity Data Type	Determines the data type of feedback velocity and feedback acceleration and all related attributes.	1 = REAL (hard-coded)
2 (0x2)	Feedback Position	Actual position of the feedback device.	Feedback Counts Safety data with a safe value defined by Position Safe State Behavior
3 (0x3)	Feedback Velocity	Actual velocity of the feedback device.	Feedback Units/s Safety data with a safe value defined by Velocity Safe State Behavior.
4 (0x4)	Feedback Acceleration	Actual acceleration of the feedback device.	Feedback Units/s <sup>2</sup> Safety data with a safety state of 0.
5 (0x5)	Feedback Mode	Motion Feedback mode.	0 = Not Used (default) 1 = Used
8 (0x8)	Feedback Fault	Status of this motion feedback channel.	0 = No Fault 1 = Faulted
9 (0x9)	Feedback Fault Reason	Determines cause of the fault detected.	0 = Reserved 1 = No Fault 2 = Invalid Configuration 3 = Exceeded Max Speed 4 = Exceeded Max Acceleration 5 = Sin <sup>2</sup> +Cos <sup>2</sup> Error 6 = Quadrature Error 7 = Discrepancy Error 8 = Partner Faulted 9 = Supply Voltage Error 10 = Feedback Signal Noise 11 = Feedback Signal Lost 12 = Feedback Data Loss 13 = Feedback Device Failure 100 = DSL ECN Mismatch 101 = DSL Unexpected UEI 102 = DSL Position Comparison Failure 103 = DSL Position Checksum Failure 104 = DSL Multi-Axis FPGA Failure 105 = DSL Test Message Failure 106 = DSL Power-on Self-test Failure
10 (0xA)	Reset Feedback Fault	Resets a motion feedback fault (read/write access).	0 to 1 transition required to reset



Table 41 - Safety Feedback Attributes (Class 0x58) (Continued)

Attribute ID Decimal (Hex)	Attribute Name	Attribute Description	Values
11 (0xB)	Position Safe State Behavior	Defines behavior for value reporting when faulted.	2 = Hold Last Value
13 (0xD)	Velocity Safe State Behavior	Defines behavior for value reporting when faulted.	0 = Use Velocity Safe State Value (default)
14 (0xE)	Velocity Safe State Value	Safe Velocity Feedback and Acceleration Feedback value.	Default = 0
15 (0xF)	Feedback Resolution Unit	Unit of measure for feedback resolution used by Feedback Cycle Resolution attribute.	Default = 0
16 (0x10)	Feedback Unit	Unit of measure for the feedback device.	0 = Rev (default)
17 (0x11)	Feedback Type	Identifies the type of feedback device.	0 = Not Specified (default) 2 = Sine/Cosine 3 = Hiperface 7 = Hiperface DSL
18 (0x12)	Feedback Polarity	Feedback polarity of Normal provides increasing position values when the feedback device is moved in position according to the encoder manufacture specifications. For feedback devices internal to Allen-Bradley® motors, the Normal direction is clockwise rotation of the shaft when facing the end of the motor shaft.	0 = Normal (default) 1 = Inverted
19 (0x13)	Feedback Cycle Resolution	This is the number of feedback cycles per revolution of the encoder. For a Sin/Cos encoder, this is the number of sinusoidal cycles per revolution.	0 = Default
20 (0x14)	Feedback Cycle interpolation	This value is the number of feedback counts per feedback cycle. This value is always 4 for sin/cos or incremental encoders and 1 for DSL encoders.	Counts/Cycle Default = 0 4 for Feedback Type=2/3/4 Otherwise 1
22 (0x16)	Velocity Average Time	A moving average filter is applied to velocity that is provided by the Motion Safety instance of the drive. This parameter specifies the window of time where the average is taken. Feedback velocity is provided as a REAL data type.	0 = Disable Averaging (default) 1 to 65565 ms
31 (0x1F)	Motion Positive	Indicates positive motion according to the direction and Standstill Speed attribute.	0 = No Positive Motion 1 = Positive Motion
32 (0x20)	Motion Negative	Indicates negative motion according to the direction and Standstill Speed attribute.	0 = No Negative Motion 1 = Negative Motion
33 (0x21)	Standstill Speed	Defines the speed below which motion is considered stopped.	Feedback Units/s Default = 0
110 (0x6E)	Feedback Valid	Safety Feedback object is supported, configured, not faulted and is currently producing valid safety feedback data from a connected feedback device.	0 = Safety Feedback Data Invalid 1 = Safety Feedback Data Valid

## Safe Stop Function Attributes

Safe-stop function attributes provide configuration and status information for safety feedback.

Single-axis drives (inverters) have one safe-stop function instance. Safe-stop function attributes provide status and configuration data. All attributes can be read using explicit messages. Attributes that can be written are indicated in the table. Configuration attributes can be read but cannot be written using an explicit message.

Table 42 - Safe Stop Function Instance Numbers

Safe Stop Instance	Kinetix 5700 Drive	Motion Safety Category
1	Single-axis inverters	Motion Safety

Table 43 - Safe Stop Function Attributes (Class 0x5A)

Attribute ID Decimal (Hex)	Attribute Name	Attribute Description	Values
10 (0xA)	Safety Reset	Reset all safety functions.	0 to 1 transition required to reset
11 (0xB)	Restart Type	Selects safety function restart behavior while operating.	1 = Automatic
12 (0xC)	Cold Start Type	Selects safety function restart behavior when applying controller power or mode change to Run.	1 = Automatic
20 (0x14)	Safety Feedback Instance	Instance ID of a Safety Feedback instance to provide position, velocity, and acceleration data used by safe stop functions.	0 = No feedback (default) 1,2 = 2198-Sxxx-ERS4 1,2,3,4 = 2198-Dxxx-ERS4
21 (0x15)	Safety Feedback Fault	Copy of feedback status from the Safety Feedback instance.	0 = No Fault 1 = Faulted

Table 43 – Safe Stop Function Attributes (Class 0x5A) (Continued)

Attribute ID Decimal (Hex)	Attribute Name	Attribute Description	Values
22 (0x16)	Safety Feedback Fault Type	Condition detected that caused the Feedback Status attribute to fault.	0 = Reserved 1 = No Fault 2 = Invalid Configuration 1 3 = Exceeded Max Speed 1 5 = Sin <sup>2</sup> +Cos <sup>2</sup> Error 1 6 = Quadrature Error 1 7 = Discrepancy Error 1 8 = Partner Faulted 1 9 = Supply Voltage Error 1 10 = Feedback Signal Noise 1 11 = Feedback Signal Lost 1 12 = Feedback Data Loss 1 13 = Feedback Device Failure 1 52 = Invalid Configuration 2 53 = Exceeded Max Speed 2 55 = Sin <sup>2</sup> +Cos <sup>2</sup> Error 2 56 = Quadrature Error 2 57 = Discrepancy Error 2 58 = Partner Faulted 2 59 = Supply Voltage Error 2 60 = Feedback Signal Noise 2 61 = Feedback Signal Lost 2 62 = Feedback Data Loss 2 63 = Feedback Device Failure 2
30 (0x1E)	Safety Function Fault	Logical OR of all Fault attributes that reference this instance.	0 = No Fault 1 = Faulted
31 (0x1F)	Safety Stop Fault	Logical OR of all Stop Fault attributes in this instance.	0 = No Fault 1 = Faulted
32 (0x20)	Safety Limit Fault	Logical OR of all Limit Fault attributes that reference this instance.	0 = No Fault No Limit Functions Supported
33 (0x21)	Safety Limit Active	Logical OR of all Limit Active attributes that reference this instance.	0 = No Limit No Limit Functions Supported
34 (0x22)	Restart Required	A stop function has been activated and Restart Type is Manual.	0 = Restart Not Required 1 = Restart Required
40 (0x28)	Safety Stop Status	Collection of Safety Stop Status bits:	Bit: 0 = Safety Function Fault 1 = Safety Reset 2 = Restart Required 3 = STO Active 4 = Torque Disabled 7 = SS1 Active
41 (0x29)	Safety Stop Faults	Collection of Safety Stop Fault bits:	Bit: 2 = Feedback Fault 3 = STO Fault 4 = SS1 Fault 5 = SS2 Fault 6 = SOS Fault 7 = SBC Fault 8 = SMT Fault
50 (0x32)	Connection Loss Action	Safety Output Connection is lost (or closed) and optional Connection Loss Action is Set to STO (default).	0 = STO (default) 1 = SS1
51 (0x33)	Connection Idle Action	Safety Output Connection's Run/Idle bit transitions from Run to Idle and Optional Connection Idle Action is Set to STO (default).	0 = STO (default) 1 = SS1
100 (0x64)	Safety IO Status	State of MPU inputs	Bit: 0 = PWM Power On (1 On) 1 = PWM Enable A (1 Enable) 2 = Enable A Readback (1 Enabled) 3 = Enable Test A (1 Enabled) 4 = Safety Input A (0 Energized) 8 = Pulse Test Enable (1 Enabled) 9 = PWM Enable B (1 Enable) 10 = Enable B Readback (1 Enabled) 11 = Enable Test B (1 Enabled) 12 = PWM Power Status (0 On) 13 = Safety Input B (0 Energized)
101 (0x65)	STO Delay	Specify delay time from STO Active to Torque Disabled. This delay allows the time for an external brake to engage before torque disabled.	Delay in milliseconds Default = 0

Table 43 – Safe Stop Function Attributes (Class 0x5A) (Continued)

Attribute ID Decimal (Hex)	Attribute Name	Attribute Description	Values
110 (0x6E)	SBC Ready	Safe Break Control safety function is supported, configured, and ready for operation.	0 = Not Ready SBC Function Not Supported
111 (0x6F)	SS1 Ready	Safe Stop 1 safety function is supported, configured, and ready for operation.	0 = Not Ready 1 = Ready
112 (0x70)	SS2 Ready	Safe Stop 2 safety function is configured and ready for activation.	0 = Not Ready SS2 Function Not Supported
113 (0x71)	SOS Ready	Safe Operating Stop safety function is configured and ready for activation.	0 = Not Ready SOS Function Not Supported
114 (0x72)	SMT Ready	Safe Motor Temperature safety function is configured and ready for activation.	0 = Not Ready SMT Function Not Supported
260 (0x104)	STO Mode	Safe torque-off mode.	1 = Used 2 = Permit Torque
261 (0x105)	STO Output	Enables or disables energy to the motor that can generate torque (or force in the case of a linear motor).	0 = Disable Torque 1 = Permit Torque Safety data with a safety state of 0.
262 (0x106)	STO Active	Output of STO Activation block.	0 = Permit Torque 1 = Disable Torque
263 (0x107)	STO Fault	Safe Torque-off fault.	0 = No Fault 1 = Faulted
264 (0x108)	STO Fault Type	Detailed information about a fault.	1 = No Fault 2 = Invalid Configuration 3 = Circuit Error 4 = Stuck At Low 5 = Stuck At High 6 = Cross Connection 102 = Hardwired STO Input Discrepancy 104 = Hardwired STO Input Active in Network Safety
265 (0x109)	STO Activation	Bit string showing status of all inputs to the STO Activation block.	Bit: 0 = STO Output Active 1 = SS1 Complete 2 = Safety Stop Fault 3 = Safety Limit Fault 4 = Safety Limit Action 5 = Connection Loss 6 = Connection Idle
266 (0x10A)	Torque Disabled	Status of Safe Torque-off.	0 = Torque Permitted 1 = Torque Disabled
280 (0x118)	SS1 Mode	Safe Stop 1 mode.	0 = Not Used 1 = Timed SS1 (default) 2 = Monitored SS1
281 (0x119)	SS1 Request	Select Safe Stop 1 request.	0 = No Request 1 = Request
282 (0x11A)	SS1 Active	Safe Stop 1 function active.	0 = Not Active 1 = Active
283 (0x11B)	SS1 Fault	Safe Stop 1 fault.	0 = No Fault 1 = Faulted
284 (0x11C)	SS1 Fault Type	Describes detailed information about the Fault.	1 = No Fault 2 = Invalid Configuration 3 = Deceleration Rate 4 = Maximum Time 100 = STO Request during SS1 101 = SS1 Request while Feedback not valid
285 (0x11D)	SS1 Max Stop Time	Allowed time to stop.	0-65535 milliseconds Default = 0
286 (0x11E)	SS1 Standstill Speed	Defines the speed below which motion is considered stopped.	Feedback Units / s Default = 0
287 (0x11F)	SS1 Stop Monitor Delay	Delay before deceleration is monitored.	0-65535 milliseconds Default = 0
288 (0x120)	SS1 Decel Ref Rate	Minimum rate of deceleration while stopping.	Feedback Units / s <sup>2</sup> 0 = No Decel Check (default)

Table 43 - Safe Stop Function Attributes (Class 0x5A) (Continued)

Attribute ID Decimal (Hex)	Attribute Name	Attribute Description	Values
289 (0x121)	SS1 Activation	The source of the SS1 activation.	Bit: 0 = SS1 Request 1 = Safe Limit Active 2 = Connection Loss 3 = Connection Idle
290 (0x122)	SS1 Decel Ref Tolerance	Defines the speed tolerance applied to the deceleration ramp check. This attribute is optional in the implementation.	Feedback Units/s <sup>2</sup> Default = 0
291 (0x123)	SS1 Ext Max Stop Time	Allowed time to stop with extended range to support possibility of long stop times. This attribute is optional in the implementation.	0-4294967296 ms Default = 0
292 (0x124)	SS1 Max Stop Time Source	Selects which Max Stop Time attribute determines the allowed time to stop. Must be supported if optional SS1 Ext Max Stop Time is supported.	0 = Max Stop Time 1 = Ext Max Stop Time
303 (0x12F)	SS2 Fault	Safe stop 2 fault.	0 = No Fault 1 = Faulted
304 (0x130)	SS2 Fault Type	Detailed information about a fault.	1 = No Fault 2 = Invalid Configuration SS2 Function Not Supported
323 (0x143)	SOS Fault	Safe Operating Stop fault.	0 = No Fault 1 = Faulted
324 (0x144)	SOS Fault Type	Detailed information about a fault.	1 = No Fault 2 = Invalid Configuration SOS Function Not Supported
341 (0x155)	SMT Fault	Safe motor temperature fault.	0 = No Fault 1 = Faulted
342 (0x156)	SMT Fault Type	Detailed information about a fault.	1 = No Fault 2 = Invalid Configuration SMT Function Not Supported
363 (0x16B)	SBC Fault	Safe brake control fault.	0 = No Fault 1 = Faulted
364 (0x16C)	SBC Fault Type	Detailed information about a fault.	1 = No Fault 2 = Invalid Configuration SBC Function Not Supported

## Dual Channel Feedback Attributes

These parameters are set by using the Studio 5000 Logix Designer application only when dual-channel feedback is configured. These attributes cannot be individually set by using explicit messaging, but can be read by using a message command.

**Table 44 - Dual Channel Feedback Attributes (Class 0x59)**

Attribute ID Decimal (Hex)	Attribute Name	Attribute Description	Values
1 (0x1)	Dual Channel Mode	Selects the mode for the two channels of the Safety Dual Channel Feedback.	0 = Single Feedback 1 = Dual Velocity Check
2 (0x2)	Dual Channel Evaluation Status	Status of the Dual Channel evaluation.	0 = No Discrepancy 1 = Discrepancy Detected
3 (0x3)	Discrepancy Time	The time limit at which the input discrepancy becomes an error.	0 = No Monitoring (default) 1 to 65535 ms
4 (0x4)	Primary Feedback Instance	Instance ID of one of the pair of Safety Feedback instances that forms the Safety Dual Channel Feedback (primary channel).	Default = 0, no pairing
5 (0x5)	Secondary Feedback Instance	Instance ID of the second instance of the dual channel safety feedback pair (secondary channel).	Default = 0, no pairing
6 (0x6)	Velocity Ratio	Ratio of velocity from primary channel divided by velocity from secondary channel.	Positive REAL value
7 (0x7)	Velocity Discrepancy Deadband	Allowed difference for the channel.	Default = 0, no Deadband
8 (0x8)	Velocity Discrepancy Measured	Measured velocity discrepancy.	Feedback Units/s
9 (0x9)	Velocity Discrepancy Status	Status of the Dual Channel evaluation.	0 = No Discrepancy 1 = Discrepancy Detected
110 (0x6E)	Discrepancy Checking Active	Safety Dual Channel Feedback object is supported, configured for dual channel operation, is actively checking primary and secondary feedback data discrepancy, and no discrepancies have been detected.	0 = Feedback Discrepancy Checking Inactive 1 = Feedback Discrepancy Checking Active

**Notes:**

## Safety Function Validation Checklist

Use this appendix to validate your Drive Safety instructions. Each instruction has a checklist with test commands and results to verify for normal operation and abnormal operation scenarios.

Topic	Page
Safe Stop 1 (SS1)	107
Safe Stop 2 (SS2)	108
Safe Operating Stop (SOS)	111
Safely Limited Speed (SLS)	113
Safely Limited Position (SLP)	113
Safe Direction (SDI)	115
Safe Feedback Interface (SFX)	115
Safe Brake Control (SBC)	117

### Safe Stop 1 (SS1)

Use this SS1 instruction checklist to verify normal operation and the abnormal operation scenarios.

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**IMPORTANT** Perform I/O verification and validation before validating your safety ladder program. SFX instruction must be verified within your application.  
 When possible, use immediate operands for instructions to reduce the possibility of systematic errors in your ladder program.  
 Instruction operands must be verified for your safety ladder program.

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**Table 45 - SS1 Instruction Checklist**

Test Type	Test Description	Test Status
Normal Operation	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Operate the machine at the desired operating system speed.	
	Set up a trend with expected time scale and the following tags to graphically capture this information: <ul style="list-style-type: none"> <li>SFX_Name.ActualSpeed</li> <li>SSL_Name.SpeedLimit</li> <li>SSL_Name.DecelerationRamp</li> <li>SSL_Name.01</li> </ul>	
	Initiate SS1 demand.	
	Make sure that the instruction output SSL_Name.01 turns off without generating a fault and that the drive initiates an STO instruction. <ul style="list-style-type: none"> <li>Verify that the STO instruction de-energizes the motor for a normal safe condition.</li> </ul>	
	While the system is stopped with the sensor subsystems in a safe state, initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the STO instruction remains de-energized for a normal safe condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	While the system is stopped with the SS1 demand removed, initiate a Reset command of the STO and SS1 instructions. <ul style="list-style-type: none"> <li>Verify that the STO instruction remains de-energized</li> <li>Verify proper machine status and safety application program status</li> </ul>	

Table 45 - SS1 Instruction Checklist (Continued)

Test Type	Test Description	Test Status
Abnormal Operation 1	Change the actual motion deceleration rate within the motion task associated with this SS1 function so that it is slower than the calculated speed limit used by the SS1 instruction.	
	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Operate machine at the desired operating system speed.	
	Set up a trend with expected time scale and the following tags to graphically capture this information: <ul style="list-style-type: none"> <li>SFX_Name.ActualSpeed</li> <li>SS1_Name.SpeedLimit</li> <li>SS1_Name.DecelerationRamp</li> <li>SS1_Name.O1</li> </ul>	
	Initiate SS1 demand.	
	Make sure that the instruction generates a deceleration fault and that the drive initiates an STO instruction. <ul style="list-style-type: none"> <li>Verify that the STO instruction de-energizes the motor for a normal safe condition</li> </ul>	
	While the system is stopped with the sensor subsystems in a safe state, initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the STO instruction remains de-energized for a normal safe condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	While the system is stopped with the SS1 demand removed, initiate a Reset command of the STO and SS1 instructions. <ul style="list-style-type: none"> <li>Verify that the STO instruction remains de-energized</li> <li>Verify proper machine status and safety application program status</li> </ul>	
Abnormal Operation 2	Change the motion deceleration rate within the motion task associated with this SS1 function so that the stop delay time is exceeded without triggering a deceleration fault.	
	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Operate machine at desired operating system speed.	
	Set up a trend with expected time scale and the following tags to graphically capture this information: <ul style="list-style-type: none"> <li>SFX_Name.ActualSpeed</li> <li>SS1_Name.SpeedLimit</li> <li>SS1_Name.DecelerationRamp</li> <li>SS1_Name.O1</li> </ul>	
	Initiate SS1 demand.	
	Make sure that the instruction generates a maximum time fault and that the drive initiates an STO instruction. <ul style="list-style-type: none"> <li>Verify that the STO instruction de-energizes the motor for a normal safe condition</li> </ul>	
	While the system is stopped with the sensor subsystems in a safe state, initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the STO instruction remains de-energized for a normal safe condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	While the system is stopped with the SS1 demand removed, initiate a Reset command of the STO and SS1 instructions. <ul style="list-style-type: none"> <li>Verify that the STO instruction remains de-energized</li> <li>Verify proper machine status and safety application program status</li> </ul>	

## Safe Stop 2 (SS2)

Use this SS2 instruction checklist to verify normal operation and the abnormal operation scenarios.

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**IMPORTANT** Perform I/O verification and validation before validating your safety ladder program. SFX instruction must be verified within your application.

When possible, use immediate operands for instructions to reduce the possibility of systematic errors in your ladder program.

Instruction operands must be verified for your safety ladder program.

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Table 46 - SS2 Instruction Checklist

Test Type	Test Description	Test Status
Normal Operation	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Operate machine at the desired operating system speed.	
	Set up a trend with expected time scale and the following tags to graphically capture this information: <ul style="list-style-type: none"> <li>SFX_Name.ActualSpeed</li> <li>SS2_Name.SpeedLimit</li> <li>SS2_Name.DecelerationRamp</li> <li>SS2_Name.ActualPosition</li> <li>SS2_Name.StandstillSetPoint</li> <li>SS2_Name.Output 1</li> </ul>	
	Initiate SS2 demand.	
	Make sure that while the SS2 instruction is monitoring that the motor decelerates below the SS2_Name.SS2StandstillSpeed setting and then maintains a speed below the SS2_Name.SOSStandstillSpeed (or for position mode, maintains the SS2_Name.StandstillSetpoint without exceeding the SS2_Name.StandstillDeadband setting).	
	While the system is in standstill state and with the sensor subsystems in a safe state, remove the SS2 demand. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status.</li> </ul>	
	Resume normal machine operation. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status.</li> </ul>	
Abnormal Operation 1	Change the actual motion deceleration rate within the motion task associated with this SS2 function so that it is slower than the calculated speed limit used by the SS2 instruction.	
	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Operate machine at the desired operating system speed.	
	Set up a trend with expected time scale and the following tags to graphically capture this information: <ul style="list-style-type: none"> <li>SFX_Name.ActualSpeed</li> <li>SS2_Name.SpeedLimit</li> <li>SS2_Name.DecelerationRamp</li> <li>SS2_Name.ActualPosition</li> <li>SS2_Name.StandstillSetPoint</li> <li>SS2_Name.Output 1</li> </ul>	
	Initiate SS2 demand.	
	Make sure that the instruction generates a deceleration fault and that the drive initiates an STO instruction. <ul style="list-style-type: none"> <li>Verify that the STO instruction de-energizes the motor for a normal safe condition</li> </ul>	
	While the system is stopped with the sensor subsystems in a safe state, initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the STO instruction remains de-energized for a normal safe condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
While the system is stopped with the SS1 demand removed, initiate a Reset command of the STO and SS2 instructions. <ul style="list-style-type: none"> <li>Verify that the STO instruction remains de-energized</li> <li>Verify proper machine status and safety application program status</li> </ul>		

Table 46 - SS2 Instruction Checklist (Continued)

Test Type	Test Description	Test Status
Abnormal Operation 2	Change the motion deceleration rate within the motion task associated with this SS2 function so that the stop delay time is exceeded without triggering a deceleration fault.	
	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Operate machine at desired operating system speed.	
	Set up a trend with expected time scale and the following tags to graphically capture this information: <ul style="list-style-type: none"> <li>SFX_Name.ActualSpeed</li> <li>SS2_Name.SpeedLimit</li> <li>SS2_Name.DecelerationRamp</li> <li>SS2_Name.ActualPosition</li> <li>SS2_Name.StandstillSetPoint</li> <li>SS2_Name.Output 1</li> </ul>	
	Initiate SS2 demand.	
	Make sure that the instruction generates a maximum time fault and that the drive initiates an STO instruction. <ul style="list-style-type: none"> <li>Verify that the STO instruction de-energizes for a normal safe condition</li> </ul>	
	While the system is stopped with the sensor subsystems in a safe state, initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the STO instruction remains de-energized for a normal safe condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	While the system is stopped with the SS2 demand removed, initiate a Reset command of the STO and SS2 instructions. <ul style="list-style-type: none"> <li>Verify that the STO instruction remains de-energized</li> <li>Verify proper machine status and safety application program status</li> </ul>	
Abnormal Operation 3 (Speed mode)	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Operate the machine at maximum (normal) operating system speed.	
	Set up a trend with expected time scale and the following tags to graphically capture this information: <ul style="list-style-type: none"> <li>SFX_Name.ActualSpeed</li> <li>SS2_Name.SpeedLimit</li> <li>SS2_Name.DecelerationRamp</li> <li>SS2_Name.ActualPosition</li> <li>SS2_Name.StandstillSetPoint</li> <li>SS2_Name.Output 1</li> </ul>	
	Initiate SS2 demand.	
	Make sure that while the SS2 instruction is monitoring, that the motor decelerates below the SS2_Name.SS2StandstillSpeed setting and then maintains a speed below the SS2_Name.SOSStandstillSpeed.	
	While the system is in the standstill state, initiate a motion command that violates the standstill speed. <ul style="list-style-type: none"> <li>Verify that standstill speed fault is generated and STO is initiated</li> <li>Verify that the STO instruction de-energizes for a normal safe condition</li> </ul>	
	While the system is stopped with the sensor subsystems in a safe state, initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the STO instruction remains de-energized for a normal safe condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	While the system is stopped with the SS2 demand removed, initiate a Reset command of the STO and SS2 instructions. <ul style="list-style-type: none"> <li>Verify that the STO instruction remains de-energized</li> <li>Verify proper machine status and safety application program status</li> </ul>	

Table 46 - SS2 Instruction Checklist (Continued)

Test Type	Test Description	Test Status
Abnormal Operation 4 (Position mode)	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Operate the machine at maximum (normal) operating system speed.	
	Set up a trend with expected time scale and the following tags to graphically capture this information: <ul style="list-style-type: none"> <li>SFX_Name.ActualSpeed</li> <li>SS2_Name.SpeedLimit</li> <li>SS2_Name.DecelerationRamp</li> <li>SS2_Name.ActualPosition</li> <li>SS2_Name.StandstillSetPoint</li> <li>SS2_Name.Output 1</li> </ul>	
	Initiate SS2 demand.	
	Make sure that while SS2 instruction is monitoring, that the motor maintains the SS2_Name.StandstillSetPoint without exceeding the SS2_Name.StandstillDeadband setting).	
	While the system is in the standstill state, initiate a motion command that violates the standstill deadband. <ul style="list-style-type: none"> <li>Verify that standstill position fault is generated and STO is initiated</li> <li>Verify that the STO instruction de-energizes for a normal safe condition</li> </ul>	
	While the system is stopped with the sensor subsystems in a safe state, initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the STO instruction remains de-energized for a normal safe condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	While the system is stopped with the SS2 demand removed, initiate a Reset command of the STO and SS2 instructions. <ul style="list-style-type: none"> <li>Verify that the STO instruction remains de-energized</li> <li>Verify proper machine status and safety application program status</li> </ul>	

## Safe Operating Stop (SOS)

Use this SOS instruction checklist to verify normal operation and the abnormal operation scenarios.

<b>IMPORTANT</b>	<p>Perform I/O verification and validation before validating your safety ladder program. SFX instruction must be verified within your application.</p> <p>When possible, use immediate operands for instructions to reduce the possibility of systematic errors in your ladder program.</p> <p>Instruction operands must be verified for your safety ladder program.</p>
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Table 47 - SOS Instruction Checklist

Test Type	Test Description	Test Status
Normal Operation	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Operate machine at the desired operating system speed.	
	Set up a trend with expected time scale and the following tags to graphically capture this information: <ul style="list-style-type: none"> <li>SFX_Name.ActualSpeed</li> <li>SFX_Name.ActualPosition</li> <li>SOS_Name.StandstillSpeed</li> <li>SOS_Name.StandstillDeadband</li> <li>SOS_Name.Output 1</li> </ul>	
	Initiate SOS demand.	
	Make sure that while the SOS instruction maintains a speed below the SOS_Name.StandstillSpeed (or for position mode, maintains position within the SOS_Name.StandstillDeadband setting).	
	While the system is in standstill state and with the sensor subsystems in a safe state, remove the SOS demand. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status</li> </ul>	
	Resume normal machine operation. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status</li> </ul>	

Table 47 - SOS Instruction Checklist (Continued)

Test Type	Test Description	Test Status
Abnormal Operation 1 (Speed mode)	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Operate machine at the desired operating system speed.	
	Set up a trend with expected time scale and the following tags to graphically capture this information: <ul style="list-style-type: none"> <li>SFX_Name.ActualSpeed</li> <li>SFX_Name.ActualPosition</li> <li>SOS_Name.StandstillSpeed</li> <li>SOS_Name.StandstillDeadband</li> <li>SOS_Name.Output 1</li> </ul>	
	Initiate SOS demand.	
	Make sure that the SOS instruction maintains a speed below the SOS_Name.StandstillSpeed.	
	While the system is in the standstill state, initiate a motion command that violates the SOS_Name.StandstillSpeed. <ul style="list-style-type: none"> <li>Verify that the standstill speed fault is generated and that the STO is initiated</li> <li>Verify that the STO instruction de-energizes for a normal safe condition</li> </ul>	
	While the system is stopped with the sensor subsystems in a safe state, initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the STO instruction remains de-energized for a normal safe condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	While the system is stopped with the SOS demand removed, initiate a Reset command of the STO and SOS instructions. <ul style="list-style-type: none"> <li>Verify that the STO instruction remains de-energized</li> <li>Verify proper machine status and safety application program status</li> </ul>	
Abnormal Operation 2 (Position mode)	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Operate the machine at maximum (normal) operating system speed.	
	Set up a trend with expected time scale and the following tags to graphically capture this information: <ul style="list-style-type: none"> <li>SFX_Name.ActualSpeed</li> <li>SFX_Name.ActualPosition</li> <li>SOS_Name.StandstillSpeed</li> <li>SOS_Name.StandstillDeadband</li> <li>SOS_Name.Output 1</li> </ul>	
	Initiate SOS demand.	
	Make sure that the SOS instruction maintains position within the SOS_Name.StandstillDeadband setting.	
	While the system is in the standstill state, initiate a motion command that violates the SOS_Name.StandstillDeadband. <ul style="list-style-type: none"> <li>Verify that standstill position fault is generated and STO is initiated</li> <li>Verify that the STO instruction de-energizes for a normal safe condition</li> </ul>	
	While the system is stopped with the sensor subsystems in a safe state, initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the STO instruction remains de-energized for a normal safe condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	While the system is stopped with the SOS demand removed, initiate a Reset command of the STO and SOS instructions. <ul style="list-style-type: none"> <li>Verify that the STO instruction remains de-energized</li> <li>Verify proper machine status and safety application program status</li> </ul>	

## Safely Limited Speed (SLS)

Use this SLS instruction checklist to verify normal operation and the abnormal operation scenarios.

---

**IMPORTANT** Perform I/O verification and validation before validating your safety ladder program. SFX instruction must be verified within your application.

When possible, use immediate operands for instructions to reduce the possibility of systematic errors in your ladder program.

Instruction operands must be verified for your safety ladder program.

---

**Table 48 - SLS Instruction Checklist**

Test Type	Test Description	Test Status
Normal Operation	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Operate the machine within the desired speed range.	
	Set up a trend with expected time scale and the following tags to graphically capture this information: <i>SFX_Name.ActualSpeed</i> <i>SLS_Name.SLSLimit</i> <i>SLS_Name.ActiveLimit</i> <i>SLS_Name.Output 1</i>	
	Initiate SLS demand.	
	Verify that the drive achieves the speed below the <i>SLS_Name.ActiveLimit</i> without asserting the <i>SLS_Name.SLSLimit</i> output.	
	While the system is in SLS monitoring state and with the sensor subsystems in a safe state, remove the SLS demand. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status</li> </ul>	
	Resume normal machine operation. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status</li> </ul>	
Abnormal Operation 1	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Operate the machine within the normal speed range.	
	Set up a trend with expected time scale and the following tags to graphically capture this information: <i>SFX_Name.ActualSpeed</i> <i>SLS_Name.SLSLimit</i> <i>SLS_Name.ActiveLimit</i> <i>SLS_Name.Output 1</i>	
	Initiate SLS demand.	
	Verify that the drive achieves the speed below the <i>SLS_Name.ActiveLimit</i> without asserting the <i>SLS_Name.SLSLimit</i> output.	
	While the system is in the SLS monitoring state, initiate a motion command that violates the <i>SLS_Name.ActiveLimit</i> . <ul style="list-style-type: none"> <li>Verify that the <i>SLS_Name.SLSLimit</i> output is asserted and the programmed stop action is initiated</li> </ul>	
	While the system is stopped with the sensor subsystems in a safe state, initiate a Start command. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status</li> </ul>	
	While the system is stopped, initiate a Reset command. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status</li> </ul>	

## Safely Limited Position (SLP)

Use this SLP instruction checklist to verify normal operation and the abnormal operation scenarios.

---

**IMPORTANT** Perform I/O verification and validation before validating your safety ladder program. SFX instruction must be verified within your application.

When possible, use immediate operands for instructions to reduce the possibility of systematic errors in your ladder program.

Instruction operands must be verified for your safety ladder program.

---

Table 49 - SLP Instruction Checklist

Test Type	Test Description	Test Status
Normal Operation	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Operate the machine within the desired position range.	
	Set up a trend with expected time scale and the following tags to graphically capture this information: <ul style="list-style-type: none"> <li>SFX_Name.ActualPosition</li> <li>SLP_Name.SLPLimit</li> <li>SLP_Name.PositiveTravellimit</li> <li>SLP_Name.NegativeTravellimit</li> <li>SLP_Name.Output 1</li> </ul>	
	Initiate SLP demand.	
	Verify that the drive achieves and maintains a position between the SLP_Name.PositiveTravellimit and the SLP_Name.NegativeTravellimit without asserting the SLP_Name.SLPLimit output.	
	While the system is in SLP monitoring state and with the sensor subsystems in a safe state, remove the SLP demand. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status</li> </ul>	
	Resume normal machine operation. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status</li> </ul>	
Abnormal Operation 1	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Operate the machine within the desired position range.	
	Set up a trend with expected time scale and the following tags to graphically capture this information: <ul style="list-style-type: none"> <li>SFX_Name.ActualPosition</li> <li>SLP_Name.SLPLimit</li> <li>SLP_Name.PositiveTravellimit</li> <li>SLP_Name.NegativeTravellimit</li> <li>SLP_Name.Output 1</li> </ul>	
	Initiate SLP demand.	
	Verify that the drive achieves and maintains a position between the SLP_Name.PositiveTravellimit and the SLP_Name.NegativeTravellimit without asserting the SLP_Name.SLPLimit output.	
	While the system is in the SLP monitoring state, initiate a motion command that violates the SLP_Name.PositiveTravellimit. <ul style="list-style-type: none"> <li>Verify that SLP_Name.SLPLimit output is asserted and the programmed stop action is initiated</li> </ul>	
	While the system is stopped with the sensor subsystems in a safe state, initiate a Start command. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status</li> </ul>	
	While the system is stopped, initiate a Reset command. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status</li> </ul>	
Abnormal Operation 2	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Operate the machine within the desired position range.	
	Set up a trend with expected time scale and the following tags to graphically capture this information: <ul style="list-style-type: none"> <li>SFX_Name.ActualPosition</li> <li>SLP_Name.SLPLimit</li> <li>SLP_Name.PositiveTravellimit</li> <li>SLP_Name.NegativeTravellimit</li> <li>SLP_Name.Output 1</li> </ul>	
	Initiate SLP demand.	
	Verify that the drive achieves and maintains a position between the SLP_Name.PositiveTravellimit and the SLP_Name.NegativeTravellimit without asserting the SLP_Name.SLPLimit output.	
	While the system is in the SLP monitoring state, initiate a motion command that violates the SLP_Name.NegativeTravellimit. <ul style="list-style-type: none"> <li>Verify that SLP_Name.SLPLimit output is asserted and the programmed stop action is initiated</li> </ul>	
	While the system is stopped with the sensor subsystems in a safe state, initiate a Start command. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status</li> </ul>	
	While the system is stopped, initiate a Reset command. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status</li> </ul>	

## Safe Direction (SDI)

Use this SDI instruction checklist to verify normal operation and the abnormal operation scenarios.

---

**IMPORTANT** Perform I/O verification and validation before validating your safety ladder program. SFX instruction must be verified within your application.

When possible, use immediate operands for instructions to reduce the possibility of systematic errors in your ladder program.

Instruction operands must be verified for your safety ladder program.

---

Table 50 - SDI Instruction Checklist

Test Type	Test Description	Test Status
Normal Operation	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Operate the machine within the desired operating range.	
	Set up a trend with expected time scale and the following tags to graphically capture this information: <ul style="list-style-type: none"> <li>SFX_Name.ActualPosition</li> <li>SDL_Name.SDILimit</li> <li>SDL_Name.PositionWindow</li> <li>SDL_Name.Output 1</li> </ul>	
	Initiate SDI demand.	
	Verify that motion is in the intended direction and the <i>SDL_Name.SDILimit</i> output is not asserted.	
	While the system is in SDI monitoring state and with the sensor subsystems in a safe state, remove the SDI demand. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status</li> </ul>	
	Resume normal machine operation. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status</li> </ul>	
Abnormal Operation 1	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Operate the machine within the desired operating range.	
	Set up a trend with expected time scale and the following tags to graphically capture this information: <ul style="list-style-type: none"> <li>SFX_Name.ActualPosition</li> <li>SDL_Name.SDILimit</li> <li>SDL_Name.PositionWindow</li> <li>SDL_Name.Output 1</li> </ul>	
	Initiate SDI demand.	
	Verify that motion is in the intended direction and the <i>SDL_Name.SDILimit</i> output is not asserted.	
	While the system is in the SDI monitoring state, initiate a motion command that violates the <i>SDL_Name.PositionWindow</i> in the unintended direction. <ul style="list-style-type: none"> <li>Verify that <i>SDL_Name.SDILimit</i> output is asserted and the programmed stop action is initiated</li> </ul>	
	While the system is stopped with the sensor subsystems in a safe state, initiate a Start command. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status</li> </ul>	
	While the system is stopped, initiate a Reset command. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status</li> </ul>	

## Safe Feedback Interface (SFX)

Use this SFX instruction checklist to verify normal operation and the abnormal operation scenarios.

---

**IMPORTANT** Perform I/O verification and validation before validating your safety ladder program. SFX instruction must be verified within your application.

When possible, use immediate operands for instructions to reduce the possibility of systematic errors in your ladder program.

Instruction operands must be verified for your safety ladder program.

---

Table 51 - SFX Instruction Checklist

Test Type	Test Description	Test Status
Normal Scaling Operation	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Operate the machine within the normal operating range.	
	Set up a trend with the expected time scale and the following tags to graphically compare the motion position and speed from the Main task to the scaled position and speed in the Safety task. <ul style="list-style-type: none"> <li>Axis_Name.ActualPosition</li> <li>Axis_Name.ActualSpeed</li> <li>SFX_Name.ActualPosition</li> <li>SFX_Name.ActualSpeed</li> </ul>	
	Verify that the standard and safety position and speed are correlated as expected.	
Normal Homing Operation	Initiate a Start command.	
	Initiate a Homing procedure. <ul style="list-style-type: none"> <li>Verify that the Home Position in the SFX instruction is set</li> </ul>	
	Set up a trend with the expected time scale and the following tags to graphically compare the motion position and speed from the Main task to the scaled position and speed in the Safety task. <ul style="list-style-type: none"> <li>Axis_Name.ActualPosition</li> <li>SFX_Name.ActualPosition</li> </ul>	
	Verify that the standard and safety position are correlated as expected.	
Abnormal Operation 1	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Operate the machine within the normal operating range.	
	Set up a trend with the expected time scale and the following tags to graphically compare the motion position and speed from the Main task to the scaled position and speed in the Safety task. <ul style="list-style-type: none"> <li>Axis_Name.ActualPosition</li> <li>Axis_Name.ActualSpeed</li> <li>SFX_Name.ActualPosition</li> <li>SFX_Name.ActualSpeed</li> </ul>	
	Verify that the standard and safety position and speed are correlated as expected.	
	Disconnect the feedback between the motor/encoder and drive.	
	Verify the generation of a Fault Type: 100 Feedback Invalid by checking Device_Name.SI.PrimaryFeedbackValid tag.	
	Verify the system fault action takes place as configured.	
	While the system is stopped with the sensor subsystems in a safe state, initiate a Start command. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status</li> </ul>	
While the system is stopped, initiate a Reset command. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status</li> </ul>		
Abnormal Operation 2	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Operate the machine within the normal operating range.	
	Set up a trend with the expected time scale and the following tags to graphically compare the motion position and speed from the Main task to the scaled position and speed in the Safety task. <ul style="list-style-type: none"> <li>Axis_Name.ActualPosition</li> <li>Axis_Name.ActualSpeed</li> <li>SFX_Name.ActualPosition</li> <li>SFX_Name.ActualSpeed</li> </ul>	
	Verify that the standard and safety position and speed are correlated as expected.	
	Disconnect the Ethernet cable between the controller and the drive.	
	Verify the generation of a Fault Type: 101 Connection Fault by checking the Device_Name.SI.ConnectionFaulted tag.	
	Verify the system fault action takes place as configured	
	While the system is stopped with the sensor subsystems in a safe state, initiate a Start command. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status</li> </ul>	
While the system is stopped, initiate a Reset command. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status</li> </ul>		



## Safe Brake Control (SBC)

Use this SBC instruction checklist to verify normal operation and the abnormal operation scenarios.

---

**IMPORTANT** Perform I/O verification and validation before validating your safety ladder program.

When possible, use immediate operands for instructions to reduce the possibility of systematic errors in your ladder program.

Instruction operands must be verified for your safety ladder program.

---

**Table 52 - SBC Instruction Checklist**

Test Type	Test Description	Test Status
Normal Operation	Verify that the brake feedback is properly wired to the input module as documented.	
	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Set up a trend with expected time scale and the following tags to graphically capture this information: <ul style="list-style-type: none"> <li><i>SBC_Name.B01</i></li> <li><i>SBC_Name.B02</i></li> <li><i>SBC_Name.TOR</i></li> <li><i>Device_Name.STOOutput</i></li> </ul>	
	Initiate an SBC request and initiate the STO event. <ul style="list-style-type: none"> <li>Verify expected coordination of the STO output initiation and the <i>SBC_Name.B01</i> and <i>SBC_Name.B02</i> outputs</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	While the system is stopped, initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the system remains de-energized for a normal safe condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	While the system is stopped, initiate a Reset command. <ul style="list-style-type: none"> <li>Verify that the system remains de-energized for a normal safe condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
Abnormal Operation	Verify that brake feedback is properly wired to the input module as documented.	
	Initiate a Start command. <ul style="list-style-type: none"> <li>Verify that the machine is in a normal machine run condition</li> <li>Verify proper machine status and safety application program status</li> </ul>	
	Initiate machine function to make sure the brake is released.	
	Set up a trend with expected time scale and the following tags to graphically capture this information: <ul style="list-style-type: none"> <li><i>SBC_Name.B01</i></li> <li><i>SBC_Name.B02</i></li> <li><i>SBC_Name.TOR</i></li> <li><i>Device_Name.STOOutput</i></li> </ul>	
	Remove brake feedback wires from the input module. <ul style="list-style-type: none"> <li>Verify that the appropriate diagnostic code is generated</li> <li>Verify that the brake output <i>SBC_Name.B01</i> and <i>SBC_Name.B02</i> bits clear</li> <li>Verify the external brake engagement</li> </ul>	
	While the system is stopped with the sensor subsystems in a safe state, initiate a Start command. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status</li> </ul>	
	While the system is stopped, initiate a Reset command. <ul style="list-style-type: none"> <li>Verify proper machine status and safety application program status</li> </ul>	

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# Rockwell Automation Support

Use these resources to access support information.

<b>Technical Support Center</b>	Find help with how-to videos, FAQs, chat, user forums, Knowledgebase, and product notification updates.	<a href="http://rok.auto/support">rok.auto/support</a>
<b>Local Technical Support Phone Numbers</b>	Locate the telephone number for your country.	<a href="http://rok.auto/phonesupport">rok.auto/phonesupport</a>
<b>Technical Documentation Center</b>	Quickly access and download technical specifications, installation instructions, and user manuals.	<a href="http://rok.auto/techdocs">rok.auto/techdocs</a>
<b>Literature Library</b>	Find installation instructions, manuals, brochures, and technical data publications.	<a href="http://rok.auto/literature">rok.auto/literature</a>
<b>Product Compatibility and Download Center (PCDC)</b>	Download firmware, associated files (such as AOP, EDS, and DTM), and access product release notes.	<a href="http://rok.auto/pcdc">rok.auto/pcdc</a>

## Documentation Feedback

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## Waste Electrical and Electronic Equipment (WEEE)



At the end of life, this equipment should be collected separately from any unsorted municipal waste.





Rockwell Automation maintains current product environmental compliance information on its website at [rok.auto/pec](http://rok.auto/pec).

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