Safe Speed Monitor Option Module for PowerFlex 750-Series AC Drives

Catalog Number 20-750-S1

Allen-Bradley
by ROCKWELL AUTOMATION

Safety Reference Manual

Original Instructions

Important User Information

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

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

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

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

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

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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.

Rockwell Automation recognizes that some of the terms that are currently used in our industry and in this publication are not in alignment with the movement toward inclusive language in technology. We are proactively collaborating with industry peers to find alternatives to such terms and making changes to our products and content. Please excuse the use of such terms in our content while we implement these changes.

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About This Publication

This manual explains how the PowerFlex® 750-Series Safe Speed Monitor option module can be used in Safety Integrity Level (SIL) 3, Performance Level [PLe], or Category (cat.) 4 applications. It describes the safety requirements, including PFDavg and PFH values and application verification information, and provides information on how to install, configure, and troubleshoot the Safe Speed Monitor option module.

Use this manual if you are responsible for designing, installing, configuring, or troubleshooting safety applications that use the PowerFlex 750-Series Safe Speed Monitor option module.

Rockwell Automation recognizes that some of the terms that are currently used in our industry and in this publication are not in alignment with the movement toward inclusive language in technology. We are proactively collaborating with industry peers to find alternatives to such terms and making changes to our products and content. Please excuse the use of such terms in our content while we implement these changes.

The 20-750-S1 Safe Speed Monitor option module applies to the following PowerFlex 750-Series drives:

- PowerFlex 755TL low harmonic, non-regenerative drives
- PowerFlex 755TR regenerative drives
- PowerFlex 755TM drive systems with regenerative bus-supplies and common-bus inverters
- PowerFlex 755TS AC drives
- PowerFlex 755 AC drives
- PowerFlex 753 AC drives

You must have a basic understanding of the electrical circuitry and familiarity with these products. You must be trained and experienced in the creation, operation, and maintenance of safety systems.

Summary of Changes

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

Topic	Page
Updated configuration steps for the hardware enable and safety enable jumpers.	28

Download Firmware, AOP, EDS, and Other Files

Download firmware, associated files (such as AOP, EDS, and DTM), and access product release notes from the Product Compatibility and Download Center at rok.auto/pcdc.

Conventions

In this manual, configuration parameters are listed by number followed by the name in brackets. For example, P24 [OverSpd Response].

Throughout this manual, PowerFlex 755T drive products is used to refer to PowerFlex 755TL drives, PowerFlex 755TR drives, PowerFlex 755TM drive systems, and PowerFlex 755TS drives.

Terminology

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

Abbreviations and Definitions

Abbreviation	Full Term	Definition
1oo2	One out of Two	Refers to the behavioral design of a dual-channel safety system.
cat.	Category	Classification of the safety-related parts of a control system in respect of their resistance to faults and their subsequent behavior in the fault condition, and which is achieved by the structural arrangement of the parts, fault detection, and/or by their reliability (source EN ISO 13849-1).
CL	Claim Limit	The maximum Safety Integrity Level (SIL) rating that can be claimed for a safety-related electrical control system subsystem in relation to architectural constraints and systematic safety integrity (source IEC 62061).
DC	Door Control	A Safety Function that attempts to maintain the last state (locked or unlocked) when a fault occurs.

Abbreviations and Definitions (Continued)

Abbreviation	Full Term	Definition
DM	Door Monitoring	A Safety Function that monitors the status of the door to indicate if it is open or closed.
EN	European Norm	The official European Standard.
ESD	Emergency Shutdown Systems	A system, usually independent of the main control system, that is designed to safely shut down an operating system.
ESM	Enabling Switch Monitoring	A Safety Function where the ON state is used to enable motion under mode-specific conditions in the Safely-limited Speed with Enabling Switch (Lim Speed ES) and Safe Limited Speed with Door Monitoring and Enabling Switch Monitoring (LimSpd DM ES) modes.
ESPE	Electro-sensitive Protective Equipment	An assembly of devices and/or components working together for protective tripping or presence-sensing purposes and comprising as a minimum: a sensing device. controlling/monitoring devices. output signal-switching devices (OSSD).
HFT	Hardware Fault Tolerance	The HFT equals *n*, where *n*+1 faults could cause the loss of the safety function. An HFT of 1 means that 2 faults are required before safety is lost.
HIM	Human Interface Module	A module used to configure a device.
IEC	International Electrotechnical Commission	The International Electrotechnical Commission (IEC) is the world's leading organization that prepares and publishes International Standards for all electrical, electronic, and related technologies.
IGBT	Insulated Gate Bi-polar Transistors	Typical power switch used to control main current.
ISO	International Organization for Standardization	The International Organization for Standardization is an international standard-setting body that is composed of representatives from various national standards organizations.
LM	Lock Monitoring	A Safety Function that is used to verify the operation of the door locking mechanism to help prevent access to the hazard during motion.
NC	Normally Closed	A set of contacts on a relay or switch that are closed when the relay is de-energized or the switch is de-activated.
NO	Normally Open	A set of contacts on a relay or switch that are open when the relay is de-energized or the switch is de-activated.
OSSD	Output Signal Switching Device	The component of the electro-sensitive protective equipment (ESPE) connected to the control system of a machine, which, when the sensing device is actuated during normal operation, responds by going to the OFF-state.
PELV	Protective Extra Low Voltage	An electrical system where the voltage cannot exceed ELV under normal conditions, and under single-fault condition, except earth faults in other circuits.
PFD_{avg}	Probability of Dangerous Failure on Demand	The average probability of a system to fail to perform its design function on demand.
PFH	Average Frequency of a Dangerous Failure per Hour	The average frequency of a system to have a dangerous failure occur per hour.
PL	Performance Level	EN ISO 13849-1 safety rating
PM	Permanent Magnet	In permanent magnet (PM) motors, magnets mounted on or embedded in the rotor, couple with the motor's current-induced internal magnetic fields generated by electrical input to the stator.
SDM	Safe Direction Monitoring	An EN 61800-5-2 Safety Function that prevents the motor shaft from moving in the unintended direction.
SELV	Safety Extra Low Voltage Circuit	A secondary circuit that is designed and protected so that, under normal and single fault conditions, its voltages do not exceed a safe value.

Additional Resources

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

Resource	Description
PowerFlex 750-Series Products with TotalFORCE® Control Technical Data, publication 750-TD100	Provides detailed information on: • Drive and bus supply specifications • Option specifications • Fuse and circuit breaker ratings
PowerFlex 750-Series AC Drives Technical Data, publication 750-TD001	Provides detailed information on: • Packaged drive specifications • Option specifications • Fuse and circuit breaker ratings
PowerFlex 755TM IP00 Open Type Kits Technical Data, publication 750-TD101	Provides detailed information on: • Kit selection • Kit ratings and specifications • Option specifications
PowerFlex 750-Series Products with TotalFORCE Control Installation Instructions, publication 750-IN100	Provides the basic steps to install PowerFlex 755TL drives, PowerFlex 755TR drives, and PowerFlex 755TM bus supplies.
PowerFlex 755TS Products with TotalFORCE Control Installation Instructions, publication 750-IN119	Provides the basic steps to install PowerFlex 755TS drives.
PowerFlex 755TM IP00 Open Type Kits Installation Instructions, publication 750-IN101	Provides instructions to install IP00 Open Type kits in user-supplied enclosures.
PowerFlex Drives with TotalFORCE Control Programming Manual, publication 750-PM100	Provides detailed information on: • I/O, control, and feedback options • Parameters and programming • Faults, alarms, and troubleshooting
PowerFlex 750-Series AC Drive Installation Instructions, publication 750-IN001	Provides information on installing the Safe Speed Monitor option module in PowerFlex 750-Series drives.
PowerFlex 750-Series AC Drives Programming Manual, publication 750-PM001	Provides information on mounting, installing, and configuring PowerFlex 750-Series drive.
PowerFlex 20-HIM-A6 and 20-HIM-C6S HIM (Human Interface Module) User Manual, publication 20HIM-UM001	Provides information on using the 20-HIM-A6 human interface module to configure PowerFlex 750-Series drives and the Safe Speed Monitor option module.
Connected Components Workbench™ software Online Help, rok.auto/ccw	Online Help that provides a description of the different elements of the Connected Components Workbench software.
PowerFlex 750-Series Safe Torque Off User Manual, publication 750-UM002	Provides information on installing and configuring your Safe Torque Off option module with PowerFlex 750-Series drives.
EtherNet/IP Network Devices User Manual, ENET-UM006	Describes how to configure and use EtherNet/IP devices to communicate on the EtherNet/IP network.
Ethernet Reference Manual, ENET-RM002	Describes basic Ethernet concepts, infrastructure components, and infrastructure features.
System Security Design Guidelines Reference Manual, SECURE-RM001	Provides guidance on how to conduct security assessments, implement Rockwell Automation products in a secure system, harden the control system, manage user access, and dispose of equipment.
UL Standards Listing for Industrial Control Products, publication CMPNTS-SR002	Assists original equipment manufacturers (OEMs) with construction of panels, to help ensure that they conform to the requirements of Underwriters Laboratories.
American Standards, Configurations, and Ratings: Introduction to Motor Circuit Design, publication IC-AT001	Provides an overview of American motor circuit design based on methods that are outlined in the NEC.
Industrial Components Preventive Maintenance, Enclosures, and Contact Ratings Specifications, publication IC-TD002	Provides a quick reference tool for Allen-Bradley industrial automation controls and assemblies.
Safety Guidelines for the Application, Installation, and Maintenance of Solid-state Control, publication SGI-1.1	Designed to harmonize with NEMA Standards Publication No. ICS 1.1-1987 and provides general guidelines for the application, installation, and maintenance of solid-state control in the form of individual devices or packaged assemblies incorporating solid-state components.
Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1	Provides general guidelines for installing a Rockwell Automation industrial system.
Product Certifications website, rok.auto/certifications.	Provides declarations of conformity, certificates, and other certification details.

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

Notes:

Safety Concept

This chapter describes the safety performance-level concept and how the PowerFlex® 750-Series drives with the Safe Speed Monitor option module meet the requirements for SIL 3, cat. 4, or PLe applications.

Safety Certification

The PowerFlex 750-Series Safe Speed Monitor option module is certified for use in safety applications up to and including:

- SIL 3 according to EN/IEC 61800-5-2, IEC 61508
- SIL CL3 according to EN 62061
- Performance Level PLe, and cat. 4 according to EN ISO 13849-1.

Safety requirements are based on the standards current at the time of certification.

The TÜV Rheinland group has approved the PowerFlex 750-Series Safe Speed Monitor option module for use in safety-related applications where the de-energized state is considered to be the safe state. The examples related to I/O included in this manual are based on achieving de-energization as the safe state for typical Machine Safety and Emergency Shutdown (ESD) systems.

Important Safety Considerations

The system user is responsible for the following:

- The setup, safety rating, and validation of any sensors or actuators connected to the system
- Completing a system-level risk assessment and reassessing the system any time a change is made
- Certification of the system to the desired safety Performance Level
- Project management and proof testing
- Programming the application software and the safety option module configurations in accordance with the information in this manual
- Access control to the system, including password handling
- Analyzing all configuration settings and choosing the proper setting to achieve the required safety rating

IMPORTANT	When applying functional safety, restrict access to qualified, authorized personnel who are trained and experienced.

ATTENTION: When designing your system, consider how personnel exit the machine if the door locks while they are in the machine. Additional safeguarding devices can be required for your specific application.

Safety Category 4 Performance Definition

To achieve Safety Category 4, according to EN ISO 13849-1, design the safety-related parts according to these guidelines:

- The safety-related parts of machine control systems and/or their protective equipment, and their components, shall be designed, constructed, selected, assembled, and

combined in accordance with relevant standards so that they can withstand expected conditions

- Basic safety principles shall be applied
- A single fault in any of its parts does not lead to a loss of safety function
- A single fault is detected at or before the next demand of the safety function, or, if this detection is not possible, then an accumulation of faults shall not lead to a loss of the safety function
- The average diagnostic coverage of the safety-related parts of the control system shall be high, including the accumulation of faults
- The mean time to dangerous failure of each of the redundant channels shall be high
- Measures against common cause failure shall be applied

Stop Category Definitions

You must use a risk assessment to select a stop category for each stop function.

- Stop Category 0 is achieved with immediate removal of power to the actuator, resulting in an uncontrolled coast to stop. Safe Torque Off accomplishes a Stop Category 0 stop.
- Stop Category 1 is achieved with power available to the machine actuators to achieve the stop. Power is removed from the actuators when the stop is achieved.
- Stop Category 2 is a controlled stop with power available to the machine actuators. The stop is followed by a holding position under power.

See Safe Stop Mode on page 55 for more information.

IMPORTANT	When designing the machine application, consider timing and distance for a coast to stop (Stop Category 0 or Safe Torque Off). For more information on stop categories and Safe Torque Off, refer to EN 60204-1 and EN/IEC 61800-5-2, respectively.

Performance Level and Safety Integrity Level (SIL) 3

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

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

See Chapter 10 for more information on the requirements for configuration and verification of a safety-related system which contains the PowerFlex 750-Series drives.

Functional Proof Tests

The functional safety standards require that functional proof tests be performed on the equipment that is used in the system. Proof tests are performed at user-defined intervals and are dependent upon PFD and PFH values.

IMPORTANT	Your specific application determines the time frame for the proof test interval.

PFD_{avg} and PFH Definitions

Safety-related systems can be classified as operating in either a Low Demand mode, or in a High Demand/Continuous mode.

- Low Demand mode: where the frequency of demands for operation made on a safety-related system is no greater than one per year or no greater than twice the proof test frequency.

- High Demand/Continuous mode: where the frequency of demands for operation made on a safety-related system is greater than once per year or greater than twice the proof test interval.

The SIL value for a low demand safety-related system is directly related to order-of-magnitude ranges of its average probability of failure to satisfactorily perform its safety function on demand or, simply, average probability of failure on demand (PFD_{avg}). The SIL value for a High Demand/Continuous mode safety-related system is directly related to the average frequency of a dangerous failure (PFH) per hour.

Safety Data

These PFD_{avg} and PFH calculations are based on the equations from Part 6 of EN 61508 and show worst-case values.

This table provides data for a 20-year proof test interval and 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 year.

Table 1 - PFDavg and PFH for PowerFlex 753 and PowerFlex 755 Drives

Attribute	PowerFlex 753 and PowerFlex 755 Drives Frames 1...7	PowerFlex 755 Drives Frame 8	PowerFlex 755 Drives Frame 9	PowerFlex 755 Drives Frame 10
PFD_{avg}	2.35E-4	3.75E-4	4.67E-4	5.58E-4
PFH (1/hour)	2.67E-9	4.28E-9	5.33E-9	6.38E-9
SIL	3	3	3	3
PL	e	e	e	e
Category	4	4	4	4
$MTTF_D$years	143	171.9	104.4	75.5
DC_{avg}%	99% (high)	97.4% (high)	97.5% (high)	97.5% (high)
HFT	1 (1oo2)	1 (1oo2)	1 (1oo2)	1 (1oo2)
Mission time	20 years	20 years	20 years	20 years

Table 2 - PFD_{avg} and PFH for PowerFlex 755T Drive Products

Attribute	Drive Frame 5 and 6	Drive Frame 7 and 8	Drive Frame 9	Drive Frame 10	Drive Frame 11	Drive Frame 12	Drive Frame 13	Drive Frame 14	Drive Frame 15
PFD_{avg}	2.39E-4	4.50E-4	4.76E-4	5.02E-4	5.28E-4	5.54E-4	5.80 E-4	6.32 E-4	6.84 E-4
PFH (1/hour)	2.72E-9	5.15E-9	5.45E-9	5.75E-9	6.05E-9	6.35E-9	6.64 E-9	7.24 E-9	7.84 E-9
SIL	3	3	3	3	3	3	3	3	3
PL	e	e	e	e	e	e	e	e	e
Category	4	4	4	4	4	4	4	4	4
$MTTF_D$years	134.6 (high)	84.5 (high)	74.1 (high)	66.1 (high)	59.6 (high)	54.2 (high)	49.8 (high)	42.8 (high)	37.5 (high)
DC_{avg}%	94.2 (high)	95.1 (high)	95.3% (high)	95.5% (high)	95.6% (high)	95.7% (high)	95.8 (high)	95.9 (high)	96.0 (high)
HFT	1 (1oo2)	1 (1oo2)	1 (1oo2)	1 (1oo2)	1 (1oo2)	1 (1oo2)	1 (1oo2)	1 (1oo2)	1 (1oo2)
Mission time	20 years	20 years	20 years	20 years	20 years	20 years	20 years	20 years	20 years

Table 3 - PFDavg and PFH for PowerFlex 755TS Drive Products

Attribute	Drive Frame 1...7
PFD_{avg}	2.35E-04
PFH (1/hour)	2.67E-09
SIL	3
PL	e
Category	4
$MTTF_D$years	143.1
DC_{avg}%	94.1 (high)
HFT	1 (1oo2)
Mission time	20 Years

Safe State

The safe state encompasses all operation that occurs outside of the other monitoring and stopping behavior that is defined as part of the safety option module. In addition, configuration takes place in the safe state. While the safety option module is in the safe state, all safety control outputs, except the Door Control (DC_Out) output, are in their safe state (de-energized). The Door Control (DC_Out) output is in the locked state or in the de-energized state depending on the condition that resulted in the safe state. The drive safe state is defined as preventing force-producing power from being provided to the motor. For more information on the safe state, see EN/IEC 61800-5-2.

When you cycle power, the safety option module enters the safe state for self-testing. If the self-tests pass and there is a valid configuration, the safety option module remains in the safe state until a successful request for Safe Speed Monitoring occurs.

If a Safe State fault is detected, the safety option module goes to the safe state. This includes faults that are related to integrity of hardware or firmware.

For more information on faults, refer to Chapter 12.

ATTENTION:
- In the event of the failure of two output IGBTs in the drive, when the safety option module has controlled the drive outputs to the OFF state, the drive can provide energy for up to 180° of rotation in a 2-pole motor before torque production in the motor ceases.
- In circumstances where external influences (for example, falling of suspended loads) are present, additional measures (for example, mechanical brakes) can be necessary to prevent any hazard.
- The drive is in the safe state if the safety function is installed and the drive Status is 'Not Enabled'. Drive 'Ready' is NOT a safe state even if there is no motion.

Safety Reaction Time

The safety reaction time is the amount of time from a safety-related event as input to the system until the system is in the safe state.

The safety reaction time from an input signal condition that triggers a safe stop, to the initiation of the configured Stop Type, is shown in Table 4.

Table 4 - Safety Reaction Time

Drive Family	Value, max
PowerFlex 753 drives Frames 1...7	20 ms
PowerFlex 755 drives Frames 1...10	20 ms
PowerFlex 755TL drives, PowerFlex 755TR drives, and PowerFlex 755TM drive systems Frames 7...12	21 ms
PowerFlex 755T drives Frames 5, 6	32 ms
PowerFlex 755TS drives Frames 1...7	20 ms

The safety reaction time from an overspeed event that triggers a safe stop, to the actual initiation of the configured Stop Type, is equal to the value of the P24 [OverSpd Response] parameter.

For more information on overspeed response time, see Overspeed Response Time on page 44.

Considerations for Safety Ratings

The achievable safety rating of PowerFlex 750-Series drive applications that use the safety option module is dependent upon many factors, including the encoder setup, drive options, output pulse testing, and the type of motor.

When using two independent encoders to monitor motion and when installed in a manner to avoid any common cause dangerous failure, the safety option module can be used in applications up to and including SIL 3, PLe, and cat. 4.

For applications that rely on commutation to generate torque and motion, a safety rating up to and including SIL 3, PLe, and cat. 4 can be achieved.

IMPORTANT	Some of the diagnostics that are performed on the encoder signals require motion to detect faults. You must make sure that motion occurs at least once every six months.

Output Pulse Test Considerations

If the pulse testing of **any** safety output is disabled, the maximum safety rating is up to and including SIL 2, PLd, and cat. 3 for any safety chain that incorporates **any input or output** of the safety option module.

IMPORTANT	Setting any of the P72 [SS Out Mode], P73 [SLS Out Mode], or P74 [DC Out Mode] parameters to 1 = No Pulse Test disables internal diagnostics, and external diagnostics, required to achieve higher safety ratings. You must exercise the SS_In input at least once every six months.

Disable pulse-testing if the connected device does not support OSSD inputs. See the product documentation for your connected device.

Supported Encoders

Table 5 describes the supported encoder types based on the feedback card that is used and the physical terminal it is connected to. The Achievable System Safety Rating column shows the highest achievable safety rating for a system using the components listed. Other lower safety ratings may be achievable in specific situations. You must determine the actual system safety rating based on the encoder types used, the encoder diagnostics described in this

chapter, the contents of this safety manual, and safety information provided by the encoder manufacturer. Contact the encoder manufacturer for further guidance.

Table 5 - Supported Feedback Cards and Encoder Types

Feedback Option	Primary Channel		Secondary Channel		Achievable System Safety Rating
	Encoder Type	Encoder Motion Axis	Encoder Type	Encoder Motion Axis	
20-750-UFB-1	Sine/Cosine	Motor Feedback	Not Used	Not Used	• SIL 2/PL d with rated encoder OR • PL d with standard encoder(1)
			Digital AqB	Load Feedback	• SIL 3/PL e with two rated encoders OR • PL e with two standard encoders(1)
20-750-DENC-1	Digital AqB		Not Used	Not Used	• SIL 2/PL d with rated encoder
			Digital AqB	Load Feedback	• SIL 3/PL e with two rated encoders(2)

(1) When using a standard sine/cosine encoder, safety relevant data (MTTF) and safety diagnostic measures to achieve required diagnostic coverage need be considered. Encoder diagnostics for sine/cosine encoders provided by this product include: encoder voltage monitoring, sin2 + cos2 vector length monitoring, zero crossing detection, and signal offset (described in the section below). Additional (customer supplied) diagnostics may be required. You must determine the suitability of the encoder and the system safety rating.

(2) To achieve a SIL 3 rating when using two encoders of the same type, consider whether the two encoders used have sufficient independence per IEC 61508-2 clauses 7.4.3.2 and 7.4.3.4.

Requirements for Single and Dual Encoder Systems

IMPORTANT You are responsible for validating that a particular encoder achieves the required safety rating.

Single Encoder

A single encoder can achieve SIL 2, PLd when the following requirements are met.

- These encoder diagnostics, provided by the safety option module, are used:
  - Sin2 + Cos2 diagnostic
  - Detection of open or short-circuits
  - Encoder supply voltage monitoring
  - Detection of illegal quadrature transitions of the sine and cosine signals
- For SIL 2, PLd applications, a safety-rated encoder is recommended
- The motor-to-encoder coupling is designed to exclude shaft slippage as a dangerous failure mechanism.

Dual Encoder

A dual encoder system can achieve SIL 3, PLe when the primary encoder meets the requirements that are listed for Single Encoder and the primary and secondary encoders are connected properly.

- When using the 20-750-UFB-1 option:
  - The primary encoder is connected to terminals -SN, +SN, -Cs, +Cs
  - The secondary encoder is connected to terminals -A, A, -B, B
- When using the 20-750-DENC-1 option:
  - The “primary encoder” is connected to terminals 0A, 0A-, 0B, 0B-
  - The “secondary encoder” is connected to terminals 1A, 1A-, 1B, 1B-

Single Encoder with PM Synchronous Motor

A single encoder system with a PM synchronous motor in Permanent Magnet Motor, Flux Vector Control mode, can achieve SIL 3, PLe if the following requirements are met.

- The encoder meets the requirements that are listed for Single Encoder.
- The motor is a permanent magnet (PM) brushless AC motor.

- The motor controller must be configured as a closed-loop application with field-oriented control using the single-encoder for commutation.
  - Set P35 [Motor Cntl Mode] = 6 "PM FV"
  - Set P125 [Pri Vel Fdbk Sel] = the safety "primary encoder"
- The controller is not configured for auto transition to encoderless commutation in the event of encoder failure.
  - Set P635 [Spd Options Ctrl] bit 7 "Auto Tach Sw" = 0

Understanding Commutation

Permanent magnet (PM), brushless AC motors are a class of synchronous motor that depends on electronic brushless commutation for their operation. In PM brushless motors, an electromagnetic field is created by the permanent magnets on the rotor. A rotating magnetic field is created by a number of electromagnets commutated electronically with IGBTs at the right speed, order, and times. Movement of the electromagnetic field is achieved by switching the currents in the coils of the stator winding. This process is called commutation. Interaction of the two electromagnetic fields produces magnetic force or torque.

For example, with the PowerFlex 755 drive, follow these guidelines to make sure that the incremental encoder or high-resolution feedback device is used for commutation:

- Set P35 [Motor Cntl Mode] = 6 'PM FV'
- Set P125 [Pri Vel Fdbk Sel] = the feedback device must be the "primary encoder"
- Set P635 [Spd Options Ctrl] bit 7 'Auto Tach SW' = 0

Contact Information if Safety Option Failure Occurs

If you experience a failure with any safety-certified device, contact local Rockwell Automation sales office or Allen-Bradley® distributor. With this contact, you can do the following:

- Return the device to Rockwell Automation so the failure is appropriately logged for the catalog number that is affected and a record is made of the failure.
- Request a failure analysis (if necessary) to determine the probable cause of the failure.

Notes:

About the PowerFlex Safe Speed Monitor Option Module

This chapter describes the Safe Speed Monitor option module features designed for PowerFlex® 750-Series drives.

Safety Functions

The PowerFlex 750-Series Safe Speed Monitor option module features five inputs, three sets of safety outputs, and one bipolar safety output. Each of the inputs supports a specific safety function.

- Safe Stop (SS)
- Safe Limited Speed Monitoring (SLS)
- Door Monitoring (DM)
- Enabling Switch Monitoring (ESM)
- Lock Monitoring (LM)

An additional reset input provides for reset and monitoring of the safety circuit.

The safety option module can be used in single-axis or multi-axis applications, and can be configured as a master or slave, based on its location in the system.

Safety Modes

Parameter 21 [Safety Mode] is used to configure the safety option module to operate in one of 11 user-selectable safety modes, based on combinations of the safety functions listed on page 21.

Table 6 - Parameter 21 Safety Modes

P21 Option	**Mode –** Description	Page
0	**Disabled** – In this mode, all safety functions are disabled.	22
1	**Safe Stop** – The safety option module activates the configured Safe Stop Type upon deactivation of the Safe Stop input or the occurrence of a Stop Category fault.	55
2	**Safe Stop with Door Monitoring** – In addition to monitoring for Safe Stop, the safety option module monitors the status of the door.	64
3	**Safe Limited Speed** – In addition to monitoring for Safe Stop, the safety option module monitors the feedback velocity and compares it to a configurable Safe Speed Limit. If the velocity exceeds the limit, the safety option module initiates the configured Safe Stop Type.	67
4	**Safe Limited Speed with Door Monitoring** – In addition to monitoring for Safe Stop and Safe Limited Speed, the safety option module monitors the status of the door.	70
5	**Safe Limited Speed with Enabling Switch Control** – In addition to monitoring for Safe Stop and Safe Limited Speed, the safety option module monitors the status of the Enabling Switch input.	73
6	**Safe Limited Speed with Door Monitor and Enabling Switch** – In addition to monitoring for Safe Stop and Safe Limited Speed, the safety option module monitors the status of the door and the Enabling Switch input.	75
7	**Safe Limited Speed** (status only) – In addition to monitoring for Safe Stop, the safety option module monitors the feedback velocity and compares it to a configurable Safe Speed Limit. If the velocity exceeds the limit, the system status is made available as a safe output intended for a safety programmable logic controller. No stopping action takes place.	79

Table 6 - Parameter 21 Safety Modes

P21 Option	**Mode –** Description	Page
8	**Slave, Safe Stop** – The safety option module performs the same functions as Safe Stop. However, it regards the Door Monitor input as a Door Control output from an upstream axis, and performs a logical AND with its internal Door Control signal to form the cascaded Door Control output.	86
9	**Slave, Safe Limited Speed** – The safety option module performs the same functions as Safe Limited Speed mode. However, it regards the Door Monitor input as a Door Control output from an upstream axis, and performs a logical AND with its internal Door Control signal to form the cascaded Door Control output.	90
10	**Slave, Safe Limited Speed** (status only) – The safety option module performs the same functions as Safe Limited Speed Status Only mode. However, it regards the Door Monitor input as a Door Control output from an upstream axis, and performs a logical AND with its internal Door Control signal to form the cascaded Door Control output.	94

IMPORTANT The Safe Speed Monitor option module must be used with the 20-750-DENC-1 dual-incremental encoder module or the 20-750-UFB-1 universal feedback module.

Disabled Mode

When P21 [Safety Mode] = 0 'Disabled' and P6 [Operating Mode] = 1 'Run' all safety functions are disabled. Input, output, or speed monitoring diagnostics do not take place and all outputs are in their safe state. Motion power is enabled for drive commissioning in this mode.

IMPORTANT The safety option module monitors motion for Safe Stop in every mode except Disabled.

Lock Monitoring

Lock monitoring helps prevent access to the hazard during motion. In many applications, it is not sufficient for the machine to initiate a stop command once the door has been opened because a high-inertia machine can take a long time to stop. Preventing access to the hazard until a safe speed has been detected can be the safest condition. The lock monitoring feature is used to verify the operation of the door locking mechanism.

Lock monitoring can be enabled on single units or on the first unit in a multi-axis system. If the Lock Monitor input (LM_In) indicates that the door is unlocked when the Door Control output (DC_Out) is in the locked state, or if the Lock Monitor input indicates locked when the Door Monitor input (DM_In) transitions from closed to open, the configured Safe Stop Type is initiated.

Safe Maximum Speed, Safe Maximum Acceleration, and Safe Direction Monitoring

Three additional safety functions, Safe Maximum Speed (SMS), Safe Maximum Acceleration (SMA) and Safe Direction Monitoring (SDM), operate independent of the other modes, relying on the Safe Stop function. When you configure the safety option module for Safe Maximum Speed, the feedback velocity is monitored and compared against a user-configurable limit. If the measured velocity is greater than or equal to the limit, the configured Safe Stop Type is executed.

When Safe Acceleration Monitoring is enabled, the option monitors the acceleration rate and compares it to a configured Safe Maximum Acceleration Limit. If acceleration is detected as greater than or equal to the Safe Maximum Acceleration Limit, an Acceleration fault occurs. If an Acceleration fault is detected while the option is actively monitoring motion, the configured Safe Stop Type is initiated.

Safe Direction Monitoring is also activated via option configuration. The option monitors the feedback direction and executes the configured Safe Stop Type when motion in the illegal direction is detected.

Refer to Chapter 9 for detailed information on these functions.

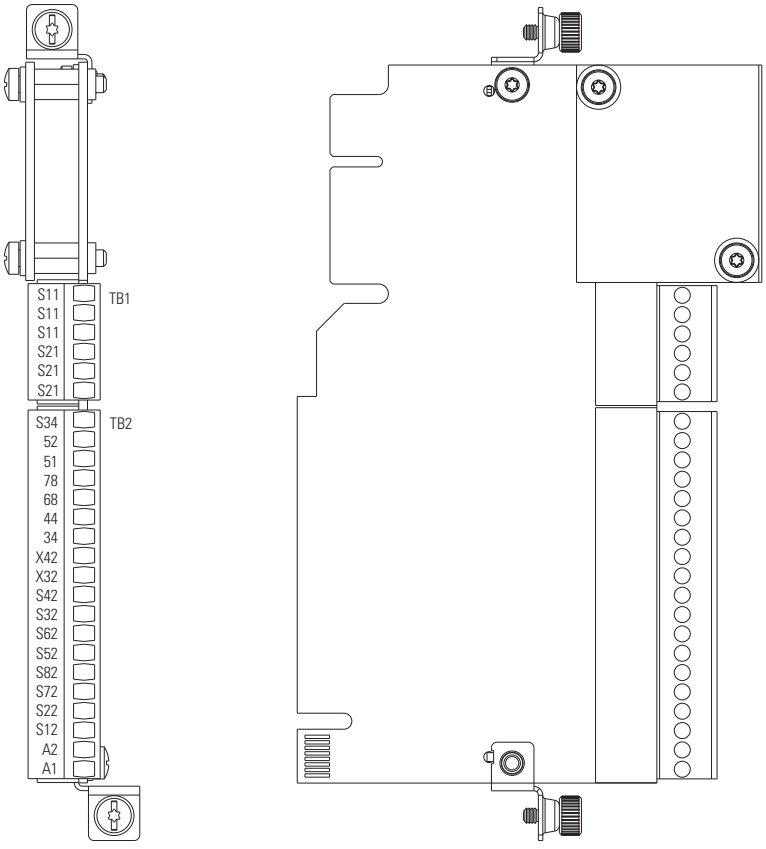
Hardware Features

The safety option module features five dual-channel inputs, two sets of sourcing safety outputs, and one bipolar safety output. You can configure dual-channel inputs to accept a following-contact configuration with two normally closed contacts, or one normally closed and one normally open contact. They can also be configured for single channel operation.

IMPORTANT	Single-channel operation does not meet SIL 3, PLe, cat. 4 safety integrity.

These inputs also support output signal switching devices (OSSD). Each output has integral pulse test checking circuitry.

Figure 1 - PowerFlex 750-Series Safe Speed Monitor Option Module



Configuration

Configure the PowerFlex 750-Series safety option module by setting configuration parameters with a HIM, RSLogix 5000® software, the Studio 5000 Logix Designer® application, or Connected Components Workbench™ software.

Table 7 - Parameter Configuration Options

Drive Family	RSLogix 5000 Software	Studio 5000 Logix Designer Application	Connected Components Workbench Software
PowerFlex 753 Frames 1...7	Version 16 or later with Drives AOP v3.01 or later	Version 21 or later	Version 9.01 or later
PowerFlex 755 Frames 1...7	Version 16 or later with Drives AOP v2.01 or later		
PowerFlex 755 Frames 8...10	Version 16 or later with Drives AOP v3.02 or later		
PowerFlex 755TR and PowerFlex 755TL Frames 8...12	Version 20 or later with PowerFlex 755T AOPs.		Version 10.0 or later
PowerFlex 755TR and PowerFlex 755TL Frames 5...7	Version 20 or later with PowerFlex 755T AOPs v1.08 or later.		
PowerFlex 755TS Frames 1...7	Version 20 or later with PowerFlex 755T AOPs v1.08 or later.		

All of these software configuration tools let you save the configuration and download it to another PowerFlex 750-Series drive. They also let you edit the configuration offline. We recommend that you always use the latest Drives AOP or version of Connected Components Workbench software. These are available for free download from the Product Compatibility and Download Center at: rok.auto/pcdc.

When the safety option module configuration is complete, it can be safety-locked to prevent unauthorized changes to the safety configuration. If a password was set to protect the safety configuration, you must enter the password before you can lock or unlock the configuration. Refer to Chapter 10 for instructions on setting up and resetting passwords. Refer to the PowerFlex 750-Series Drives Programming Manual, publication 750-PM001, for additional information about configuring the safety option module and configuration using the HIM.

RSLogix 5000 software, version 20 or later, and the Logix Designer application let you configure a Logix 5000™ controller for Automatic Device Configuration (ADC). This feature enables the controller to download the configuration into a new device. When this feature is used with the safety option module, manual steps are required after the controller downloads the configuration into the safety option module.

Installation and Wiring

This chapter provides details on connecting devices and wiring the safety option module board.

	**ATTENTION:** The following information is a guide for proper installation. Rockwell Automation does not assume responsibility for the compliance or the noncompliance to any code, national, local, or otherwise for the proper installation of this equipment. A hazard of personal injury and/or equipment damage exists if codes are ignored during installation.

IMPORTANT	Installation must be in accordance with the instructions in this user manual and the installation instructions for your drive. Only qualified, authorized personnel that are trained and experienced in functional safety can plan, implement, and apply functional safety systems.

IMPORTANT	During installation and maintenance, check your drive firmware release notes for known anomalies and verify that there are no safety-related anomalies.

The PowerFlex 750-Series Safe Speed Monitor option module is intended to be part of the safety-related control system. Before installation, perform a risk assessment that compares the PowerFlex 750-Series Safe Speed Monitor option module specifications and all foreseeable operational and environmental characteristics of the control system.

A safety analysis of the machine section that is controlled by the drive is required to determine how often to test the safety function for proper operation during the life of the machine.

Power Supply Requirements

The external power supply must conform to the Directive 2006/95/EC, 2014/35/EU Low Voltage, and UK Regulation 2016 No. 1101, by applying the requirements of EN61131-2 Programmable Controllers, Part 2 - Equipment Requirements and Tests and one of the following:

- EN60950 - SELV (Safety Extra Low Voltage)
- EN60204 - PELV (Protective Extra Low Voltage)
- IEC 60536 Safety Class III (SELV or PELV)
- UL 508 Limited Voltage Circuit
- 24V DC ±10% must be supplied by a power supply that complies with IEC/EN60204 and IEC/EN 61558-1.

IMPORTANT	The power supply for this safety option must be dedicated to the safety option and not connected to other machine I/O.

For specific power supply recommendations, refer to your drive installation instructions:

- PowerFlex 750-Series Products with TotalFORCE Control Installation Instructions, publication 750-IN100.
- PowerFlex 750-Series AC Drives Installation Instructions, publication 750-IN001.

For planning information, see the guidelines in Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1.

Remove Power to the System

Before performing any work on this drive, remove all power to the system.

ATTENTION:
- Electrical Shock Hazard. Verify that all sources of AC and DC power are de-energized and locked out or tagged out in accordance with the requirements of ANSI/NFPA 70E, Part II.
- To avoid an electric shock hazard, verify that the voltage on the bus capacitors has discharged before performing any work on the drive. Measure the DC bus voltage at the +DC and -DC terminals or test points. The voltage must be zero.

For the location of the terminal block and test point sockets, see the manual for your drive:

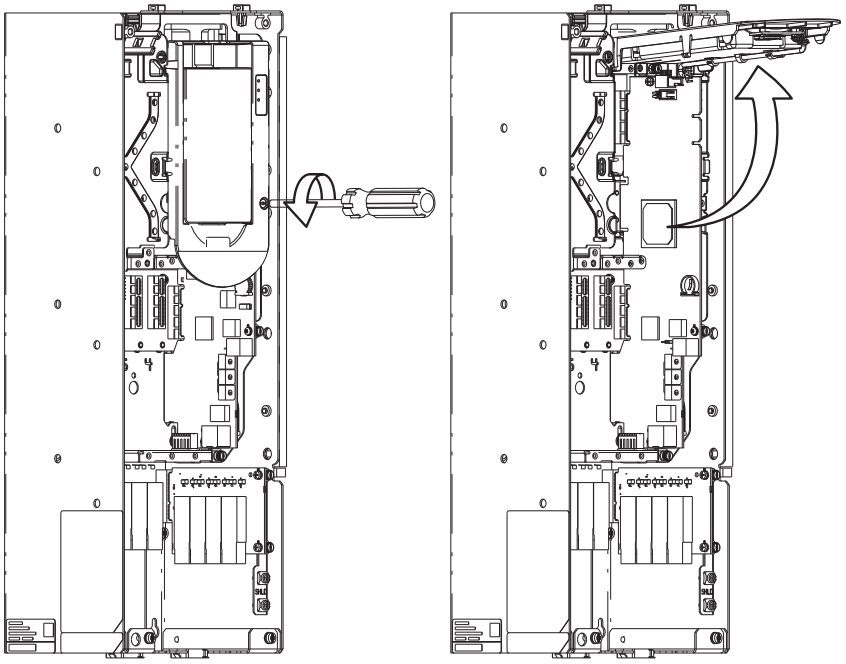
- PowerFlex 750-Series AC Drives Installation Instructions, publication 750-IN001 for more information.
- PowerFlex 750-Series Products with TotalFORCE Control Installation Instructions, publication 750-IN100.
- PowerFlex 755TM IP00 Open Type Kits Installation Instructions, publication 750-IN101.
- In Safe Torque Off mode, hazardous voltages may still be present at the motor. To avoid an electric shock hazard, disconnect power to the motor and verify that the voltage is zero before performing any work on the motor.

Access the Control Pod

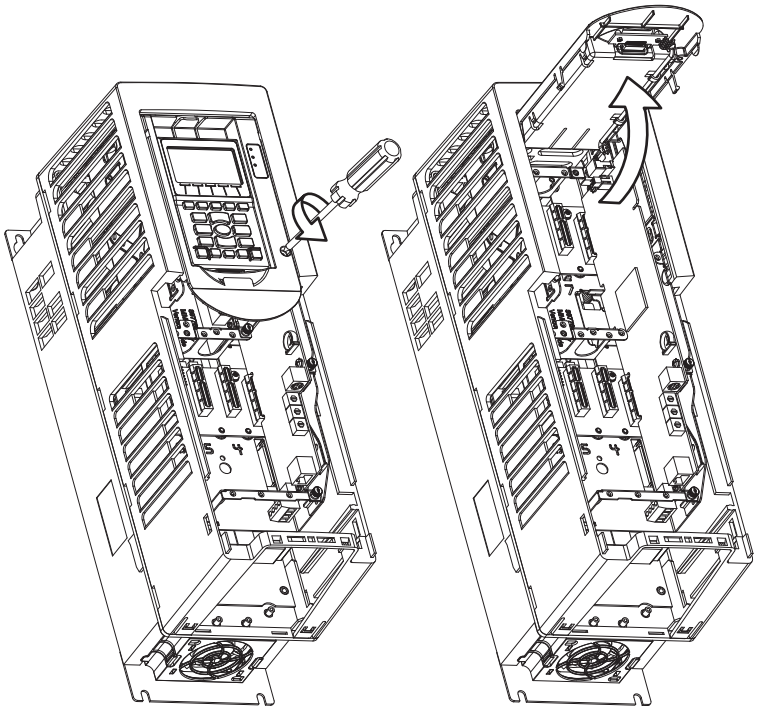
The option module is installed in the drive control pod. Different drives have different ways to access the control pod.

To access the control pod, follow these steps.

1. Open the door or remove the cover.
2. Loosen the retention screw on the HIM cradle.
3. Lift the cradle until the latch engages.



Panel-mounted Drives



Drives in Cabinet Enclosures

See the installation instructions for your drive for more information.

Set the SAFETY and Hardware ENABLE Jumpers

The drive ships with the SAFETY enable jumper and the hardware ENABLE jumper installed. Both of these jumpers are on the main control board.

IMPORTANT PowerFlex 755 drives (frames 8...10) control boards do not have a SAFETY enable jumper.

To configure the product to use the Safe Speed Monitor option module for PowerFlex 750-Series AC Drives, complete the following steps.

1. Access the control pod.
2. Locate and remove the SAFETY enable jumper on the main control board.
   If the SAFETY enable jumper is installed when using a safety option the drive will fault.
3. Locate and make sure that the hardware ENABLE jumper is installed.

Figure 2 - PowerFlex 753 Jumper Locations

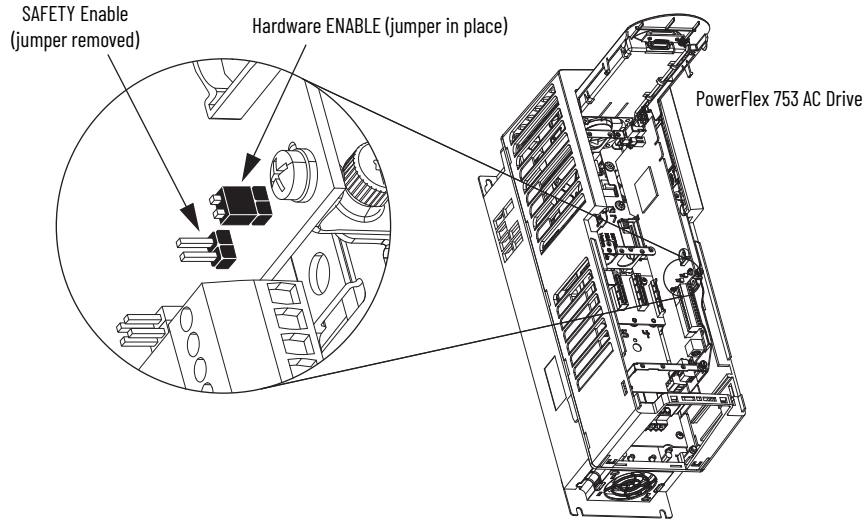
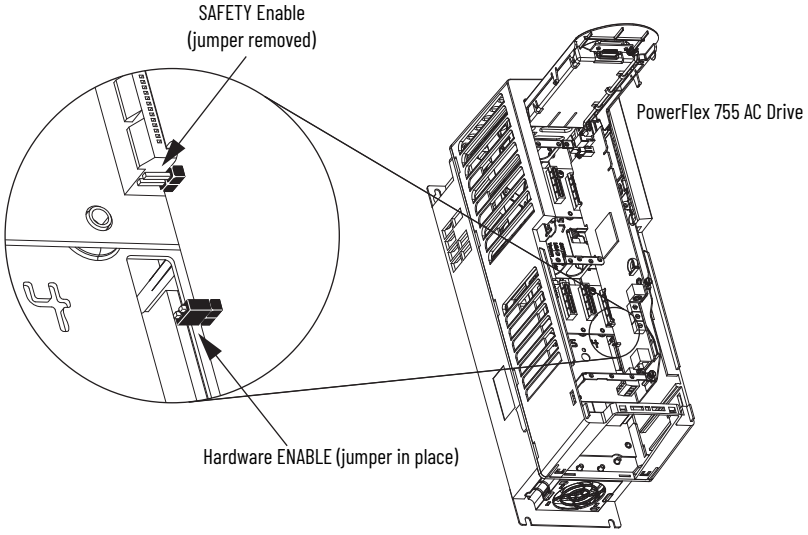


Figure 3 - PowerFlex 755 Jumper Locations (frames 1...7 only)



PowerFlex 755 (frames 8, 9, and 10) drives do not have a safety enable jumper.

Figure 4 - PowerFlex 755T Drive Products Jumper Locations

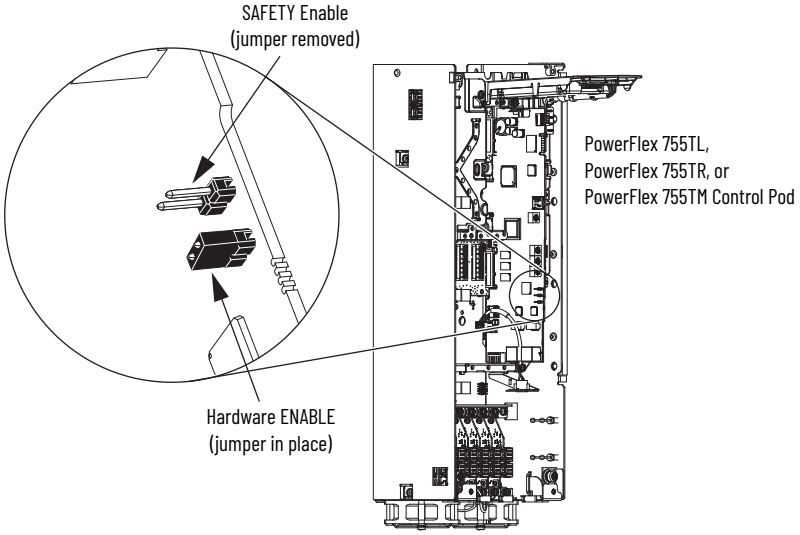
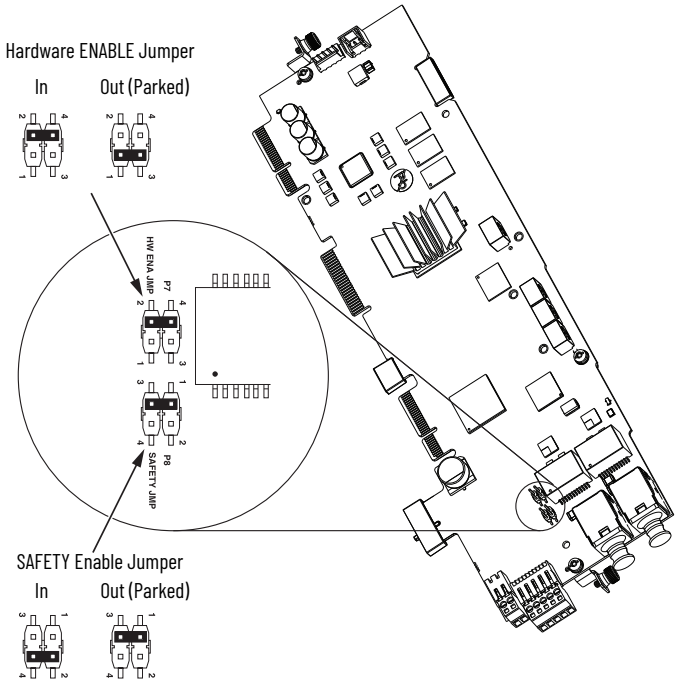


Figure 5 - PowerFlex 755TS Drive Jumper Location



Install the Safe Speed Monitor Option Module

There are multiple option module port positions in PowerFlex 750-Series drives. Restrictions and/or recommendations apply to selected option modules.

IMPORTANT	The PowerFlex Safe Speed Monitor option module must be installed in port 4, 5, or 6 and must be used with the 20-750-DENC-1 dual-incremental encoder module or the 20-750-UFB-1 universal feedback module. When used in an integrated motion application, the Safe Speed Monitor option module must be installed in port 6.

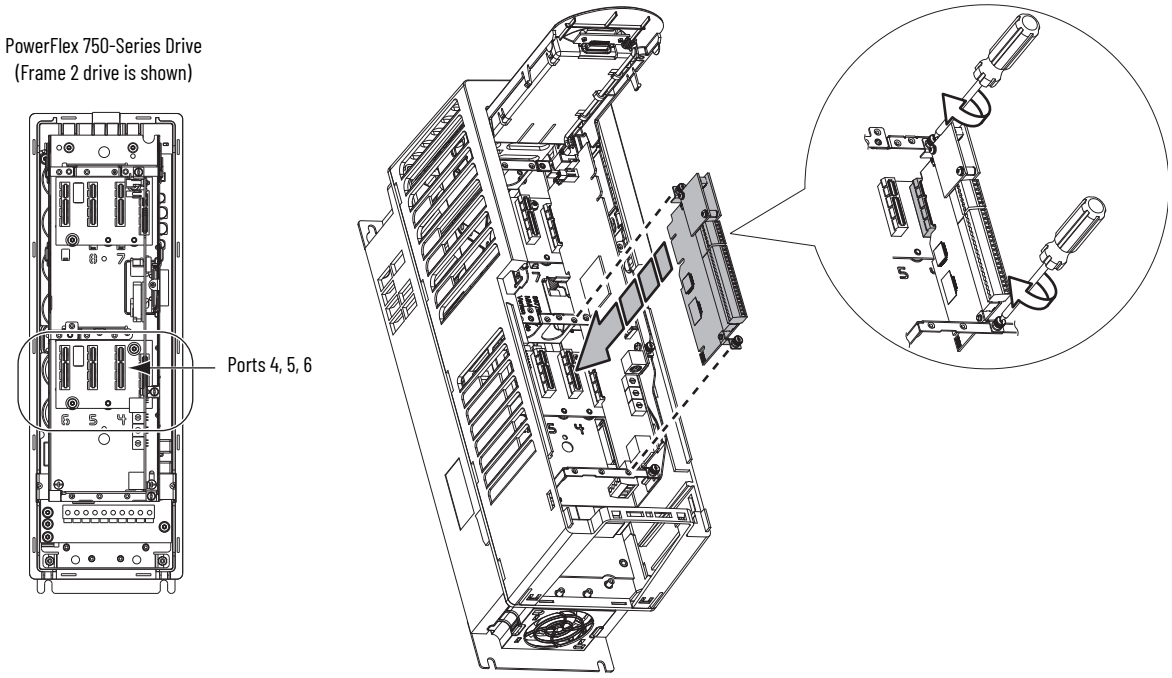
IMPORTANT	Only one safety option module can be installed at a time. Multiple or duplicate safety option module installations are not supported.

ATTENTION: Hazard of equipment damage exists if an option module is installed or removed while the drive has power applied. To avoid damaging the drive, verify that the voltage on the bus capacitors has discharged before performing any work on the drive.
- See PowerFlex 750-Series AC Drive Installation Instructions, publication 750-IN001 for more information.
- See PowerFlex 750-Series Products with TotalFORCE Control Installation Instructions, publication 750-IN100, for more information.

Follow these steps to install the safety option module.

1. Firmly press the option module edge connector into the desired option module port.
2. Tighten the top and bottom retaining screws.
   - Recommended torque = 0.45 N•m (4.0 lb•in)
   - Recommended screwdriver = T15 Hexalobular

IMPORTANT Do not overtighten retaining screws.



Installation in Frame 8 and Larger Drives

When installed in PowerFlex 755T drive products (Frame 8 or larger drive), an EMC Core Kit, catalog number 20-750-EMCSSM1-F8, is required.

Terminal Connections

Prepare wires for termination on the Safe Speed Monitor option module with a 6 mm (0.25 in.) strip length. Tighten all terminal screws firmly and recheck them after all connections have been made. Recommended terminal screw torque is 0.2 N•m (1.8 lb•in).

IMPORTANT Shielded cable is required for wiring the Safe Speed Monitor option module.

See page 139 for the I/O signal electrical specifications. To meet EMC requirements for I/O wiring and shielding, refer to the PowerFlex 750-Series AC Drive Installation Instructions,

publication 750-IN001, and PowerFlex 750-Series Products with TotalFORCE Control Installation Instructions, publication 750-IN100.

Table 8 - Safe Speed Monitor Option Module TB1 Pinouts

Terminal	Description	Signal Name
S11	Pulse Test	TEST_OUT_0
S11	Pulse Test	TEST_OUT_0
S11	Pulse Test	TEST_OUT_0
S21	Pulse Test	TEST_OUT_1
S21	Pulse Test	TEST_OUT_1
S21	Pulse Test	TEST_OUT_1

Table 9 - Safe Speed Monitor Option Module TB2 Pinouts

Terminal	Description	Signal Name
S34	Reset Input	RESET_IN
52	Door Control Output	DC_OUT_CH1
51	Door Control Output	DC_OUT_CH0
78	Safe Limited Speed Output	SLS_OUT_CH1
68	Safe Limited Speed Output	SLS_OUT_CH0
44	Safe Stop Output	SS_OUT_CH1
34	Safe Stop Output	SS_OUT_CH0
X42	Lock Monitoring Input	LM_IN_CH1
X32	Lock Monitoring Input	LM_IN_CH0
S42	Door Monitoring Input	DM_IN_CH1
S32	Door Monitoring Input	DM_IN_CH0
S62	Safe Limited Speed Input	SLS_IN_CH1
S52	Safe Limited Speed Input	SLS_IN_CH0
S82	Enabling Switch Monitoring Input	ESM_IN_CH1
S72	Enabling Switch Monitoring Input	ESM_IN_CH0
S22	Safe Stop Input	SS_IN_CH1
S12	Safe Stop Input	SS_IN_CH0
A2	Common, customer supplied	24V_COM
A1	+24V DC, customer supplied	+24V

Compatible Encoders

These feedback devices, or equivalents, are supported.

Cat. No. and Description		Additional Resources
Sin/Cos Encoders (1)	842HR-x*J**xxx*15FWY*x*	Refer to the Essential Components Selection Guide, publication EC-CA100, for catalog number, dimensions, and specifications for 842HR Sin/Cosine, and 847T and 847H Incremental Encoders.
Incremental Encoders (2)	847T-*xxxx- xxx*1024	
	847H-*xxxx- xxx*1024	
Rotary Motors	1326AB-B*xxxx*-M2L/S2L servo motors	Refer to the Kinetix® Rotary Motion Technical Data, publication KNX-TD001, for more information on these motors.
	MP-Series™ motors with embedded Sin/Cos or incremental encoders	
	HPK-Series™ Asynchronous Servo Motors	
	Any motor with SRS-60 Stegmann encoder	Refer to the product documentation for your specific motor to determine the encoder type.
	Any motor with SRM-60 Stegmann encoder	
	Any motor with SHS-170 Stegmann encoder	Refer to the product documentation for your specific motor to determine the encoder type.
	Any motor with SCS-60 Stegmann encoder	
	Any motor with SCS-Kit 101 Stegmann encoder	
	Any motor with SRS660 Stegmann encoder	

(1) Maximum cable length for sin/cos encoders is 90 m (295 ft).
(2) Maximum cable length for incremental encoders is 183 m (600 ft) when using 12V or 30.5 m (100 ft) when using 5V.

Connect an Encoder

The safety option module uses feedback that is connected to the 20-750-DENC-1 dual-incremental encoder module or the 20-750-UFB-1 universal feedback module.

Table 10 - Feedback Module Selection

Use This Feedback Module Cat. No.	With This Drive Family
20-750-DENC-1	PowerFlex 753 and PowerFlex 755 drives, or PowerFlex 755T drive products
20-750-UFB-1	PowerFlex 755 or PowerFlex 755T drive products

IMPORTANT The 20-750-DENC-1 dual-incremental encoder module and 20-750-UFB-1 universal feedback module have specified jumper or slider settings to enable use with the Safe Speed Monitor option module. Modules must be installed on the same backplane using ports 4, 5, or 6.

These are required parameter settings when used with the 20-750-UFB-1 universal feedback module.

- Set Safe Speed Monitor parameter P28 [Fbk 1 Type] to option 0 Sine/Cosine.
- Set Universal Feedback parameter P6 [FB0 Device Sel] and/or P36 [FB1 Device Sel] to a Sine/Cosine type device.

Table 11 - Dual Incremental Encoder Jumper Settings

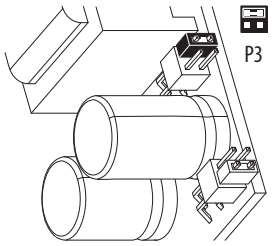
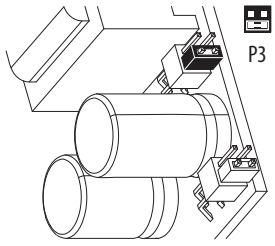
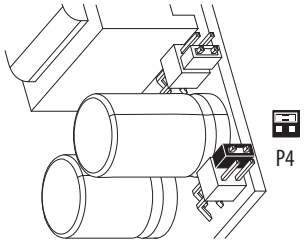
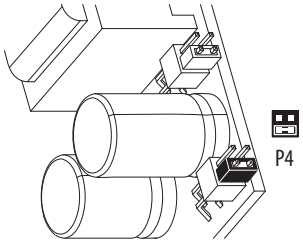
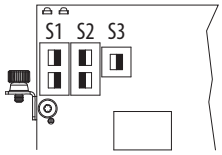
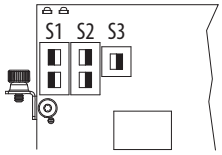
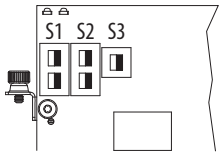
Jumper	Enabled Position	Storage Position
P3 - Safety Jumper Enables use with speed monitoring safety option module.		
P4 - 12V Jumper Enables use with 12 volt supply in 'Enabled' position and 5 volt supply in 'Storage' position.		

Table 12 - Universal Feedback Option Module DIP Switch Settings - Safety Application

Safety Channel Selection	DIP Switch Settings (1)
Primary Safety Channel To connect feedback signals to the Primary Safety Channel, set: S1 sliders to ON S2 sliders to OFF S3 slider to ON	
Secondary Safety Channel To connect feedback signals to the Secondary Safety Channel, set: S1 sliders to OFF S2 sliders to ON S3 slider to ON	
Primary and Secondary Safety Channels To connect feedback signals to both the Primary and Secondary Safety Channels, set: S1 sliders to ON S2 sliders to ON S3 slider to ON	

(1) DIP switches only function when safety channels are used.

For more information on how to connect encoders to the safety option module, refer to these publications:

- PowerFlex 750-Series Products with TotalFORCE Control Installation Instructions, publication 750-IN100.
- PowerFlex 750-Series AC Drive Installation Instructions, publication 750-IN001.

Notes:

Speed Monitoring I/O Signals

This chapter describes the input and output signals of the Safe Speed Monitor option module.

Inputs

The safety option module has five inputs capable of safety-certified dual-channel support. Each dual-channel input supports a specific safety function of the drive: Safe Stop, Safe Limited Speed, Door Monitoring, Enabling Switch Monitoring, and Lock Monitoring.

All five inputs are electrically identical and rely on the same pair of pulse test outputs, Test_Out_0 and Test_Out_1, when not using the OSSD configuration.

The inputs can be configured for one of the following settings:

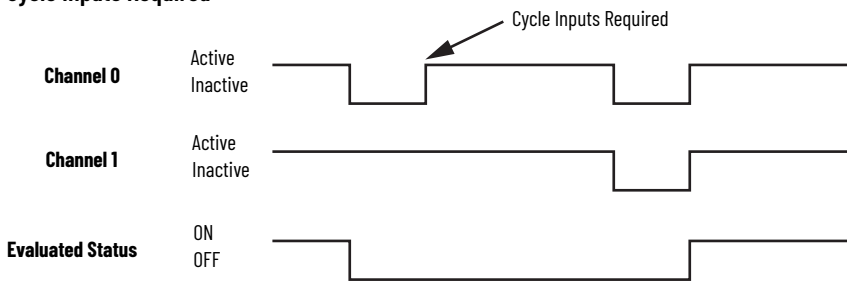
- 1 = Dual-channel equivalent (2 Normally Closed)
- 2 = Dual-channel equivalent 3 s (2 Normally Closed 3 Seconds)
- 3 = Dual-channel complementary (1 Normally Closed + 1 Normally Open)
- 4 = Dual-channel complementary 3 s (1 Normally Closed + 1 Normally Open 3 Seconds)
- 5 = Dual-channel SS equivalent 3 s (2 Output Signal Switching Devices 3 Seconds)
- 6 = Single Channel

IMPORTANT Single-channel configuration (1NC) is not SIL 3, PLe, cat. 4.

When configured for dual-channel operation, the consistency between the two channels is evaluated. For dual-channel equivalent configurations, the active state for both channel 0 and channel 1 is ON. For dual-channel complementary configurations, the active state for channel 0 is ON and the active state for channel 1 is OFF. Any time both channels are not active, the input pair is evaluated as OFF.

When both channels are active, if one channel's input terminal transitions from active to inactive and back to active, while the other channel's input terminal remains active, both channels must go inactive simultaneously before the evaluated status can return to ON. This condition is called 'cycle inputs required.'

Figure 6 - Cycle Inputs Required



If inputs are configured with the following dual channel settings, an Input fault occurs if the inputs are discrepant for longer than 3 seconds, or if a 'cycle inputs required' condition exists for longer than 3 seconds.

- 2 = Dual-channel equivalent 3 s (2NC 3 s)
- 4 = Dual-channel complementary 3 s (1NC + 1NO 3 s)
- 5 = Dual-channel SS equivalent 3 s (2 OSSD 3 s)

If inputs are configured with one of the following dual-channel settings that have no limit on the length of time that inputs can be discrepant, an input fault does not occur for any discrepant condition or for any 'cycle inputs required' condition.

- 1 = Dual-channel equivalent (2NC)
- 3 = Dual-channel complementary (1NC + 1NO)

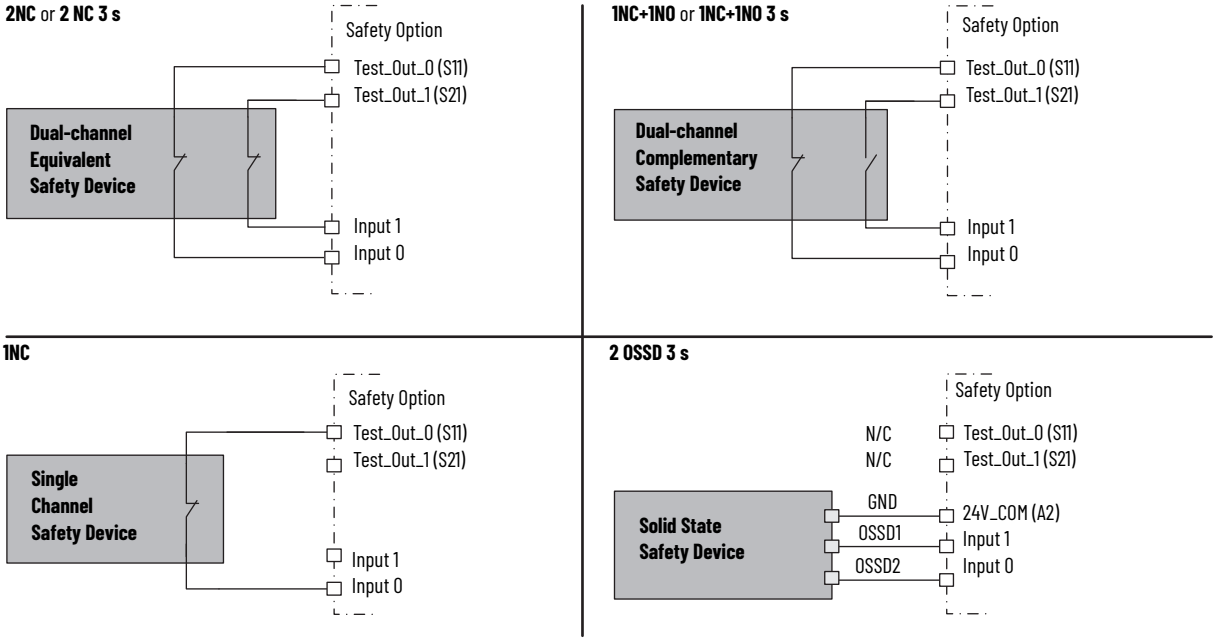
For all input settings except Dual-channel SS equivalent 3 s (2 OSSD 3 s), if one or two channels are connected to a 24V DC source other than terminals S11 and S21, a fault occurs.

I/O faults are Stop Category faults that initiate the configured Safe Stop Type. I/O faults are latched until the safety option module is successfully reset.

For more information on I/O faults, refer to Troubleshoot the PowerFlex Safe Speed Monitor Option Module on page 131.

When using a dual-channel complementary (1NC + 1NO) device, the normally open input must be connected to the second input, as shown in the illustration. For example, if the door is open when the input is ON, the normally open contact must be the second input (Input 1).

Figure 7 - Safety Input Wiring Examples



IMPORTANT Cross wiring of Test Outputs to Inputs is not allowed. For example, do not connect TEST_OUT_0 to Input 1 or TEST_OUT_1 to Input 0.

Table 13 - Safety Option Input Terminals

Function	Safe Stop (SS_In)	Safe Limited Speed (SLS_In)	Door Monitoring (DM_In)	Enabling Switch Monitoring (ESM_In)	Lock Monitoring (LM_In)
Input 0 = Channel 0	S12	S52	S32	S72	X32
Input 1 = Channel 1	S22	S62	S42	S82	X42

Short-circuits of the input loop to ground or 24V are detected. For dual-channel inputs, cross loops are also detected.

Safe Stop Input (SS_In)

The SS_In input is intended for connection to an E-stop device.

The SS_In input must be active to initiate Safe Stop monitoring. If the SS_In input is being monitored, a transition from ON to OFF (closed to open) is used to request the configured Safe Stop Type.

In a cascaded configuration, the SS_In inputs of the middle and last drives are connected to the Safe Stop (SS_Out) output of an upstream safety option module.

Safe Limited Speed Input (SLS_In)

The SLS_In input is used to connect to a switch whose OFF state requests Safe Limited Speed monitoring.

If Safe Limited Speed monitoring is configured, the SLS_In input is monitored from the time of a successful Safe Stop Reset or Safe Limited Speed Reset, until the time that the configured Safe Stop Type is initiated, or the safe state is entered.

If the SLS_In input is being monitored, the OFF state is used to request the Safe Limited Speed monitoring functionality of the safety option module.

In a cascaded configuration, the SLS_In inputs of the middle and last drives are connected to the Safe Limited Speed (SLS_Out) output of an upstream safety option module.

Door Monitor Input (DM_In)

This input monitors the status of the door to indicate if it is open or closed. The DM_In input can be connected to a non-guardlocking switch if the door does not need to be locked. The first unit in multi-axis systems monitors the door status.

The DM_In input is intended for connection to a guardlocking switch when the safety option module is configured as a master device with door monitoring. When the safety option module is configured as a slave in a cascaded system, its DM_In input is connected to the Door Control output (DC_Out) of the upstream safety option module.

See Door Control Output (DC_Out) on page 40 for more information.

Enabling Switch Monitor Input (ESM_In)

The ESM_In input is intended to be connected to an enabling switch. A 440J-N21TNPM enabling switch is recommended. The safety option module uses the ESM_In input as a safety enable only, not for control. The ESM_In inputs function and monitoring is performed by the first unit in multi-axis systems.

The ESM_In input ON state is used to enable motion under mode-specific conditions in the Safety Limited Speed with Enabling Switch (Lim Speed ES) and Safe Limited Speed with Door Monitoring and Enabling Switch Monitoring (LimSpd DM ES) modes.

See Safe Limited Speed with Door Monitoring Mode on page 70 and Safe Limited Speed with Door Monitoring and Enabling Switch Monitoring Mode on page 75 for the conditions that must be true to start monitoring the ESM_In input.

If the ESM_In input is OFF while it is being monitored, an ESM Monitoring fault (Stop Category Fault) occurs and the safety option module initiates the configured Safe Stop Type.

See Chapter 12 for information on faults and how to recover from them.

Lock Monitor Input (LM_In)

The LM_In input verifies that the guardlocking solenoid switch is locked. It is intended to confirm the door control function.

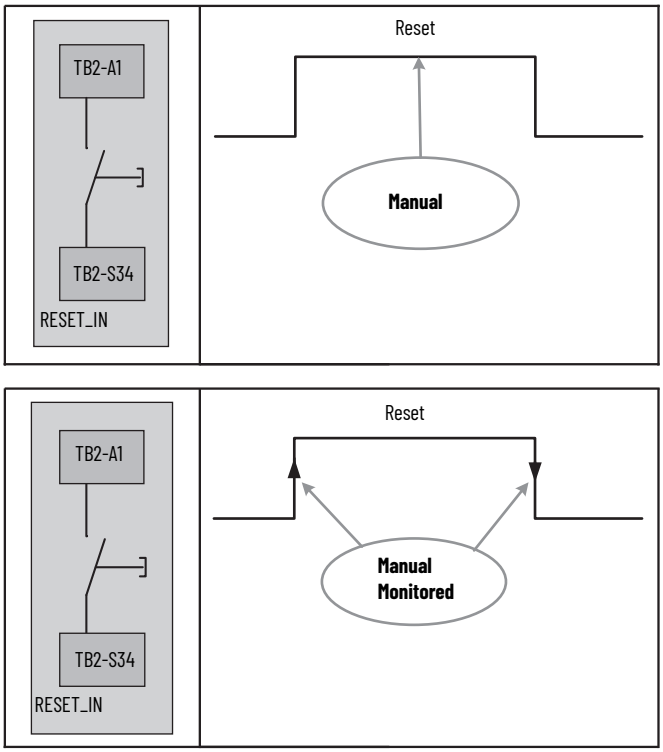
The LM_In input is monitored by the first unit in multi-axis systems.

Reset Input (Reset_In)

The Reset input is for reset and monitoring of the safety circuit. You can configure the reset input for automatic, manual, or manual-monitored reset types.

Wire the reset input terminal (TB2-S34) to the 24V DC input terminal (TB2-A1), depending on the configured reset type, as shown.

Figure 8 - Reset Input Examples



IMPORTANT	If you configure the safety option module for automatic reset, wiring of the reset input terminal (TB2-S34) is not required.

Outputs

The safety option module has three safety control outputs. The outputs have various output current capabilities, depending on function.

See the specifications in Specifications, Certifications, CE, and UKCA Conformity A to verify your power requirements.

Safe Stop Output (SS_Out)

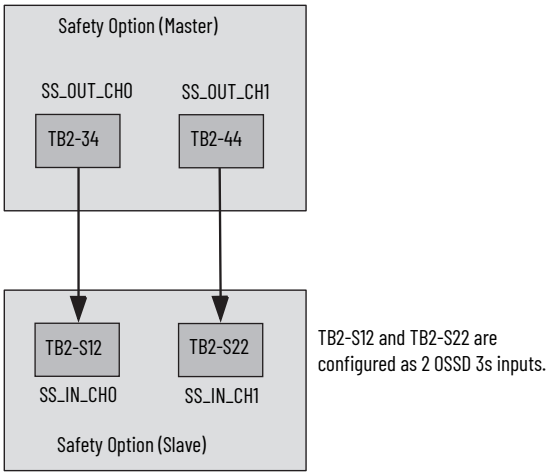
The safe state for this signal is OFF.

These outputs are typically used in multi-axis applications. In multi-axis applications, you can use these outputs to daisy-chain the master safety option module to a slave.

For SS_Out to SS_In cascaded signals, the interface is a dual-channel sourcing solid-state safety output that is connected to a dual-channel safety input configured as OSSD. The outputs are pulse-tested when the P72 [SS Out Mode] parameter is configured for pulse-testing.

IMPORTANT	If you disable pulse-testing on this output, the achievable SIL, Category, and PL ratings of your entire safety system are reduced.

Figure 9 - SS_Out to SS_In Connections for Multi-axis Applications



For more information on multi-axis configurations, see Cascaded Configurations starting on page 85.

Alternately, the first SS_Out output can be used to signal a programmable logic controller (PLC) that a Safe Stop has been requested.

If the SS_In is ON (closed) and a successful Safe Stop Reset is performed, the SS_Out output is turned ON. If Lock Monitoring is not enabled or the door control logic state is Unlock, the SS_Out signal turns ON immediately when the SS_In turns ON. If Lock Monitoring is enabled, and the door control logic state is Lock, the SS_Out signal is not turned ON until the door has been locked by using the DC_Out signal and the LM_In input has been verified as ON.

If the Safe Stop Type is initiated or if a Safe Stop is initiated due to a fault, the SS_Out output is turned OFF.

If an error is detected on either channel of the dual-channel output, a fault occurs. I/O faults are Stop Category faults that initiate the configured Safe Stop Type. The fault is latched until the safety option module is successfully reset.

For more information on faults, refer to Chapter 12.

Safe Limited Speed Output (SLS_Out)

The safe state for this signal in all cases is OFF.

The SLS_Out output functionality is determined by the configured Safety mode. If the SLS_In is ON and a successful Safe Stop or Safe Limited Speed reset is performed, the SLS_Out turns ON in all Safe Limited Speed modes except Safe Limited Speed Status Only.

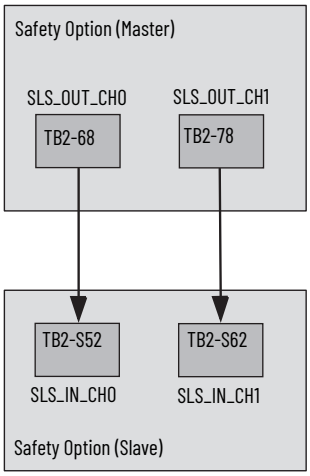
For the Safe Limited Speed modes (SLS), the SLS_Out is used to interconnect speed monitoring safety option modules in multi-axis applications. For SLS_Out to SLS_In cascaded signals, the interface is a dual-channel sourcing solid-state safety output that is connected to a dual-channel safety input configured as OSSD. The outputs are read back and pulse-tested when the P73 [SLS Out Mode] parameter is configured for pulse-testing.

IMPORTANT	If you disable pulse-testing on this output, the achievable SIL, Category, and PL ratings of your entire safety system are reduced.

For a single unit system or the last unit in a cascaded system, the SLS_Out is intended to be connected to an input of a safety programmable logic controller (PLC). The same PLC could also control the Safe Stop function with a safe PLC output that is connected to the Safe Stop input (SS_In).

For the first or middle units in a cascaded system, the SLS_Out is intended to be connected to the Safe Limited Speed input (SLS_In) of the next safety option module in the cascaded system. This lets one SLS switch enable Safe Limited Speed on all axes simultaneously.

Figure 10 - SLS_Out to SLS_In Connections for Multi-axis Applications



For more information on multi-axis configurations, see Cascaded Configurations starting on page 85.

For Safe Limited Speed Status Only modes, the SLS_Out output is used as an indication that the Safe Limited Speed monitoring is active and the monitored speed is less than the configured Safe Speed Limit. If the speed is greater than or equal to the Safe Speed Limit, the SLS_Out is turned OFF. When Safe Limited Speed monitoring is not active or the safety option module is in an SLS Monitoring Delay [LimSpd Mon Delay], the SLS_Out output is OFF. The SLS_Out output is turned OFF when a Safe Stop has been initiated, a fault has occurred, or the safety option module is in the safe state.

See Safe Limited Speed Status Only Mode on page 79 for more information.

If an error is detected on either channel of the dual-channel output, a fault occurs. I/O faults are Stop Category faults that initiate the configured Safe Stop Type. The fault is latched until the safety option module is successfully reset.

For more information on faults, refer to Chapter 12.

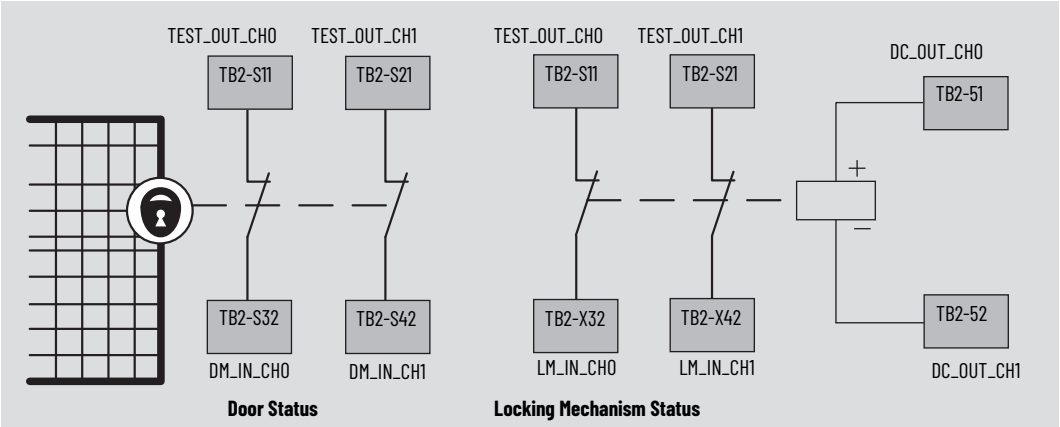
Door Control Output (DC_Out)

You can use this output for door control in single-axis and multi-axis systems. This output attempts to maintain last state when a fault occurs.

The DC_Out output is updated based on door control logic status, the P57 [Door Out Type] parameter setting, and any safe state faults that are detected.

This output is Unlocked only when motion is verified to be at Standstill Speed or Safe Limited Speed.

Figure 11 - Door Control and Lock Monitoring



Check your interlock switch for internal jumpers before installation.

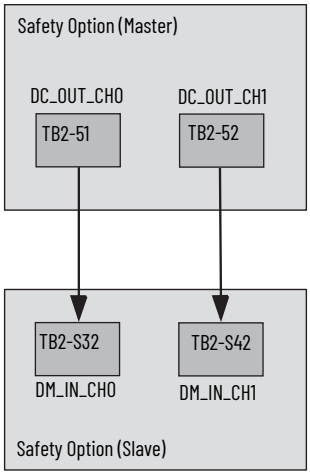
If an error is detected on either channel of the dual-channel output, a fault occurs. I/O faults are Stop Category faults that initiate the configured Safe Stop Type. The fault is latched until the safety option module is successfully reset.

For more information on faults, refer to Chapter 12.

The DC_Out output can be used as a bipolar output in Power to Release or Power to Lock configurations, or it can be configured as Cascading (2Ch Sourcing).

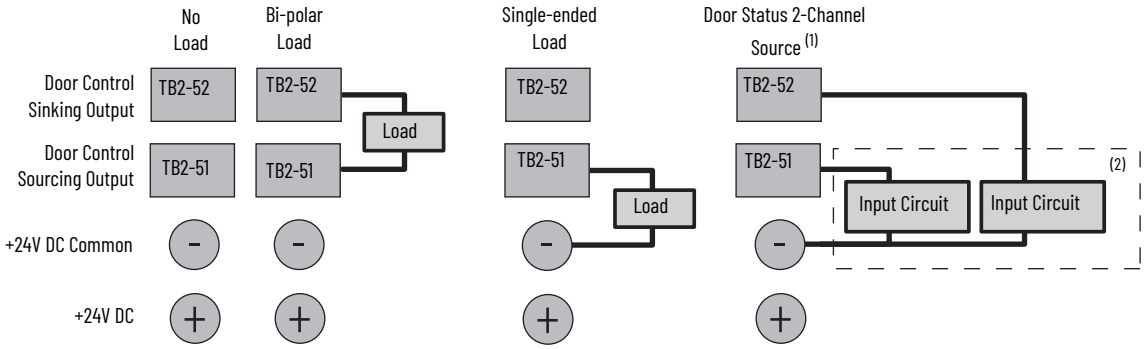
When the Door Control output is configured as cascading (2Ch Sourcing), the dual-channel bipolar output acts as two sourcing outputs capable of driving the OSSD Door Monitor input (DM_In) of the next speed monitoring safety option module in the cascaded chain. The DC_out output can also be used as a source for general-purpose inputs. In this configuration, the current is limited to 20 mA.

Figure 12 - Door Control Cascading Outputs



Only these wiring configurations which are shown below, are supported for the Door Control output.

Figure 13 - Door Control Output Wiring



(1) When wired as a source for a safety input, current is limited to 20 mA per output.
(2) For example, SmartGuard™ 600 controller, Guard I/O™ module.

Short-circuits of the output loop to ground or 24V are detected. For cascaded outputs, cross loops are also detected.

The outputs are pulse-tested when the P74 [Door Out Mode] parameter is configured for pulse-testing.

IMPORTANT	If you disable pulse-testing on this output, the achievable SIL, Category, and PL ratings of your entire safety system are reduced.

General Device and Feedback Monitoring Configuration

This chapter describes the general and feedback configuration settings that must be configured to operate the Safe Speed Monitor option module.

Cascaded Configuration

The safety option module can be used in single-axis or multi-axis applications. The P20 [Cascaded Config] parameter indicates the location of the safety option module in the system: Single Unit (Single), Cascaded First Unit (Multi First), Cascaded Middle Unit (Multi Mid), or Cascaded Last Unit (Multi Last). Single unit and cascaded first options are system masters.

See Chapter 8 for more information on cascaded configurations.

Safety Mode

You can configure the safety option module to operate in one of 11 user-selectable Safety modes, based on combinations of the safety functions that the option supports. The modes, except for Disabled, are described in detail in subsequent chapters of this manual.

Table 14 - Safety Mode Chapters

Safety Mode	Chapter
Master, Safe Stop (Safe Stop)	Chapter 6, Safe Stop and Safe Stop with Door Monitoring Modes
Master, Safe Stop with Door Monitoring (Safe Stop DM)	
Master, Safe Limited Speed (Lim Speed)	Chapter 7, Safe Limited Speed (SLS) Modes
Master, Safe Limited Speed with Door Monitoring (Lim Speed DM)	
Master, Safe Limited Speed with Enabling Switch Control (Lim Speed ES)	
Master, Safe Limited Speed with Door Monitor and Enabling Switch (LimSpd DM ES)	
Master, Safe Limited Speed Status Only (Lim Spd Stat)	
Slave, Safe Stop (Slv Safe Stp)	Chapter 8, Slave Modes for Multi-axis Cascaded Systems
Slave, Safe Limited Speed (Slv Lim Spd)	
Slave, Safe Limited Speed Status Only (Slv Spd Stat)	

Reset Type

You can configure the P22 [Reset Type] parameter as automatic, manual, or manual monitored. The default is manual monitored. The configured Reset Type applies to both Safe Stop and Safe Limited Speed Resets.

The Reset input does not require wiring for automatic reset configurations.

See Safe Stop Reset on page 59 and page 65, and Safe Limited Speed Reset on page 68, page 71, and page 73 for details on how the P22 [Reset Type] parameter affects Safe Stop and Safe Limited Speed operation.

ATTENTION: For all types of reset (automatic, manual, or manual monitored), if a reset of the Safe Stop or Safe Limited Speed functions can result in machine operation, the other speed monitoring functions must be configured to detect and prevent dangerous motion.

ATTENTION: The Safe Stop Reset does not provide safety-related restart according to EN 60204-1. Restart must be performed by external measures if automatic restart can result in a hazardous situation. You are responsible for determining whether automatic restart can pose a hazard.

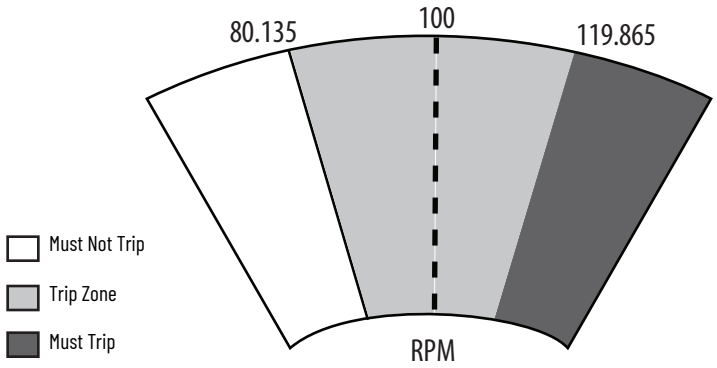
Overspeed Response Time

The P24 [OverSpd Response] parameter setting determines the maximum reaction time from an overspeed event to the initiation of the configured P45 [Safe Stop Type]. The safety reaction time from an overspeed event that triggers a Safe Stop Type, to the actual initiation of that Safe Stop Type, is equal to the value of the P24 [OverSpd Response] parameter. The configurable options are 42, 48, 60, 84, 132, 228, and 420 ms.

The P24 [OverSpd Response] parameter setting also determines the speed resolution that can be achieved. The Overspeed Response Time and the encoder resolution affect the speed resolution accuracy as shown in the tables on the following pages.

For example, if your Safe Maximum Speed is configured for 100.0 RPM, an encoder resolution of 128 and Overspeed Response Time of 42 ms results in a speed resolution accuracy of ±19.865 RPM. An SMS Speed fault can occur when encoder 1 is at 80.135 RPM. However, it's possible the SMS Speed fault won't occur until encoder 1 reaches 119.865 RPM.

Figure 14 - Overspeed Response Time Example



If your encoder resolution is not listed in the tables, use these equations.

For rotary systems, the conversion from Overspeed Response Time [OverSpd Response] to Speed Resolution in revolutions per minute is:

$$\text{Speed Resolution (RPM)} = \frac{15000}{(\text{OverSpd Response} - 36) \times \text{Feedback Resolution}} + \frac{\text{Speed (RPM)} \times 0.02}{(\text{OverSpd Response} - 36)}$$

For linear systems, the conversion from Overspeed Response Time [OverSpd Response] to mm/s is:

$$\text{Speed Resolution (mm/s)} = \frac{250}{(\text{OverSpd Response} - 36) \times \text{Feedback Resolution}} + \frac{\text{Speed (RPM)} \times 0.02}{(\text{OverSpd Response} - 36)}$$

Speed Resolution Accuracy for Rotary Systems

Table 15 - Encoder Resolution 16 lines/rev

Overspeed Response Time, P24 (OverSpd Response) Setting	Speed (RPM)					
	1	10	100	1000	10,000	100,000
42	156.253	156.283	156.583	159.583	189.583	489.583
48	78.127	78.142	78.292	79.792	94.792	244.792
60	39.063	39.071	39.146	39.896	47.396	122.396
84	19.532	19.535	19.573	19.948	23.698	61.198
132	9.766	9.768	9.786	9.974	11.849	30.599
228	4.883	4.884	4.893	4.987	5.924	15.299
420	2.441	2.442	2.447	2.493	2.962	7.650

Table 16 - Encoder Resolution 128 lines/rev

Overspeed Response Time, P24 (OverSpd Response) Setting	Speed (RPM)					
	1	10	100	1000	10,000	93,750
42	19.535	19.565	19.865	22.865	52.865	332.031
48	9.767	9.782	9.932	11.432	26.432	166.016
60	4.884	4.891	4.966	5.716	13.216	83.008
84	2.442	2.446	2.483	2.858	6.608	41.504
132	1.221	1.223	1.242	1.429	3.304	20.752
228	0.610	0.611	0.621	0.715	1.652	10.376
420	0.305	0.306	0.310	0.357	0.826	5.188

Table 17 - Encoder Resolution 1000 lines/rev

Overspeed Response Time, P24 (OverSpd Response) Setting	Speed (RPM)					
	1	10	100	1000	10,000	12,000
42	2.503	2.533	2.833	5.833	35.833	42.500
48	1.252	1.267	1.417	2.917	17.917	21.250
60	0.626	0.633	0.708	1.458	8.958	10.625
84	0.313	0.317	0.354	0.729	4.479	5.313
132	0.156	0.158	0.177	0.365	2.240	2.656
228	0.078	0.079	0.089	0.182	1.120	1.328
420	0.039	0.040	0.044	0.091	0.560	0.664

Table 18 - Encoder Resolution 1024 lines/rev

Overspeed Response Time, P24 (OverSpd Response) Setting	Speed (RPM)					
	1	10	100	1000	10,000	11,718.75
42	2.445	2.475	2.775	5.775	35.775	41.504
48	1.222	1.237	1.387	2.887	17.887	20.752
60	0.611	0.619	0.694	1.444	8.944	10.376
84	0.306	0.309	0.347	0.722	4.472	5.188
132	0.153	0.155	0.173	0.361	2.236	2.594
228	0.076	0.077	0.087	0.180	1.118	1.297
420	0.038	0.039	0.043	0.090	0.559	0.648

Table 19 - Encoder Resolution 3000 lines/rev

Overspeed Response Time, P24 (OverSpd Response) Setting	Speed (RPM)				
	1	10	100	1000	4000
42	0.837	0.867	1.167	4.167	14.167
48	0.418	0.433	0.583	2.083	7.083
60	0.209	0.217	0.292	1.042	3.542
84	0.105	0.108	0.146	0.521	1.771
132	0.052	0.054	0.073	0.260	0.885
228	0.026	0.027	0.036	0.130	0.443
420	0.013	0.014	0.018	0.065	0.221

Table 20 - Encoder Resolution 5000 lines/rev

Overspeed Response Time, P24 (OverSpd Response) Setting	Speed (RPM)				
	1	10	100	1000	2400
42	0.503	0.533	0.833	3.833	8.500
48	0.252	0.267	0.417	1.917	4.250
60	0.126	0.133	0.208	0.958	2.125
84	0.063	0.067	0.104	0.479	1.063
132	0.031	0.033	0.052	0.240	0.531
228	0.016	0.017	0.026	0.120	0.266
420	0.008	0.008	0.013	0.060	0.133

Speed Resolution Accuracy for Linear Systems

Table 21 - Encoder Resolution 500 lines/mm

Overspeed Response Time, P24 (OverSpd Response) Setting	Speed (mm/s)					
	0.01	0.1	1	10	100	400
42	0.083	0.084	0.087	0.117	0.417	1.417
48	0.042	0.042	0.043	0.058	0.208	0.708
60	0.021	0.021	0.022	0.029	0.104	0.354
84	0.010	0.010	0.011	0.015	0.052	0.177
132	0.005	0.005	0.005	0.007	0.026	0.089
228	0.003	0.003	0.003	0.004	0.013	0.044
420	0.001	0.001	0.001	0.002	0.007	0.022

Table 22 - Encoder Resolution 1000 lines/mm

Overspeed Response Time, P24 (OverSpd Response) Setting	Speed (mm/s)					
	0.01	0.1	1	10	100	200
42	0.042	0.042	0.045	0.075	0.375	0.708
48	0.021	0.021	0.023	0.038	0.188	0.354
60	0.010	0.011	0.011	0.019	0.094	0.177
84	0.005	0.005	0.006	0.009	0.047	0.089
132	0.003	0.003	0.003	0.005	0.023	0.044
228	0.001	0.001	0.001	0.002	0.012	0.022
420	0.001	0.001	0.001	0.001	0.006	0.011

Table 23 - Encoder Resolution 5000 lines/mm

Overspeed Response Time, P24 (OverSpd Response) Setting	Speed (mm/s)				
	0.01	0.1	1	10	40
42	0.008367	0.008667	0.011667	0.041667	0.141667
48	0.004183	0.004333	0.005833	0.020833	0.070833
60	0.002092	0.002167	0.002917	0.010417	0.035417
84	0.001046	0.001083	0.001458	0.005208	0.017708
132	0.000523	0.000542	0.000729	0.002604	0.008854
228	0.000261	0.000271	0.000365	0.001302	0.004427
420	0.000131	0.000135	0.000182	0.000651	0.002214

Table 24 - Encoder Resolution 20,000 lines/mm

Overspeed Response Time, P24 (OverSpd Response) Setting	Speed (mm/s)			
	0.01	0.1	1	10
42	0.002117	0.002417	0.005417	0.035417
48	0.001058	0.011208	0.002708	0.017708
60	0.000529	0.000604	0.001354	0.008854
84	0.000265	0.000302	0.000677	0.004427
132	0.000132	0.000151	0.000339	0.002214
228	0.000066	0.000076	0.000169	0.001107
420	0.000033	0.000038	0.000085	0.000553

General Parameter List

Set these parameters to configure general operation of the safety option module.

File	Group	No.	Display Name Full Name Description	Values		Read-Write	Data Type
HOST GROUPS	General	20	**Cascaded Config** Cascaded Configuration Defines whether the speed monitoring safety option module is a single unit or if it occupies a first, middle, or last position in a multi-axis cascaded system. 'Single' (0) - Single Unit System 'Milti First' (1) - Cascaded System First Unit 'Multi Mid' (2) - Cascaded System Middle Unit 'Multi Last' (3) - Cascaded System Last Unit	Default: Options:	0 = 'Single' 0 = 'Single' 1 = 'Multi First' 2 = 'Multi Mid' 3 = 'Multi Last'	RW	8-bit Integer
		21	**Safety Mode** Safety Mode Defines the primary operating mode of the speed monitoring safety functions. 'Safe Stop' (1) - Master, Safe Stop 'Safe Stop DM' (2) - Master, Safe Stop with Door Monitoring 'Lim Speed' (3) - Master, Safe Limited Speed 'Lim Speed DM' (4) -Master, Safe Limited Speed with Door Monitoring 'Lim Speed ES' (5) - Master, Safe Limited Speed with Enabling Switch Control 'LimSpd DM ES' (6) - Master, Safe Limited Speed with Door Monitoring and Enabling Switch Control 'Lim Spd Stat' (7) - Master, Safe Limited Speed Status Only 'Slv Safe Stp' (8) - Slave, Safe Stop 'Slv Lim Spd' (9) - Slave, Safe Limited Speed 'Slv Spd Stat' (10) - Slave, Safe Limited Speed Status Only	Default: Options:	1 = 'Safe Stop' 0 = 'Disabled' 1 = 'Safe Stop' 2 = 'Safe Stop DM' 3 = 'Lim Speed' 4 = 'Lim Speed DM' 5 = 'Lim Speed ES' 6 = 'LimSpd DM ES' 7 = 'Lim Spd Stat' 8 = 'Slv Safe Stp' 9 = 'Slv Lim Spd' 10 = 'Slv Spd Stat'	RW	8-bit Integer
		22	**Reset Type** Reset Type Defines the type of reset used by the safety option module.	Default: Options:	2 = 'Monitored' 0 = 'Automatic' 1 = 'Manual' 2 = 'Monitored' (Manual Monitored)	RW	8-bit Integer
		24	**OverSpd Response** Over Speed Response Configuration for the feedback interface sampling rate.	Default: Options:	0 = '42 ms' 0 = '42 ms' 1 = '48 ms' 2 = '60 ms' 3 = '84 ms' 4 = '132 ms' 5 = '228 ms' 6 = '420 ms'	RW	8-bit Integer

Feedback Monitoring

The P27 [Fbk Mode] parameter defines whether the feedback monitoring devices are configured as a single encoder or as dual encoders. When two encoders are used, the P27 [Fbk Mode] parameter also defines the type of discrepancy checking that is performed between the two encoders.

IMPORTANT	Feedback device 1 can be a Sin/Cos or incremental feedback device. Feedback device 2 can only be an incremental feedback device.

You choose the type of feedback device, either sine/cosine or incremental for encoder 1 by using the P28 [Fbk 1 Type] parameter. You also choose the feedback type, resolution, and polarity of both encoders.

Configure the feedback type as rotary or linear by using the [Fbk *x* Units] parameter. Configure the resolution in lines per revolution or lines per millimeter by using the [Fbk *x* Resolution] parameter. In these parameter names the *x* is '1' for encoder 1 and '2' for encoder 2.

For dual-encoder configurations, the resolution of the first encoder can be different than the resolution of the second encoder. After discrepancy testing has passed, the speed, relative position, and direction used by the safety option module are based on encoder 1.

IMPORTANT	For dual-encoder configurations, the resolution of the first encoder can be different than the resolution of the second encoder, but it must be equal to or higher than the resolution of the second encoder.

Feedback Polarity

Configure the direction of polarity to be the same as the encoder or reversed by using the P30 [Fbk 1 Polarity] parameter. The safety option module defines the normal positive direction for encoders as A leading B. To use encoders where B leads A, you must enter 1 for the P30 [Fbk 1 Polarity] parameter. Set the P35 [Fbk 2 Polarity] parameter so that the resulting speed direction is of the same polarity as encoder 1.

Single Encoder

If the P27 [Fbk Mode] parameter is set to 1 Encoder, the single encoder input is processed redundantly and cross-checked in a 1oo2 architecture. The speed, direction, and stopped status are derived from the single encoder by the 1oo2 architecture.

Refer to Considerations for Safety Ratings, on page 17, for more information.

Dual Encoders

If the P27 [Fbk Mode] parameter is set to 2 Encoders, each encoder input is processed by a single channel and cross-checked in a 1oo2 architecture. Discrepancy checking is performed between the two encoders. After the discrepancy checks have passed, the speed, direction, and stopped status are derived from encoder 1.

IMPORTANT	All monitoring functions are based on the speed of encoder 1. The encoder 2 signal is used for fault diagnostics.

Speed and direction checks are affected by these parameters:

- Dual Feedback Speed Ratio, P39 [Fbk Speed Ratio]
- Dual Feedback Position Tolerance, P41 [Fbk Pos Tol]
- Dual Feedback Speed Discrepancy Tolerance, P40 [Fbk Speed Tol]

Dual Feedback Speed Ratio

The Dual Feedback Speed Ratio, P39 [Fbk Speed Ratio] parameter, is defined as the ratio of the expected speed of encoder 2 divided by the expected speed of encoder 1. This parameter configures the anticipated gearing between encoder 1 and encoder 2.

$$\text{Dual Feedback Speed Ratio P39 [Fdk Speed Ratio] Parameter} = \frac{\text{Expected Speed of Encoder 2}}{\text{Expected Speed of Encoder 1}}$$

If P27 [Fbk Mode] equals 0 (1 encoder), the only legal value for P39 [Fbk Speed Ratio] parameter is 0.0.

If P27 [Fbk Mode] is greater than 0, the range of legal values for P39 [Fbk Speed Ratio] is from 0.0001...10,000.0.

For example, if encoder 2's speed is expected to be 1000 revolutions per second while encoder 1's speed is expected to be 100 revolutions per second, configure P39 [Fbk Speed Ratio] as 10.0.

The units used to measure encoder speed are configurable as either rotary (rev) or linear (mm) units. Any combination of rotary and linear units for the two encoders is allowed.

Dual Feedback Position Discrepancy Tolerance

The Dual Feedback Position Discrepancy Tolerance, P41[Fbk Pos Tol] parameter defines the cumulative position discrepancy that is tolerated between encoder 1 and encoder 2. The position discrepancy is defined as position change relative to encoder 1.

IMPORTANT The relative position discrepancy difference is reset to zero at each Safe Stop Reset.

This discrepancy checking is performed only while the [Fbk Mode] parameter is equal to one of these values.

Feedback Mode, P27 [Fbk Mode] Parameter Settings	
1	Dual encoder with speed and position discrepancy checking
3	Dual encoder with position discrepancy checking

This table defines the legal values for each Feedback mode value.

Feedback Mode, P27 [Fbk Mode] Values		Dual Feedback Position Discrepancy Tolerance, P41 [Fbk Pos Tol] Legal Values
0	One encoder	0
1	Dual encoder with speed and position discrepancy	1...65,535 in degrees (rotary encoders) or mm (linear encoders) relative to the resolution of encoder 1
2	Dual encoder with speed discrepancy checking	0
3	Dual encoder with position discrepancy checking	1...65,535 in degrees (rotary encoders) or mm (linear encoders) relative to the resolution of encoder 1

If an illegal value is detected, an Invalid Configuration fault occurs and the safety option module remains in the Safe State.

IMPORTANT When setting discrepancy tolerances, consider that configuring a high-gear ratio between encoder 1 and encoder 2 can lead to unexpected dual-feedback position faults. This is because a very large encoder 1 movement translates into a very small encoder 2 movement.

Dual Feedback Speed Discrepancy Tolerance

The Dual Feedback Speed Discrepancy Tolerance P40 [Fbk Speed Tol], defines the discrepancy that is tolerated for a difference in speed between encoder 1 and encoder 2. This

speed is relative to encoder 1. This discrepancy checking is performed only while the Feedback mode is equal to one of these values.

Feedback Mode, P27 [Fbk Mode] Parameter Settings	
1	Dual encoder with speed and position discrepancy checking
2	Dual encoder with speed discrepancy checking

For rotary systems, the value is specified in revolutions per minute. For linear systems, the value is specified in mm per second.

Feedback Mode, P27 [Fbk Mode] Parameter Values		Dual Feedback Speed Discrepancy Tolerance, P40 [Fbk Speed Tol] Parameter Values
0	One encoder	0
1	Dual encoder with speed and position discrepancy checking	0.1...6553.5 in rev/min (rotary encoders) or mm/s (linear encoders)
2	Dual encoder with speed discrepancy checking	0.1...6553.5 in rev/min (rotary encoders) or mm/s (linear encoders)
3	Dual encoder with position discrepancy checking	0

If an illegal value is detected, an Invalid Configuration fault occurs and the safety option module remains in the Safe State.

Feedback Voltage Monitor Range

Use the P32 [Fbk 1 Volt Mon] and P37 [Fbk 2 Volt Mon] parameters to set the feedback voltage monitoring range. The monitoring ranges help define the trip zone for encoder 1 and encoder 2, respectively.

Table 25 - Feedback Voltage Monitoring Range

	Fbk *x* Volt Mon Setting	**5**	**9**	**12**	**14**
	Range	**4.5...5.5V**	**7...12V**	**11...14V**	**11.5...15V**
	Must Trip	< 4.5V	< 7V	< 11V	< 11.5V
The encoder must be specified	Trip	4.5...4.75V	7...7.4V	11...11.6V	11.5...12.25V
to operate across this complete	Must Not Trip	4.75...5.25V	7.4...11.4V	11.6...13.3V	12.25...14.75V
range or larger.	Trip	5.25...5.5V	11.4...12.0V	13.3...14.0V	14.75...15.5V
	Must Trip	>5.5V	> 12.0V	>14.0V	>15.5V

Your power supply must stay within the No Trip range.

Feedback Fault

The allowable frequency of feedback input signals is limited. The safety option module monitors feedback signals whenever its configuration is valid and the Safety mode is not configured as Disabled.

Table 26 - Maximum Feedback Frequency

Encoder Type	Maximum Frequency
Sine/cosine	≤ 100 kHz
Incremental	≤ 200 kHz

If the feedback signals indicate greater than or equal to the maximum value, a Feedback_*x* fault (Safe State fault) occurs (*x* equals 1 or 2 depending on which encoder has the fault).

Diagnostics are performed on the encoder input signals. If the encoder diagnostic tests fail, a Feedback_*x* fault (Safe State fault) occurs.

Feedback Parameter List

To define the type of feedback used by the safety option module, set these parameters.

Table 27 - Feedback Parameter List

File	Group	No.	Display Name Full Name Description	Values		Read-Write	Data Type
HOST GROUPS	Feedback	27	**Fbk Mode** Feedback Mode Selects the number of feedback devices and the type of discrepancy checking. 'Single Fbk' (0) - 1 Encoder 'Dual S/P Chk' (1) - 2 Encoders with Speed and Position Discrepancy Checking 'Dual Spd Chk' (2) - 2 Encoders with Speed Discrepancy Checking 'Dual Pos Chk' (3) - 2 Encoders with Position Discrepancy Checking	Default: Options:	0 = 'Single Fbk' 0 = 'Single Fbk' 1 = 'Dual S/P Chk' 2 = 'Dual Spd Chk' 3 = 'Dual Pos Chk'	RW	8-bit Integer
		28	**Fbk 1 Type** Feedback 1 Type Selects the type of feedback for encoder 1. When using the Safe Speed Monitor option module with a 20-750-UFB-1 Universal Feedback module, set this parameter to 0 'Sine/Cosine' and make sure that the Universal Feedback module is set to a Sine/Cosine type device (P6 [FB0 Device Sel] and/or P36 [FB1 Device Sel]).	Default: Options:	1 = 'TTL' 0 = 'Sine/Cosine' 1 = 'TTL' (Incremental)	RW	8-bit Integer
		29	**Fbk 1 Units** Feedback 1 Units Selects rotary or linear feedback for encoder 1.	Default: Options:	0 = 'Rev' 0 = 'Rev' (Rotary) 1 = 'mm' (Linear)	RW	8-bit Integer
		30	**Fbk 1 Polarity** Feedback 1 Polarity Defines the direction polarity for encoder 1.	Default: Options:	0 = 'Normal' 0 = 'Normal' (Same as encoder) 1 = 'Reversed'	RW	8-bit Integer
		31	**Fbk 1 Resolution** Feedback 1 Resolution Counts/Revolution. 1...65,535 pulses/revolution or pulses/mm based on rotary or linear configuration defined by P29 [Fbk 1 Units].	Default: Min/Max:	1024 1 / 65,535	RO	16-bit Integer

Table 27 - Feedback Parameter List (Continued)

File	Group	No.	Display Name Full Name Description	Values		Read-Write	Data Type
HOST GROUPS	Feedback	32	**Fbk 1 Volt Mon** Feedback 1 Voltage Monitor Encoder 1 voltage to be monitored.	Default: Options:	0 = Voltage not monitored 0 = Voltage not monitored 5 = 5V +/- 5% 9 = 7...12V 12 = 12V +/- 5% 24 = 24V - 10%...24V + 5%	RW	8-bit Integer
		33	**Fbk 1 Speed** Feedback 1 Speed Displays the output speed of encoder 1. Units based on rotary or linear configuration defined by P29 [Fbk 1 Units].	Units: Min/Max:	RPM mm/s -214,748,364.8 / 214,748,364.7 RPM -214,748,364.8 / 214,748,364.7mm/s	RO	32-bit Integer
		34	**Fbk 2 Units** Feedback 2 Units Selects rotary or linear feedback for encoder 2.	Default: Options:	0 = 'Rev' 0 = 'Rev' (Rotary) 1 = 'mm' (Linear)	RW	8-bit Integer
		35	**Fbk 2 Polarity** Feedback 2 Polarity Defines the direction polarity for encoder 2.	Default: Options:	0 = 'Normal' 0 = 'Normal' (Same as encoder) 1 = 'Reversed'	RW	8-bit Integer
		36	**Fbk 2 Resolution** Feedback 2 Resolution Counts/Revolution. 0...65,535 pulses/revolution or pulses/mm based on rotary or linear configuration defined by P34 [Fbk 2 Units].	Default: Min/Max:	0 1 / 65,535	RO	16-bit Integer
		37	**Fbk 2 Volt Mon** Feedback 2 Voltage Monitor Encoder 2 voltage to be monitored.	Default: Options:	0 = Voltage not monitored 0 = Voltage not monitored 5 = 5V +/- 5% 9 = 7...12V 12 = 12V +/- 5% 24 = 24V - 10%...24V + 5%	RW	8-bit Integer
		38	**Fbk 2 Speed** Feedback 2 Speed Displays the output speed of encoder 2. Units based on rotary or linear configuration defined by P34 [Fbk 2 Units].	Units: Min/Max:	RPM mm/s -214,748,364.8 / 214,748,364.7 RPM -214,748,364.8 / 214,748,364.7mm/s	RO	32-bit Integer
		39	**Fbk Speed Ratio** Feedback Speed Ratio Defines the ratio of the expected speed of encoder 2 divided by the expected speed of encoder 1. Ratio based on rotary or linear configuration defined by P29 [Fbk 1 Units].	Default: Min/Max:	0.0000 0.0001 / 10,000.0	RW	Real
		40	**Fbk Speed Tol** Feedback Speed Tolerance Acceptable difference in speed between P33 [Fbk 1 Speed] and P38 [Fbk 2 Speed]. Units are based on rotary or linear configuration defined by P29 [Fbk 1 Units].	Units: Min/Max:	RPM mm/s 0 / 6553.5 RPM 0 / 6553.5 mm/s	RW	16-bit Integer
		41	**Fbk Pos Tol** Feedback Position Tolerance Acceptable difference in position between encoder 1 and encoder 2. Units are based on rotary or linear configuration defined by P29 [Fbk 1 Units].	Units: Default: Min/Max:	Deg mm 0 0 / 65,535 deg 0 / 65,535 mm	RW	16-bit Integer

Secondary feedback parameter settings are not required when P27 [Fbk Mode] is set to 0 'Single Fbk.'

Notes:

Safe Stop and Safe Stop with Door Monitoring Modes

This chapter describes the Safe Stop modes of operation, provides a list of configuration parameters, and wiring examples for each Safe Stop mode.

Safe Stop Mode

When properly configured for Safe Stop, the safety option module monitors the Safe Stop input (SS_In) and initiates the configured Safe Stop Type upon deactivation of the input. The Safe Stop Type is configurable as Safe Torque Off with or without Standstill Checking, Safe Stop 1, or Safe Stop 2. The safety option module recognizes motion as stopped when encoder 1 feedback signals indicate that the system has reached the configured Standstill Speed. Once Standstill Speed has been reached, the Door Control output (DC_Out) is set to Unlock.

IMPORTANT	Because the Safe Stop 2 feature does not initiate a Safe Operating Stop (SOS) and provide energy to the motor to enable it to resist external forces, no motor torque is available at zero speed after DC braking has completed.

In addition to setting the Standstill Speed, you configure both the Stop Delay P47 [Max Stop Time], the period during which deceleration occurs after a Safe Stop is initiated, and an optional Stop Monitoring Delay P46 [Stop Mon Delay], which is a delay between the action that requests the Safe Stop and the initiation of the configured Safe Stop Type. A P46 [Stop Mon Delay] can be configured only for Safe Stop 1 or Safe Stop 2.

When properly configured for Safe Stop mode, the safety option module also monitors for faults and initiates the appropriate reaction. If the fault is a Safe State fault, the option module enters the Safe State. If the fault is a Stop Category fault, the option module initiates the configured Safe Stop Type.

Safe Stop Types

Use the P45 [Safe Stop Type] parameter to configure the type of stop that the system executes when a Safe Stop is initiated. A Safe Stop can be initiated by a transition of the SS_In input from ON to OFF or by the occurrence of a Stop Category fault.

While the safety option module executes the configured Safe Stop Type, it continues to monitor the system. If a Stop Category fault is detected, the safety option module sets the outputs to a faulted state, but allows for the door control logic to be set to Unlock if the feedback signals indicate Standstill Speed has been reached.

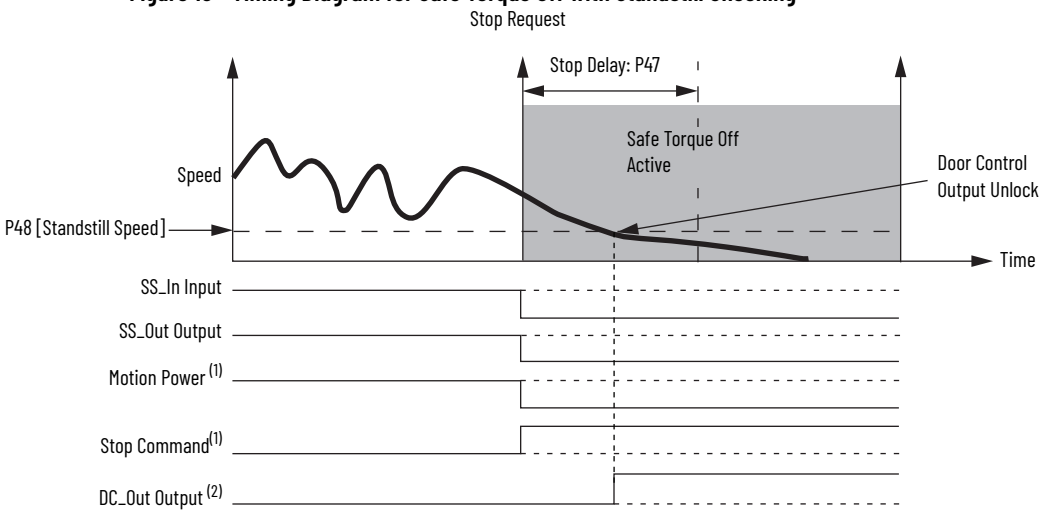
Safe Torque Off with Standstill Checking

This Safe Stop Type lets you access the hazard area immediately after motion is detected as stopped rather than waiting until a specific time has elapsed.

When Safe Torque Off with Standstill Checking is initiated, motion power is removed immediately and the configured Stop Delay P47 [Max Stop Time] begins. If the configured Standstill Speed is detected any time after the Safe Stop has been initiated and before the end of the configured Stop Delay, door control logic is set to Unlock.

If the Standstill Speed is not detected by the end of the configured Stop Delay, a Stop Speed fault occurs and the door control logic remains set to Lock until Standstill Speed is detected.

Figure 15 - Timing Diagram for Safe Torque Off with Standstill Checking



(1) This signal is internal, between the safety option module and drive.
(2) DC_Out output shown configured as Power to Release. See Door Control on page 60 for more information.

Safe Stop 1 and Safe Stop 2

When Safe Stop 1 or 2 is initiated by a transition of the SS_In input from ON to OFF, the safety option module does not initiate the configured Stop Delay P47 [Max Stop Time] until after the optional Stop Monitoring Delay P46 [Stop Mon Delay] expires, unless a Stop Category fault occurs during the Stop Monitoring Delay.

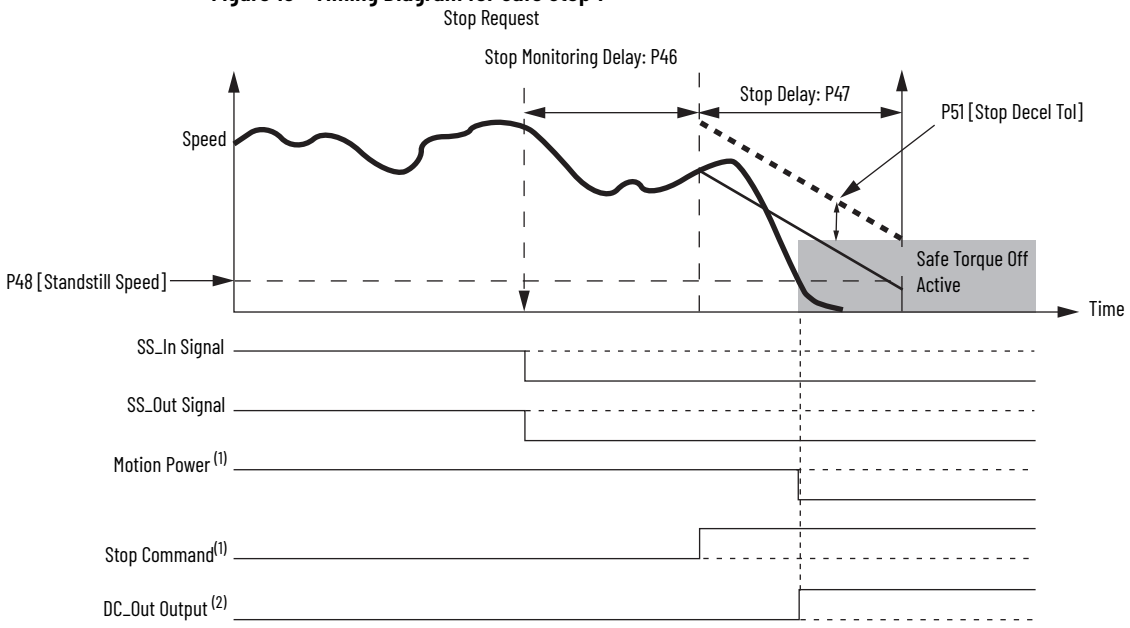
When Safe Stop 1 or 2 is initiated by a Stop Category fault, the Stop Delay P47 [Max Stop Time] begins immediately, regardless of whether a Stop Monitoring Delay P46 [Stop Mon Delay] is configured.

Deceleration monitoring takes place during the Stop Delay P47 [Max Stop Time]. These three configurable parameters define the deceleration profile that is used:

- Deceleration Reference Speed, P50 [Decel Ref Speed]
- Deceleration Tolerance, P51 [Stop Decel Tol]
- Stop Delay, P47 [Max Stop Time]

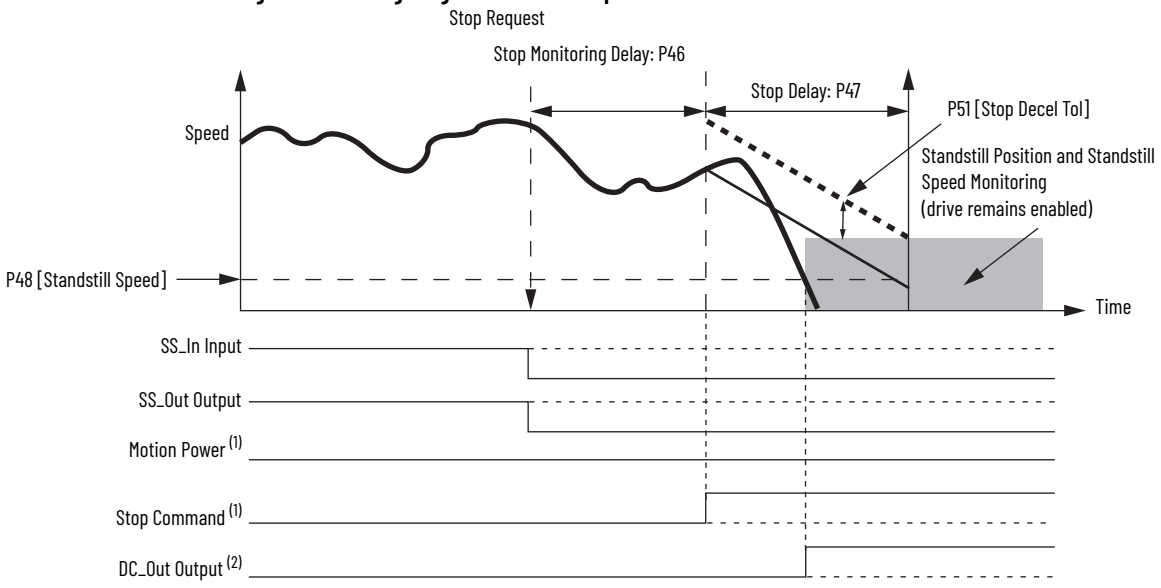
If Standstill Speed is detected any time after the Safe Stop has been initiated and before the Stop Delay P47 [Max Stop Time] expires, door control logic is set to Unlock. If the Standstill Speed is not detected by the end of the configured Stop Delay P47 [Max Stop Time], a Stop Speed fault occurs. For Safe Stop 1, motion power is removed when Standstill Speed is reached. For Safe Stop 2, motion power is not removed.

Figure 16 - Timing Diagram for Safe Stop 1



(1) This signal is internal, between the safety option module and drive.
(2) DC_Out output shown configured as Power to Release. See Door Control on page 60 for more information.

Figure 17 - Timing Diagram for Safe Stop 2

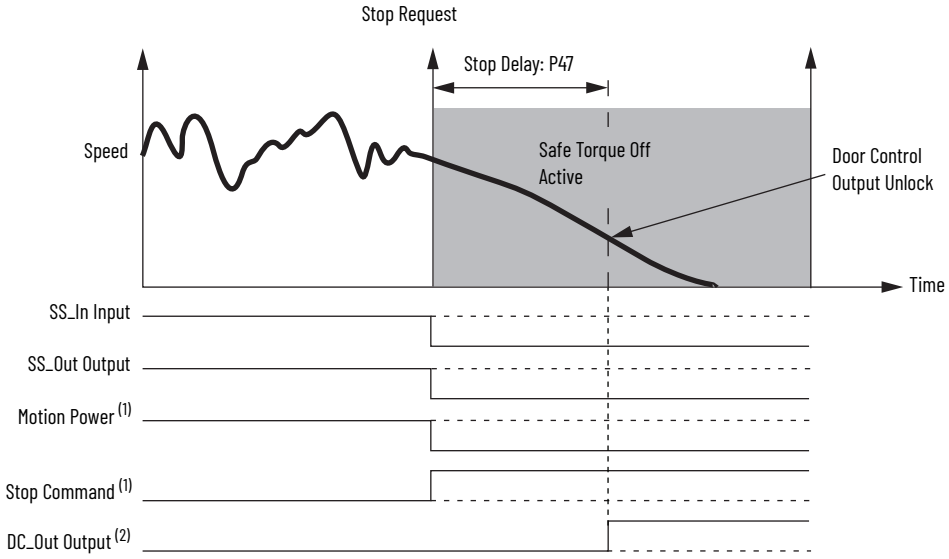


(1) This signal is internal, between the safety option module and drive.
(2) DC_Out output shown configured as Power to Release. See Door Control on page 60 for more information.

Safe Torque Off without Standstill Checking

When Safe Torque Off without Standstill Checking is initiated, motion power is removed immediately and the configured Stop Delay P47 [Max Stop Time] begins. Door control logic is set to Unlock when the Stop Delay P47 [Max Stop Time] expires, regardless of speed.

Figure 18 - Timing Diagram for Safe Torque Off without Standstill Checking



(1) This signal is internal, between the safety option module and drive.
(2) DC_Out output shown configured as Power to Release. See Door Control on page 60 for more information.

All Stop Types require an encoder to be connected.

Standstill Speed and Position Tolerance

For Safe Stop Types that include Standstill Checking, you set the Standstill Speed and Standstill Position Tolerance.

IMPORTANT	The P48 [Standstill Speed] and P49 [Standstill Pos] parameters are not used for Safe Torque Off without Standstill Checking configurations. Set these parameters to zero.

Standstill Speed is used to declare motion as stopped. The system is at standstill when the speed detected is less than or equal to the configured Standstill Speed. The P48 [Standstill Speed] parameter defines the speed limit before the safety option module determines standstill has been reached and the door control logic is set to Unlock.

IMPORTANT	Standstill detection relies on the encoder 1 signal. The encoder 2 signal is used for fault diagnostics.

The P49 [Standstill Pos] parameter defines the position limit in encoder 1 units that is tolerated after standstill has been reached. If the position changes by more than the amount specified by the Standstill Position Tolerance, after standstill has been reached and the door is unlocked, a Motion After Stopped fault occurs. This type of fault results in the safety option module entering the safe state.

The time required to verify that the Standstill Speed has been reached can be considerable when a very small Standstill Speed is configured and the encoder resolution of encoder 1 is very low.

- For rotary systems, the time (in seconds) exceeds 15 / [Standstill Speed (RPM) x Encoder 1 Resolution].
- For linear systems, the time (in seconds) exceeds 0.25 / [Standstill Speed (mm/s) x Encoder 1 Resolution].

Deceleration Monitoring

Deceleration monitoring takes place during the configured Stop Delay P47 [Max Stop Time], when the Safe Stop Type is configured as Safe Stop 1 or Safe Stop 2. The deceleration start

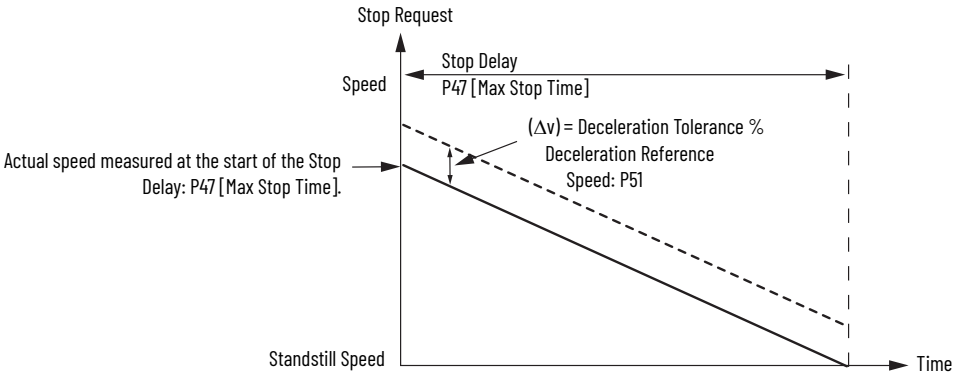
speed is captured at the beginning of the Stop Delay P47 [Max Stop Time] and used to calculate the deceleration profile.

These parameters define the deceleration profile:

- Deceleration Reference Speed, P50 [Decel Ref Speed]
- Deceleration Tolerance, P51 [Stop Decel Tol]
- Stop Delay, P47 [Max Stop Time]

The Deceleration Reference Speed is relative to encoder 1. The P51 [Stop Decel Tol] parameter defines the percentage of the Deceleration Reference Speed that is tolerated above the calculated deceleration profile.

Figure 19 - Deceleration Monitoring



To account for system overshoot and drive delay, choose Δv and set P50 [Decel Ref Speed] to the highest normal operating speed to calculate the Deceleration Tolerance. Remember that P51 [Stop Decel Tol] parameter is a percentage.

When deceleration monitoring is being performed, the speed limit monitored during the Stop Delay P47 [Max Stop Time] must be less than the Deceleration Monitoring Value or a Deceleration fault occurs. A Deceleration fault places outputs in the faulted state, but the door can be unlocked when the feedback signals indicate Standstill Speed has been reached.

Safe Stop Reset

The Safe Stop Reset (SS Reset) is a reset from the Safe State or from a stopping condition to actively monitoring motion. The reset is successful if the SS_In input is ON and no faults are present.

ATTENTION: For all types of reset (automatic, manual, or manual monitored), if a reset of the Safe Stop or Safe Limited Speed functions can result in machine operation, the other speed monitoring functions must be configured to detect and prevent dangerous motion.

When an SS Reset is requested, all diagnostic tests that can be performed prior to outputs being energized are performed prior to a successful SS Reset. If a diagnostic test can be performed only when outputs are energized, the test is performed immediately following the SS Reset.

IMPORTANT An SS Reset is not attempted if the Wait SS Cyc attribute is set (1), indicating that an error, other than an invalid configuration fault or ESM_In input fault, occurred.

The Wait SS Cyc attribute is bit 25 of the P68 [Guard Status] parameter.

Automatic

If the SS Reset is configured as automatic, the safety option module always attempts a reset if it is in the Safe State or has initiated a Safe Stop Type. The reset is attempted when the SS_In input transitions from OFF to ON or if SS_In is ON at powerup.

Manual

If the SS Reset is configured as manual, the reset is attempted when the SS_In input is ON and the Reset_In input is ON.

Manual Monitored

A manual monitored reset requires an OFF to ON to OFF transition of the Reset_In input.

If at any time before the closing and opening of the Reset_In input, the SS_In input transitions from ON to OFF, the reset is aborted.

Faults

If a fault occurs, other than an Invalid Configuration fault or an ESM Monitoring fault, the SS_In input must turn OFF and ON again to reset the Wait SS Cyc bit before a successful SS Reset can occur.

Door Control

The status of door control logic (Lock or Unlock) and the Door Monitor Input (DM_In), along with the safety option module's location in the system P20 [Cascaded Config] and Door Control Output Type P57 [Door Out Type] determine whether the Door Control output (DC_Out) is locked or unlocked during normal operation.

When the DC_Out output has no faults, the safety option module is configured for Safe Stop, and the option module is monitoring motion, the door control logic state is Locked. It remains locked while a Safe Stop is being executed. For all Safe Stop Types except Safe Torque Off without Standstill Checking, door control logic is set to Unlock only when Standstill Speed has been reached.

ATTENTION: If the Safe Stop Type is Safe Torque Off without Standstill Checking, door control logic is set to Unlock when the Stop Delay P47 [Max Stop Time] has elapsed, regardless of speed.

Configuration

You configure the type of door control for each Safe Speed Monitor option module in the system.

P57 [Door Out Type] Settings		DC_Out Status and Lock State
Single and Last Units	**First and Middle Units**	
0 = Power to Release	Not valid	ON = Door is unlocked. OFF = Door is locked.
1 = Power to Lock	Not valid	ON = Door is locked. OFF = Door is unlocked.
2 = Cascading (2 Ch Sourcing)	2 = Cascading (2 Ch Sourcing)	ON = Door is unlocked. OFF = Door is locked.

A single or last safety option module in a cascaded system can be configured for any Door Output Type setting. For example, choose 2 Ch Sourcing to connect to a safety programmable

controller input. The first or middle safety option module in a cascaded system must be configured as 2 Ch Sourcing.

ATTENTION: When the DC_Out output is configured as Power to Lock (P57 [Door Out Type] = 1), the safe state and faulted state is Unlocked. Make sure that this possibility does not create a hazard.

IMPORTANT When the DC_Out output is configured for no pulse testing (P74 [Door Out Mode] = 1) and the P57 [Door Out Type] setting is Power to Lock, and a reset is attempted, the DC_Out output is pulsed low for 12 ms. During the 12 ms, the door is unlocked.

Effect of Faults

These fault conditions affect the integrity of the DC_Out output and force the DC_Out output to its safe state (OFF) regardless of the status of door control logic:

- DC Out fault
- Invalid Configuration fault
- Internal Power Supply or MPU faults

ATTENTION: If a fault occurs after Standstill Speed has been reached, door control remains unlocked.

For fault conditions where the DC_Out output can maintain its integrity, both door control logic and the DC_Out output hold last state. If hold last state cannot be maintained, faults can turn the DC_Out output OFF.

Lock Monitoring

If Lock Monitoring is enabled, the Lock Monitoring input (LM_In) must be in the ON state any time the Door Control output (DC_Out) is in the Lock state, except for the 5 seconds following the DC_Out output's transition from the Unlocked state to the Locked state. If the LM_In input is not ON during this time, a Lock Monitoring fault occurs. The LM_In input must be OFF when the DM_In input transitions from ON to OFF (the door opens).

A Lock Monitoring fault is a Stop Category fault that initiates the configured Safe Stop Type.

Safe Stop Parameter List

To configure the safety option module for Safe Stop mode, set these parameters in addition to the General and Feedback parameters listed on page 47 and page 52.

Table 28 - Safe Stop Parameter List

File	Group	No.	Display Name Full Name Description	Values		Read-Write	Data Type
HOST GROUPS	General	21	**Safety Mode** Safety Mode Defines the primary operating mode of the speed monitoring safety functions.	Setting:	1 = 'Safe Stop'	RW	8-bit Integer
	Stop	44	**Safe Stop Input** Safe Stop Input Configuration for Safe Stop input (SS_In). '2NC' (1) – Dual-channel equivalent '2NC 3s' (2) – Dual-channel equivalent 3 s '1NC+1NO' (3) – Dual-channel complementary '1NC+1NO 3s' (4) – Dual-channel complementary 3 s '2 OSSD 3s' (5) – Dual-channel SS equivalent 3 s '1NC' (6) – Single channel equivalent	Default: Options:	1 = '2NC' 0 = 'Not used' 1 = '2NC' 2 = '2NC 3s' 3 = '1NC+1NO' 4 = '1NC+1NO 3s' 5 = '2 OSSD 3s' 6 = '1NC'	RW	8-bit Integer
		45	**Safe Stop Type** Safe Stop Type Safe operating stop type selection. This defines the type of Safe Stop that is performed if the Safe Stop function is initiated by a stop type condition. 'Torque Off' (0) – Safe Torque Off With Standstill Checking 'Torque Off NoCk' (3) – Safe Torque Off Without Standstill Checking	Default: Options:	0 = 'Torque Off' 0 = 'Torque Off' 1 = 'Safe Stop 1' 2 = 'Safe Stop 2' 3 = 'Torque Off NoCk'	RW	8-bit Integer
		46	**Stop Mon Delay** Stop Monitoring Delay Defines the monitoring delay between the request and the Max Stop Time when the request for a Safe Stop 1 or a Safe Stop 2 is initiated by an SS_In input ON to OFF transition. If the Safe Stop Type is Safe Torque Off With or Without Standstill Speed Checking, the Stop Monitor Delay must be 0 or a Invalid Configuration Fault occurs.	Units: Default: Min/Max:	Secs 0 0 / 6553.5	RW	16-bit Integer
		47	**Max Stop Time** Maximum Stop Time Defines the maximum stop delay time that is used when the Safe Stop function is initiated by a stop type condition.	Units: Default: Min/Max:	Secs 0 0 / 6553.5	RW	16-bit Integer

Table 28 - Safe Stop Parameter List (Continued)

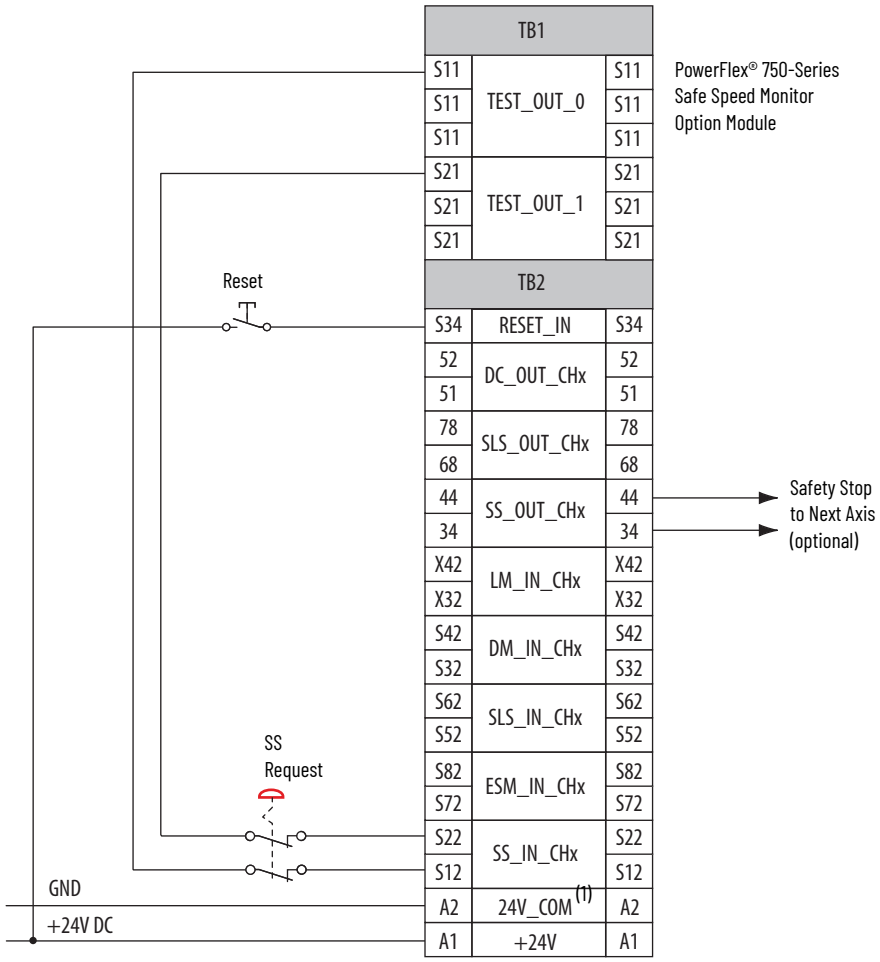
File	Group	No.	Display Name Full Name Description	Values		Read-Write	Data Type
HOST GROUPS	Stop	48	**Standstill Speed** Standstill Speed Defines the speed limit that is used to declare motion as stopped. Units are based on rotary or linear configuration defined by P29 [Fbk 1 Units]. Not valid for Safe Torque Off without Standstill Checking.	Units: Default: Min/Max:	RPM mm/s 0.001 0.001/ 65.535 RPM 000/ 65.535 mm/s	RW	16-bit Integer
		49	**Standstill Pos** Standstill Position Defines the position limit window in encoder 1 degrees or mm that are tolerated after a safe stop condition has been detected. Degrees (360° = 1 revolution) or mm based on rotary or linear configuration defined by P29 [Fbk 1 Units]. Not valid for Safe Torque Off without Standstill Checking.	Units: Default: Min/Max:	Deg mm 10 0 / 65,535 deg 0 / 65.535 mm	RW	16-bit Integer
		50	**Decel Ref Speed** Deceleration Reference Speed Determines deceleration rate to monitor for Safe Stop 1 or Safe Stop 2. Units are based on rotary or linear configuration defined by encoder 1 feedback configuration, P29 [Fbk 1 Units].	Units: Default: Min/Max:	RPM mm/s 0 0 / 65,535 RPM 0 / 65,535 mm/s	RW	16-bit Integer
		51	**Stop Decel Tol** Stop Deceleration Tolerance This is the acceptable tolerance above the deceleration rate set by the Decel Ref Speed parameter.	Units: Default: Min/Max:	% 0 0 / 100	RW	8-bit Integer
	Door Control	57	**Door Out Type** Door Output Type Defines the lock and unlock state for door control output (DC_Out). When Door Out Type equals power to release, DC_Out is OFF in the lock state and ON in the unlock state. When Door Out Type equals power to lock, DC_Out is ON in the lock state and OFF in the unlock state. The first and middle units of a multi-axis system must be configured as cascading (2).	Default: Options:	0 = 'Pwr to Rel' 0 = 'Pwr to Rel' 1 = 'Pwr to Lock' 2 = '2 Ch Sourcing'	RW	8-bit Integer
		59	**Lock Mon Enable** Lock Monitor Enable Lock Monitoring can be enabled only when the safe speed monitor option module is a single unit or as the first unit in a multi-axis system (P20 [Cascaded Config] = 0 or 1).	Default: Options:	0 = 'Disable' 0 = 'Disable' 1 = 'Enable'	RW	8-bit Integer
		60	**Lock Mon Input** Lock Monitor Input Configuration for the Lock Monitor input (LM_In). '2NC' (1) – Dual-channel equivalent '2NC 3s' (2) – Dual-channel equivalent 3 s '1NC+1NO' (3) – Dual-channel complementary '1NC+1NO 3s' (4) – Dual-channel complementary 3 s '2 OSSD 3s' (5) – Dual-channel SS equivalent '1NC' (6) – Single channel equivalent	Default: Options:	0 = 'Not used' 0 = 'Not used' 1 = '2NC' 2 = '2NC 3s' 3 = '1NC+1NO' 4 = '1NC+1NO 3s' 5 = '2 OSSD 3s' 6 = '1NC'	RW	8-bit Integer
	General	72	**SS Out Mode** Defines whether the SS_Out output is pulse-tested. (1) If pulse-testing is turned off for any output, the SIL, Category, and PL rating is reduced for the entire safety system.	Default: Options:	0 = 'Pulse test' 0 = 'Pulse test' 1 = 'No pulse test'	RW	8-bit Integer

(1) If pulse-testing is turned off for any output, the SIL, Category, and PL rating is reduced for the entire safety system.

Safe Stop Wiring Example

This example illustrates safe stop wiring.

Figure 20 - Master, Safe Stop (First or Single Unit)



(1) 24V_Com must be at the same potential as the drive common because of the encoder signal.

Safe Stop with Door Monitoring Mode

When properly configured for Safe Stop with Door Monitoring, the safety option monitors the Safe Stop input (SS_In) and initiates the configured Safe Stop Type upon deactivation of the input as described in Safe Stop Mode on page 55.

In addition, the safety option module verifies through monitoring the Door Monitor input (DM_In) that the door interlock solenoid controlled by the Door Control output (DC_Out) is in an expected state. The DM_In input is ON when the door is closed and OFF when the door is open. If the door is monitored as opened during Safe Stop monitoring, a Door Monitoring fault occurs and the safety option module initiates the configured Safe Stop Type.

You can monitor the door's status with or without using the Door Control (lock/unlock) function. When door control logic is set to Lock, the safety option module puts the solenoid into the locked state when the machine is not at a safe speed or at Standstill Speed.

Lock Monitoring

If a Safety mode that includes Door Monitoring is selected and Lock Monitoring is enabled, the Lock Monitor input (LM_In) signal must be OFF any time that the Door Monitor input (DM_In) transitions from ON to OFF.

IMPORTANT	If your application uses Lock Monitoring without Door Monitoring, you must use some means to make sure that the Lock Monitor is not stuck at Lock indication.

SS Reset

If the Door Monitor input (DM_In) is OFF when a Safe Stop (SS) Reset is attempted in any state other than actively monitoring Safe Limited Speed, a Door Monitoring fault occurs and the safety option module initiates the configured Safe Stop Type.

Safe Stop with Door Monitoring Parameter List

To configure the safety option module for Safe Stop with Door Monitoring, set the DM Input parameter in addition to the Safe Stop parameters listed on page 61.

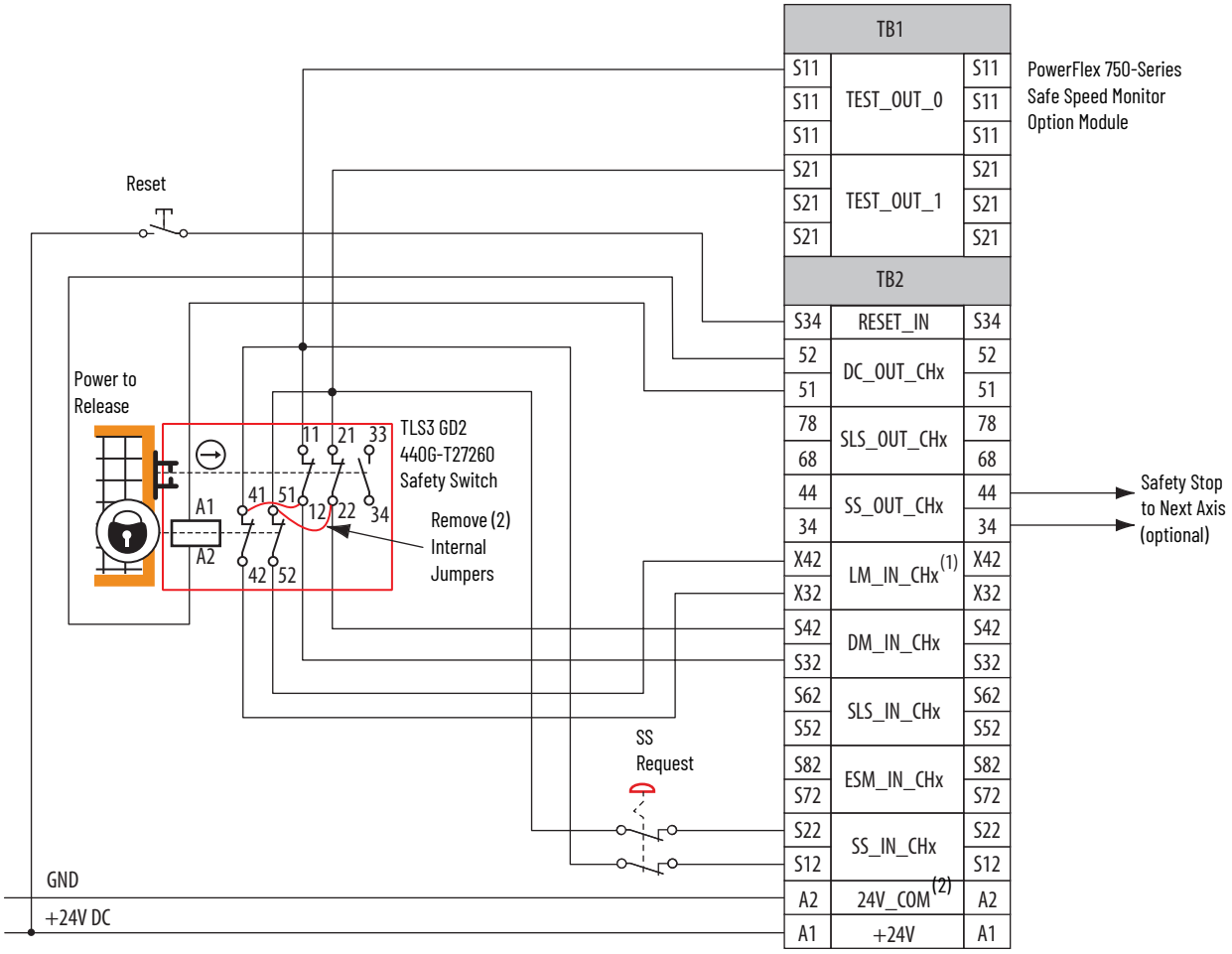
File	Group	No.	Display Name Full Name Description	Values		Read-Write	Data Type
HOST GROUPS	General	21	**Safety Mode** Safety Mode Defines the primary operating mode of the speed monitoring safety functions.	Setting:	2 = 'Safe Stop DM'	RW	8-bit Integer
	Door Control	58	**DM Input** Door Monitor Input Configuration for the Door Monitor input (DM_In). '2NC' (1) – Dual-channel equivalent '2NC 3s' (2) – Dual-channel equivalent 3 s '1NC+1NO' (3) – Dual-channel complementary '1NC+1NO 3s' (4) – Dual-channel complementary 3 s '2 OSSD 3s' (5) – Dual-channel SS equivalent 3 s '1NC' (6) – Single channel equivalent	Default: Options:	0 = 'Not used' (1) 0 = 'Not used' 1 = '2NC' 2 = '2NC 3s' 3 = '1NC+1NO' 4 = '1NC+1NO 3s' 5 = '2 OSSD 3s' 6 = '1NC'	RW	8-bit Integer

(1) You must configure this parameter with a non-zero value in this mode.

Safe Stop with Door Monitoring Wiring Example

This example illustrates wiring for safe stop with door monitoring.

Figure 21 - Master, Safe Stop with Door Monitoring (first or single unit)



(1) Lock monitoring connections are not required for Safe Limited Speed with Door Monitoring mode operation.
(2) 24V_Com must be at the same potential as the drive common because of the encoder signal.

Safe Limited Speed (SLS) Modes

This chapter describes the Safe Limited Speed (SLS) modes of safety operation, provides a list of configuration parameters, and wiring examples for each mode.

Safe Limited Speed (SLS) Mode

When properly configured for Safe Limited Speed, the safety option module performs Safe Limited Speed (SLS) monitoring functions in addition to the Safe Stop function described in Safe Stop Mode on page 55. When the Safe Limited Speed input (SLS_In) is OFF, feedback velocity is monitored and compared against a configurable Safe Speed Limit.

If the feedback velocity is below the Safe Speed Limit during Safe Limited Speed monitoring, the Door Control output (DC_Out) is unlocked after the P53 [LimSpd Mon Delay], if configured, has expired.

ATTENTION: Make sure that an unlocked door does not result in a hazardous situation.
If a Safe Stop Type is initiated or a fault occurs while the safety option module is actively monitoring Safe Limited Speed, door control remains unlocked. In the safe state of the SLS_In input, the door is unlocked.

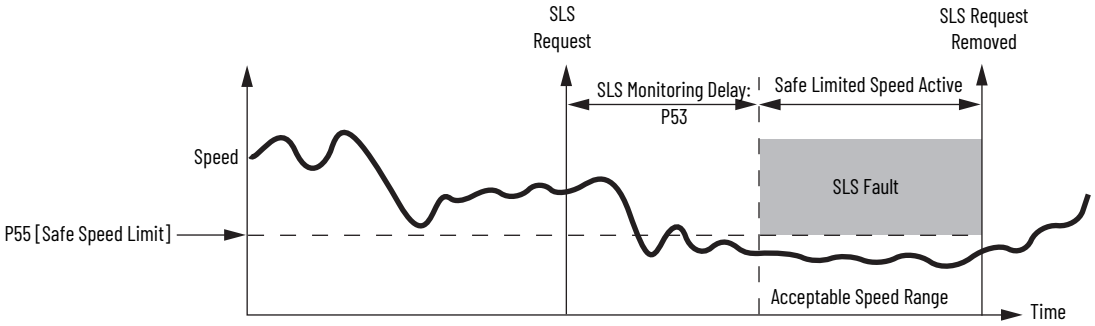
If the measured velocity exceeds the Safe Speed Limit, an SLS fault occurs and the configured P45 [Safe Stop Type] is initiated. An optional P53 [LimSpd Mon Delay] can be configured to delay the start of Safe Limited Speed monitoring.

Safe Limited Speed monitoring is requested by a transition of the Safe Limited Speed input (SLS_In) from ON to OFF. When the SLS_In input is ON, the safety option module does not monitor for Safe Limited Speed and the measured velocity can be above or below the Safe Speed Limit.

ATTENTION: If the Reset Type is configured as Automatic, Safe Limited Speed monitoring is disabled when the SLS_In input is turned ON and the machine operates at its normal run speed. Make sure that the SLS_In input cannot transition to ON while someone is in the hazardous area.

If you configure a P53 [LimSpd Mon Delay], the delay begins when Safe Limited Speed monitoring is requested by the SLS_In transition from ON to OFF. The safety option module begins monitoring for Safe Limited Speed when the delay times out. If system speed is greater than or equal to the configured Safe Speed Limit during Safe Limited Speed monitoring, an SLS fault occurs and the option module initiates the configured Safe Stop Type.

Figure 22 - Timing Diagram for Safe Limited Speed (SLS)



Safe Limited Speed Reset

A Safe Limited Speed (SLS) Reset is a transition out of actively monitoring safe limited speed. It can also occur during a P53 [LimSpd Mon Delay], if one is configured. When an SLS Reset occurs, the safety option module no longer monitors for safe limited speed and the door is locked. Speed is no longer restricted to the configured Safe Speed Limit.

The SLS Reset function monitors the SLS_In input. If an SLS Reset is requested, the safety option module checks that no faults are present and verifies that the SLS_In input is ON (closed circuit) before the reset is performed.

When the input is OFF, Safe Limited Speed monitoring takes place, after the P53 [LimSpd Mon Delay], if one is configured. An SLS Reset can be requested during active Safe Limited Speed monitoring or during a Safe Limited Speed Monitoring Delay. If a reset is requested during a Safe Limited Speed Monitoring Delay, the reset does not wait for the delay to time out.

Automatic

Once the SLS_In input is ON (closed), the safety option module lets the drive resume normal operating speed. No reset button is required to re-enter the normal run state.

Manual

When the SLS_In input transitions from OFF to ON and the Reset_In input is ON, an SLS_Reset is attempted.

If the SLS_In transitions from OFF to ON and the Reset_In input is OFF, the safety option module stays in its current state, whether it is actively monitoring Safe Limited Speed or is in a Safe Limited Speed Monitoring Delay, and waits for the Reset_In input to transition to ON, before attempting the SLS_Reset. If at any time, the SLS_In input transitions back to OFF, the SLS_Reset is aborted.

Manual Monitored

When the SLS_In input transitions from OFF to ON, the safety option module waits for an OFF to ON to OFF transition of the Reset_In input before an SLS_Reset is attempted. If at any time during this period, the SLS_In input transitions back to OFF, the SLS_Reset is aborted.

Safe Limited Speed Parameter List

To configure the safety option module for Safe Limited Speed monitoring, set these parameters in addition to the Safe Stop parameters listed beginning on page 61.

File	Group	No.	Display Name Full Name Description	Values		Read-Write	Data Type
HOST GROUPS	General	21	**Safety Mode** Safety Mode Defines the primary operating mode of the speed monitoring safety functions.	Setting:	3 = 'Lim Speed'	RW	8-bit Integer
	Limited Speed	52	**Lim Speed Input** Limited Speed Input Configuration for Safe Limited Speed input (SLS_In). '2NC' (1) – Dual-channel equivalent '2NC 3s' (2) – Dual-channel equivalent 3 s '1NC+1NO' (3) – Dual-channel complementary '1NC+1NO 3s' (4) – Dual-channel complementary 3 s '2 OSSD 3s' (5) – Dual-channel SS equivalent 3 s '1NC' (6) – Single channel equivalent	Default: Options:	0 = 'Not used' (1) 0 = 'Not used' 1 = '2NC' 2 = '2NC 3s' 3 = '1NC+1NO' 4 = '1NC+1NO 3s' 5 = '2 OSSD 3s' 6 = '1NC'	RW	8-bit Integer
		53	**LimSpd Mon Delay** Limited Speed Monitoring Delay Defines the Safe Limited Speed Monitoring Delay between the SLS_In ON to OFF transition and the initiation of the Safe Limited Speed (SLS) or Safe Maximum Speed (SMS) monitoring.	Units: Default: Min/Max:	Secs 0 0 / 6553.5	RW	16-bit Integer
		55	**Safe Speed Limit** Safe Speed Limit Defines the speed limit that is monitored in Safe Limited Speed (SLS) mode. Units are based on rotary or linear configuration defined by P29 [Fbk 1 Units].	Units: Default: Min/Max:	RPM mm/s 0 0 / 6553.5 RPM 0 / 6553.5 mm/s	RW	16-bit Integer
	General	73	**SLS Out Mode** Defines whether the SLS_Out output is pulse-tested. (2) If pulse-testing is turned off for any output, the SIL, Category, and PL rating is reduced for the entire safety system.	Default: Options:	0 = 'Pulse test' 0 = 'Pulse test' 1 = 'No pulse test'	RW	8-bit Integer

(1) You must configure this parameter with a non-zero value in this mode.
(2) If pulse-testing is turned off for any output, the SIL, Category, and PL rating is reduced for the entire safety system.

Configuring the PowerFlex 750-Series Drive for SLS Operation

The safety option module commands the drive to enter Manual Mode during Safe Limited Speed monitoring.

IMPORTANT The drive parameters listed below must be configured for the drive to accept this command.

P326 [Manual Cmd Mask] - Turn **off** the bit corresponding to the safety option module's port to allow modules installed in other ports to continue to control the drive when it is operating in Manual Mode. For example, if the safety option module is installed in port 6, then turn off bit 6 in this parameter.

Refer to Install the Safe Speed Monitor Option Module on page 29 to review the location of ports used by the safety option module.

P327 [Manual Ref Mask] - Turn **on** the bit corresponding to the safety option module's port to allow the option module to command the drive to use its Manual Speed Reference when it is operating in Manual Mode. For example, if the option module is installed in port 6, then turn on bit 6 in this parameter.

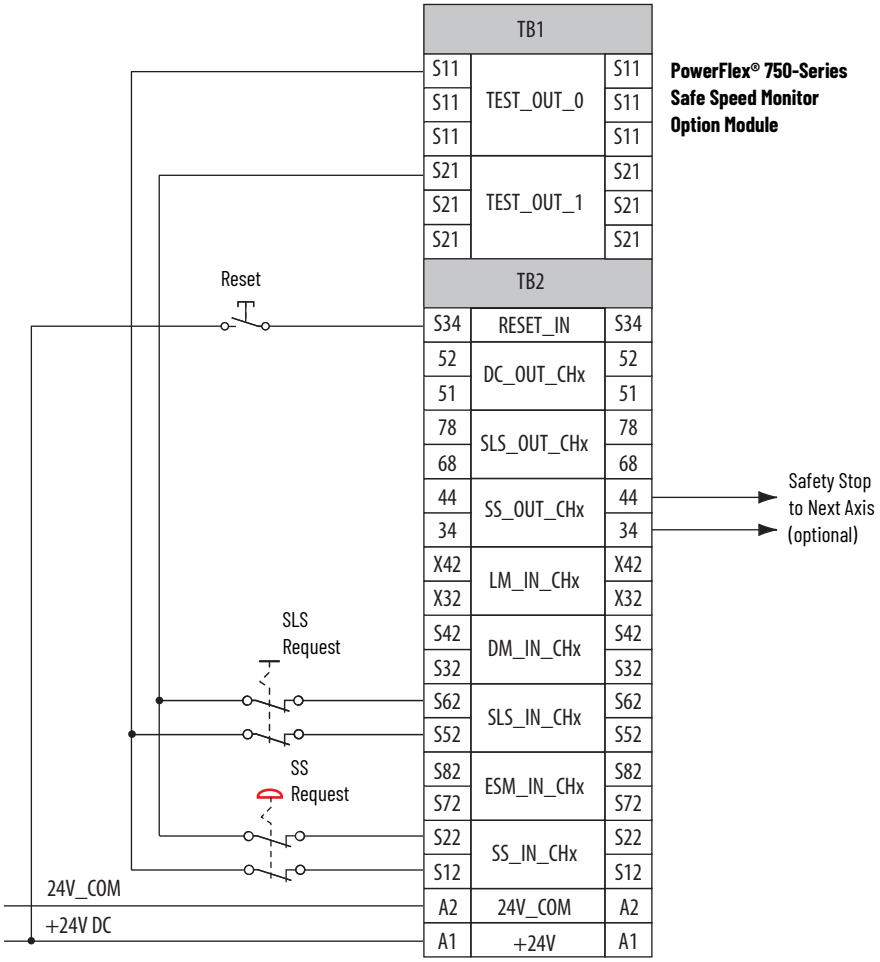
P328 [Alt Man Ref Sel] - Set this parameter to select the desired speed reference when the drive is operating in Manual Mode. For example, set this parameter to the value Port 0: Preset Speed 1 to configure the drive to use its P571 [Preset Speed 1] parameter as the Manual Speed Reference. In this case, the drive's P571 [Preset Speed 1] parameter must be less than the P55 [Safe Speed Limit] parameter in the safety option module to avoid causing an SLS Speed Fault.

When a Safe Limited Speed Reset occurs, the safety option module commands the drive to exit Manual mode and the drive resumes operation by using the speed reference that was selected prior to Safe Limited Speed monitoring.

Safe Limited Speed Wiring Example

This example illustrates wiring for safe limited speed.

Figure 23 - Master, Safe Limited Speed (first or single unit)



Safe Limited Speed with Door Monitoring Mode

When properly configured for Safe Limited Speed with Door Monitoring, the safety option module performs Safe Limited Speed (SLS) monitoring functions as described in Safe Limited Speed (SLS) Mode on page 67 in addition to the Safe Stop functions as described in Safe Stop Mode on page 55.

In addition, the safety option module verifies through monitoring the Door Monitor input (DM_In) that the option module controlled by the Door Control output (DC_Out) is in the expected state. If the door is monitored as opened when it should be closed, the safety option module initiates the configured Safe Stop Type.

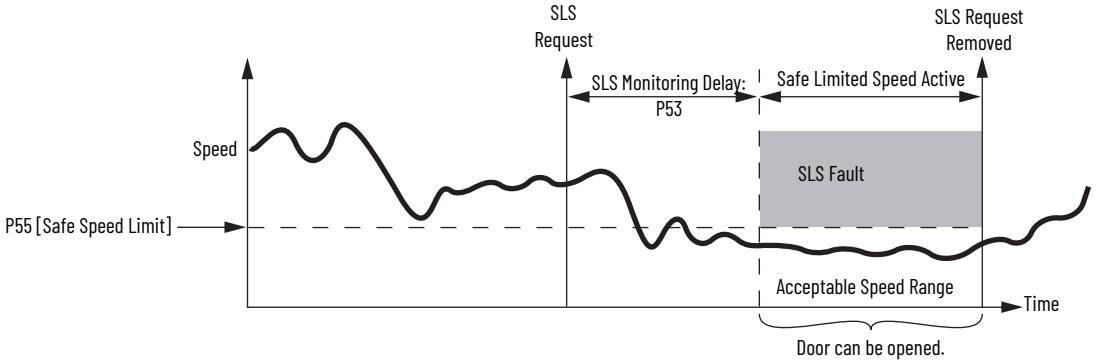
The Door Monitor input (DM_In) is ON when the door is closed and OFF when the door is open. The DM_In input must be ON (door closed) whenever Safe Limited Speed monitoring is inactive (SLS_In is ON, meaning the circuit is closed). The DM_In input must also be ON (door closed) during a Safe Limited Speed Monitoring Delay [LimSpd Mon Delay]. A Door Monitor fault is a Stop Category fault that initiates the configured Safe Stop Type.

If Safe Limited Speed Monitoring is active (SLS_In input is OFF) and the safety option module has verified a safe speed condition, the door can be unlocked and opened.

ATTENTION: Make sure that an open door does not result in a hazardous situation.
If a Safe Stop Type is initiated or a fault occurs while the safety option module is actively monitoring Safe Limited Speed, door control remains unlocked. In the safe state of the SLS_In input, the door is unlocked.

You can monitor the door's status with or without the door control (lock/unlock) function. When door control logic is set to lock, it prevents personnel from entering the hazardous area when the machine is not at a safe speed or at Standstill Speed.

Figure 24 - Timing Diagram for Safe Limited Speed (SLS) with Door Monitoring Mode



Safe Limited Speed Reset

When properly configured for Safe Limited Speed with Door Monitoring, the safety option module must be monitoring motion (SLS_In input is OFF) if the door is open (DM_In is OFF). Make sure the door is closed before requesting an SLS Reset.

A Safe Limited Speed Reset results in a Door Monitoring fault if the door is open (DM_In is OFF) when the reset is requested by a transition of the SLS_In input from OFF to ON. A Door Monitor fault is a Stop Category fault that initiates the configured Safe Stop Type.

SLS with Door Monitoring Parameter List

To configure the safety option module for Safe Limited Speed with Door Monitoring, set the DM Input parameter in addition to the Safe Stop parameters listed on page 61 and the Safe Limited Speed parameters listed on page 68.

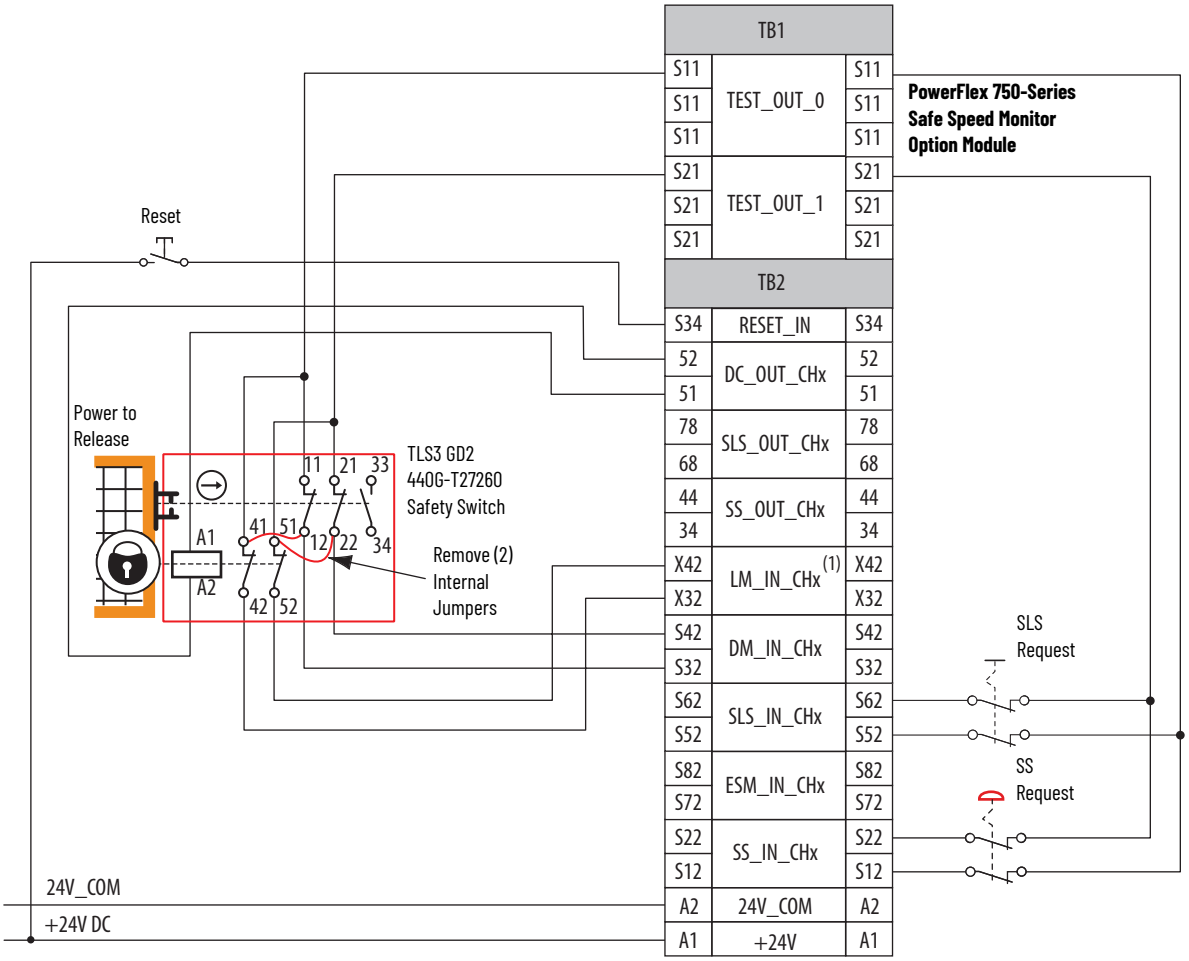
File	Group	No.	Display Name Full Name Description	Values		Read-Write	Data Type
HOST GROUPS	General	21	**Safety Mode** Safety Mode Defines the primary operating mode of the speed monitoring safety functions.	Setting:	4 = 'Lim Speed DM'	RW	8-bit Integer
	Door Control	58	**DM Input** Door Monitor Input Configuration for the Door Monitor input (DM_In). '2NC' (1) – Dual-channel equivalent '2NC 3s' (2) – Dual-channel equivalent 3 s '1NC+1NO' (3) – Dual-channel complementary '1NC+1NO 3s' (4) – Dual-channel complementary 3 s '2 OSSD 3s' (5) – Dual-channel SS equivalent 3 s '1NC' (6) – Single channel equivalent	Default: Options:	0 = 'Not used' (1) 0 = 'Not used' 1 = '2NC' 2 = '2NC 3s' 3 = '1NC+1NO' 4 = '1NC+1NO 3s' 5 = '2 OSSD 3s' 6 = '1NC'	RW	8-bit Integer

(1) You must configure this parameter with a non-zero value in this mode.

SLS with Door Monitoring Wiring Example

This example illustrates wiring for SLS with door monitoring.

Figure 25 - Master, Safe Limited Speed with Door Monitoring (single unit)



(1) Lock monitoring connections are not required for Safe Limited Speed with Door Monitoring mode operation.

Safe Limited Speed with Enabling Switch Monitoring Mode

When properly configured for Safe Limited Speed with Enabling Switch Monitoring, the safety option module performs Safe Limited Speed (SLS) monitoring functions as described in Safe Limited Speed (SLS) Mode on page 67 in addition to the Safe Stop functions as described in Safe Stop Mode on page 55.

In addition, the safety option module monitors the Enabling Switch Monitor input (ESM_In) after the Safe Limited Speed Monitoring Delay [LimSpd Mon Delay] times out. Once the enabling switch is activated, the ESM_In input must remain ON while Safe Limited Speed monitoring is active or an ESM Monitoring fault occurs. An ESM Monitoring fault is a Stop Category fault that initiates the configured Safe Stop Type.

IMPORTANT When Safe Limited Speed Monitoring is inactive, the ESM_In input is not monitored.

Safe Stop Reset (SS Reset) and Safe Limited Speed Reset (SLS Reset)

If an ESM Monitoring Fault occurs due to the ESM_In input turning OFF (enabling switch is released), the safety option module can be reset without cycling the SS_In input. To perform an SLS Reset, first return the ESM_In input to ON (grip the enabling switch in the middle position). Then, press and release the reset button. This is the only case where the SS_In input does not need to be cycled to reset the safety option module following a fault.

While Safe Limited Speed is being monitored after the P53 [LimSpd Mon Delay] times out, if the SLS_In input is ON and an SLS Reset occurs, the ESM_In is not monitored.

ATTENTION: Make sure that the SLS_In input cannot transition to ON while someone is in the hazard area.
Use appropriate procedures when selecting safe limited speed to prevent other users from changing the mode while personnel are in the machine area.

If you attempt an SS Reset when the SLS_In input is OFF and the ESM_In input is OFF, an ESM Monitoring fault occurs. An ESM Monitoring fault is a Stop Category fault that initiates the configured Safe Stop Type.

SLS with Enabling Switch Monitoring Parameter List

To configure the safety option module for Safe Limited Speed with Enabling Switch Monitoring, set the P54 [Enable SW Input] parameter in addition to the Safe Stop parameters listed on page 61 and the Safe Limited Speed parameters listed on page 68.

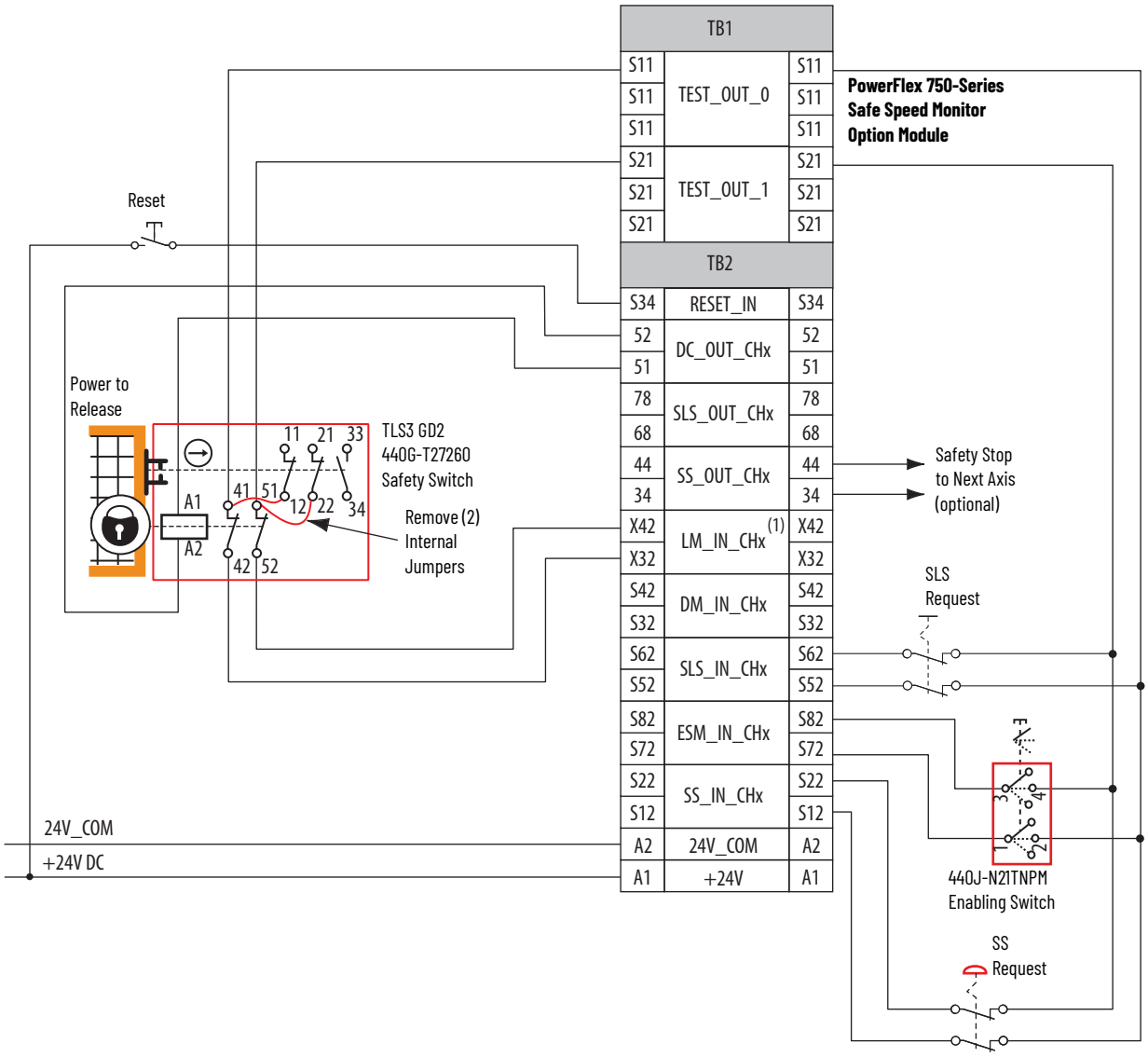
File	Group	No.	Display Name Full Name Description	Values		Read-Write	Data Type
HOST GROUPS	General	21	**Safety Mode** Safety Mode Defines the primary operating mode of the speed monitoring safety functions.	Setting:	5 = 'Lim Speed ES'	RW	8-bit Integer
	Limited Speed	54	**Enable SW Input** Enable Switch Input Configuration for the Enabling Switch input (ESM_In). '2NC' (1) – Dual-channel equivalent '2NC 3s' (2) – Dual-channel equivalent 3 s '1NC+1NO' (3) – Dual-channel complementary '1NC+1NO 3s' (4) – Dual-channel complementary 3 s '2 OSSD 3s' (5) – Dual-channel SS equivalent 3 s '1NC' (6) – Single channel equivalent	Default: Options:	0 = 'Not used' (1) 0 = 'Not used' 1 = '2NC' 2 = '2NC 3s' 3 = '1NC+1NO' 4 = '1NC+1NO 3s' 5 = '2 OSSD 3s' 6 = '1NC'	RW	8-bit Integer

(1) You must configure this parameter with a non-zero value in this mode.

SLS with Enabling Switch Monitoring Wiring Example

This example illustrates wiring for SLS with enabling switch monitoring.

Figure 26 - Master, Safe Limited Speed with Enabling Switch Monitoring (first or single unit)



(1) Lock monitoring connections are not required for Safe Limited Speed with Enabling Switch Monitoring mode operation.

Safe Limited Speed with Door Monitoring and Enabling Switch Monitoring Mode

When properly configured for Safe Limited Speed with Door Monitoring and Enabling Switch Monitoring, the safety option module performs Safe Limited Speed (SLS) monitoring functions as described on page 67, in addition to the Safe Stop functions as described in Safe Stop Mode on page 55.

The safety option module also monitors both the Enabling Switch Monitor input (ESM_In) and the Door Monitor input (DM_In). This mode lets you access the hazardous area when the machine is under a Safe Limited Speed condition. The following is a typical procedure for accessing the hazardous area by using this mode.

1. Set the SLS_In input to OFF.

   The Safe Speed Limit must not be exceeded after the P53 [LimSpd Mon Delay], if configured, times out.

2. After the Safe Limited Speed Monitoring Delay has timed out, hold the enabling switch in the middle position

   Once a safe speed is detected and the enabling switch is in the middle position, the safety option module unlocks the door.

3. Continue to hold the enabling switch while you open the door, enter the hazard area, and perform the required maintenance.

Follow these steps to remove the safe speed condition and resume normal run operation.

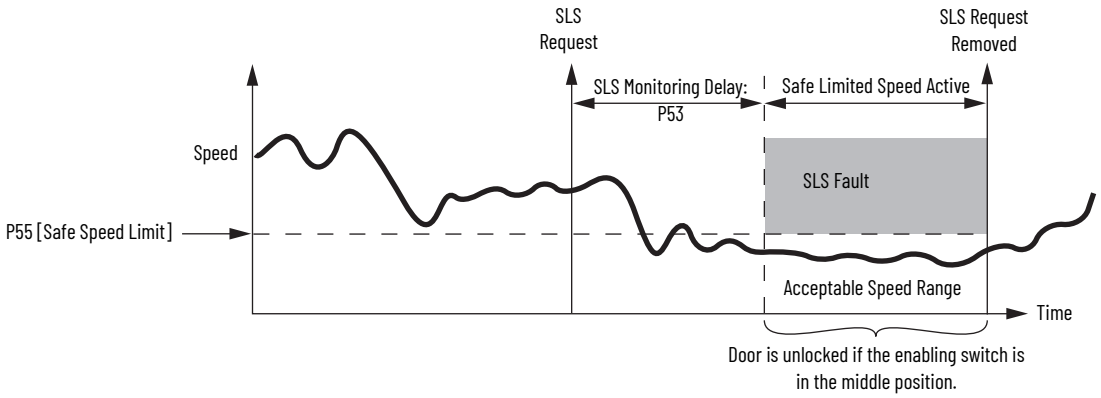
1. Leave the hazard area while holding the enabling switch.
2. Hold the enabling switch until the door is closed and you have disabled the SLS_In input by setting it to the ON or closed position.
3. Press the reset button, if manual reset is configured.
4. Release the enabling switch.

   The machine resumes normal run operation.

ATTENTION:

ATTENTION: Make sure that the SLS_In input cannot transition to ON while someone is in the hazard area.
Use appropriate procedures when selecting safe limited speed to prevent other users from changing the mode while personnel are in the machine area.

Figure 27 - Timing Diagram for Safe Limited Speed (SLS) with Door Monitoring and Enabling Switch Monitoring Mode



Behavior During SLS Monitoring

When Safe Limited Speed monitoring is active, door control logic is set to Unlock if the ESM_In input is ON and the speed is detected at below the Safe Speed Limit.

If the ESM_In input is ON, the door can be opened (DM_In transitions from ON to OFF). However, if the ESM_In input transitions to OFF after the door has been opened, an ESM Monitoring fault occurs. An ESM Monitoring fault is a Stop Category fault that initiates the configured P45 [Safe Stop Type].

If the DM_In input transitions from ON to OFF (door is opened), while the ESM_In input is OFF, a Door Monitoring fault occurs. A Door Monitoring fault is a Stop Category fault that initiates the configured P45 [Safe Stop Type].

ATTENTION: While Safe Limited Speed Monitoring is active, the ESM_In input is not monitored until the DM_In input is detected as OFF. Make sure that the ESM_In input is not relied upon for safety until the DM_In input has transitioned to OFF.

After the DM_In input turns OFF, it could turn back ON again if the door is closed behind the operator but the ESM_In input is still monitored.

Table 29 - Safe Limited Speed Operation

Safety Function Status	Drive In Safe State	Drive Able To Run (Ready)	Drive Able To Run (Ready)
DM_In	Off	On	Off
ESM_In	Off	On or Off	On

Behavior While SLS Monitoring is Inactive

If Safe Limited Speed monitoring is inactive, the DM_In input must be ON (door closed) or a Door Monitoring fault occurs and the safety option module initiates the configured P45 [Safe Stop Type]. The ESM_In input can be ON or OFF.

Behavior During SLS Monitoring Delay

The status of the ESM_In input does not affect the operation of the system during a P53 [LimSpd Mon Delay]. However, the DM_In input must be ON (door closed) during the delay or a Door Monitoring fault occurs and the safety option module initiates the configured P45 [Safe Stop Type].

Safe Stop Reset (SS Reset) and Safe Limited Speed Reset (SLS Reset)

The door must be closed when an SS Reset or SLS Reset is requested. An SS Reset results in a Door Monitoring fault if the door is open when the reset is requested by a transition of the SS_In input from OFF to ON. An SLS Reset also results in a Door Monitoring fault if the door is open when the reset is requested by a transition of the SLS_In input from OFF to ON. A Door Monitor fault is a Stop Category fault that initiates the configured P45 [Safe Stop Type].

If an SS Reset is attempted while the SLS_In input is OFF, an ESM Monitoring fault occurs. An ESM Monitoring fault is a Stop Category fault that initiates the configured P45 [Safe Stop Type].

SLS with Door Monitoring and Enabling Switch Monitoring Parameter List

To configure the safety option module for Safe Limited Speed with Door Monitoring and Enabling Switch Monitoring, set the P58 [DM Input] and P54 [Enable SW Input] parameters in addition to the Safe Stop parameters listed on page 61 and the Safe Limited Speed parameters listed on page 68.

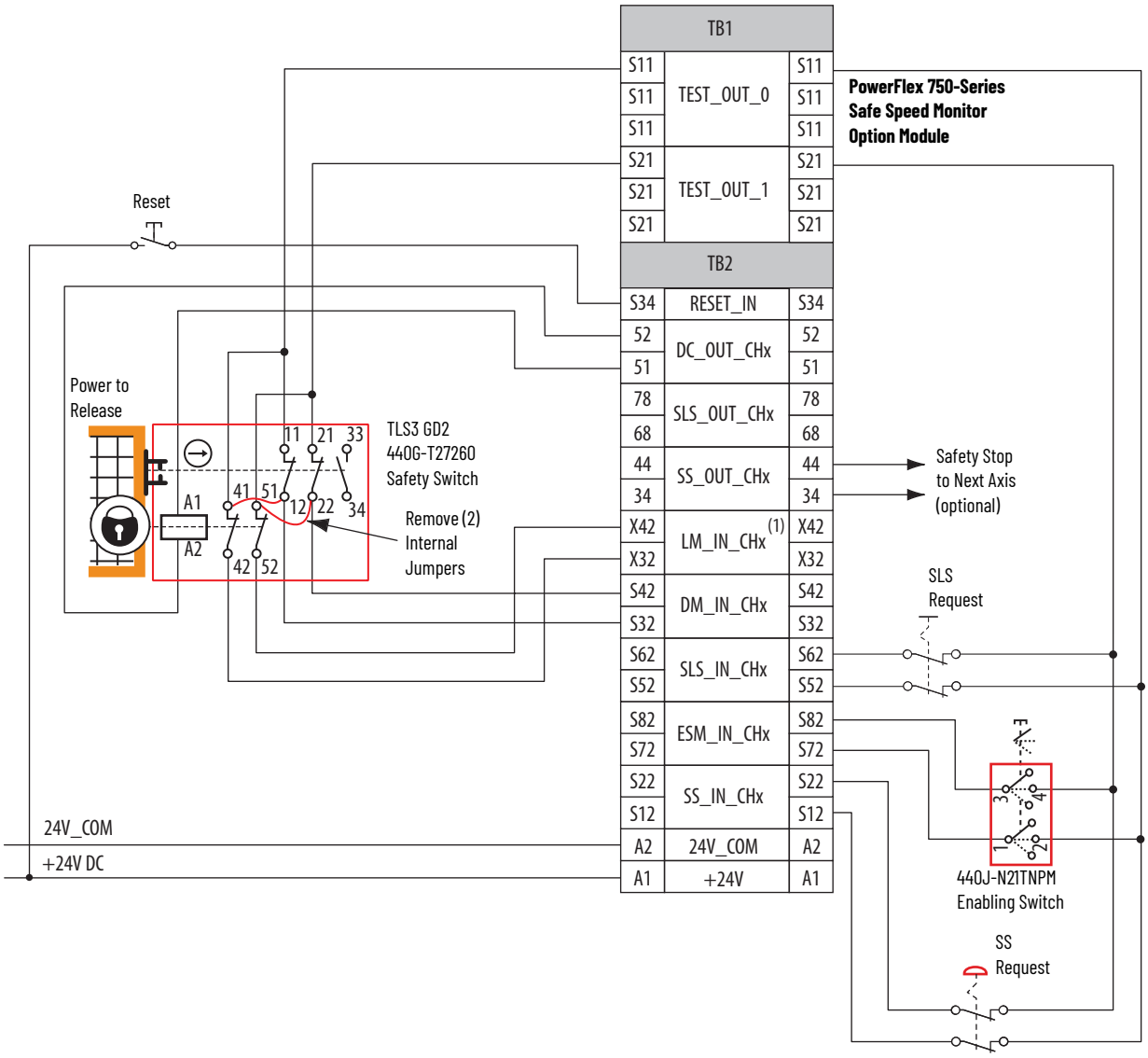
File	Group	No.	Display Name Full Name Description	Values		Read-Write	Data Type
HOST GROUPS	General	21	**Safety Mode** Safety Mode Defines the primary operating mode of the speed monitoring safety functions.	Setting:	6 = 'LimSpd DM ES'	RW	8-bit Integer
	Door Control	58	**DM Input** Door Monitor Input Configuration for the Door Monitor input (DM_In). '2NC' (1) – Dual-channel equivalent '2NC 3s' (2) – Dual-channel equivalent 3 s '1NC+1NO' (3) – Dual-channel complementary '1NC+1NO 3s' (4) – Dual-channel complementary 3 s '2 OSSD 3s' (5) – Dual-channel SS equivalent 3 s '1NC' (6) – Single channel equivalent	Default: Options:	0 = 'Not used' 0 = 'Not used' 1 = '2NC' 2 = '2NC 3s' 3 = '1NC+1NO' 4 = '1NC+1NO 3s' 5 = '2 OSSD 3s' 6 = '1NC'	RW	8-bit Integer
	Limited Speed	54	**Enable SW Input** Enable Switch Input Configuration for the Enabling Switch input (ESM_In). '2NC' (1) – Dual-channel equivalent '2NC 3s' (2) – Dual-channel equivalent 3 s '1NC+1NO' (3) – Dual-channel complementary '1NC+1NO 3s' (4) – Dual-channel complementary 3 s '2 OSSD 3s' (5) – Dual-channel SS equivalent 3 s '1NC' (6) – Single channel equivalent	Default: Options:	0 = 'Not used' (1) 0 = 'Not used' 1 = '2NC' 2 = '2NC 3s' 3 = '1NC+1NO' 4 = '1NC+1NO 3s' 5 = '2 OSSD 3s' 6 = '1NC'	RW	8-bit Integer

(1) You must configure this parameter with a non-zero value in this mode.

SLS with Door Monitoring and Enabling Switch Monitoring Wiring Example

This example illustrates wiring for SLS with door monitoring and enabling switch monitoring.

Figure 28 - Master, Safe Limited Speed with Door Monitoring and Enabling Switch Monitoring (first or single unit)



(1) Lock monitoring connections are not required for Safe Limited Speed with Door Monitoring and Enabling Switch Monitoring mode operation.

Safe Limited Speed Status Only Mode

When properly configured for Safe Limited Speed Status Only, the safety option module provides Safe Limited Speed status information in addition to the Safe Stop functions as described in Safe Stop Mode on page 55.

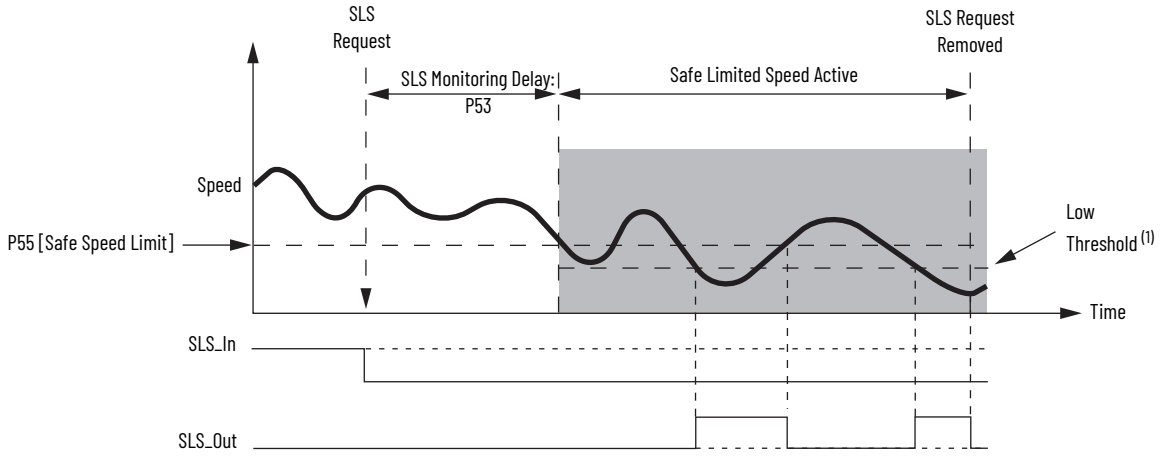
When the Safe Limited Speed input (SLS_In) is OFF, the feedback velocity is monitored and compared against a configurable Safe Speed Limit. If the measured velocity exceeds the limit, no stopping action takes place. Instead, the system status is made available as a safe output intended for a safety programmable logic controller (PLC).
You can program an optional P53 [LimSpd Mon Delay] to delay the start of Safe Limited Speed monitoring.

In Safe Limited Speed Status Only mode, Door Monitoring and Enabling Switch Monitoring are not available.

ATTENTION: When the safety option module is properly configured for Safe Limited Speed Status Only mode, it does not automatically initiate a Safe Stop in the event of an overspeed condition.

Safe Limited Speed monitoring is requested by a transition of the SLS_In input from ON to OFF. If you configure a P53 [LimSpd Mon Delay], the delay begins when Safe Limited Speed monitoring is requested by the SLS_In input transition from ON to OFF. The safety option module begins monitoring for Safe Limited Speed when the delay times out. The SLS_Out output is ON if Safe Limited Speed monitoring is active and the speed is below the configured Safe Speed Limit, considering hysteresis.

Figure 29 - Timing Diagram for Safe Limited Speed Status Only



(1) Low Threshold = (P56 [Speed Hysteresis]/100) x P55 [Safe Speed Limit]

Speed Hysteresis

The P56 [Speed Hysteresis] parameter provides hysteresis for the SLS_Out output when the safety option module is configured for SLS Status Only and Safe Limited Speed monitoring is active. The SLS_Out output is turned ON if the speed is less than the Low Threshold, which equals [(Speed Hysteresis/100) x Safe Speed Limit]. The SLS_Out output is turned OFF when the speed is greater than or equal to the configured P55 [Safe Speed Limit].

The SLS_Out output remains OFF if Safe Limited Speed monitoring begins when the detected speed is less than the configured Safe Speed Limit but greater than or equal to the Low Threshold [(Speed Hysteresis/100) x Safe Speed Limit].

The SLS_Out output is held in its last state when the speed is less than the configured Safe Speed Limit and the speed is greater than or equal to the Low Threshold [(Speed Hysteresis/100) x Safe Speed Limit].

SLS Status Only Parameter List

To configure the safety option for Safe Limited Speed Status Only monitoring, set these parameters in addition to the Safe Stop parameters listed on page 61.

File	Group	No.	Display Name Full Name Description	Values		Read-Write	Data Type
HOST GROUPS	General	21	**Safety Mode** Safety Mode Defines the primary operating mode of the speed monitoring safety functions.	Setting:	7 = 'Lim Spd Stat'	RW	8-bit Integer
	Limited Speed	52	**Lim Speed Input** Limited Speed Input Configuration for Safe Limited Speed input (SLS_In). '2NC' (1) – Dual-channel equivalent '2NC 3s' (2) – Dual-channel equivalent 3 s '1NC+1NO' (3) – Dual-channel complementary '1NC+1NO 3s' (4) – Dual-channel complementary 3 s '2 OSSD 3s' (5) – Dual-channel SS equivalent 3 s '1NC' (6) – Single channel equivalent	Default: Options:	0 = 'Not used' (1) 0 = 'Not used' 1 = '2NC' 2 = '2NC 3s' 3 = '1NC+1NO' 4 = '1NC+1NO 3s' 5 = '2 OSSD 3s' 6 = '1NC'	RW	8-bit Integer
		53	**LimSpd Mon Delay** Limited Speed Monitoring Delay Defines the Safe Limited Speed Monitoring Delay between the SLS_In ON to OFF transition and the initiation of the Safe Limited Speed (SLS) or Safe Maximum Speed (SMS) monitoring.	Units: Default: Min/Max:	Secs 0 0 / 6553.5	RW	16-bit Integer
		55	**Safe Speed Limit** Safe Speed Limit Defines the speed limit that is monitored in Safe Limited Speed (SLS) mode. Units are based on rotary or linear configuration defined by P29 [Fbk 1 Units].	Units: Default: Min/Max:	RPM mm/s 0 0 / 6553.5 RPM 0 / 6553.5 mm/s	RW	16-bit Integer
		56	**Speed Hysteresis** Speed Hysteresis Provides hysteresis for SLS_Out output when Safe Limited Speed monitoring is active. 0% when P21 [Safety Mode] = 1, 2, 3, 4, 5, 6, 8, or 9 10...100% when P21 [Safety Mode] = 7 or 10	Units: Default: Min/Max:	% 0 0 / 100	RW	8-bit Integer

(1) You must configure this parameter with a non-zero value in this mode.

SLS Status Only Wiring Examples

These examples illustrate wiring for SLS status only operation.

Figure 30 - Master, Safe Limited Speed Status Only (single unit)

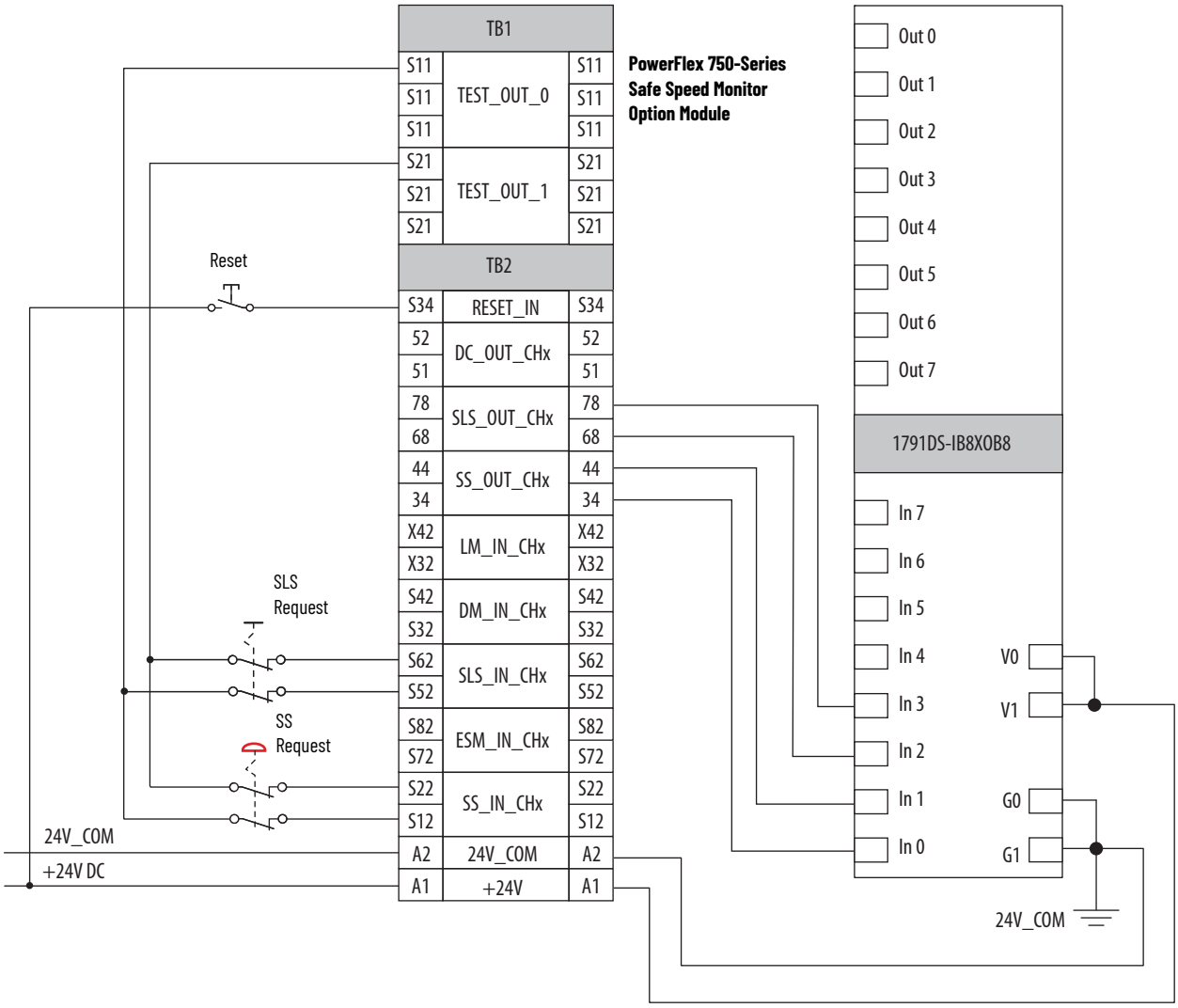
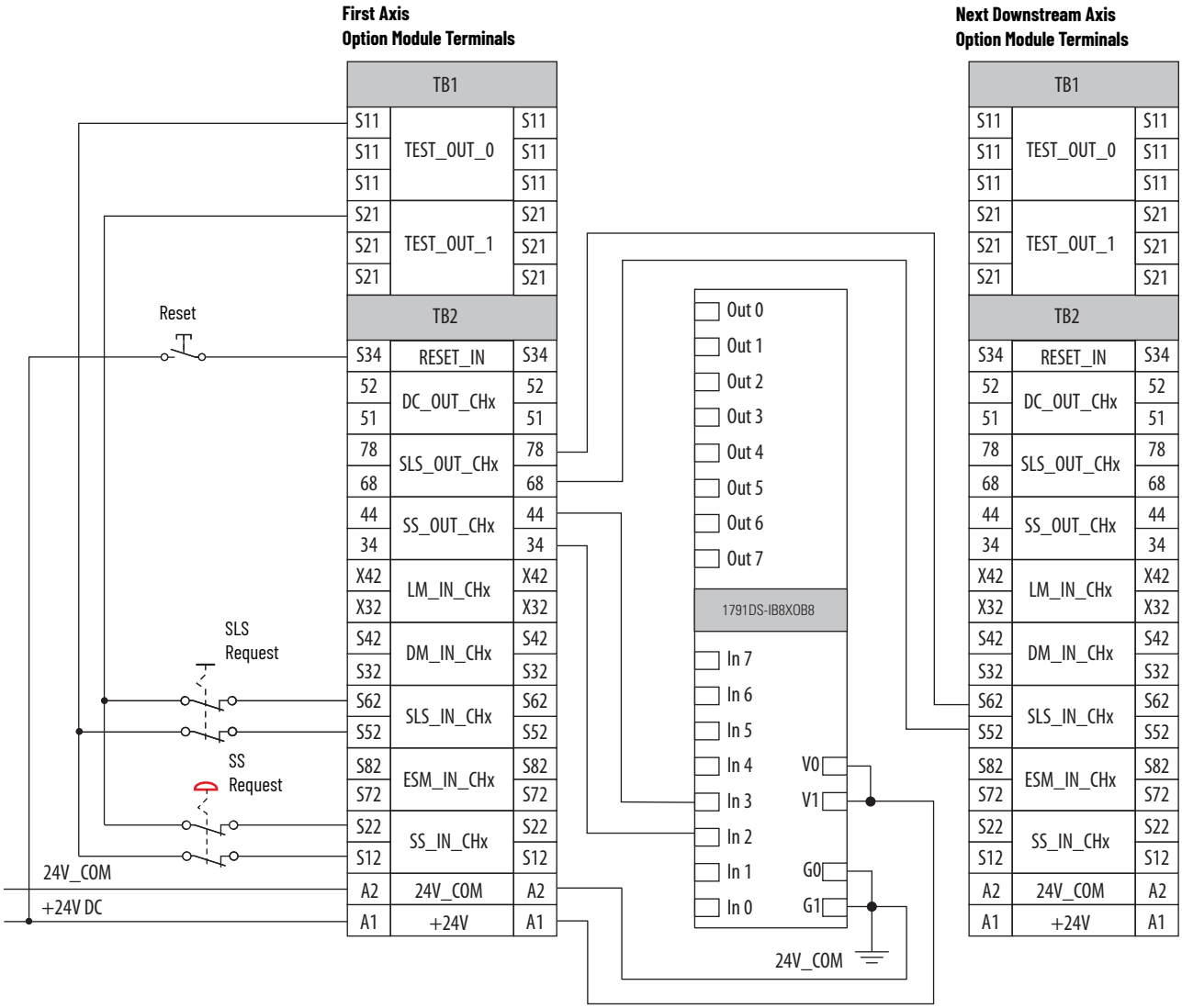


Figure 31 - Master, Safe Limited Speed Status Only (first unit)

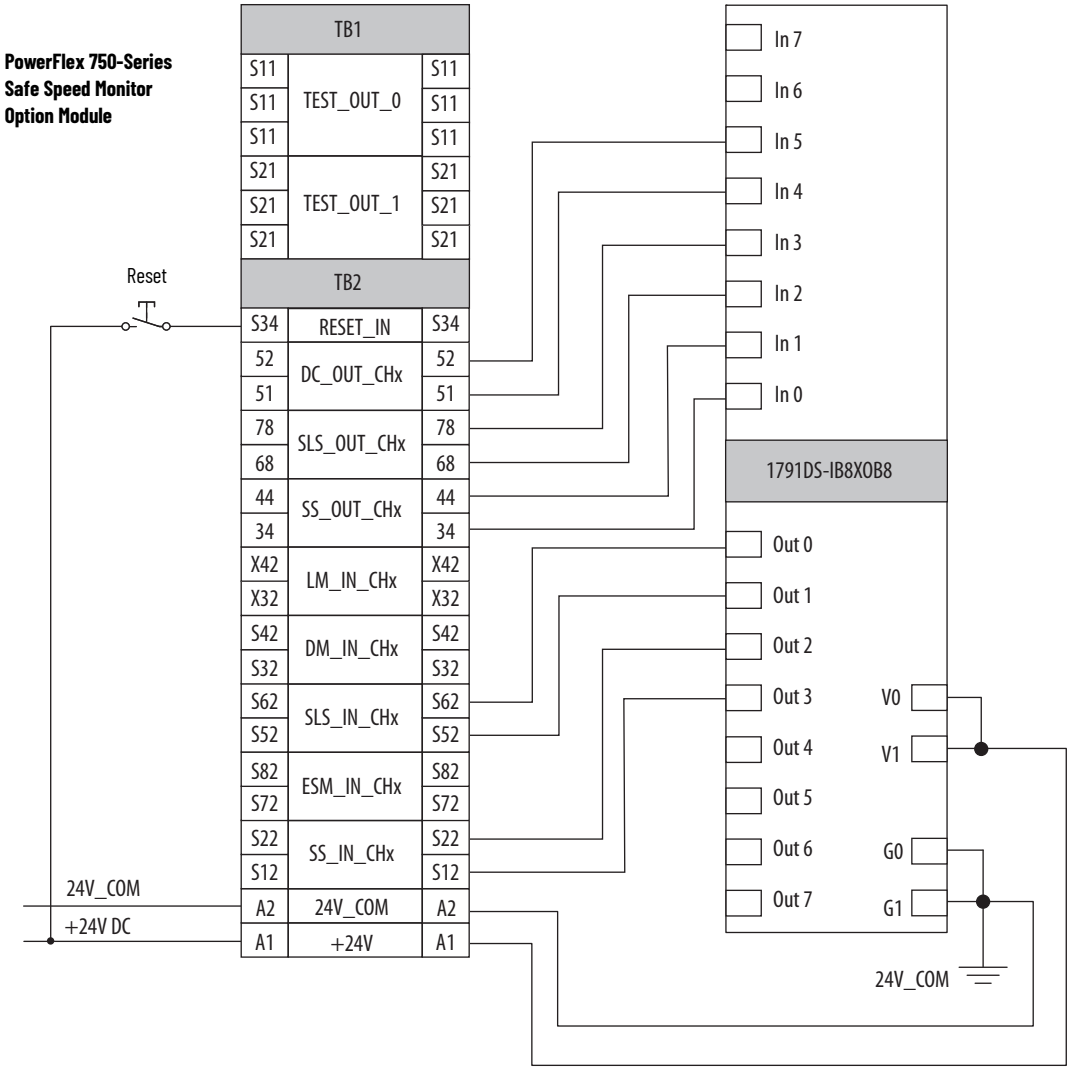


This example assumes that a programmable safety controller is monitoring all safety option module functions and controlling the safety option module. The SS_In and SLS_In inputs are connected to the I/O module; however, standard safety component inputs could also be used.

These functions are not performed by the safety option module in this scenario:

- Guardlocking switch inputs
- Door locking
- Door status (open or closed)
- Enabling switch

Figure 32 - Safe Limited Speed Status Only with Programmable Controller Monitoring



Slave Modes for Multi-axis Cascaded Systems

This chapter describes the slave modes of operation and provides wiring examples of cascaded multi-axis configurations.

Cascaded Configurations

Use the P20 [Cascaded Config] parameter to define the safety option module's position in the system as Single Unit (Single), Cascaded First Unit (Multi First), Cascaded Middle Unit (Multi Mid), or Cascaded Last Unit (Multi Last). Only the middle or last safety option module in a multi-axis system can be configured for slave modes.

For cascaded safety option modules, connect the safety switches to the safety inputs (SS_In, SLS_In, DM_In, ESM_In, and LM_In) of the first (master) axis only. Each feedback for Safe Stop functions are connected to their respective axis. The inputs are cascaded from one safety option module to the next by connecting the outputs from the previous safety option module to the inputs of the next safety option module.

Figure 33 - Cascaded Connections

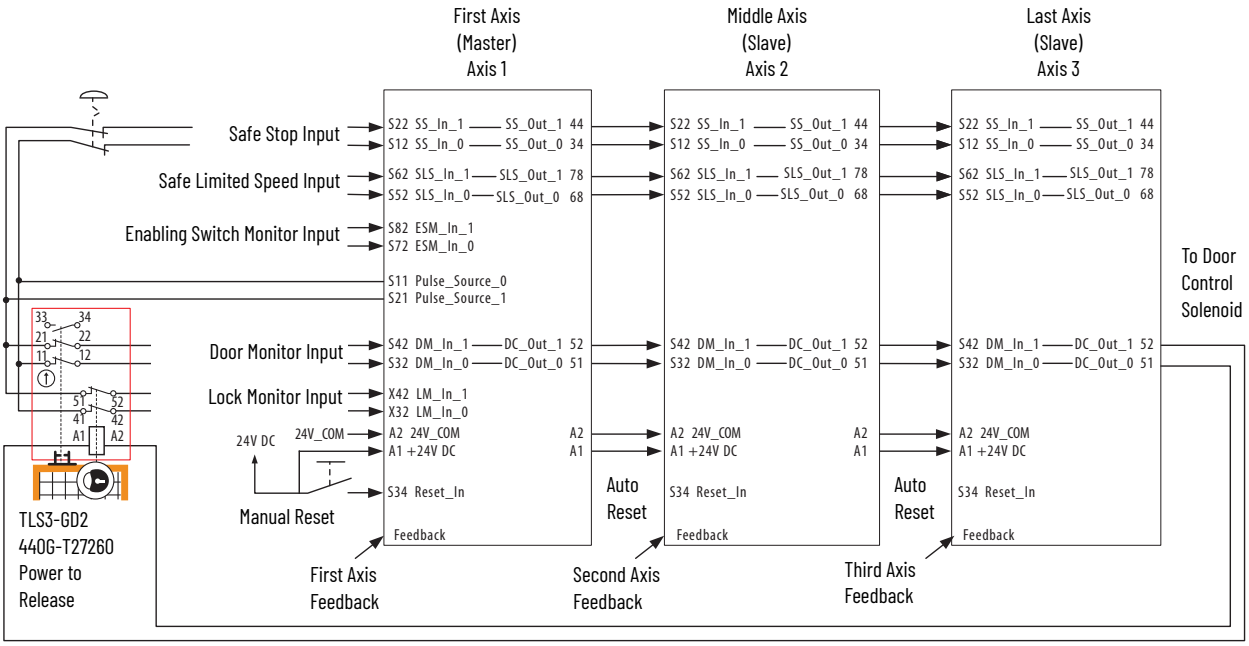


Figure 33 is for reference only. See the following diagrams for more information:

- Figure 37 on page 92
- Figure 38 on page 93
- Figure 39 on page 94

The inputs from the safety switches are monitored by the first (master) safety option module. A Safe Limited Speed Reset detected by the first safety option module is cascaded to the subsequent safety option modules via the SLS_Out to SLS_In chain.

IMPORTANT	It is recommended to use automatic reset in all slave units to follow the master unit's reset type.

Any fault or transition of the SS_In input to OFF is detected by the first safety option module and initiates the configured P45 [Safe Stop Type] to all of the safety option modules via the SS_Out to SS_In chain.

Any fault in a slave safety option module initiates the configured P45 [Safe Stop Type] only to that safety option module and to slave safety option modules further down the chain.

IMPORTANT Safe Stop monitoring is not initiated for non-faulted units earlier in the cascaded chain.

IMPORTANT The safety reaction time for a cascaded system includes the sum of the reaction times of each safety option module in the chain.

Slave, Safe Stop Mode

When properly configured for Slave, Safe Stop mode, the safety option module performs the same functions as Safe Stop except that the safety option module regards the Door Monitor input as a Door Control output from an upstream axis, and performs a logical AND with its internal Door Control signal to form the cascaded Door Control output. This makes sure that the Door Control output commands the door to unlock only if all units command the door to unlock.

Slave, Safe Stop Parameter List

To configure the safety option module for a Slave, Safe Stop mode, set these parameters. See Multi-axis Connections on page 97 for details on configuring slave safety option modules.

Table 30 - Slave, Safe Stop Parameter List

File	Group	No.	Display Name Full Name Description	Values		Read-Write	Data Type
HOST GROUPS	General	20	**Cascaded Config** Cascaded Configuration Defines whether the speed monitoring safety option module is a single unit or if it occupies a first, middle, or last position in a multi-axis cascaded system.	Options:	2 = 'Multi Mid' 3 = 'Multi Last'	RW	8-bit Integer
		21	**Safety Mode** Safety Mode Defines the primary operating mode of the speed monitoring safety functions.	Option:	8 = 'Slv Safe Stp'	RW	8-bit Integer
	Stop	44	**Safe Stop Input** Safe Stop Input Configuration for Safe Stop input (SS_In). '2 OSSD 3s' (5) – Dual-channel SS equivalent 3 s	Options	5 = '2 OSSD 3s'	RW	8-bit Integer
		45	**Safe Stop Type** Safe Stop Type Safe operating stop type selection. This defines the type of Safe Stop that is performed if the Safe Stop function is initiated by a stop type condition.	Default: Options:	0 = 'Torque Off' 0 = 'Torque Off' 1 = 'Safe Stop 1' 2 = 'Safe Stop 2' 3 = 'Torque Off NoCk'	RW	8-bit Integer
		46	**Stop Mon Delay** Stop Monitoring Delay Defines the monitoring delay between the request and the Max Stop Time when the request for a Safe Stop 1 or a Safe Stop 2 is initiated by an SS_In input ON to OFF transition. If the Safe Stop Type is Safe Torque Off With or Without Standstill Speed Checking, the Stop Monitor Delay must be 0 or a Invalid Configuration Fault occurs.	Units: Default: Min/Max:	Secs 0 0 / 6553.5	RW	16-bit Integer
		47	**Max Stop Time** Maximum Stop Time Defines the maximum stop delay time that is used when the Safe Stop function is initiated by a stop type condition.	Units: Default: Min/Max:	Secs 0 0 / 6553.5	RW	16-bit Integer
		48	**Standstill Speed** Standstill Speed Defines the speed limit that is used to declare motion as stopped. Units are based on rotary or linear configuration defined by P29 [Fbk 1 Units]. Not valid for Safe Torque Off without Standstill Checking.	Units: Default: Min/Max:	RPM mm/s 0.001 0.001/ 65.535 RPM 000/ 65.535 mm/s	RW	16-bit Integer

Table 30 - Slave, Safe Stop Parameter List (Continued)

File	Group	No.	Display Name Full Name Description	Values		Read-Write	Data Type
HOST GROUPS	Stop	49	**Standstill Pos** Standstill Position Defines the position limit window in encoder 1 degrees or mm that is tolerated after a safe stop condition has been detected. Degrees (360° = 1 revolution) or mm based on rotary or linear configuration defined by P29 [Fbk 1 Units]. Not valid for Safe Torque Off without Standstill Checking.	Units: Default: Min/Max:	Deg mm 10 0 / 65,535 deg 0 / 65.535 mm	RW	16-bit Integer
		50	**Decel Ref Speed** Deceleration Reference Speed Determines deceleration rate to monitor for Safe Stop 1 or Safe Stop 2. Units are based on rotary or linear configuration defined by encoder 1 feedback configuration, P29 [Fbk 1 Units].	Units: Default: Min/Max:	RPM mm/s 0 0 / 65,535 RPM 0 / 65,535 mm/s	RW	16-bit Integer
		51	**Stop Decel Tol** Stop Deceleration Tolerance This is the acceptable tolerance above the deceleration rate set by the Decel Ref Speed parameter.	Units: Default: Min/Max:	% 0 0 / 100	RW	8-bit Integer
	Door Control	57	**Door Out Type** Door Output Type Defines the lock and unlock state for door control output (DC_Out). When Door Out Type equals power to release, DC_Out is OFF in the lock state and ON in the unlock state. When Door Out Type equals power to lock, DC_Out is ON in the lock state and OFF in the unlock state. The first and middle units of a multi-axis system must be configured as cascading (2).	Default: Options:	0 = 'Pwr to Rel' 0 = 'Pwr to Rel' 1 = 'Pwr to Lock' 2 = '2 Ch Sourcing'	RW	8-bit Integer
		58	**DM Input** Door Monitor Input Configuration for the Door Monitor input (DM_In). '2 OSSD 3s' (5) – Dual-channel SS equivalent 3 s	Options:	5 = '2 OSSD 3s'	RW	8-bit Integer

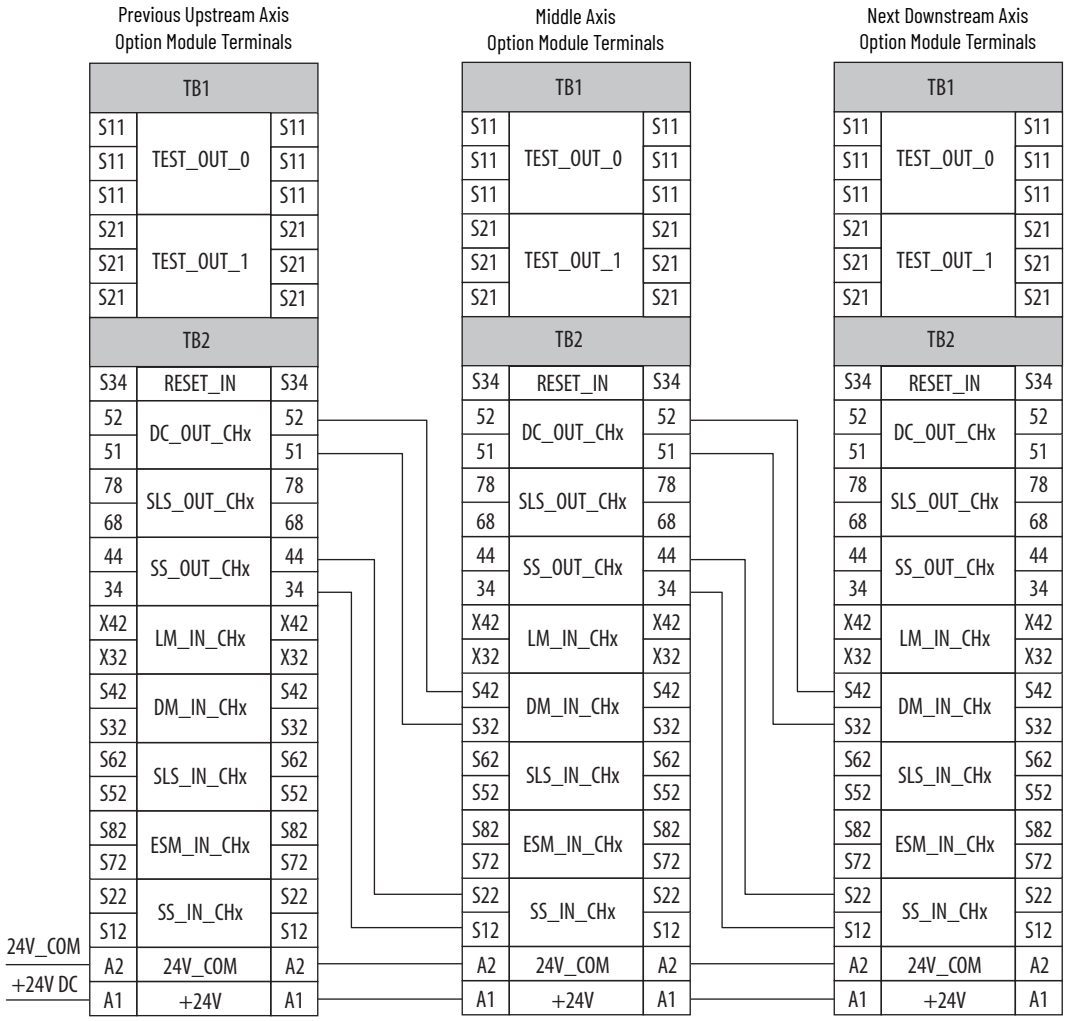
Slave, Safe Stop Wiring Examples

These examples show two different Slave, Safe Stop configurations.

The first example shows the safety option module configured as a cascaded middle unit via the P20 [Cascaded Config] parameter (Multi Mid). It has SS_In and DM_In input connections from the previous upstream safety option module, as well as SS_Out and DC_Out output connections to the next downstream safety option module. This unit is configured with automatic reset so it follows the function of the previous axis.

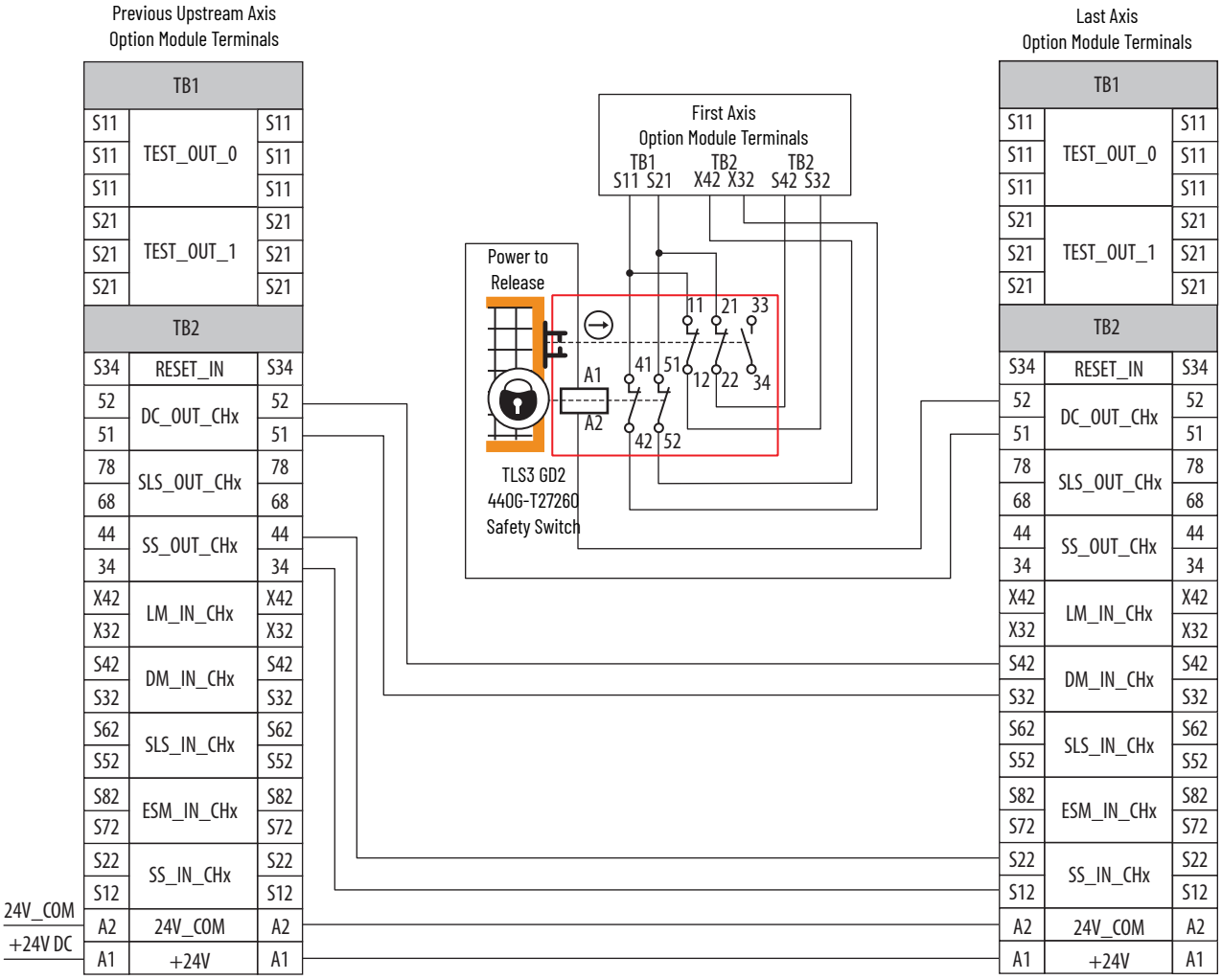
See Safe Stop with Door Monitoring Wiring Example on page 66 for an example of a first (master) unit.

Figure 34 - Slave, Safe Stop, Middle Unit



This example shows the last cascaded slave safety option module in the system. It has SS_In and DM_In inputs from the previous upstream safety option module, but its DC_Out output is connected to a guardlocking interlock switch. This unit is configured with automatic reset so it follows the function of the previous axis.

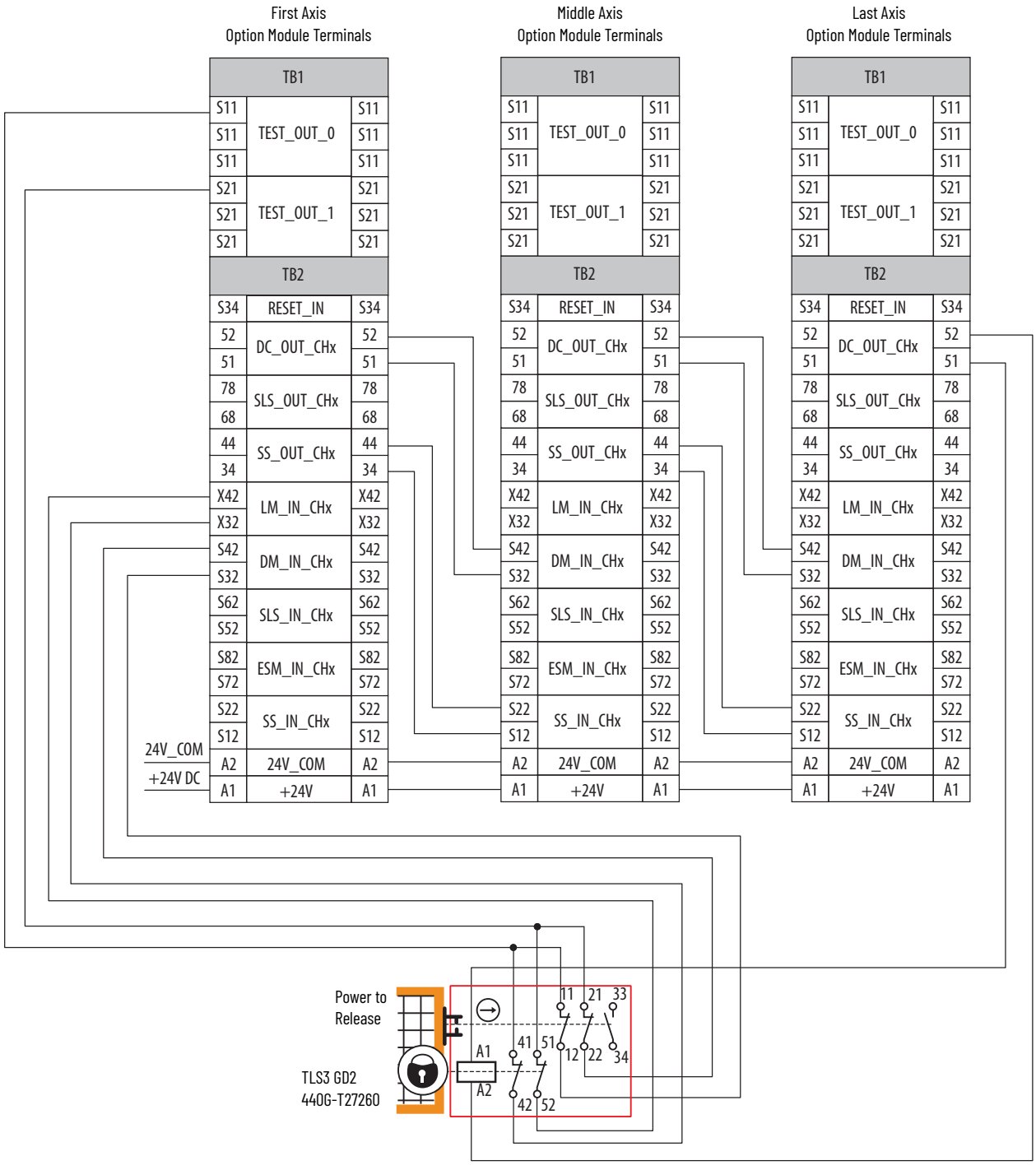
Figure 35 - Slave, Safe Stop, Last Unit



This example shows three safety option modules connected together in a cascaded system.

IMPORTANT All Safe Speed Monitor option modules must share a common ground.

Figure 36 - Cascaded System with Door Control and Lock Monitoring



Slave, Safe Limited Speed Mode

When properly configured for Slave, Safe Limited Speed mode, the safety option module performs the same functions as Safe Limited Speed mode as described on page 67.

However, the safety option module regards the Door Monitor input as a Door Control output from an upstream axis, and performs a logical AND with its internal Door Control signal to form the cascaded Door Control output. Door Monitoring, Enabling Switch Monitoring, and Lock Monitoring functions are not allowed in this mode.

For the door to unlock, all axes must be below safe limited speed.

Only the middle and last safety option module in a multi-axis system can be configured for slave modes.

Slave, Safe Limited Speed Parameters

To configure the safety option module for Slave, Safe Limited Speed monitoring, set these parameters in addition to the Slave, Safe Stop parameters listed on page 86. See Multi-axis Connections on page 97 for details on configuring slave safety option modules.

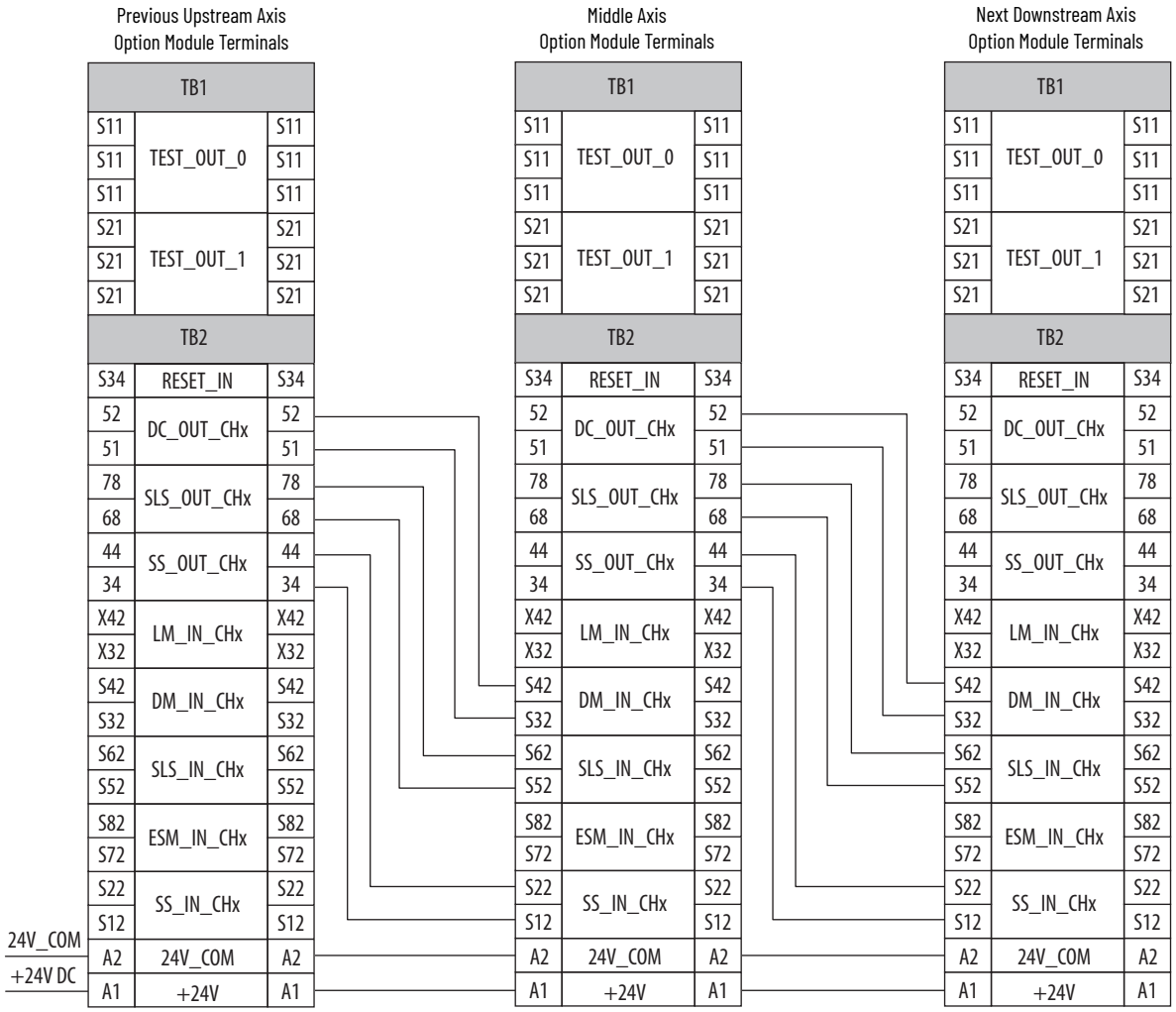
File	Group	No.	Display Name Full Name Description	Values		Read-Write	Data Type
HOST GROUPS	General	20	**Cascaded Config** Cascaded Configuration Defines whether the speed monitoring safety option module is a single unit or if it occupies a first, middle, or last position in a multi-axis cascaded system.	Options:	2 = 'Multi Mid' 3 = 'Multi Last'	RW	8-bit Integer
		21	**Safety Mode** Safety Mode Defines the primary operating mode of the speed monitoring safety functions. 'Slv Lim Spd' (9) - Slave, Safe Limited Speed	Option:	9 = 'Slv Lim Spd'	RW	8-bit Integer
	Limited Speed	52	**Lim Speed Input** Limited Speed Input Configuration for Safe Limited Speed input (SLS_In). '2 OSSD 3s' (5) – Dual-channel SS equivalent 3 s	Option:	5 = '2 OSSD 3s'	RW	8-bit Integer
		53	**LimSpd Mon Delay** Limited Speed Monitoring Delay Defines the Safe Limited Speed Monitoring Delay between the SLS_In ON to OFF transition and the initiation of the Safe Limited Speed (SLS) or Safe Maximum Speed (SMS) monitoring.	Units: Default: Min/Max:	Secs 0 0 / 6553.5	RW	8-bit Integer
		55	**Safe Speed Limit** Safe Speed Limit Defines the speed limit that is monitored in Safe Limited Speed (SLS) mode. Units are based on rotary or linear configuration defined by P29 [Fbk 1 Units].	Units: Default: Min/Max:	RPM mm/s 0 0 / 6553.5 RPM 0 / 6553.5 mm/s	RW	16-bit Integer

Slave, Safe Limited Speed Wiring Examples

These examples show two different Slave, Safe Limited Speed configurations.

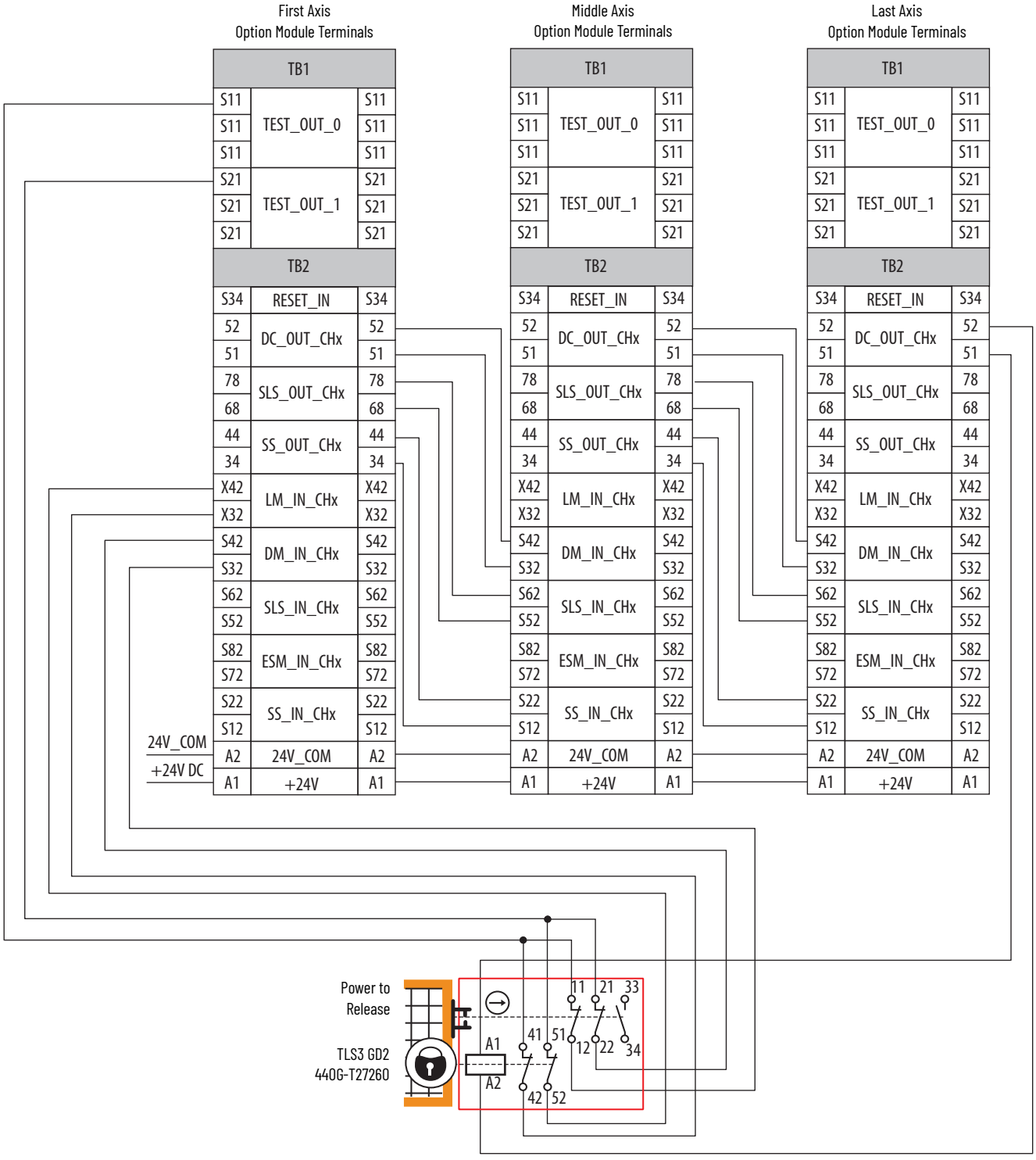
The first example is configured as a cascaded middle unit via the P20 [Cascaded Config] parameter (Multi Mid). It has SS_In, SLS_In, and DM_In input connections from the previous upstream safety option module, as well as SS_Out, SLS_Out, and DC_Out output connections to the next downstream safety option module.

Figure 37 - Slave, Safe Limited Speed, Middle Unit



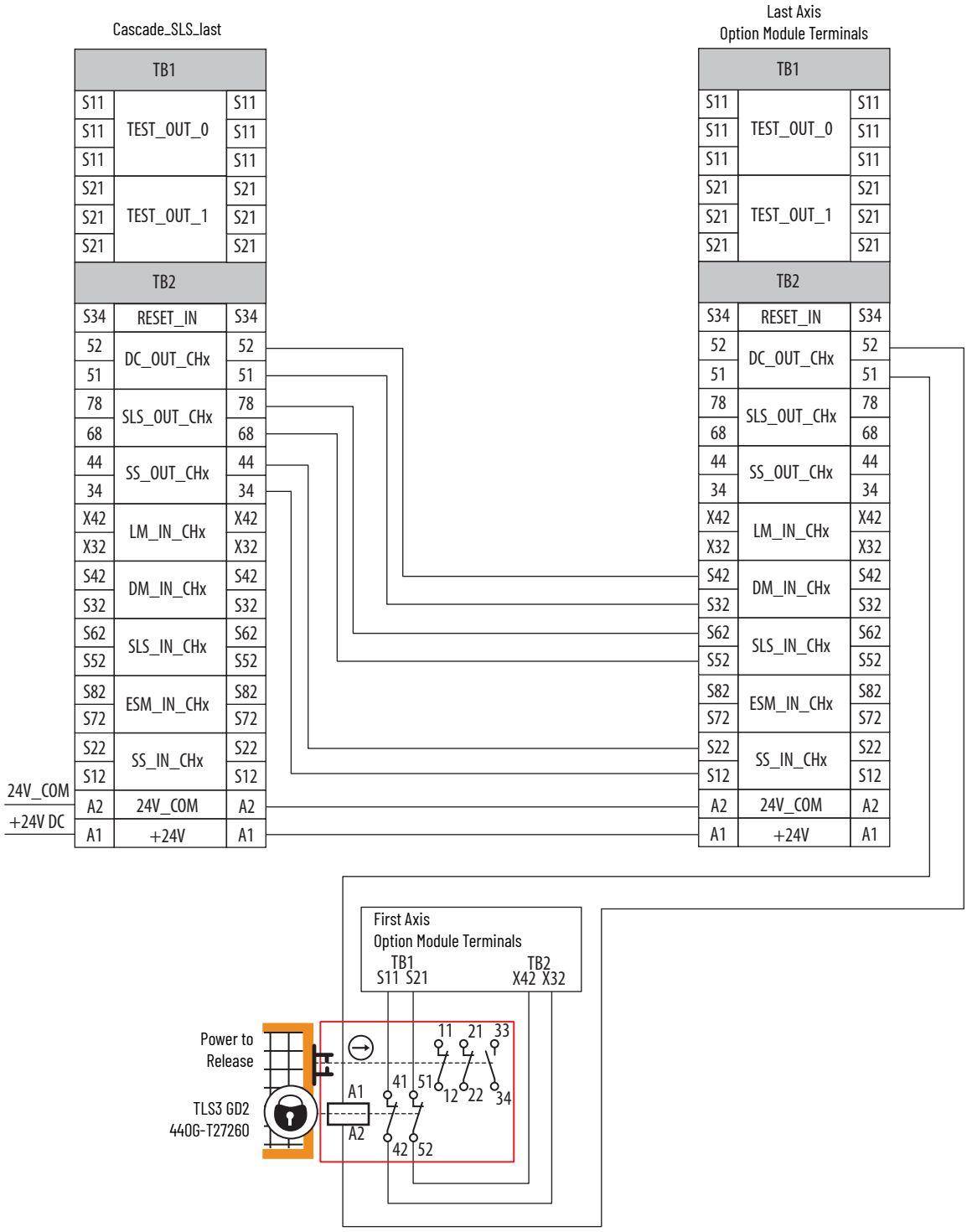
The following diagram shows the first, middle, and last axis in a cascaded Safe Limited Speed configuration.

Figure 38 - First, Middle, and Last Axis in a Cascaded Safe Limited Speed Configuration



This second example is configured as a cascaded last unit via the P20 [Cascaded Config] parameter (Multi Last). It has SS_In, SLS_In, and DM_In input connections from the previous upstream safety option module, but its DC_Out output is connected to a guardlocking interlock switch.

Figure 39 - Slave, Safe Limited Speed, Last Unit



Slave, Safe Limited Speed Status Only Mode

When properly configured for Slave, Safe Limited Speed Status Only mode, the Safe Speed Monitor option module performs the same functions as Safe Limited Speed Status Only mode as described on page 79. However, the safety option module regards the Door Monitor input as a Door Control output from an upstream axis, and performs a logical AND with its internal Door Control signal to form the cascaded Door Control output.

The SLS_Out output of the last safety option module in a cascaded chain goes high only when all axes are below the Safe Speed Limit. In Safe Limited Speed Status Only mode, each subsequent unit does not enable Safe Limited Speed until the previous unit has reached the Safe Speed Limit.

Door Monitoring and Enabling Switch Monitoring functions are not allowed in this mode.

Only the middle and last safety option module in a multi-axis system can be configured for slave modes.

Slave, Safe Limited Speed Status Only Parameter List

To configure the safety option module for Slave, Safe Limited Speed Status Only monitoring, set these parameters in addition to the Slave, Safe Stop parameters listed on page 86 and the Slave, Safe Limited Speed parameters listed on page 91. See Multi-axis Connections on page 97 for details on configuring slave safety option modules.

File	Group	No.	Display Name Full Name Description	Values		Read-Write	Data Type
HOST GROUPS	General	20	**Cascaded Config** Cascaded Configuration Defines whether the speed monitoring safety option module is a single unit or if it occupies a first, middle, or last position in a multi-axis cascaded system.	Options:	2 = 'Multi Mid' 3 = 'Multi Last'	RW	8-bit Integer
		21	**Safety Mode** Safety Mode Defines the primary operating mode of the speed monitoring safety functions. 'Slv Spd Stat' (10) - Slave, Safe Limited Speed Status Only	Option:	10 = 'Slv Spd Stat'	RW	8-bit Integer
	Limited Speed	56	**Speed Hysteresis** Speed Hysteresis Provides hysteresis for SLS_Out output when Safe Limited Speed monitoring is active. 0% when P21 [Safety Mode] = 1, 2, 3, 4, 5, 6, 8, or 9 10...100% when P21 [Safety Mode] = 7 or 10	Units: Default: Min/Max:	% 0 0 / 100	RW	8-bit Integer

Slave, Safe Limited Speed Status Only Wiring Examples

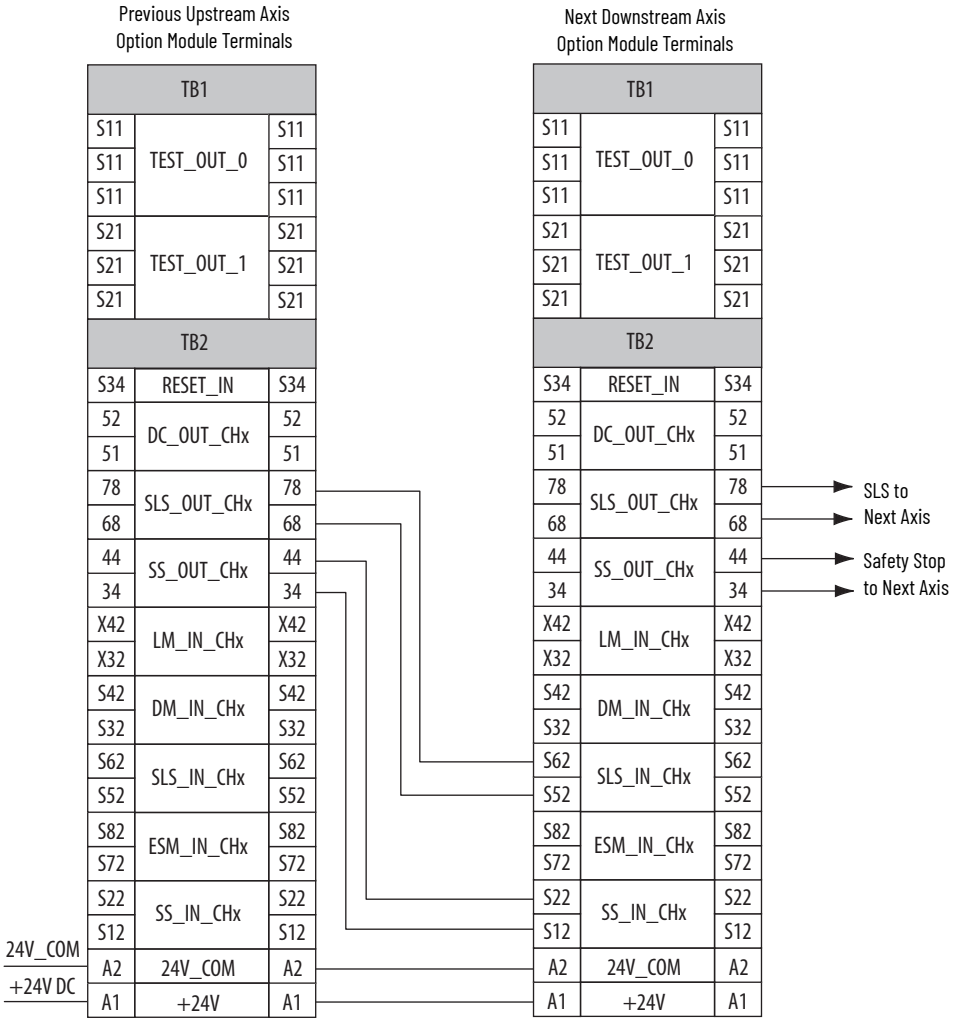
These examples show two different Slave, Safe Limited Speed Status Only configurations.

The first example is configured as a cascaded middle unit via the P20 [Cascaded Config] parameter (Multi Mid). It has SS_In, SLS_In, and DM_In input connections from the previous upstream safety option module, as well as SS_Out, SLS_Out, and DC_Out output connections to the next downstream safety option module.

IMPORTANT The SLS_Out signals change state immediately based on the speed relative to the Safe Speed Limit if the Safe Limited Speed Monitoring Delay (SLS Mon Delay) is set to zero.

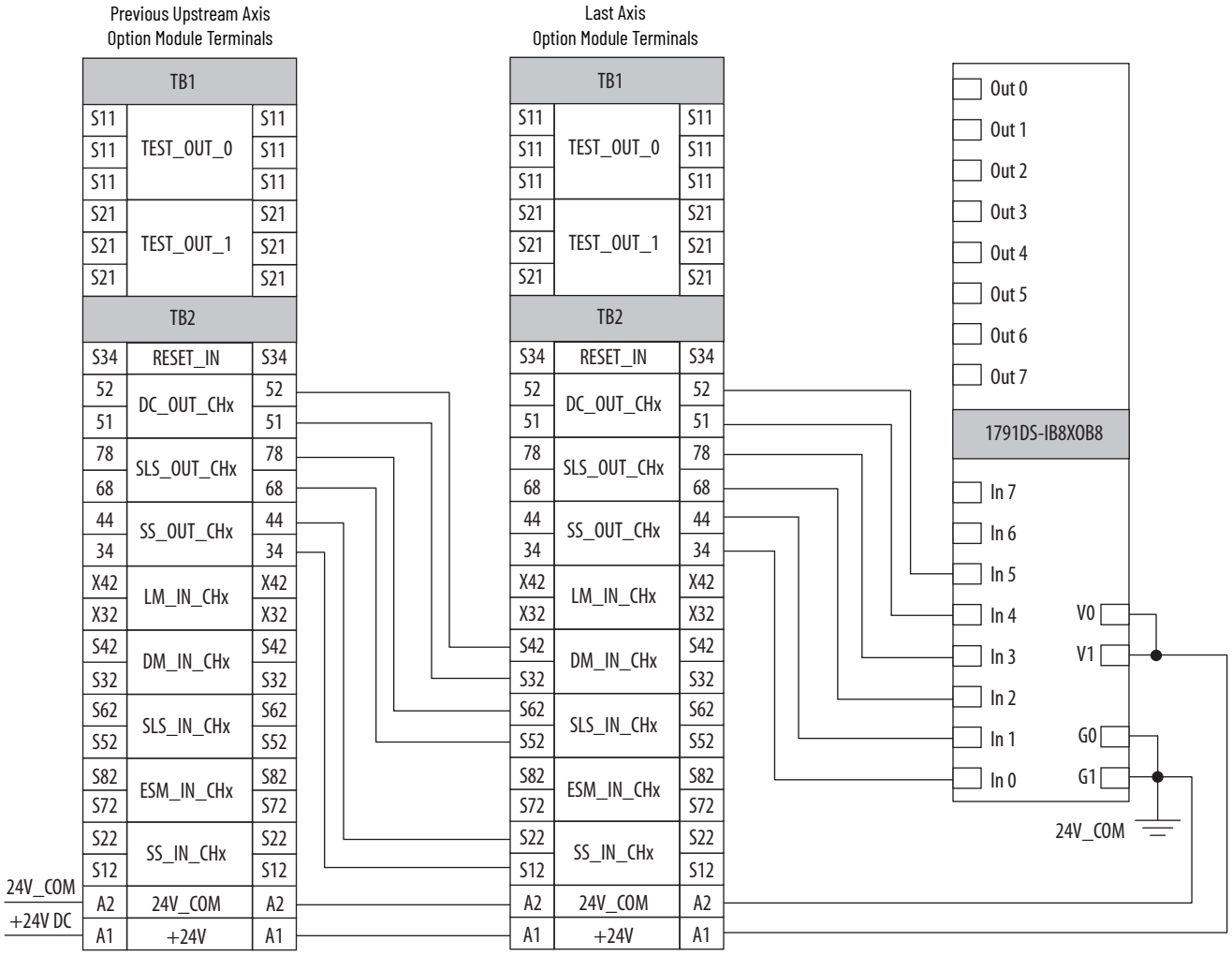
See SLS Status Only Wiring Examples starting on page 82 for an example of a first (master) unit.

Figure 40 - Slave, Safe Limited Speed Status Only, Middle Safety Option



This second example is configured as a cascaded last unit via the P20 [Cascaded Config] parameter (Multi Last). It has SS_In, SLS_In, and DM_In input connections from the previous upstream safety option module, but its SS_Out, SLS_Out, and DC_out outputs are connected to a Bulletin 1791DS module.

Figure 41 - Slave, Safe Limited Speed Status Only, Last Safety Option



Multi-axis Connections

When configuring a multi-axis system, you need to consider the location of each safety option module in the system. The type of cascaded connections that can be made are dependent upon the Safety mode configurations of the master and slave safety option modules and their positions in the system.

Middle and last units in the cascaded chain can be configured for Automatic reset. A single reset by the first unit also resets all following units in the chain. If a fault occurs after the first axis in the cascaded chain, only the subsequent axis enters the safe state. To reset all axes, you must cycle the SS_In input on the first axis.

For slave units in a multi-axis system, the SS_In, SLS_In, and DM_In input signal types (if used) must be configured for output switching signal devices (OSSD) because the output from the previous unit is also configured for OSSD.

For middle or last units in multi-axis systems, the safety option module regards the Door Monitor input as a Door Control output from an upstream axis, and performs a logical AND with its internal Door Control signal to form the cascaded Door Control output.

For information on door control in the master unit, see Door Control on page 60.

Table 31 - Typical Safety Mode Combination

Master Safety Option	First Slave Safety Option (1) (Second Safety Option in System)	Cascaded Connections Allowed		
		SS_Out to SS_In	SLS_Out to SLS_In	DC_Out to DM_In (2)
Safe Stop	Slave - Safe Stop	Yes	–	Yes
Safe Stop with Door Monitoring	Slave - Safe Stop	Yes	–	Yes
Safe Limited Speed	Slave - Safe Stop	Yes	–	Yes
	Slave - Safe Limited Speed	Yes	Yes	Yes
Safe Limited Speed with Door Monitoring	Slave - Safe Stop	Yes	–	Yes
	Slave - Safe Limited Speed	Yes	Yes	Yes
Safe Limited Speed with Enabling Switch Monitoring	Slave - Safe Stop	Yes	–	Yes
	Slave - Safe Limited Speed	Yes	Yes	Yes
Safe Limited Speed with Door Monitoring and Enabling Switch Monitoring	Slave - Safe Stop	Yes	–	Yes
	Slave - Safe Limited Speed	Yes	Yes	Yes
Safe Limited Speed Status Only	Slave - Safe Stop	Yes	–	Yes
	Slave - Safe Limited Speed Status Only	Yes	Yes	–

(1) P20 [Cascaded Config] parameter equals Cascaded Middle Unit (Multi Mid).
(2) DC_Out to DM_In connections are required only for systems implementing door control or systems monitoring cascaded stopped status.

This table shows the supported Safety modes for slave safety option modules (*n*+1) cascaded from slaves (*n*).

Table 32 - Supported Safety Modes (for slave option modules [n+1] cascaded from slaves [n])

Supported Safety Mode Combinations		Cascaded Connections Allowed		
Slave Safety Option (*n*)	Slave Safety Option (*n*+1)	SS_Out to SS_In	SLS_Out to SLS_In	DC_Out to DM_In (1)
Slave - Safe Stop	Slave - Safe Stop	Yes	–	Yes
Slave - Safe Limited Speed	Slave - Safe Stop	Yes	–	Yes
	Slave - Safe Limited Speed	Yes	Yes	Yes
Slave - Safe Limited Speed Status Only	Slave - Safe Stop	Yes	–	Yes
	Slave - Safe Limited Speed Status Only	Yes	Yes	Yes

(1) DC_Out to DM_In connections are required only for systems implementing door control.

Safe Maximum Speed and Direction Monitoring

This chapter describes Safe Maximum Speed (SMS), Safe Maximum Acceleration (SMA), and Safe Direction (SDM) monitoring modes of operation and provides a list of configuration parameters.

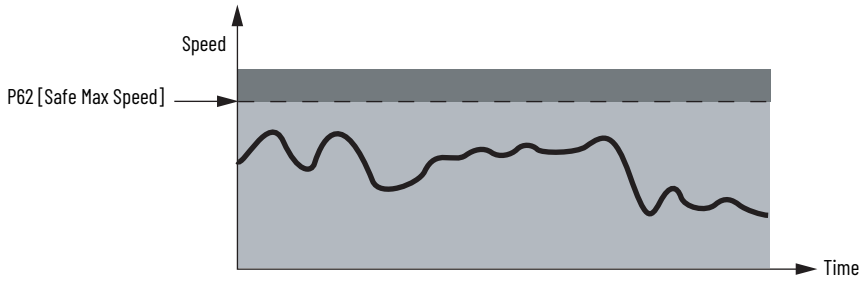
Safe Maximum Speed (SMS) Monitoring

Configure Safe Maximum Speed monitoring by setting the P61 [Max Speed Enable] parameter to Enable. When configured, Safe Maximum Speed monitoring is active any time the safety option module configuration is valid and the Safety mode is not Disabled.

When you configure the safety option module for Safe Maximum Speed, the feedback velocity is monitored and compared against a user-configurable limit.

The P62 [Safe Max Speed] parameter is relative to encoder 1. If the monitored speed is greater than or equal to the configured P62 [Safe Max Speed] value, an SMS Speed fault (Stop Category fault) occurs.

Figure 42 - Safe Max Speed Timing Diagram



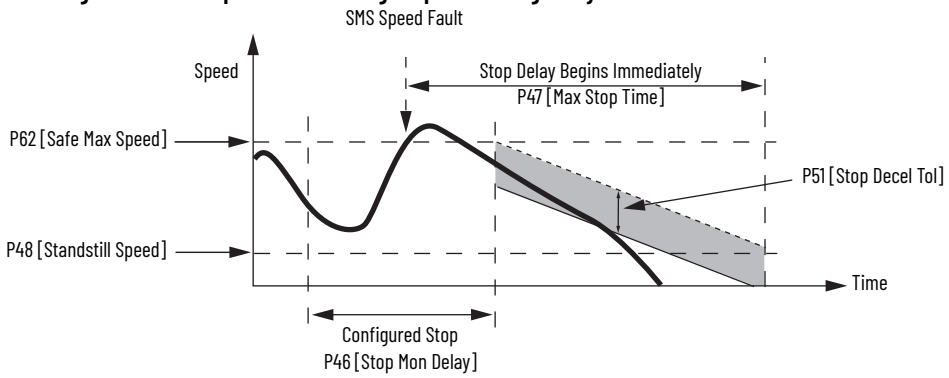
You define the Safe Stop Type initiated by the safety option module in the event of an SMS Speed fault by using the P63 [Max Spd Stop Typ] parameter.

Table 33 - P63 [Max Spd Stop Typ] Parameter

P63 [Max Spd Stop Typ] Parameter	Description
0 = Use Safe Torque Off with Check for Standstill (Torque Off)	The safety option module initiates Safe Torque Off with Check for Standstill any time an SMS Speed fault is detected while the safety option module is monitoring motion.
1 = Use Configured Stop Type (Safe Stp Typ)	The safety option module initiates the configured P45 [Safe Stop Type] parameter any time an SMS Speed fault is detected while the safety option module is monitoring motion.

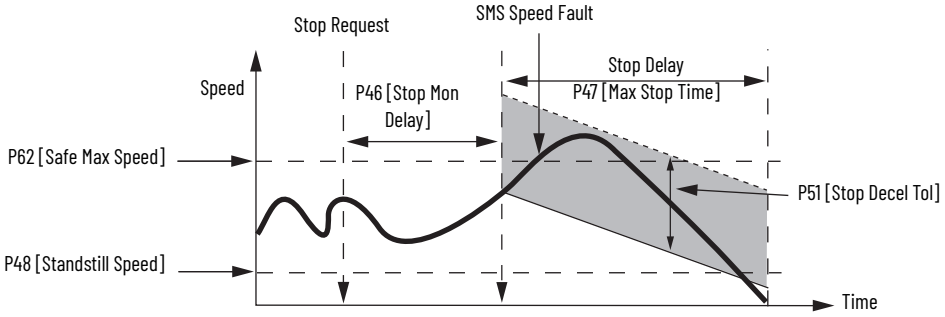
If an SMS Speed fault is detected during a Stop Monitoring Delay, P46 [Stop Mon Delay], the delay ends immediately and the configured Stop Delay P47 [Max Stop Time] begins.

Figure 43 - SMS Speed Fault During Stop Monitoring Delay



If an SMS Speed fault is detected during the Stop Delay [Max Stop Time], and the P63 [Max Spd Stop Typ] parameter equals Use Configured Stop Type (Safe Stp Typ), and the feedback signals indicate less than maximum frequency(1) for your encoder type, the fault is reported, but no further action is taken. Deceleration monitoring performs the safety function during the Stop Delay P47 [Max Stop Time]. That is, if an SMS Speed fault occurs during the Stop Delay P47 [Max Stop Time], the fault is ignored and the stopping action continues.

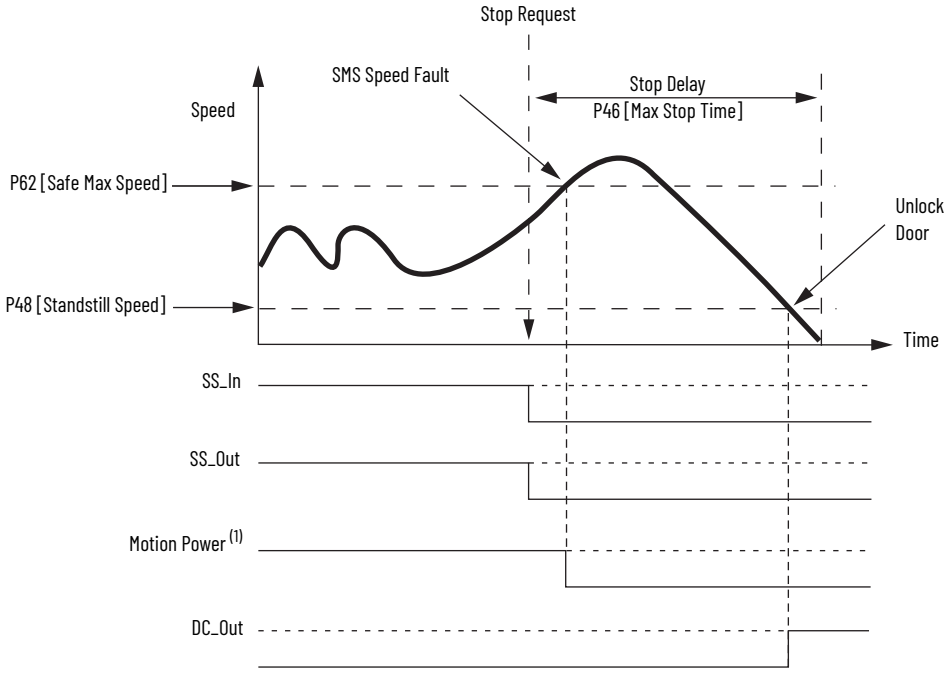
Figure 44 - SMS Speed Fault When P63 [Max Spd Stop Typ] Set to 'Use Configured Stop Type (Safe Stp Typ)'



If an SMS Speed fault is detected during the Stop Delay P47 [Max Stop Time] and the P63 [Max Spd Stop Typ] parameter equals Use Safe Torque Off with Check for Standstill (Torque Off), the SMS Speed fault is reported and motion power is removed. The Stop Delay P47 [Max Stop Time] continues with standstill checking enabled.

(1) 100 kHz for Sin/Cos or 200 kHz for Incremental

Figure 45 - SMS Speed Fault When P63 [Max Spd Stop Typ] Set to 'Use Safe Torque Off with Check for Standstill (Torque OFF)'



(1) This signal is internal, between the safety option module and drive.

For more information about faults, see Fault Reactions on page 133.

Safe Maximum Acceleration (SMA) Monitoring

Configure Safe Maximum Acceleration monitoring by setting the P64 [Max Accel Enable] parameter to Enable. When configured, Safe Maximum Acceleration Monitoring is active any time the safety option module configuration is valid and Safety mode is not set to Disabled.

The resolution accuracy of the acceleration monitoring in revolutions/second^2 is equal to the speed resolution in:

$$\frac{(\text{RPM} \times 2) \div 60}{[(\text{OverSpd Response} - 36)/1000]\ \text{seconds}}$$

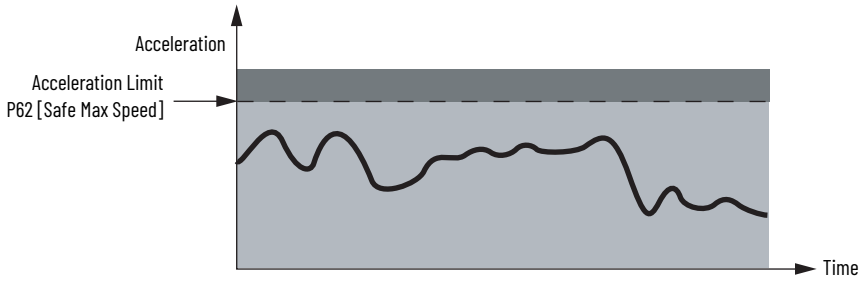
The resolution accuracy of the acceleration monitoring in mm/second^2 is equal to the speed resolution in:

$$\frac{(\text{mm/s} \times 2)}{[(\text{OverSpd Response} - 36)/1000]\ \text{seconds}}$$

IMPORTANT Acceleration is measured within the Overspeed Response Time, P24 [OvrSpd Response] parameter.

When you configure the safety option module for Safe Maximum Acceleration, the safety option module monitors the acceleration rate and compares it to a configured Safe Maximum Acceleration Limit, P65 [Safe Accel Limit]. If the acceleration is greater than or equal to the configured P65 [Safe Accel Limit], an Acceleration fault (Stop Category fault) occurs.

Figure 46 - Acceleration Timing Diagram



You define the Safe Stop Type initiated by the safety option module in the event of an Acceleration fault by using the P66 [Max Acc Stop Typ] parameter.

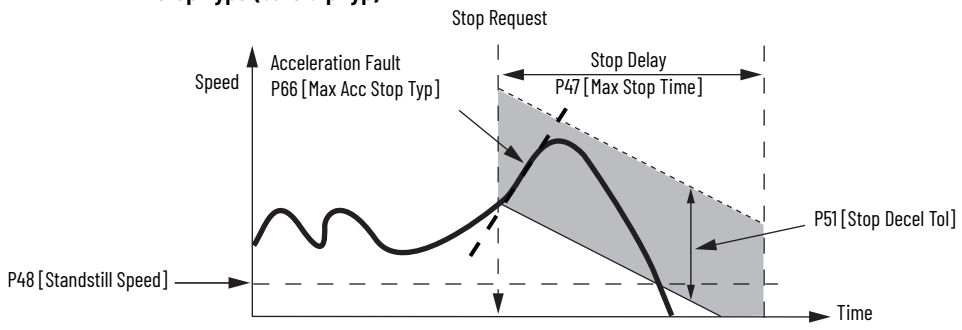
Table 34 - P66 [Max Acc Stop Typ] Parameter

P66 [Max Acc Stop Typ] Parameter	Description
0 = Use Safe Torque Off with Check for Standstill (Torque Off)	The safety option module initiates Safe Torque Off with Check for Standstill any time an Acceleration fault is detected while the safety option module is monitoring motion.
1 = Use Configured Stop Type (Safe Stp Typ)	The safety option module initiates the configured Safe Stop Type any time an Acceleration fault is detected while the safety option module is monitoring motion.

If an Acceleration fault is detected during a Stop Monitoring Delay P46 [Stop Mon Delay] and the P66 [Max Acc Stop Typ] parameter is configured as Use Safe Torque Off with Check for Standstill (Torque Off), the Stop Monitoring Delay P46 [Stop Mon Delay] ends immediately and Stop Delay P47 [Max Stop Time] begins.

If an Acceleration fault is detected during the Stop Delay P47 [Max Stop Time], and the P66 [Max Acc Stop Typ] parameter equals Use Configured Stop Type (Safe Stp Typ), and feedback signals indicate less than the maximum frequency(1) for your encoder type, then the fault occurs with no further action. Deceleration Monitoring performs the safety function during the Stop Delay P47 [Max Stop Time]. That is, if an Acceleration fault occurs during the Stop Delay P47 [Max Stop Time], the fault is ignored and the stopping action continues.

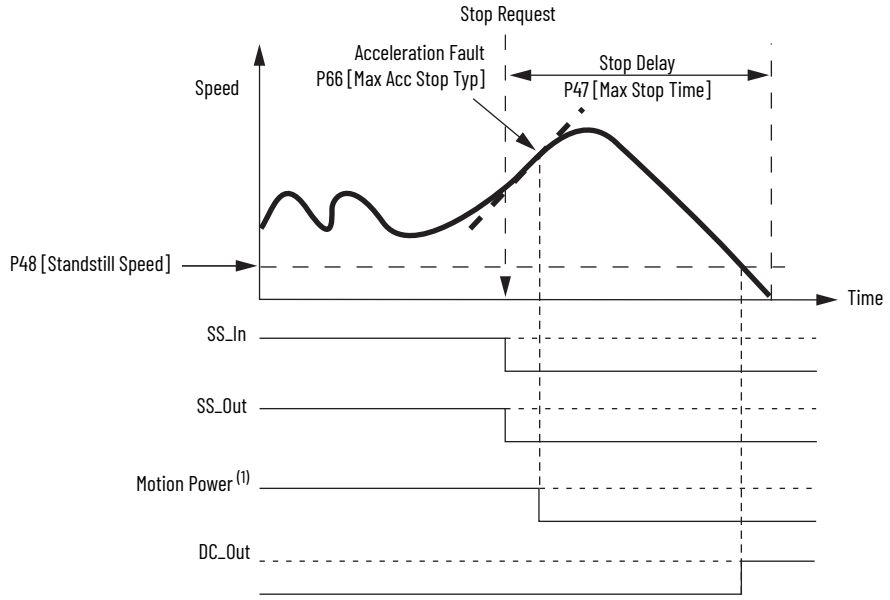
Figure 47 - Acceleration Fault When P66 [Max Acc Stop Typ] Set to 'Use Configured Stop Type (safe stp typ)'



If an Acceleration fault is detected during the Stop Delay P47 [Max Stop Time] and the P66 [Max Acc Stop Typ] parameter equals Use Safe Torque Off with Check for Standstill (Torque Off), the Acceleration fault is reported and Motion Power is removed. The Stop Delay P47 [Max Stop Time] continues with standstill checking enabled.

(1) 100 kHz for Sin/Cos or 200 kHz for Incremental

Figure 48 - Acceleration Fault When P66 [Max Acc Stop Typ] Set to 'Use Safe Torque Off with Check for Standstill (torque-off)'



(1) This signal is internal, between the safety option module and drive.

For more information about faults, see Fault Reactions on page 133.

Safe Direction Monitoring (SDM)

When configured for Safe Direction Monitoring, the safety option module monitors the feedback direction and initiates the configured Safe Stop Type when motion in the illegal direction is detected. You configure Safe Direction Monitoring by using the P42 [Direction Mon] parameter. This parameter also determines the direction, positive or negative, in which motion is allowed.

Table 35 - Enable Safe Direction Monitoring

P42 [Direction Mon] Parameter	Description
0 = Disabled	Safe Direction Monitoring is disabled.
1 = Positive Always	Safe Direction Monitoring is active any time the configuration is valid and not Disabled.
2 = Negative Always	
3 = Positive During SLS	Safe Direction Monitoring is performed only when the safety option module is actively monitoring Safe Limited Speed.
4 = Negative During SLS	

IMPORTANT Be sure to set the P30 [Fbk 1 Polarity] and P35 [Fbk 2 Polarity] configuration parameters properly for a consistent direction between encoder 1 and encoder 2.

You can configure a position limit, in encoder units, tolerated in the wrong direction before a Direction fault occurs, by using the P43 [Direction Tol] parameter.

Figure 49 - Positive Safe Direction Monitoring Timing Diagram

P42 [Direction Mon] = 1 'Pos Always'

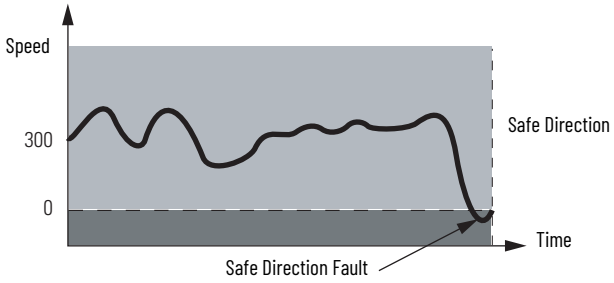
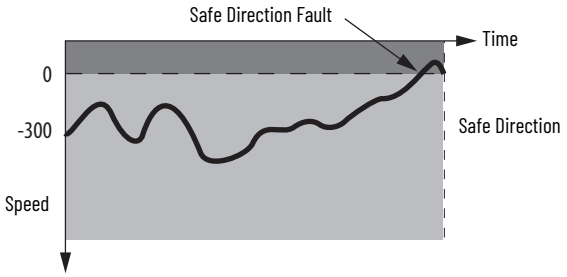


Figure 50 - Negative Safe Direction Monitoring Timing Diagram

P42 [Direction Mon] = 2 'Neg Always'



If motion is detected in the incorrect direction while Safe Direction Monitoring is active, a Direction fault occurs. If a Direction fault is detected while the safety option module is monitoring motion, the configured P45 [Safe Stop Type] is initiated and direction monitoring is not performed during the safe stop. If a Direction fault is first detected after the initiation of the safe stop, then all outputs go to their faulted state.

For more information about faults, see Fault Reactions on page 133.

Max Speed, Max Accel, and Direction Monitoring Parameter List

Set these parameters to configure Safe Maximum Speed, Safe Maximum Acceleration, and Safe Direction Monitoring.

File	Group	No.	Display Name Full Name Description	Values		Read-Write	Data Type
HOST GROUPS	Feedback	30	**Fbk 1 Polarity** Feedback 1 Polarity Defines the direction polarity for encoder 1.	Default: Options:	0 = 'Normal' 0 = 'Normal' (Same as encoder) 1 = 'Reversed'	RW	8-bit Integer
		35	**Fbk 2 Polarity** Feedback 2 Polarity Defines the direction polarity for encoder 2.	Default: Options:	0 = 'Normal' 0 = 'Normal' (Same as encoder) 1 = 'Reversed'	RW	8-bit Integer
	Feedback	42	**Direction Mon** Direction Monitoring Defines the allowable direction if Safe Direction Monitoring is enabled. 'Pos Always' (1) – Positive always 'Neg Always' (2) – Negative always 'Pos in SLS' (3) – Positive during safe limited speed monitoring 'Neg in SLS' (4) – Negative during safe limited speed monitoring	Default: Options:	0 = 'Disabled' 0 = 'Disabled' 1 = 'Pos Always' 2 = 'Neg Always' 3 = 'Pos in SLS' 4 = 'Neg in SLS'	RW	8-bit Integer
		43	**Direction Tol** Direction Tolerance The position limit in encoder units tolerated in the wrong direction when Safe Direction Monitoring is active. Units are based on rotary or linear configuration defined by P29 [Fbk 1 Units].	Units: Default: Min/Max:	Deg mm 10 0 / 65,535 deg 0 / 65,535 mm	RW	16-bit Integer
	Max Speed	61	**Max Speed Enable** Maximum Speed Enable Enable Safe Maximum Speed Monitoring.	Default: Options:	0 = 'Disable' 0 = 'Disable' 1 = 'Enable'	RW	8-bit Integer
		62	**Safe Max Speed** Safe Maximum Speed Defines the maximum speed limit that is tolerated if Safe Maximum Speed monitoring is enabled.	Units: Default: Min/Max:	RPM mm/s 0 0 / 65,535 RPM 0 / 65,535 mm/s	RW	16-bit Integer
		63	**Max Spd Stop Typ** Maximum Speed Stop Type Defines the safe stop type that is initiated in the event of a SMS Speed Fault. 'Torque Off' (0) – Safe Torque Off With Standstill Checking 'Safe Stp Typ' (1) – Safe Torque Off Without Standstill Checking	Default: Options:	0 = 'Torque Off' 0 = 'Torque Off' 1 = 'Safe Stp Typ'	RW	8-bit Integer
		64	**Max Accel Enable** Maximum Acceleration Enable Enable Safe Maximum Acceleration Monitoring.	Default: Options:	0 = 'Disable' 0 = 'Disable' 1 = 'Enable'	RW	8-bit Integer
		65	**Safe Accel Limit** Safe Acceleration Limit Defines the Safe Maximum Acceleration Limit, relative to encoder 1, for which the system is being monitored. Units are based on rotary or linear configuration defined by P29 [Fbk 1 Units].	Units: Default: Min/Max:	Rev/s^2 mm/s^2 0 0 / 65,535 rev/s^2 0 / 65,535 mm/s^2	RW	16-bit Integer
		66	**Max Acc Stop Typ** Maximum Acceleration Stop Type Defines the safe stop type that is initiated in the event of an Acceleration Fault. 'Torque Off' (0) – Safe Torque Off With Standstill Checking 'Safe Stp Typ' (1) – Safe Torque Off Without Standstill Checking	Default: Options:	0 = 'Torque Off' 0 = 'Torque Off' 1 = 'Safe Stp Typ'	RW	8-bit Integer

Notes:

Safety Configuration and Verification

This chapter provides guidelines for configuring your PowerFlex® 750-Series Safe Speed Monitor option module.

Safety Configuration

When you configure a speed monitoring safety system, you must record and verify the configuration signature and set the safety-lock status of the system configuration. Though optional, you can configure a password to help protect the system configuration from unauthorized modifications.

Configuration Signature ID

The configuration Signature ID is an identification number that uniquely identifies a specific configuration for a safety option module. Each time the system is configured or reconfigured, a new configuration signature is generated to identify that specific configuration.

You can view the configuration Signature ID by accessing the P10 [Signature ID] parameter.

Safety-lock Configuration

When you have verified the operation of the system and recorded the configuration Signature ID, you must lock the configuration to protect it from modification.

IMPORTANT	If you do not safety-lock the configuration, untested or unintentional changes can be made to the safety option module configuration that could result in unexpected system behavior.

You can lock the configuration by using the P5 [Lock State] parameter.

You can check the safety-lock status of the system by viewing the Configuration Lock bit (bit 1) in the P68 [Guard Status] parameter. If the bit equals 1, the configuration is locked. If it equals 0, the configuration is unlocked.

Set and Change a Password

You can protect the system configuration by using an optional password. If you set a password, edits to the configuration, as well as safety-locking and safety option module reset operations require the password to be entered. You can set a password when the safety option module is not safety-locked and the P6 [Operating Mode] parameter value equals 0 (Program).

Follow these steps to set a new password.

1. If you previously configured a password, enter the password by using the P1 [Password] parameter.
2. Enter the new password by using the P13 [New Password] parameter.

3. Set the P17 [Password Command] parameter to 1 (Change Password).

File	Group	No.	Display Name Full Name Description	Values		Read-Write	Data Type
HOST GROUPS	Security	1	**Password** Password Password for Lock and Unlock function.	Default: Min/Max:	N/A 0 / 4,294,967,295	RO	32-bit Integer
		13	**New Password** New Password 32-bit configuration password.	Default: Min/Max:	N/A 0 / 4,294,967,295	RW	32-bit Integer
		17	**Password Command** Password Command Save new password command.	Default: Options:	0 = 'No action' 0 = 'No action' 1 = 'Change PW' (Change Password) 2 = 'Reset PW' (Reset Password)	RW	8-bit Integer

Reset the Password

If you forget the password and need to reset it, follow these steps.

1. Read the contents of the P18 [Security Code] parameter.
2. Contact Rockwell Automation Technical Support and provide the Security Code value and the serial number of the safety option module.

   A technical support representative uses the security code to calculate a Vendor Password value.
3. Enter the value provided by your Rockwell Automation Technical Support representative into the P19 [Vendor Password] parameter.
4. Set the P17 [Password Command] parameter to 2 (Reset Password).
5. Enter the new password by using the P13 [New Password] parameter.
6. Set the P17 [Password Command] parameter to 1 (Change Password).

Reset the Configuration

When the safety option module is unlocked and the P6 [Operating Mode] parameter equals 0 (Program), you can reset the safety option module's configuration parameters to their factory default settings, by setting the P7 [Reset Defaults] parameter to 1. The reset parameters are sent to the safety option module when the P6 [Operating Mode] parameter is changed to 1 (Run).

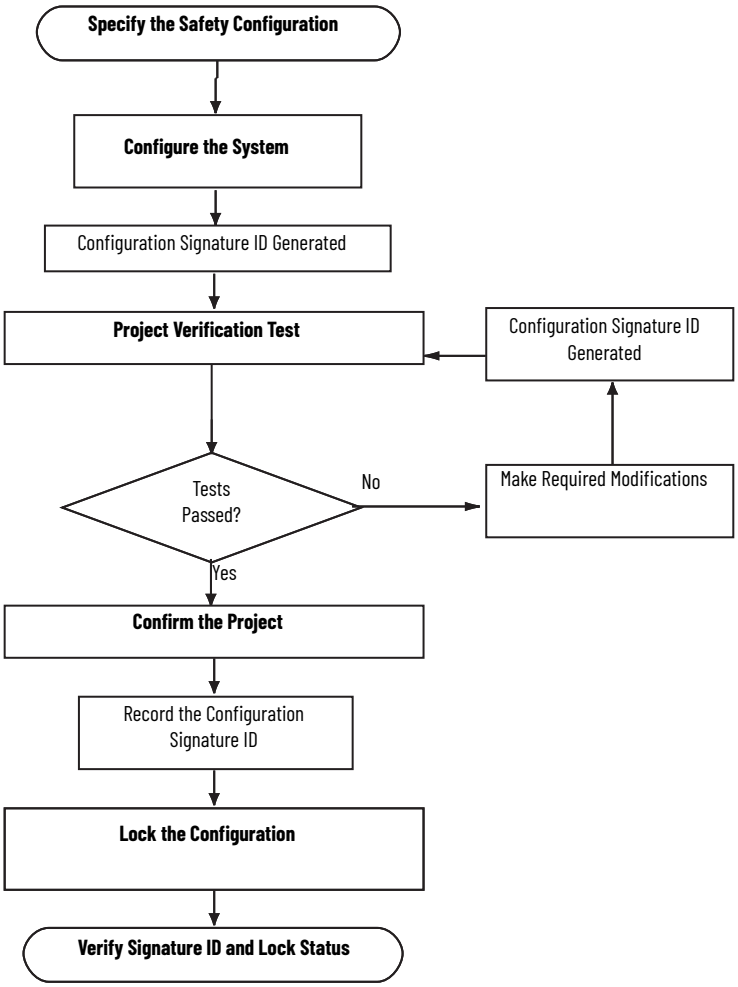
Basics of Application Development and Testing

Configuration for the intended SIL 3, PLe, or cat. 4 system must be carried out by the system integrator or an operator trained and experienced in safety applications. Follow these good design practices:

- Use functional specifications, including flow charts, timing diagrams and sequence charts.
- Perform a configuration review.
- Perform configuration validation.

Commission the System

The flowchart shows the steps required for commissioning a Safe Speed Monitor system. The items in bold are explained in the following sections.



Specify the Safety Configuration

You must create a specification for the system configuration that addresses the safety requirements identified by a risk assessment of your application. Use the specification to verify that the configuration is selected correctly and that it fully addresses your application's functional and safety control requirements. The specification must be a detailed description that can include (if applicable) the following:

- A sequence of operations
- Flow and timing diagrams
- Sequence charts
- A configuration description of each parameter
- Documented descriptions of the steps with step conditions and actuators to be controlled
- Input and output definitions
- I/O wiring diagrams and references
- A theory of operation
- A matrix or table of stepped conditions and the actuators to be controlled, including sequence and timing diagrams
- A definition of marginal conditions, for example, operating modes

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

- Sensors (Digital or Analog)
  - Signal in standard operation (dormant current principle for digital sensors, sensors OFF means no signal)
  - Determination of redundancies required for SIL levels
  - Discrepancy monitoring and visualization, including your diagnostic logic
- Actuators
  - Position and activation in standard operation (normally OFF)
  - Safe reaction/positioning when switching OFF or power failure.
  - Discrepancy monitoring and visualization, including your diagnostic logic.

Configure the Safe Speed Monitor Option Module

You can configure the safety option module by using a HIM, RSLogix 5000® software, the Studio 5000 Logix Designer® application, or Connected Components Workbench™ software. Refer to Table 7 on page 24 for the parameter configuration options.

If you are using the Automatic Device Configuration (ADC) feature, refer to Configure ADC and the Safe Speed Monitor Option Module on page 111.

The safety option module is configured in the Safe State. The safety option module must be unlocked to be configured. If a password exists, you must provide the password to unlock the safety option module.

Follow these steps to configure the safety option module.

1. If the safety option module configuration is locked, you can unlock the configuration by setting the P5 [Lock State] parameter to 0 'Unlock.'

   If an error occurs, you need to enter the password, by using the P1 [Password] parameter.
2. Place the safety option module in Program mode by setting the P6 [Operating Mode] parameter to 0.

   The value of the P10 [Signature ID] parameter value changes to 0.

IMPORTANT	When the safety option module is in Program mode, the P69 [IO Diag Status] parameter is not updated or refreshed.
3. Edit parameters to meet your system configuration specification and risk assessment requirements.
4. When you are finished editing parameters, set the P6 [Operating Mode] parameter to 1.

   The safety option module switches to Run mode. A configuration Signature ID is generated by the safety option module.
5. Record the configuration Signature ID from the contents of the P10 [Signature ID] parameter.
6. Enter the password into the P1 [Password] parameter, if required.
7. Set the P5 [Lock State] parameter to 1 'Lock.'

Project Verification Test

To check that the safety option module's configuration adheres to the application specification, you must generate a suitable set of test cases covering the application. The set of test cases must be filed and retained as the test specification. You must include a set of tests to prove the validity of the safety configuration parameters.

You must perform a complete functional test of the entire system before the operational startup of a safety-related system.

Confirm the Project

You must check each parameter to make sure it is set to the correct value according to your system configuration specification.

Safety Validation

An independent, third-party review of the safety system can be required before the system is approved for operation. An independent, third-party certification is required for IEC 61508 SIL 3.

Verify the Signature and Lock-in the Safe Speed Monitor Option Module

To meet SIL 3, PLe, or cat. 4 requirements, you must verify that the correct configuration is locked-in the safety option module.

To verify the configuration Signature ID, view the contents of the P10 [Signature ID] parameter and make sure that it matches the configuration Signature ID you recorded as part of the configuration process on page 110.

To verify the lock status, you can view the P5 [Lock State] parameter. You can also view the status of the Configuration Lock bit (bit 1) of the P68 [Guard Status] parameter. If the bit equals 1, the configuration is locked. If the bit equals 0, the configuration is unlocked.

Configure ADC and the Safe Speed Monitor Option Module

RSLogix 5000 software (version 20 or later), the Logix Designer application project (.ACD file), or Connected Components Workbench software contains the configuration settings for any PowerFlex 750-Series drive in the project. When the project is downloaded to the Logix 5000™ controller, these settings are also transferred and reside in the controller's memory. Prior to ADC, downloading configuration data was a manual process. ADC now automates the process, saving you time. The controller can also be configured to upgrade the firmware in a device with the revision that the controller requires to be present in the device.

Set Up the ADC Feature

Follow these steps to configure the ADC feature.

1. If the safety option module configuration is locked, you can unlock the configuration by setting the P5 [Lock State] parameter to 0 'Unlock.'

   If an error occurs, you need to enter the password, by using the P1 [Password] parameter.
2. Place the safety option module in Program mode by setting the P6 [Operating Mode] parameter to 0 'Program.'
3. Edit parameters to meet your system configuration specification and risk assessment requirements.
4. Enter the desired password value on the password entry page of the Add-On Profile (AOP).

5. Enable the ADC function for the safety option module by using the AOP.
6. Configure the drive and other option cards installed in the drive.
7. Apply the changes.
8. Save the program and download to the controller.

IMPORTANT	At this point, the controller attempts to open an I/O connection to the drive. Part of this process is to verify that the ADC Configuration Signatures match for each device. Because the ADC Configuration Signatures have not yet been written by the controller, the controller configures each device, including writing each device's ADC Configuration Signature. Finally, the controller opens an I/O connection to the drive.

9. Let the controller perform the ADC operation. When the ADC operation is complete, the ENET indicator on the drive changes to steady green. This indicates that an I/O connection has been opened to the drive.
10. Use a any of the configuration tools listed above to verify that the safety option module is configured correctly.
11. After verification is complete, set the P6 [Operating Mode] parameter to 1 'Run'.

    The safety option module switches to Run mode. A configuration Signature ID is generated by the safety option module.
12. Record the configuration Signature ID from the contents of the P10 [Signature ID] parameter.
13. Enter the password into the P1 [Password] parameter.
14. Set the P5 [Lock State] parameter to 1 'Lock.'

Use ADC to Configure the Safety Option

After the system has been placed in service, if a controller determines that it needs to configure the safety option module, several manual steps are required.

IMPORTANT	If the controller is on the network and powered up, it attempts to open an I/O connection to the drive when the drive is powered up. When the controller detects that the ADC Configuration Signature for the safety option module is invalid, the controller attempts to configure the safety option module. If the safety option module is locked or in Run mode, you have to unlock the safety option module and place it in Program mode before the controller can successfully configure the safety option module.

1. If the safety option module configuration is locked, you must unlock the configuration by setting the P5 [Lock State] parameter to 0 'Unlock.'

   If an error occurs, you need to enter the password, by using the P1 [Password] parameter.
2. If the safety option module is in Run mode, change it to Program mode by setting the P6 [Operating Mode] parameter to 0 'Program.'

   The value of the P10 [Signature ID] parameter changes to 0.

3. Allow the controller to perform the ADC operation. When the ADC operation is complete, the ENET indicator on the drive changes to steady green. This indicates that an I/O connection has been opened to the drive.
4. Use any of the configuration tools listed earlier to verify that the safety option module is configured correctly.
5. After verification is complete, set the P6 [Operating Mode] parameter to 1 'Run'.

   The safety option module switches to Run mode. A configuration Signature ID is generated by the safety option module.
6. Record the configuration Signature ID from the contents of the P10 [Signature ID] parameter.
7. Enter the password.
8. Set the P5 [Lock State] parameter to 1 'Lock.'

Edit the Configuration

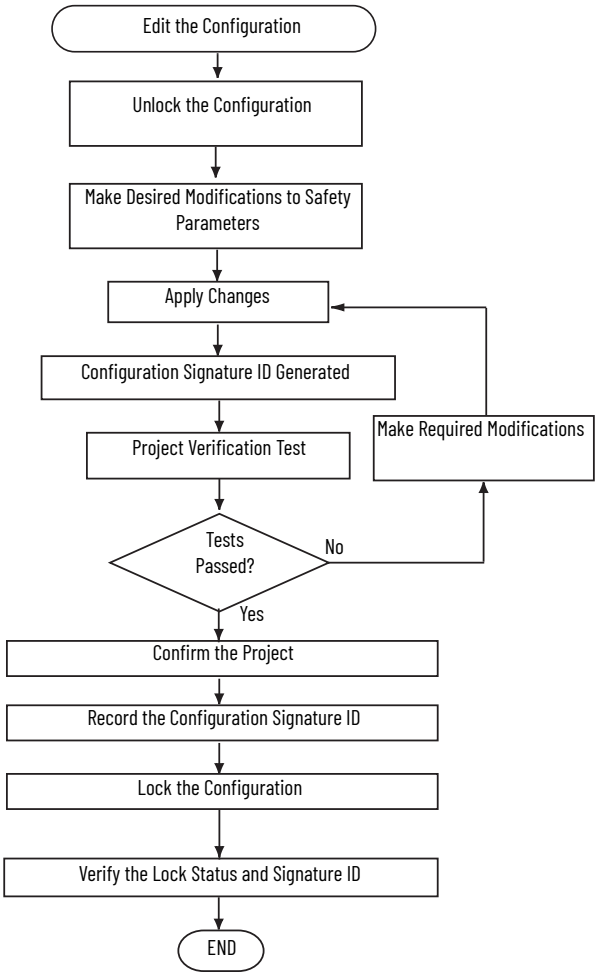
Only authorized, specially trained personnel can make edits to the configuration. Use all supervisory methods available, for example, software password protection.

When authorized, specially trained personnel make edits, they assume the central safety responsibility while the changes are in progress. These personnel must also maintain safe application operation.

You must sufficiently document all edits, including the following:

- Authorization
- Impact analysis
- Execution
- Test information
- Revision information

This flowchart shows the steps necessary to edit the safety option module's configuration.



Configuration Examples

These examples guide you through the basic steps required to program an application that use some of the safety option-module functions. The remaining chapters of this manual provide detailed information on the operation of each safety function.

As an alternative to following the steps listed in this chapter, you can configure the safety option module by using the Safe Speed Monitor Startup Wizard that is available in these software applications. The wizard is recommended.

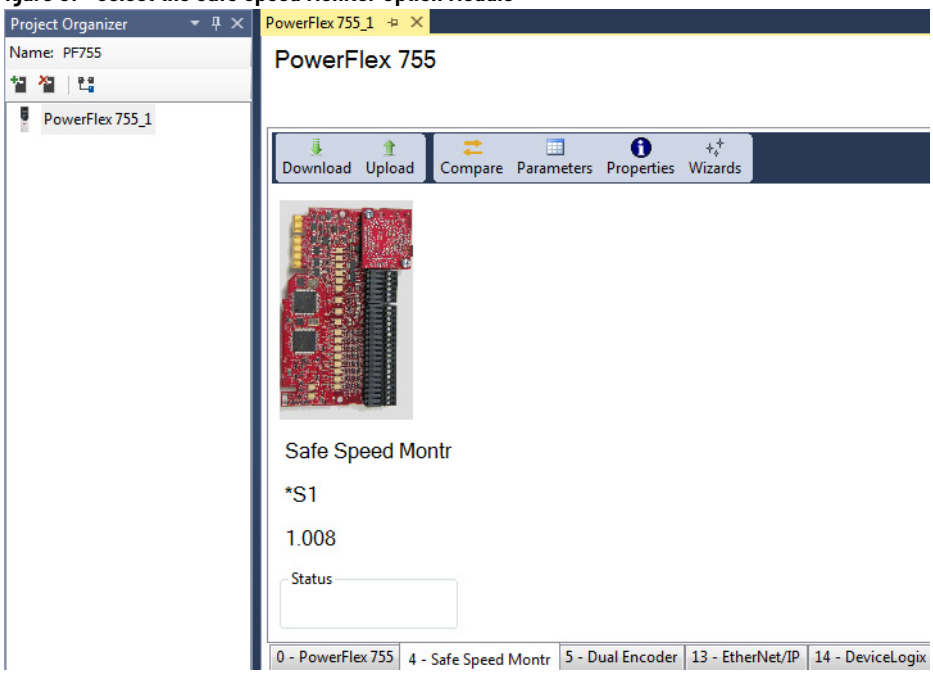
- Studio 5000 Logix Designer® application
- Connected Components Workbench™ software
- RSLogix 5000® software

Refer to Table 7 on page 24, for software versions and applicable Drives AOP.

Drives AOP (version 2.01 or later) must be installed to enable support for this wizard in RSLogix 5000 software.

Before you can configure the Safe Speed Monitor parameters, you must create a file with your PowerFlex® 750-Series drive and select the Safe Speed Monitor tab. In this example, a PowerFlex 755 drive is used.

Figure 51 - Select the Safe Speed Monitor Option Module



Example Application 1

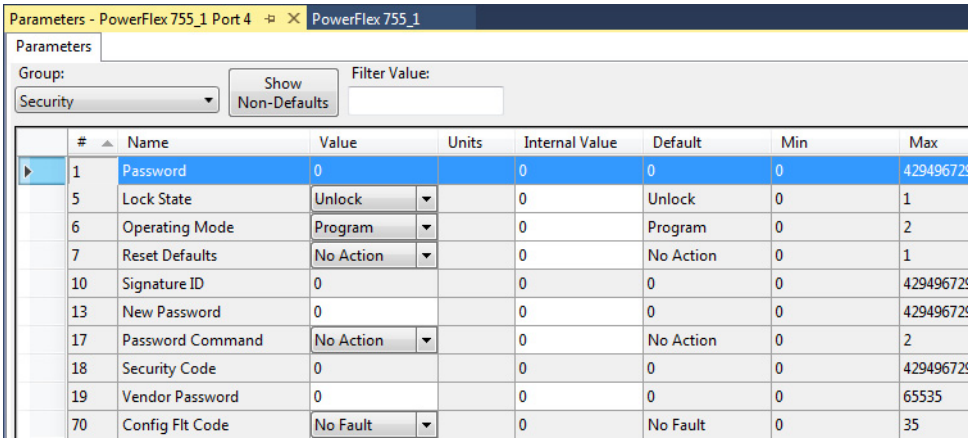
This example application uses the following basic configuration in a single-axis system.

- Safe Stop (SS) enabled with an E-stop button.
- Safe Limited Speed (SLS) initiated with a 2NC contact switch.
- Door Monitoring (DM) of a guardlocking switch (TLS-3 GD2) configured as Power to Release.
- A Reset button with 1 NO contact.
- One encoder connected with Sin/Cos output signal and resolution of 1024.
- A configured Safe Maximum Speed (SMS) limit.

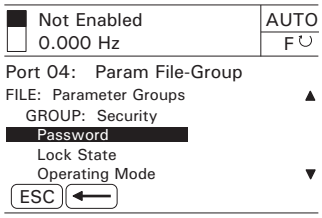
Each of the following sections describes the settings you need to enter for each parameter group. This example uses Connected Components Workbench software to configure the parameter groups, and also shows the corresponding HIM screen.

Example 1: Initial Security Group Parameter Settings

Software Dialog Box



HIM Screen



Follow these steps to put the safety option module into Program mode for configuration.

1. From the Parameters Group pull-down menu, choose Security.
2. Click the P5 [Lock State] parameter value.

   The default value of the Lock State parameter is 0 or unlocked. If the safety option module is locked (Lock State parameter value equals 1), set the P5 [Lock State] parameter value to 0.

   If an error occurs, a password is configured to protect the safety option module configuration.
3. Click the P1 [Password] parameter value.
4. In the Password value field, type the password.
5. Click the P6 [Operating Mode] parameter.

   The default value is 0 (Program).

   If the safety option module is in Run mode (Operating Mode parameter equals 1), set the P6 [Operating Mode] parameter to 0 to enable you to enter a new configuration.
6. If you want to configure a password or change the password, click the P13 [New Password] parameter value.

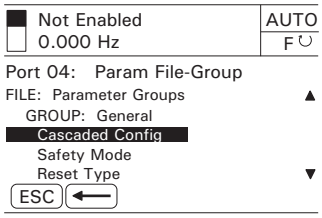
   The default value is 0.
7. In the New Password value field, type the new password.

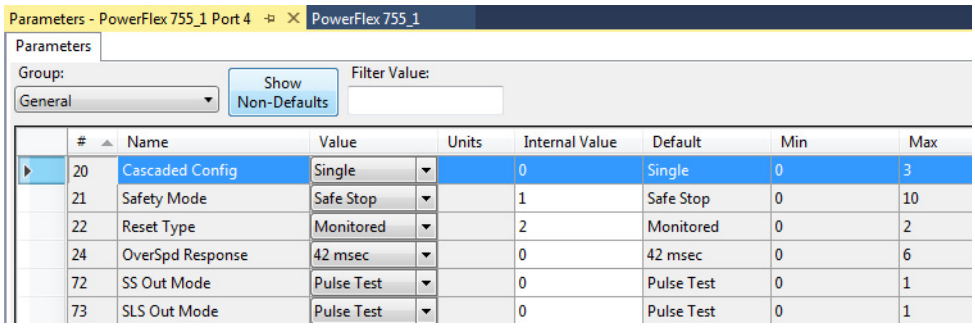
   Enter a new value from 0...4,294,967,295.
8. Click the P17 [Password Command] parameter value.
9. From the P17 [Password Command] parameter pull-down menu, choose Change PW.
10. The P17 [Password Command] parameter value changes to 1.

Example 1: General Group Parameter Settings

Software Dialog Box

HIM Screen





Follow these steps to configure the general operation of the safety option module.

1. From the Parameters Group pull-down menu, choose General.
2. Click the P20 [Cascaded Config] parameter value.

   The default value of the P20 [Cascaded Config] parameter is 0 to configure the safety option module as a Single unit.
3. Click the P21 [Safety Mode] parameter.

   The default setting is 1 (Safe Stop).
4. From the Safety Mode pull-down menu, choose Lim Speed DM.

   The P21 [Safety Mode] internal value changes to 4 for Master, Safe Limited Speed with Door Monitoring mode (Lim Speed DM).

   In this mode, the door is locked when the machine speed is above a configured Safe Speed Limit. The door can be unlocked when the machine is at Standstill Speed or is at or below the Safe Speed Limit **and** the SLS_In input is off.
5. Click the P22 [Reset Type] parameter value.

   The default value of the Set the P22 [Reset Type] parameter is 2 (Monitored). The Monitored setting requires a closing and opening of the reset circuit for a reset.
6. Click the P24 [OverSpd Response] parameter value.

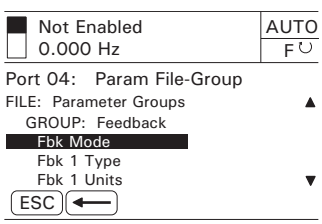
   The default Overspeed Response time is 42 ms.
7. From the OverSpd Response pull-down menu, choose 48 msec.

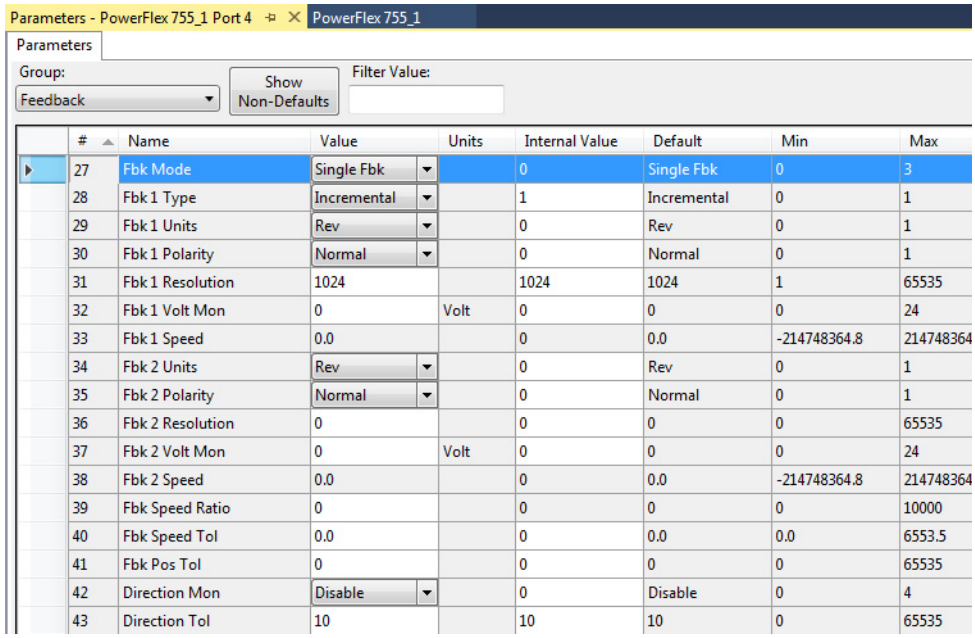
   See Overspeed Response Time on page 44 for details.

Example 1: Feedback Group Parameter Settings

Software Dialog Box

HIM Screen





Follow these steps to configure the type of feedback used by the safety option module.

1. From the Parameters Group pull-down menu, choose Feedback.
2. Click the P27 [Fbk Mode] parameter value.

   The default value for redundant processing and cross-checking of the single-encoder input in a 1oo2 architecture is 0 (Single Fbk).
3. Click the P28 [Fbk 1 Type] parameter value.

   The default value is 1 for incremental encoder input.
4. From the Fbk 1 Type pull-down menu, choose Sine/Cosine for internal monitoring of the single encoder input.

   The P28 [Fbk 1 Type] parameter value changes to 0.
5. Click the P29 [Fbk 1 Units] parameter value.

   The default P29 [Fbk 1 Units] parameter value is 0 (Rev) for rotary motor feedback.
6. Click the P30 [Fbk 1 Polarity] parameter value.

   The default P30 [Fbk 1 Polarity] parameter value is 0 (Normal) to set up the direction for monitoring to be the same as the encoder direction.
7. Click the P31 [Fbk 1 Resolution] parameter value.

   The default P31 [Fbk 1 Resolution] parameter value is 1024. You can enter any value between 1...65,535 pulses/revolution based on the encoder specifications.

8. Click the P32 [Fbk 1 Volt Mon] parameter value.

   The default P32 [Fbk 1 Volt Mon] parameter value is 0 to disable encoder voltage monitoring. Enter 5, 9, or 12V to monitor voltage in accordance with encoder specifications.

   The P33 [Fbk 1 Speed] parameter displays the output speed of the encoder as a value between -214,748,364.8...214,748,364.8 rpm based on the encoder configuration. You do not need to enter a setting or value for this parameter.

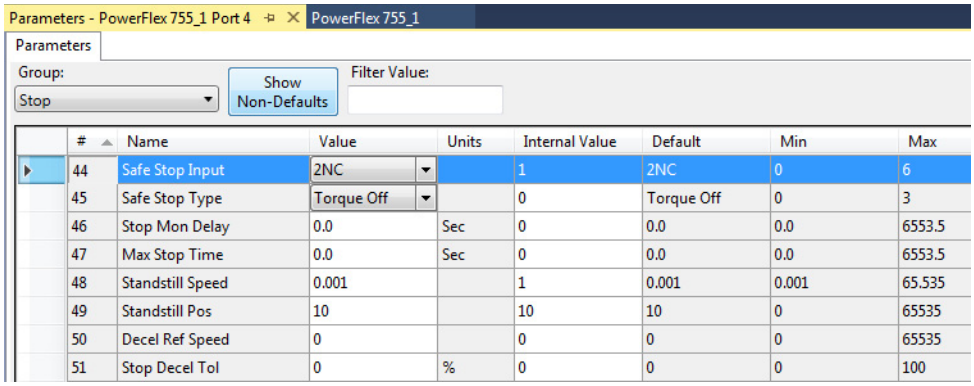
9. Click the P42 [Direction Mon] parameter value.

   The default P42 [Direction Mon] parameter value is 0 (Disabled).

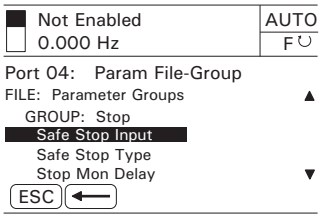
   You can disable Safe Direction Monitoring if only one direction of rotation is possible or there is no safety-related restriction on the direction of rotation.

Example 1: Stop Group Parameter Settings

Software Dialog Box



HIM Screen



Follow these steps to configure the Stop operation of the safety option module.

1. From the Parameters Group pull-down menu, choose Stop.
2. Click the P44 [Safe Stop Input] parameter value.

   The default P44 [Safe Stop Input] parameter value is 1 (2NC) for two normally closed (dual-channel equivalent) operation.

   In this example application, the Safe Stop input (SS_In) monitors an E-Stop button with two normally closed (2NC) contacts.
3. Click the P45 [Safe Stop Type] parameter value.

   The default P45 [Safe Stop Type] parameter value is 0 (Torque Off) for Safe Torque Off with Standstill Speed Checking.

   Safe Torque Off with Standstill Speed Checking (Torque Off) switches off motion power immediately after an E-Stop command and sets door control to Unlock when the Standstill Speed is detected.
4. Click the P47 [Max Stop Time] parameter value.

   The default P47 [Max Stop Time] parameter value is 0. You can enter a value from 0...6553.5 s.
5. Type the value of the expected coast-to-stop time plus a reasonable tolerance after the Safe Stop command is initiated.

   If the machine's speed is not below the Standstill Speed within the Stop Delay [Max Stop Time] period you entered, a Stop Speed Fault occurs and door control remains set to Lock until the Standstill Speed is reached.
6. Click the P48 [Standstill Speed] parameter value.

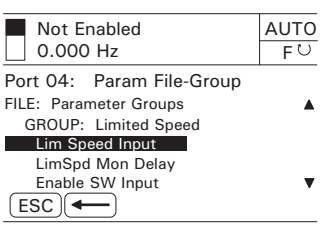
   The default P48 [Standstill Speed] parameter value is 0.001 rpm. You can enter a value from 0.001...65,535 rpm. The Standstill Speed is measured in revolutions per minute, because the P29 [Fbk 1 Units] parameter is configured for Rev (rotary feedback).

7. Enter a value in the P48 [Standstill Speed] parameter field to define the speed that motion is stopped with no relative position change before the safety option determines standstill has been reached.
8. Click the P49 [Standstill Pos] parameter value.

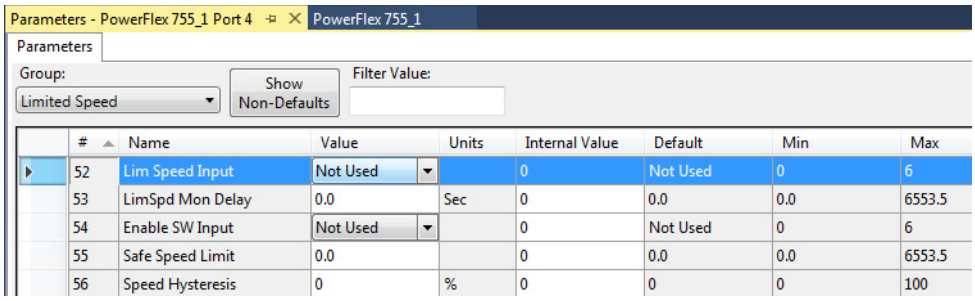
   The default P49 [Standstill Pos] parameter value is 10 degrees. You can enter a value from 0...65,535 degrees. The Standstill Position is measured in degrees because the P29 [Fbk 1 Units] parameter is configured for Rev (rotary feedback).
9. Enter the value to define the position limit in encoder units that is tolerated after standstill has been reached.

Example 1: Limited Speed Group Parameter Settings

HIM Screen



Software Dialog Box



Follow these steps to configure the Safe Limited Speed operation.

1. From the Parameters Group pull-down menu, choose Limited Speed.
2. Click the P52 [Lim Speed Input] parameter value.

   The default P52 [Lim Speed Input] parameter value is 0 (Not Used) for applications without Safe Limited Speed control.
3. From the Lim Speed Input pull-down menu, choose 2NC for two normally closed (dual-channel equivalent) operation and an internal value of 1.

   In this example application, the Safe Limited Speed input (SLS_In) monitors a switch with two normally closed (2NC) contacts. If the NC contacts are open and speed exceeds the configured Safe Limited Speed, the safety option module initiates the configured Safe Stop Type.

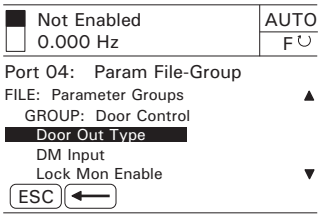
   When the safety option module is actively monitoring Safe Limited Speed and the machine speed is at or below the configured Safe Speed Limit, the gate interlock is released and the door can be opened.
4. Click the P55 [Safe Speed Limit] parameter value.

   The default P55 [Safe Speed Limit] parameter value is 0 rpm or mm/s. The valid range is from 0...6553.5.
5. Type the maximum allowable rpm value in the Safe Speed Limit value field for safe (reduced) velocity.

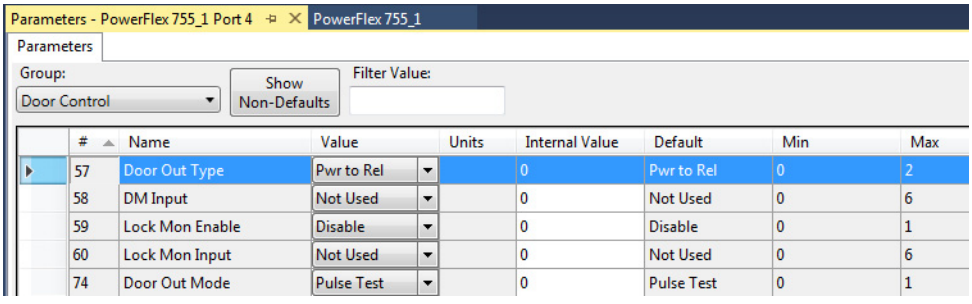
   The speed is calculated in rpm, based on the Fbk 1 Units parameter setting, 0 = Rev (rotary feedback) entered previously.

Example 1: Door Control Group Parameter Settings

HIM Screen



Software Dialog Box



Follow these steps to configure Door Control operation for the safety option module.

1. From the Parameters Group pull-down menu, choose Door Control.
2. Click the P57 [Door Out Type] parameter value.
3. The default P57 [Door Out Type] parameter value is 0 (Pwr to Rel) Power to Release.

   This setting is chosen to apply power to the solenoid inside the TLS-3 GD2 gate switch to release the gate interlock.
4. Click the P58 [DM Input] parameter.

   The default P58 [DM Input] parameter value is 0 (Not Used) for applications that do not use an interlock switch.
5. From the DM Input pull-down menu, choose 2NC for an internal value of 1 and 2NC (dual-channel equivalent) operation.

   In this example application, the DM Input (DM_In) monitors the TLS-3 GD2 switch. The switch has two normally closed (2NC) safety contacts.
6. Click the P59 [Lock Mon Enable] parameter value.

   The default P59 [Lock Mon Enable] parameter value is 0 (Disable) for applications without an interlock switch.
7. From the Lock Mon Enable pull-down menu, choose Enable with an internal value of 1, because this application uses the TLS-3 GD2 interlock switch.
8. Click the P60 [Lock Mon Input] parameter value.

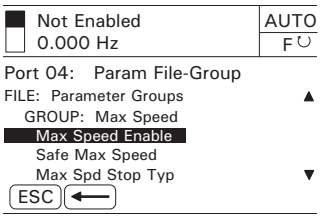
   The default P60 [Lock Mon Input] parameter value is 0 (Not Used) for applications that do not use an interlock switch.
9. From the Lock Mon Input pull-down menu, choose 2NC with an internal value of 1 for two normally closed (dual-channel equivalent) operation.

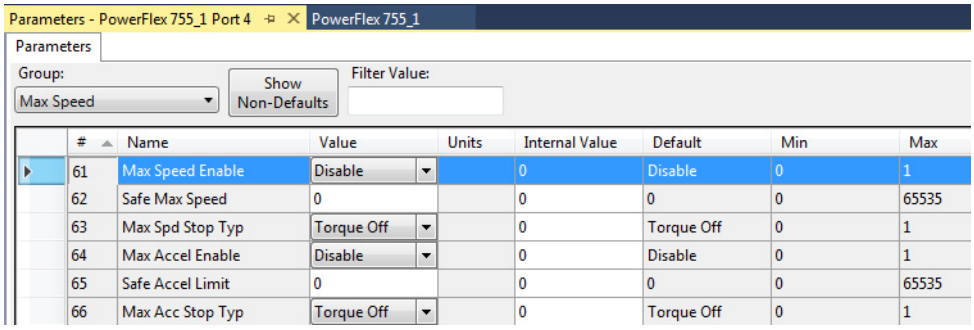
   In this example application, the Lock Monitor Input (LM_In) monitors the TLS-3 GD2 switch. The switch has two normally closed (2NC) interlock monitoring contacts.

Example 1: Max Speed Group Parameter Settings

Software Dialog Box

HIM Screen





Follow these steps to configure Maximum Speed monitoring for the safety option module.

1. From the Parameters Group pull-down menu, choose Max Speed.
2. Click the P61 [Max Speed Enable] parameter value.

   The default P61 [Max Speed Enable] parameter value is Disabled with an internal value of 1 for no maximum-speed limitation.
3. From the Max Speed Enable pull-down menu, choose Enable.

   Max Speed Enable monitors the encoder feedback signal so it does not exceed the velocity configured by using the Safe Max Speed parameter.
4. Click the P62 [Safe Max Speed] parameter value.

   The default P62 [Safe Max Speed] parameter value is 0 rpm or mm/s. Enter a value from 0...6553.5.
5. Type the maximum allowable rpm value for velocity.

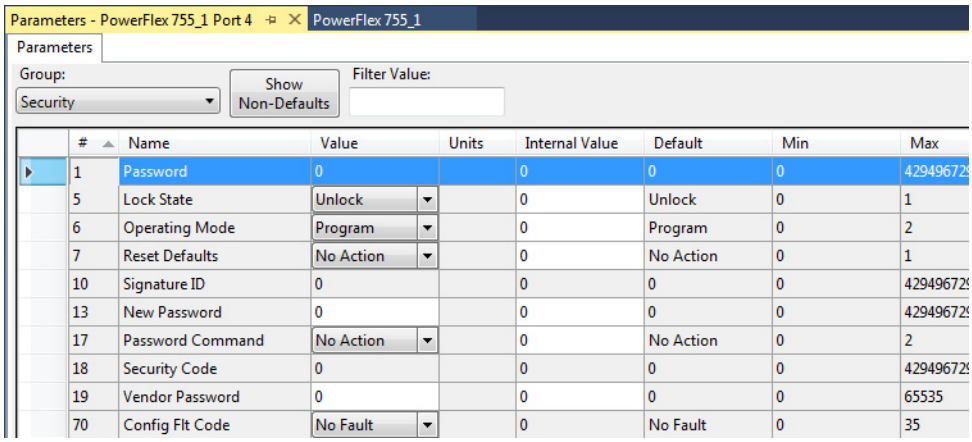
   The speed is calculated in rpm, based on the Fbk 1 Units parameter setting, 0 = Rev (rotary feedback) entered previously.
6. Click the P63 [Max Spd Stop Typ] parameter.

The default P63 [Max Spd Stop Typ] parameter value is Torque Off with an internal value of 0. Use Safe Torque Off with Standstill Checking (Torque Off).

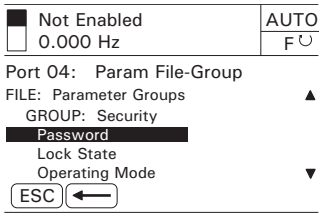
With this configuration, if speed exceeds the configured Safe Max Speed, the safety option module initiates a Safe Torque Off with Standstill Checking type of Safe Stop, regardless of the configured Safe Stop Type.

Example 1: Final Security Group Parameter Settings

Software Dialog Box



HIM Screen



This example includes only the steps for entering a configuration by using the HIM module or software program. You must also follow the requirements described in Safety Configuration and Verification on page 107.

ATTENTION: You must verify the configuration and validate the entire system, including a complete functional test, before the operational startup of any safety-related system.
Only authorized, specially trained personnel, experienced in the commissioning and operation of safety-related systems can configure, test, and verify the project.

Follow these steps to put the safety option module into Run mode, generate a configuration signature, and lock the configuration.

1. From the Parameters Group pull-down menu, choose Security.
2. Click the P6 [Operating Mode] parameter value.
3. From the Operating Mode pull-down menu, choose Run with an internal value of 1 (Run mode).

   A configuration signature is generated.
4. Click the P10 [Signature ID] parameter and record the configuration signature value stored in this parameter.
5. If you configured a password, click the P1 [Password] parameter and type the password.
6. Click the P5 [Lock State] parameter value.
7. From the Lock State pull-down menu, choose Lock with an internal value of 1 to lock the configuration.

Example Application 2

This example application shows how to change the default configuration settings to set up the safety option module for an application with these basic parameters:

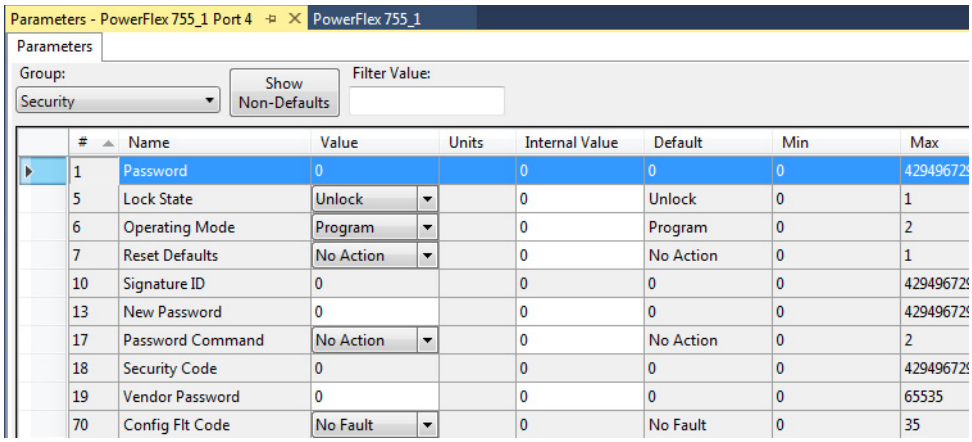
- Safe Stop (SS) enabled with an E-stop button.
- Safe Limited Speed (SLS) initiated with a 2NC contact switch.
- A configured Safe Maximum Speed (SMS) limit.
- Door Monitoring (DM)
- Door Control (DC) to control a guardlocking switch (TLS-3 GD2, Power to Release style).
- A Reset button with 1 NO contact.

- Enabling Switch (ESM) with 2NC contacts. Hold the switch in the middle position to access the machine for maintenance while it is running at Safe Limited Speed.
- One encoder connected with Sin/Cos output signal and resolution of 1024.

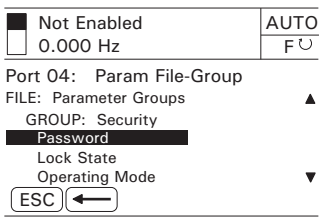
Each of the following sections describes the settings you need to enter for each parameter group. This example uses Connected Components Workbench software to configure the parameter groups, and also shows the corresponding HIM screen.

Example 2: Initial Security Group Parameter Settings

Software Dialog Box



HIM Screen



Follow these steps to put the safety option module into Program mode for configuration.

1. From the Parameters Group pull-down menu, choose Security.
2. Click the P5 [Lock State] parameter value.

   The default value of the Lock State parameter is 0 or unlocked. If the safety option module is locked (Lock State parameter value equals 1), set the P5 [Lock State] parameter value to 0.

   If an error occurs, a password is configured to protect the safety option module configuration.
3. Click the P1 [Password] parameter value.
4. In the Password value field, type the password.
5. Click the P6 [Operating Mode] parameter.

   The default value is 0 (Program).

   If the safety option module is in Run mode (Operating Mode parameter equals 1), set the P6 [Operating Mode] parameter to 0 to enable you to enter a new configuration.
6. If you want to configure a password or change the password, click the P13 [New Password] parameter value.

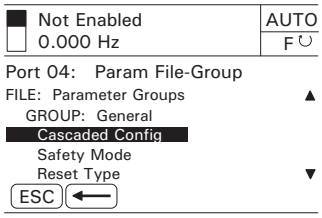
   The default value is 0.
7. In the New Password value field, type the new password.

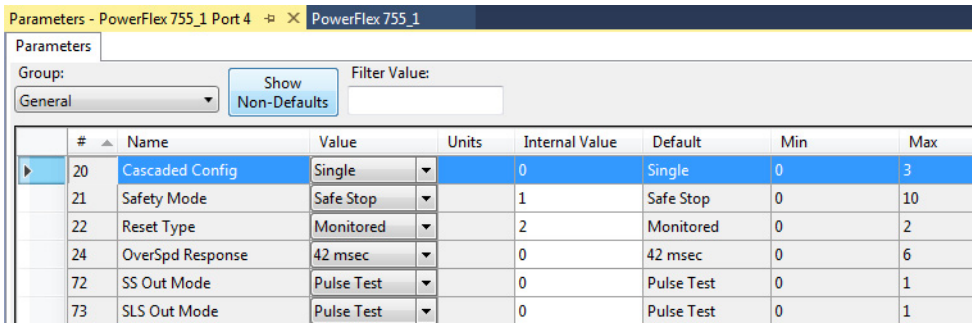
   Enter a new value from 0...4,294,967,295.
8. Click the P17 [Password Command] parameter value.
9. From the P17 [Password Command] parameter pull-down menu, choose Change PW.
10. The P17 [Password Command] parameter value changes to 1.

Example 2: General Group Parameter Settings

Software Dialog Box

HIM Screen





Follow these steps to configure the general operation of the safety option module.

1. From the Parameters Group pull-down menu, choose General.
2. Click the P20 [Cascaded Config] parameter value.

   The default value of the P20 [Cascaded Config] parameter is 0 to configure the safety option module as a Single unit.
3. Click the P21 [Safety Mode] parameter.

   The default setting is 1 (Safe Stop).
4. From the Safety Mode pull-down menu, choose Lim Speed DM ES.

   The P21 [Safety Mode] internal value changes to 6 for Master, Safe Limited Speed with Door Monitoring and Enabling Switch Monitoring mode.

   In this mode, the door is locked when the machine speed is above a configured Safe Speed Limit. The door can be unlocked when a stop has been requested and the machine is at Standstill Speed. The door can also be unlocked when Safe Limited Speed monitoring (SLS_In input = OFF) and the speed is below the configured Safe Limited Speed. When the enabling switch is held in the middle position, the door can be opened while the machine is running below Safe Limited Speed.
5. Click the P22 [Reset Type] parameter value.

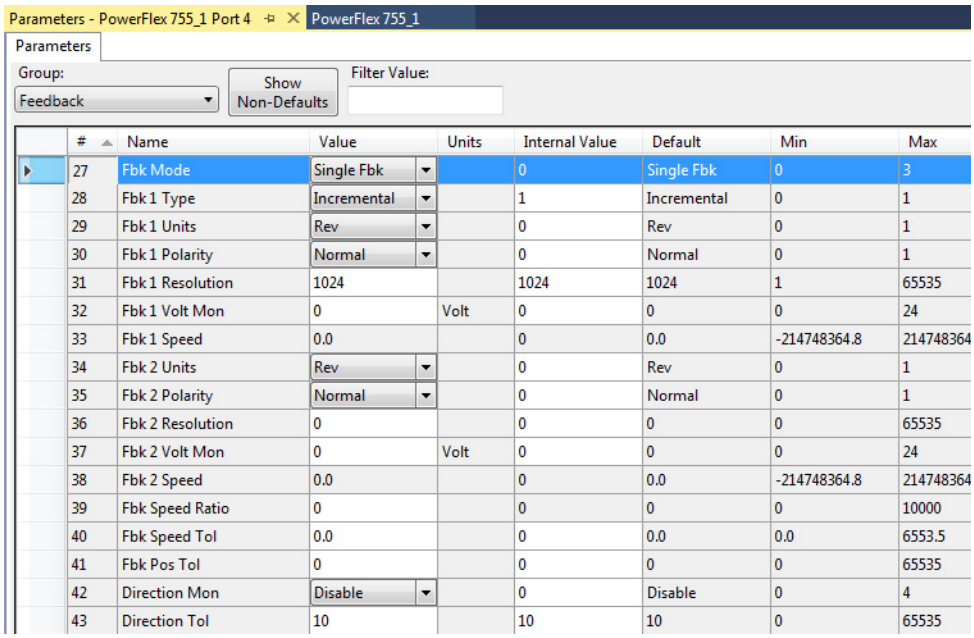
   The default value of the Set the P22 [Reset Type] parameter is 2 (Monitored). The Monitored setting requires a closing and opening of the reset circuit for a reset.
6. Click the P24 [OverSpd Response] parameter value.

   The default Overspeed Response time is 42 ms.
7. From the OverSpd Response pull-down menu, choose 48 msec.

   See Overspeed Response Time on page 44 for details.

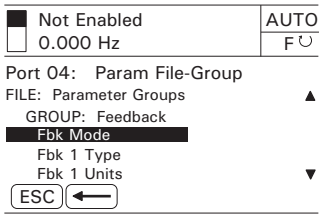
Example 2: Feedback Group Parameter Settings

Software Dialog Box



#	Name	Value	Units	Internal Value	Default	Min	Max
27	Fbk Mode	Single Fbk		0	Single Fbk	0	3
28	Fbk 1 Type	Incremental		1	Incremental	0	1
29	Fbk 1 Units	Rev		0	Rev	0	1
30	Fbk 1 Polarity	Normal		0	Normal	0	1
31	Fbk 1 Resolution	1024		1024	1024	1	65535
32	Fbk 1 Volt Mon	0	Volt	0	0	0	24
33	Fbk 1 Speed	0.0		0	0.0	-214748364.8	214748364
34	Fbk 2 Units	Rev		0	Rev	0	1
35	Fbk 2 Polarity	Normal		0	Normal	0	1
36	Fbk 2 Resolution	0		0	0	0	65535
37	Fbk 2 Volt Mon	0	Volt	0	0	0	24
38	Fbk 2 Speed	0.0		0	0.0	-214748364.8	214748364
39	Fbk Speed Ratio	0		0	0	0	10000
40	Fbk Speed Tol	0.0		0	0.0	0.0	6553.5
41	Fbk Pos Tol	0		0	0	0	65535
42	Direction Mon	Disable		0	Disable	0	4
43	Direction Tol	10		10	10	0	65535

HIM Screen



Follow these steps to configure the type of feedback used by the safety option module.

1. From the Parameters Group pull-down menu, choose Feedback.
2. Click the P27 [Fbk Mode] parameter value.

   The default value for redundant processing and cross-checking of the single-encoder input in a 1oo2 architecture is 0 (Single Fbk).
3. Click the P28 [Fbk 1 Type] parameter value.

   The default value is 1 for incremental encoder input.
4. From the Fbk 1 Type pull-down menu, choose Sine/Cosine for internal monitoring of the single encoder input.

   The P28 [Fbk 1 Type] parameter value changes to 0.
5. Click the P29 [Fbk 1 Units] parameter value.

   The default P29 [Fbk 1 Units] parameter value is 0 (Rev) for rotary motor feedback.
6. Click the P30 [Fbk 1 Polarity] parameter value.

   The default P30 [Fbk 1 Polarity] parameter value is 0 (Normal) to set up the direction for monitoring to be the same as the encoder direction.
7. Click the P31 [Fbk 1 Resolution] parameter value.

   The default P31 [Fbk 1 Resolution] parameter value is 1024. You can enter any value between 1...65,535 pulses/revolution based on the encoder specifications.
8. Click the P32 [Fbk 1 Volt Mon] parameter value.

   The default P32 [Fbk 1 Volt Mon] parameter value is 0 to disable encoder voltage monitoring. Enter 5, 9, or 12V to monitor voltage in accordance with encoder specifications.

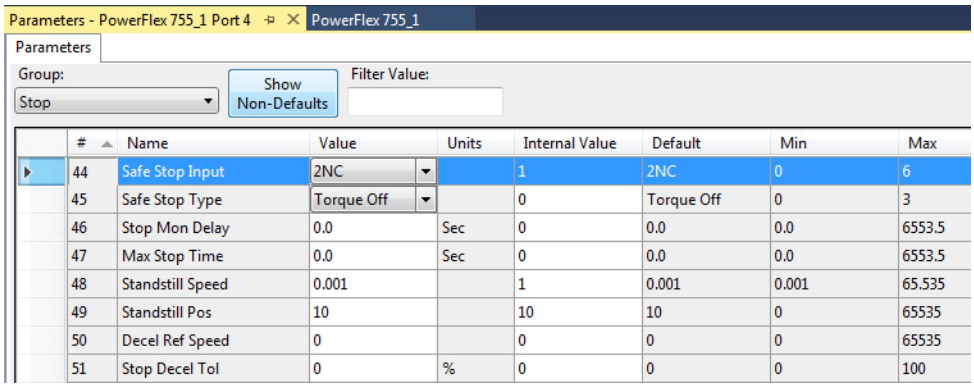
   The P33 [Fbk 1 Speed] parameter displays the output speed of the encoder as a value between -214,748,364.8...214,748,364.8 rpm based on the encoder configuration. You do not need to enter a setting or value for this parameter.
9. Click the P42 [Direction Mon] parameter value.

   The default P42 [Direction Mon] parameter value is 0 (Disabled).

   You can disable Safe Direction Monitoring if only one direction of rotation is possible or there is no safety-related restriction on the direction of rotation.

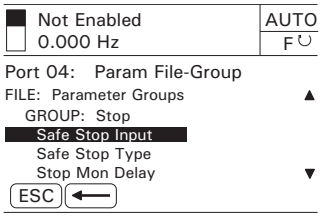
Example 2: Stop Group Parameter Settings

Software Dialog Box



#	Name	Value	Units	Internal Value	Default	Min	Max
44	Safe Stop Input	2NC		1	2NC	0	6
45	Safe Stop Type	Torque Off		0	Torque Off	0	3
46	Stop Mon Delay	0.0	Sec	0	0.0	0.0	6553.5
47	Max Stop Time	0.0	Sec	0	0.0	0.0	6553.5
48	Standstill Speed	0.001		1	0.001	0.001	65.535
49	Standstill Pos	10		10	10	0	65535
50	Decel Ref Speed	0		0	0	0	65535
51	Stop Decel Tol	0	%	0	0	0	100

HIM Screen



Follow these steps to configure the Stop operation of the safety option module.

1. From the Parameters Group pull-down menu, choose Stop.
2. Click the P44 [Safe Stop Input] parameter value.

   The default P44 [Safe Stop Input] parameter value is 1 (2NC) for two normally closed (dual-channel equivalent) operation.

   In this example application, the Safe Stop input (SS_In) monitors an E-Stop button with two normally closed (2NC) contacts.
3. Click the P45 [Safe Stop Type] parameter value.

   The default P45 [Safe Stop Type] parameter value is 0 (Torque Off) for Safe Torque Off with Standstill Speed Checking.
4. From the Safe Stop Type pull-down menu, choose Safe Stop 1 (internal value of 1).

   Safe Stop 1 monitors deceleration profiles. When Standstill Speed is detected within the Stop Delay [Max Stop Time], the safety option module switches off Motion Power and sets door control logic to Unlock.
5. Click the P47 [Max Stop Time] parameter value.

   The default P47 [Max Stop Time] parameter value is 0. You can enter a value from 0...6553.5 s.

   Safe Stop 1 monitors deceleration profiles. When Standstill Speed is detected within the Stop Delay [Max Stop Time], the safety option switches off Motion Power and sets door control logic to Unlock.
6. Type the value of the expected coast-to-stop time plus a reasonable tolerance after the Safe Stop command is initiated.

   If the machine's speed is not below the Standstill Speed within the Max Stop Time period you entered, a Stop Speed Fault occurs and door control logic remains set to Lock until Standstill Speed is reached.

7. Click the P48 [Standstill Speed] parameter value.

   The default P48 [Standstill Speed] parameter value is 0.001 rpm. You can enter a value from 0.001...65,535 rpm. The Standstill Speed is measured in revolutions per minute, because the P29 [Fbk 1 Units] parameter is configured for Rev (rotary feedback).
8. Enter a value in the P48 [Standstill Speed] parameter field to define the speed at which the safety option module determines standstill has been reached.
9. Click the P49 [Standstill Pos] parameter value.

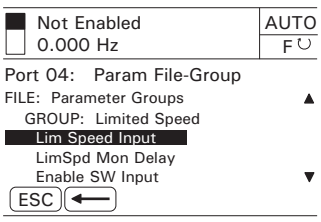
   The default value is 10 degrees, but you can enter a value from 0...65,535 degrees. The Standstill Position is measured in degrees because the P29 [Fbk 1 Units] parameter is configured for Rev (rotary feedback).
10. Enter the value to define the position limit in encoder units that is tolerated after standstill has been reached.
11. Choose the P50 [Decel Ref Speed] parameter.

    The default value is 0 RPM, but you can enter a value from 0...65,535 RPM. The Decel Ref Speed parameter is used to verify that the speed is decelerating at the desired rate.
12. Enter a number greater than the Max Speed (2000 in this example).
13. Choose the P51 [Stop Decel Tol] parameter.

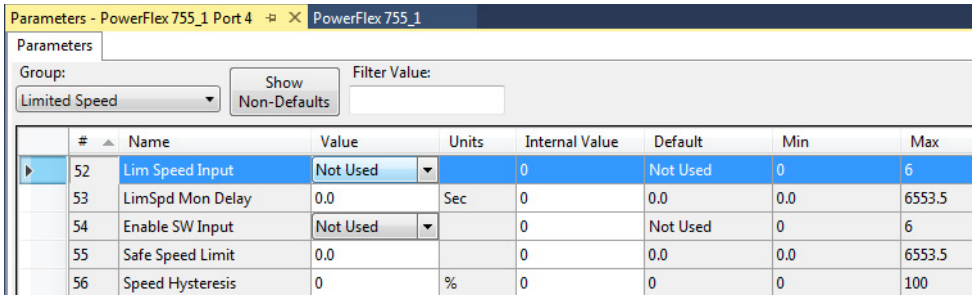
    The Stop Decel Tol parameter determines the total percentage of the Decel Ref Speed that is used as the upper limit of deceleration speed.
14. Enter 100% for this example.

Example 2: Limited Speed Group Parameter Settings

HIM Screen



Software Dialog Box



Follow these steps to configure the Safe Limited Speed operation.

1. From the Parameters Group pull-down menu, choose Limited Speed.
2. Click the P52 [Lim Speed Input] parameter value.

   The default P52 [Lim Speed Input] parameter value is 0 (Not Used) for applications without Safe Limited Speed control.
3. From the Lim Speed Input pull-down menu, choose 2NC for two normally closed (dual-channel equivalent) operation and an internal value of 1.

   In this example application, the Safe Limited Speed input (SLS_In) monitors a switch with two normally closed (2NC) contacts. If the NC contacts are open and speed exceeds the configured Safe Limited Speed, the safety option module initiates the configured Safe Stop Type.

   When the safety option module is actively monitoring Safe Limited Speed and the machine speed is at or below the configured Safe Speed Limit, the gate interlock is released and the door can be opened.
4. Click the P53 [LimSpd Mon Delay] parameter value.

   The default value is 0 s. The valid range is from 0...6553.5 s.

   Type a value to define the desired delay between the SLS_In input ON to OFF transition and the start of Safe Limited Speed monitoring.
5. Click the P54 [Enable SW Input] parameter value.

   The default P54 [Enable SW Input] parameter value is Not Used with an internal value of 0 for applications without an enabling switch.

6. From the Enable SW Input pull-down menu, choose 2NC (internal value of 1) for two normally open (dual-channel equivalent) operation.

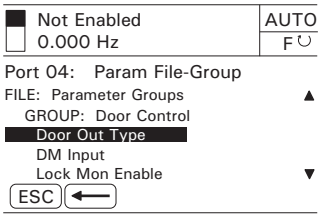
   In this example application, the ESM_In input monitors an enabling switch with two normally closed (2NC) contacts. As long as the enabling switch is held in the middle position, the safety gate can be opened during Safe Limited Speed monitoring.
7. Choose the P55 [Safe Speed Limit] parameter.

   The default value is 0 rpm or mm/s. Enter a value from 0...6553.5.
8. Type the maximum allowable rpm value in the Safe Speed Limit value field for safe (reduced) velocity.

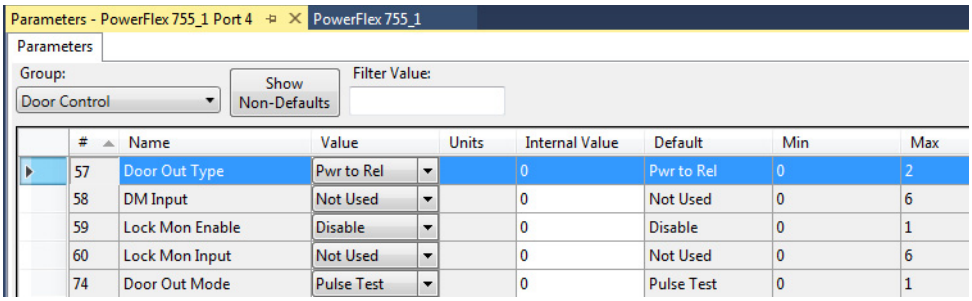
   The speed is calculated in rpm, based on the Fbk 1 Units parameter setting, 0 = Rev (rotary feedback) entered previously.

Example 2: Door Control Group Parameter Settings

HIM Screen



Software Dialog Box



#	Name	Value	Units	Internal Value	Default	Min	Max
57	Door Out Type	Pwr to Rel		0	Pwr to Rel	0	2
58	DM Input	Not Used		0	Not Used	0	6
59	Lock Mon Enable	Disable		0	Disable	0	1
60	Lock Mon Input	Not Used		0	Not Used	0	6
74	Door Out Mode	Pulse Test		0	Pulse Test	0	1

Follow these steps to configure Door Control operation for the safety option module.

1. From the Parameters Group pull-down menu, choose Door Control.
2. Click the P57 [Door Out Type] parameter value.
3. The default P57 [Door Out Type] parameter value is 0 (Pwr to Rel) Power to Release.

   This setting is chosen to apply power to the solenoid inside the TLS-3 GD2 gate switch to release the gate interlock.
4. Click the P58 [DM Input] parameter.

   The default P58 [DM Input] parameter value is 0 (Not Used) for applications that do not use an interlock switch.
5. From the DM Input pull-down menu, choose 2NC for an internal value of 1 and 2NC (dual-channel equivalent) operation.

   In this example application, the DM Input (DM_In) monitors the TLS-3 GD2 switch. The switch has two normally closed (2NC) safety contacts.
6. Click the P59 [Lock Mon Enable] parameter value.

   The default P59 [Lock Mon Enable] parameter value is 0 (Disable) for applications without an interlock switch.
7. From the Lock Mon Enable pull-down menu, choose Enable with an internal value of 1, because this application uses the TLS-3 GD2 interlock switch.
8. Click the P60 [Lock Mon Input] parameter value.

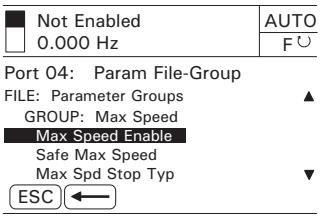
   The default P60 [Lock Mon Input] parameter value is 0 (Not Used) for applications that do not use an interlock switch.
9. From the Lock Mon Input pull-down menu, choose 2NC with an internal value of 1 for two normally closed (dual-channel equivalent) operation.

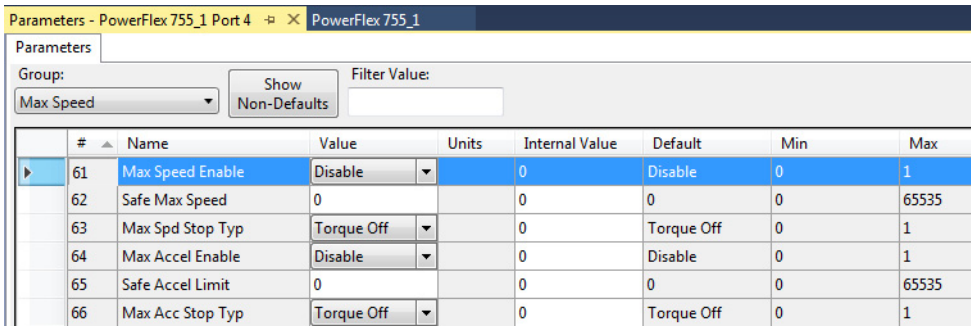
   In this example application, the Lock Monitor Input (LM_In) monitors the TLS-3 GD2 switch. The switch has two normally closed (2NC) interlock monitoring contacts.

Example 2: Max Speed Group Parameter Settings

Software Dialog Box

HIM Screen





Follow these steps to configure Maximum Speed monitoring for the safety option.

1. From the Parameters Group pull-down menu, choose Max Speed.
2. Click the P61 [Max Speed Enable] parameter value.

   The default P61 [Max Speed Enable] parameter value is Disabled with an internal value of 1 for no maximum-speed limitation.
3. From the Max Speed Enable pull-down menu, choose Enable.

   Max Speed Enable monitors the encoder feedback signal so it does not exceed the velocity configured by using the Safe Max Speed parameter.
4. Click the P62 [Safe Max Speed] parameter value.

   The default P62 [Safe Max Speed] parameter value is 0 rpm or mm/s. Enter a value from 0...6553.5.
5. Type the maximum allowable rpm value for velocity.

   The speed is calculated in rpm, based on the Fbk 1 Units parameter setting, 0 = Rev (rotary feedback) entered previously.
6. Click the P63 [Max Spd Stop Typ] parameter.

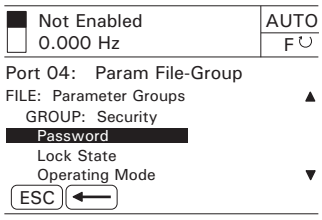
   The default P63 [Max Spd Stop Typ] parameter value is Torque Off with an internal value of 0.
7. From the Max Spd Stop Typ pull-down menu, choose Safe Stp Typ (internal value of 1).

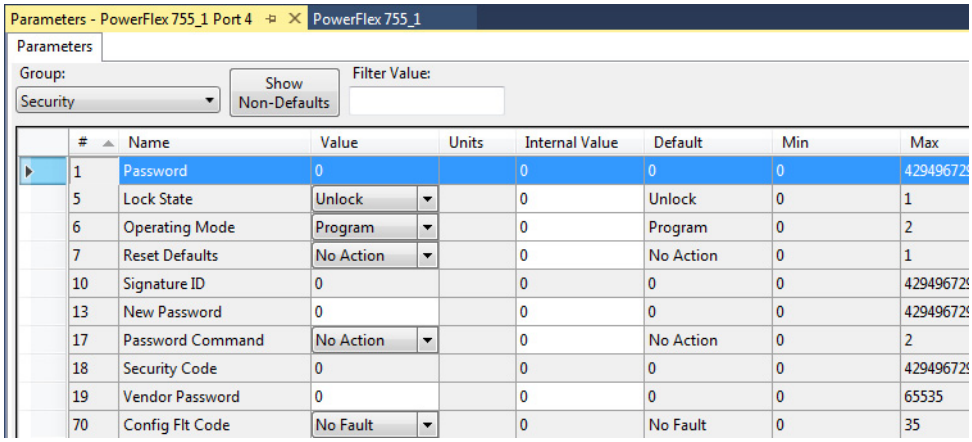
   With this configuration, if speed exceeds the configured Safe Max Speed, the safety option module initiates the configured Safe Stop Type.

Example 2: Final Security Group Settings

Software Dialog Box

HIM Screen





This example includes only the steps for entering a configuration by using the HIM module or software program. You must also follow the requirements described in Safety Configuration and Verification on page 107.

ATTENTION: You must verify the configuration and validate the entire system, including a complete functional test, before the operational startup of any safety-related system.
Only authorized, specially trained personnel, experienced in the commissioning and operation of safety-related systems can configure, test, and verify the project.

Follow these steps to put the safety option into Run mode, generate a configuration signature, and lock the configuration.

1. From the Parameters Group pull-down menu, choose Security.
2. Click the P6 [Operating Mode] parameter value.
3. From the Operating Mode pull-down menu, choose Run with an internal value of 1 (Run mode).

   A configuration signature is generated.
4. Click the P10 [Signature ID] parameter and record the configuration signature value stored in this parameter.
5. If you configured a password, click the P1 [Password] parameter and type the password.
6. Click the P5 [Lock State] parameter value.
7. From the Lock State pull-down menu, choose Lock with an internal value of 1 to lock the configuration.

Troubleshoot the PowerFlex Safe Speed Monitor Option Module

This chapter provides troubleshooting tables for diagnosing fault conditions associated with the PowerFlex® Safe Speed Monitor option module.

Interpret Status Indicators

The safety option module features two status indicators to assist in troubleshooting.

Table 36 - Safety Option Module Status Indicators

Indicator	Status	Description
P/F	Green/On	The safety option module is operating normally and is in Run mode.
	Red/Flashing	A recoverable fault has occurred.
	Red/On	A nonrecoverable fault has occurred. (All other indicators are OFF.)
	Red/Green Flashing	The configuration is being downloaded or a firmware upgrade is in progress.
MP	Green/On	Motion Power is enabled.
	Off	Motion Power is disabled.
	Red/Flashing	A Motion Power fault has been detected.

Nonrecoverable Faults

In addition to the recoverable faults described in this chapter, the safety option module also generates nonrecoverable faults when an anomaly with the safety option module hardware is detected. These faults are Safe State faults. If a Safe State fault occurs, all safety control outputs are set to their safe state.

To clear a nonrecoverable fault, cycle power. If the nonrecoverable fault persists, replace the Safe Speed Monitor option module.

Fault Recovery

If the fault is no longer present, you can clear the fault condition with a successful SS Reset and drive fault Clear command, except in the case of an Invalid Configuration fault, MP Out fault, or Reset PwrUp fault. An Invalid Configuration fault is cleared by a successful reconfiguration. An MP Out fault or Reset PwrUp fault is cleared at power down or by a successful reconfiguration.

Input and Output Faults

An input or output fault indication can be caused by several wiring fault conditions during commissioning or normal operation. If an input fault occurs, check for the following:

- One of the channels has shorted to a 24V DC source
- One of the channels has shorted to a GND source
- Two input channels have shorted together
- One or both output channels have an overcurrent condition

An input fault can also occur if only one of the channels in a dual-channel system changed state after a 3-second discrepancy time interval, and if the inputs are configured with one of the following settings:

- 2 = Dual-channel equivalent 3 s (2NC 3s)
- 4 = Dual-channel complementary 3 s (1NC + 1NO 3s)
- 5 = Dual-channel SS equivalent 3 s (2 OSSD 3s)

Fault Codes and Descriptions

Faults fall into one of three categories: Stop Category fault, Fault While Stopping fault, and Safe State fault. Stop Category faults can be Motion faults, Monitor faults, or I/O faults.

The HIM module or configuration software can display a fault history queue, which provides a record of the faults detected by the safety option module. The fault history queue stores the fault codes and timestamps for the last 10 faults that occurred. To avoid confusion about when faults occurred, a power-up marker (code 32) is placed between faults in the queue if the safety option module is powered up or reset when the queue is not empty. Code 0 equals No Entry.

These tables list the faults, fault codes, and display text for each fault. You can view these faults by accessing the P67 [Fault Status] parameter.

Table 37 - Safe State Faults

Code	Display Text	Description
0	Combined Flt	A combined fault is indicated if any error has occurred.
1	Critical Flt	A nonrecoverable microprocessor error has occurred.
2	Invalid Cfg	An Invalid Configuration fault occurs if a configuration parameter is set to an illegal value or combination of values. See the Configuration Fault Codes on page 136.
3	MP Out Flt	An MP Output fault occurs if an error is detected in the Motion Power command to the drive. If you are not using the DiO digital input on the drive's main control board as a 'hardware enable', verify that J1 ENABLE jumper, also on the drive's main control board, is installed
4	Reset PwrUp	A Reset Powerup fault occurs if the reset type is configured for Manual or Manual Monitored and the Reset_In input is detected as ON when power is cycled.
5	Fbk 1 Flt	A Feedback 1 fault occurs if any of these conditions are detected at encoder 1: • An open wire is detected. • A short-circuit is detected. • A sine/cosine fault exists, that is the amplitude of the sine signal squared plus the amplitude of the cosine signal squared is not equal to a constant value. • The feedback signals indicate a frequency greater than or equal to 100 kHz for a Sine/cosine encoder or 200 kHz for a incremental encoder. • Illegal encoder signal transitions are detected.
6	Fbk 2 Flt	A Feedback 2 fault occurs if any of these conditions are detected at encoder 2: • Illegal encoder signal transitions are detected. • The feedback signals indicate a frequency greater than or equal to 200 kHz.
7	Dual Fbk Spd	A Dual Feedback Speed fault occurs if an error is detected between the speed from the first encoder and the speed from the second encoder. Valid speed-comparison values are determined by the configured Feedback Speed Ratio and Feedback Speed Tolerance.
8	Dual Fbk Pos	A Dual Feedback Position fault occurs if a discrepancy is detected between the relative position change of encoder 1 and the relative position change of encoder 2 since the last SS Reset.
13	Mov in Stop	If the safety option module is configured for a stop type that includes stopped speed checking, a Mov in Stop fault occurs if either of the following is detected after the system is stopped and the door has been unlocked: • Speed greater than the configured Standstill Speed • A position change greater than the configured Standstill Position limit
27	Fbk 1 V Fault	An Encoder 1 Voltage fault occurs if the encoder voltage at encoder 1 is detected as out of range.
28	Fbk 2 V Fault	An Encoder 2 Voltage fault occurs if the encoder voltage at encoder 2 is detected as out of range.

Table 38 - Fault While Stopping Faults

Code	Display Text	Description
11	Decel Flt	A Deceleration fault occurs if the speed is detected at greater than the limit specified for the configured Stop Delay [Max Stop Time] when the configured Safe Stop Type is Safe Stop 1 or 2.
12	Stop Spd Flt	A Stop Speed fault occurs when the safety option module is configured for a Safe Stop Type that includes Standstill Speed checking (Safe Stop 1 or 2, and Safe Torque Off with Standstill Speed Checking) and the detected speed is greater than the configured Standstill Speed at the end of the configured Stop Delay [Max Stop Time].

Table 39 - Stop Category Faults

Code	Display Text	Description	
9	SS In Flt	I/O Faults [1]	An SS_In fault occurs if an error is detected in the SS_In dual-channel input.
10	SS Out Flt		An SS_Out fault occurs if an error is detected in the SS_Out dual-channel output.
14	SLS In Flt		An SLS_In fault occurs if an error is detected in the SLS_In dual-channel input.
15	SLS Out Flt		An SLS_Out fault occurs if an error is detected in the SLS_Out dual-channel output.
20	DM In Flt		A DM_In fault occurs if an error is detected in the DM_In dual-channel input.
22	DC Out Flt		A DC_Out fault occurs if an error is detected in the DC_Out dual-channel output.
23	LM In Flt		An LM_In fault occurs if an error is detected in the LM_In dual-channel input.
25	ESM In Flt		An ESM_In fault occurs if an error is detected in the ESM_In dual-channel input.
16	SLS Speed Flt	Motion Faults	The monitored speed was detected at greater than or equal to the Safe Speed Limit during Safe Limited Speed monitoring.
17	SMS Spd Flt		A Safe Maximum Speed fault indicates that Safe Maximum Speed (SMS) monitoring is enabled and the monitored speed was detected at greater than or equal to the configured Safe Max Speed.
18	Accel Flt		An Acceleration fault indicates that the monitored speed was detected as greater than or equal to the configured Safe Accel Rate during safe acceleration monitoring.
19	Dir Flt		A Direction fault indicates that motion was detected in the restricted direction during safe direction monitoring (SDM).
21	Door Mon Flt	Monitor Fault	If the safety option module is configured for Safe Limited Speed (SLS), but SLS monitoring is not active, the DM_In input must be ON (door closed) or a Door Monitoring fault occurs. A Door Monitoring fault occurs if the door is open (DM_In input is OFF) when an SS Reset or SLS Reset is requested (SLS_In transitions to ON). If a configured SLS Monitoring Delay P53 [LimSpd Mon Delay] is in progress prior to Safe Limited Speed monitoring being active and the DM_In input is OFF (door open), a Door Monitoring fault occurs. If the safety option module is configured for door monitoring and enabling switch monitoring and is actively monitoring safe limited speed, a Door Monitoring fault occurs if the DM_In input transitions from ON to OFF (door is opened), while the ESM_In input is OFF.
26	ESM Mon Flt		If the safety option module is configured for enabling switch monitoring and is actively monitoring safe limited speed, the ESM_In input must be ON or an ESM Monitoring fault occurs. If the safety option module is configured for enabling switch monitoring only and a configured SLS monitoring delay [LimSpd Mon Delay] is in progress, the ESM_In input must be ON when the delay times out or an ESM Monitoring fault occurs. If the ESM_In input is ON while the safety option module is actively monitoring safe limited speed, the door can be opened (DM_In transitions from ON to OFF) if no Lock Monitoring fault exists. However, if the ESM_In input transitions to OFF after the door has been opened, an ESM Monitoring fault occurs. If you attempt an SS Reset while the SLS_In input is OFF and the ESM_In input is OFF, an ESM Monitoring fault occurs.
24	Lock Mon Flt		If the safety option module is configured for lock monitoring, a Lock Monitoring fault occurs when: • the LM_In input is detected as OFF while the door control output is in the Lock state, except for the 5 seconds following the transition of the DC_Out output from Unlock to Lock. • the LM_In input is detected as ON when the DM_In signal transitioned from ON to OFF.

(1) Refer to Input and Output Faults on page 131 for more information.

Fault Reactions

When a fault occurs, the type of fault and the status of the system determine the resulting state of the system.

Safe State Faults

If a Safe State fault occurs in any operational state including the Disabled state, the safety option module goes to the Safe State. In the Safe State, all safety outputs are in their safe states.

Stop Category Faults and Fault While Stopping Faults

If a Stop Category fault or Fault While Stopping fault occurs while the Safe Speed Monitor option module is monitoring motion, the module initiates the configured Safe Stop Type.

The type of fault detected determines the module response when the fault occurs while the module is executing the configured Safe Stop Type.

Table 40 - Fault Reactions

Type of Fault Detected	Response
Fault While Stopping Faults: • Deceleration fault (Decel Flt) • Stop Speed fault (Stop Spd Flt)	Outputs are placed in a faulted state, but door control logic can be set to Unlock if feedback signals indicate that Standstill Speed has been reached. The safety option module continues to monitor for faults.
These Stop Category Faults: • SMS Speed fault when the P63 [Max Spd Stop Typ] is configured for Use Safe Torque Off with Check for Standstill (Torque Off) • Acceleration fault when the P66 [Max Acc Stop Typ] is configured for Use Safe Torque Off with Check for Standstill (Torque Off) • Direction fault (Dir Flt), if the fault occurred while a safe stop was in progress.	
These Stop Category faults: • SLS Speed fault (SLS Spd Flt) • Direction fault (Dir Flt), if the fault was detected before the safe stop was initiated. In this case, the safety option module does not perform Direction Monitoring while executing the configured Safe Stop Type. • Door Monitoring fault (Door Mon Flt) • ESM Monitoring fault (ESM Mon Flt) • Lock Monitoring fault (Lock Mon Flt) • SMS Speed fault when the P63 [Max Spd Stop Typ] is configured for Use Configured Safe Stop Type (Safe Stp Typ) • Acceleration fault when the P66 [Max Acc Stop Typ] is configured for Use Configured Safe Stop Type (Safe Stp Typ)	The safety option module continues to execute the configured Safe Stop Type and monitor for faults.

If outputs are already in a faulted state due to a previous fault, and a subsequent Stop Category fault or Fault While Stopping fault occurs, outputs remain in a faulted state, door control logic can be set to Unlock if feedback signals indicate that Standstill Speed has been reached, and the safety option module continues to monitor for faults.

If a Stop Category fault or Fault While Stopping fault occurs after Standstill Speed has been reached and the safety option module has set door control logic to Unlock, the safety option module goes to the Safe State.

ATTENTION: If a fault occurs after Standstill Speed has been reached, door control logic remains unlocked.
A Safe State fault can set the Door Control output (DC_Out) to OFF.

Status Attributes

For diagnostic purposes only, you can view status attributes by accessing the P68 [Guard Status] parameter and the P69 [IO Diag Status] parameter from a HIM module, RSLogix 5000 software or the Logix Designer application, DriveExecutive™, or Connected Components Workbench™ software.

The status attributes are valid only when the safety option module is in Run mode. If the safety option module is in Program mode or has an Invalid Configuration Fault, the status attributes are not updated.

Guard Status Attributes

These attributes are stored in the P68 [Guard Status] parameter. Each bit corresponds to a different attribute.

Table 41 - Guard Status Attributes

Bit	Display Text	Description
0	StatusOK	This bit indicates when there are no faults. It is set (1), when all of the Fault Status bits 1...31 are 0 (no faults). The bit is 0 if any Fault Status bit from 1...31 indicates a fault (1).
1	Config Lock	This bit shows the status of the P5 [Lock State] parameter. A 1 indicates the configuration is locked; a 0 indicates the configuration is unlocked.
2	MP_Out	This bit shows the status of the safety option module's Motion Power command to the drive. A 1 indicates Motion Power is enabled; a 0 indicates Motion Power is disabled.
3	SS In	This bit displays the logical value, 1 or 0, evaluated for the dual-channel SS_In input.

Table 41 - Guard Status Attributes (Continued)

Bit	Display Text	Description
4	SS Req	This bit is set to 1 when a safe stop is initiated by either a transition of the SS_In input from ON to OFF or by a Stop Category fault. This bit is reset to 0 when a successful SS Reset occurs and when the Safety mode is set to Disabled (0).
5	SS In Prog	This bit is set to 1 when a safe stop is initiated by the transition of the SS_In input from ON to OFF with no active fault conditions. It is not set to 1 when a Safe Stop is initiated by a Stop Category fault. While set to 1, this bit resets (0) if Standstill Speed is reached or any fault condition is detected.
6	SS Decel	This bit is set to 1 if the configured Stop Delay [Max Stop Time] is active for a Safe Stop 1 or Safe Stop 2 while the safety option module is executing the Safe Stop. This bit is not set during a Category 0 Safe Torque Off Safe Stop. This bit is reset (0) when Standstill Speed is detected, a Safe State fault occurs, or a SS Reset occurs.
7	SS Stopped	This bit is set to 1 if a successful Safe Stop has been executed and the speed is less than or equal to the Standstill Speed. This bit is set to 0 by an SS Reset or the occurrence of a Stop Category fault. It is always 0 when the safety option module is configured for a Safe Torque Off without Standstill Speed Checking.
8	SS Out	This bit is set to 1 if the dual-channel SS_Out output is being commanded to the ON state. This bit is the commanded value, not a readback value. This bit is set to 0 if the SS_Out output is being commanded to the OFF state.
9	SLS In	This bit reflects the logical value evaluated for the dual-channel SLS_In input.
10	SLS Req	This bit is set to 1, if the Safe Limited Speed operation has been requested while the safety option module is actively monitoring motion or a SLS Monitoring Delay [LimSpd Mon Delay] is in progress.
11	SLS In Prog	This bit is set to 1 when Safe Limited Speed monitoring is active.
12	SLS Out	This bit is set to 1 if the dual-channel SLS_Out output is being commanded to the ON state. This bit is the commanded value, not a readback value.
13	SMS In Prog	This bit is set to a 1, if Safe Maximum Speed monitoring is enabled and Safe Maximum Speed is being monitored.
14	SMA In Prog	This bit is set to 1, if Safe Maximum Acceleration monitoring is enabled and safe maximum acceleration is actively being monitored.
15	SDM In Prog	If Safe Direction monitoring is enabled and configured for Positive Always or Negative Always, the SDM_In_Progress bit is set to 1 any time the safety option module is configured for any Safety mode other than Disabled. If Safe Direction monitoring is enabled and configured for Positive During SLS or Negative During SLS, then this bit is set to 1 if the safety option module is actively monitoring for Safe Limited Speed. It is set to 0 in any other operating mode.
16	DC Lock	This bit is set to 1 if door control logic status is Lock. This bit is set to 0 if door control logic status is Unlock.
17	DC Out	This bit is set to 1 if the dual-channel DC_Out output is being commanded to the ON state. This is the commanded value, not the readback value. This bit is set to 0, if the dual-channel DC_Out output is being commanded to the OFF state.
18	DM In	This bit is set to 1 if the logical value of the dual-channel DM_In input is evaluated as 1. This bit is set to 0 if the logical value of the dual-channel DM_In input is evaluated as 0.
19	DM In Prog	The status of this bit is dependent on the safety option module's speed monitoring configuration. The bit is 1 when: • the safety option module is configured for Safe Stop with Door Monitoring and is monitoring motion, or is executing a Safe Stop. • the safety option module is configured for Safe Limited Speed with Door Monitoring and the safety option module is not actively monitoring for Safe Limited Speed, is in a SLS Monitoring Delay [LimSpd Mon Delay], or is executing a Safe Stop. • the safety option module is configured for Safe Limited Speed with Door Monitoring and Enabling Switch Monitoring, and – the safety option module is not actively monitoring for Safe Limited Speed, is in a SLS Monitoring Delay [LimSpd Mon Delay], or is executing a Safe Stop. – the safety option module is actively monitoring for Safe Limited Speed when the ESM_In input is OFF and the DM_In input is ON. This bit is always set to 0 when the safety option module is not configured for Door Monitoring.
20	LM In	This bit is set to 1 if the logical value of the dual-channel LM_In input is evaluated as 1. This bit is set to 0 if the logical value of the dual-channel LM_In input is evaluated as 0.
21	ESM In	This bit is set to 1 if the logical value of the dual-channel ESM_In input is evaluated as 1. This bit is set to 0 if the logical value of the dual-channel ESM_In input is evaluated as 0.
22	ESM In Prog	This bit is set to 1 if the Safety mode is configured for Enabling Switch Monitoring, Safe Limited Speed monitoring is active, and the SLS_In input is OFF. It is also set to 1 if the Safety mode is configured for Enabling Switch Monitoring and Door Monitoring and the DM_In input is OFF. This bit is set to 0 when the Safety mode is not configured for Enabling Switch Monitoring.
23	Reset In	This status bit reflects the state of the Reset_In input. A 1 indicates the Reset_In input is ON; a 0 indicates the Reset_In input is OFF.
24	Wait Reset	This bit indicates when an SS Reset is required. The bit is set to 1 whenever the safety option module is successfully configured and is in the Safe State or when Standstill Speed has been reached.
25	Wait SS Cyc	This bit indicates when the SS_In input must be cycled prior to a SS Reset being performed. The bit is set to 1 if the SS_In input is ON and a fault is detected or the Wait Stop Request attribute equals 1. It is set to 0 if the SS_In input is detected as OFF.

Table 41 - Guard Status Attributes (Continued)

Bit	Display Text	Description
26	Wait No Stop	This bit is set to 1 when a stop request is made by using the HIM stop button. It is set to 0 when the HIM start button is pushed, following a reset, or at powerup.
27	SLS Cmd	This bit is set to 1 when the safety option module is commanding the drive to operate in limited speed mode.
28	Stop Cmd	This bit is set to 0 when the safety option module is commanding the drive to stop.
29	Reserved	
30		
31		

I/O Diagnostic Status Attributes

These attributes are stored in the P69 [IO Diag Status] parameter. Each bit reflects the present state of I/O signal and is used for diagnostics: 0 = open;
1 = closed.

Table 42 - P69 [IO Diag Status] Attributes

Bit	Display Text
0	SS In Ch 0
1	SS In Ch 1
2	SS Out Ch 0
3	SS_Out Ch 1
4	SLS In Ch 0
5	SLS In Ch 1
6	SLS Out Ch 0
7	SLS Out Ch 1
8	ESM In Ch 0
9	ESM In Ch 1
10	DM In Ch 0
11	DM In Ch 1
12	DC Out Ch 0
13	DC Out Ch 1
14	LM In Ch 0
15	LM In Ch 1
16	Reset In
17	Reserved
18	SLS Cmd
19	Stop Cmd
20	MP Out Ch 0 (1)
21	MP Out Ch 1
Bits 22...31 are Reserved.	

(1) Refer to Guard Status Attributes, bit 2, on page 134.

IMPORTANT When the safety option module is not in Run mode, the P69 [IO Diag Status] parameter is not updated.

Configuration Fault Codes

Use these fault codes, stored in the P70 [Config Flt Code] parameter, to identify the reason for an Invalid Configuration fault.

Table 43 - P70 [Config Flt Code] Fault Codes

Value	Description	Display
0	No fault.	No Fault
1	Password Required.	Password Req
2	P21 [Safety Mode] value not legal based on P20 [Cascaded Config] value.	P21 (P20)
3	P57 [Door Out Type] value not legal based on P20 [Cascaded Config] value.	P57 (P20)
4	P46 [Stop Mon Delay] value not legal based on P45 [Safe Stop Type] value.	P46 (P45)
5	P50 [Decel Ref Spd] value not legal based on P31 [Fbk 1 Resolution] value.	P50 (P31)
6	P48 [Standstill Speed] value not legal based on P20 [Cascaded Config] value.	P48 (P20)
7	P53 [LimSpd MonDelay] value not legal based on P21 [Safety Mode] value.	P53 (P21)
8	P55 [Safe Speed Limit] value not legal based on P21 [Safety Mode] or P31 [Fbk 1 Resolution] value.	P55 (P21 P31)
9	P56 [Speed Hysteresis] value not legal based on P21 [Safety Mode] value.	P56 (P21)
10	P62 [Safe Max Speed] value not legal based on P31 [Fbk 1 Resolution] value.	P62 (P31)
11	P42 [Direction Mon] value not legal based on P21 [Safety Mode] value.	P42 (21)
12	P59 [Lock Mon Enable] value not legal based on P21 [Safety Mode] value.	P59 (P21)
13	P36 [Fbk 2 Resolution] value not legal based on P27 [Fbk Mode] value.	P36 (P27)
14	P35 [Fbk 2 Polarity] value not legal based on P27 [Fbk Mode] value.	P35 (P27)
15	P39 [Fbk SpeedRatio] value not legal based on P27 [Fbk Mode] value.	P39 (P27)
16	P41 [Fbk Pos Tol] value not legal based on P27 [Fbk Mode] value.	P41 (P27)
17	P40 [Fbk Speed Tol] value not legal based on P27 [Fbk Mode] value.	P40 (P27)
18	P44 [Safe Stop Input] value not legal based on P21 [Safety Mode] value.	P44 (P21)
19	P52 [Lim Speed Input] value not legal based on P21 [Safety Mode] value.	P52 (P21)
20	P58 [DM Input] value not legal based on P20 [Cascaded Config] and P21 [Safety Mode] value.	P58 (P20 P21)
21	P54 [Enable SW Input] value not legal based on P21 [Safety Mode] value.	P54 (P21)
22	P60 [Lock Mon Input] value not legal based on P21 [Safety Mode] value and P59 [Lock Mon Enable] value.	P60 (P21 P59)
23	Illegal P20 [Cascaded Config] value.	P20
24	Illegal P22 [Reset Type] value.	P22
25	Reserved.	Reserved
26	Illegal P45 [Safe Stop Type] value.	P45
27	Illegal P51 [Stop Decel Tol] value.	P51
28	Illegal P27 [Fbk Mode] value.	P27
29	Illegal P28 [Fbk 1 Type] value.	P28
30	Illegal P31 [Fbk 1 Resolution] value.	P31
31	Illegal P32 [Fbk 1 Volt Mon] value.	P32
32	Illegal P37 [Fbk 2 Volt Mon] value.	P37
33	Illegal P24 [OverSpd Response] value.	P24
34	Reserved.	Reserved
35	Unknown error.	Unknown Err

Notes:

Specifications, Certifications, CE, and UKCA Conformity

This appendix provides product specifications for the PowerFlex® 750-Series Safe Speed Monitor option module.

Specifications

These specifications apply to the Safe Speed Monitor option module. For additional specifications, refer to the following publications:

- PowerFlex 750-Series AC Drives Technical Data, publication 750-TD001
- PowerFlex 750-Series Products with TotalFORCE® Control Technical Data, publication 750-TD100

Table 44 - Encoder Specifications

Type	Parameter	Description (1)
Generic Incremental	Incremental encoder support	5, 9, and 12V, differential A quad B
	Differential input voltage (AM and BM)	1.0…7.0V
	High threshold level, min	3.5V
	Low threshold level, max	0.4V
	DC current draw (AM and BM)	60 mA, max
	Input signal frequency (AM and BM)	200 kHz, max
	Cable length, max	• 183 m (600 ft) max cable length with 12V encoder • 30.5 m (100 ft) max cable length with 5V encoder
Generic Sin/Cos	AM/BM input frequency	100 kHz, max
	AM/BM differential input voltage (p-p)	0.6…1.2V
Stegmann Sin/Cos	AM/BM input frequency	100 kHz, max
	AM/BM differential input voltage (p-p)	1V ±10%

(1) Use Belden 9728 cable with these encoder specifications.

Table 45 - General Specifications

Attribute	Value
Standards (when used with PowerFlex 755)	EN/IEC 61800-5, EN 61800-5-1, EN 61800-3, EN ISO 13849-1, EN 62061, EN 60204-1, IEC 61508 parts 1-7
Safety ratings (when used with PowerFlex 755)	SIL 3 according to EN 62061 / IEC 61508 SIL CL 3 according to EN/IEC 61800-5-2 / EN 62061 / IEC 61508 Cat. 4 and PL e according to EN ISO 13849-1
Standards (when used with PowerFlex 755T)	EN 61800-5-2, EN 61800-5-1, EN 61800-3, EN ISO 13849-1, EN 62061, EN 60204-1, IEC 61508 parts 1-7
Safety ratings (when used with PowerFlex 755T)	SIL 3 according to EN 62061 / IEC 61508 SIL CL 3 according to EN 61800-5-2 / EN 62061 / IEC 61508 Cat. 4 and PL e according to EN ISO 13849-1
Power supply (user I/O)	24V DC ±10%, 0.8…1.1 x rated voltage (1) PELV or SELV
Power consumption	36 W
SLS outputs 68, 78	24V DC, 20 mA, short-circuit protected
SS outputs 34, 44	24V DC, 20 mA, short-circuit protected
Door control outputs 51, 52	24V DC, short-circuit protected 0.75 A, bipolar (Power to Release/Power to Lock) configuration 20 mA, cascading (2Ch Source) configuration
Pulse outputs S11, S21	24V DC, 50 mA, short-circuit protected

Table 45 - General Specifications (Continued)

Attribute	Value
Pulse inputs S12, S22, S32, S42, S52, S62, S72, S82, X32, X42	5 mA per input, max
Input ON Voltage, min	15V
Input OFF Voltage, max	5V
Input OFF Current, max	2 mA
Input-to-output response time (SS_In, SLS_In, DM_In, ESM_In, LM_In)	20 ms
Overspeed Response Time	User-configurable
Reset Input S34	5 mA per input, max
Conductor Type	Multi-conductor shielded cable
Conductor size (2)	0.25…2.5 mm^2 (24…14 AWG)
Strip length	6 mm (0.25 in.)
Terminal screw torque	0.20…0.25 N•m (1.8…2.2 lb•in)

(1) Safety outputs need additional fuse for reverse voltage protection of the control circuit. Install a 6 A slow-blow or 10 A fast-acting fuse.
(2) Refer to Industrial Automation Wiring and Grounding Guidelines, publication 1770-4.1.

Environmental Specifications

The installation must comply with all environmental, pollution degree, and drive enclosure rating specifications required for the operating environment.

Category	Specification
Ambient temperature	For detailed information on environmental, pollution degree, and drive enclosure rating specifications, see the technical data publication for your drive. • PowerFlex 750-Series AC Drives Technical Data, publication 750-TD001 • PowerFlex 750-Series Products with TotalFORCE Control Technical Data, publication 750-TD100 • PowerFlex 755TM IP00 Open Type Kits Technical Data, publication 750-TD101
Storage temperature	
Shock Operating Packaged for shipment	
Vibration Operating Packaged for shipment Sinusoidal loose load Random secured	
Surrounding environment	

ATTENTION: Failure to maintain the specified ambient temperature can result in a failure of the safety function.

IMPORTANT Products with a safety function installed must be protected against conductive contamination by one of the following methods:

- Select a product with an enclosure type of at least IP54, NEMA/UL Type 12
- Provide an environmentally controlled location for the product that does not contain conductive contamination

Table 46 - Environmental Pollution Degree Description (EN 61800-5-1)

Surrounding Environment Pollution Degree	Conductive Contamination Allowed by Pollution Degree	Acceptable Enclosures
Pollution degree 1 and 2	No possibility of conductive dust.	All enclosures are acceptable.
Pollution degree 3 and 4	The possibility of conductive dust is allowed.	Enclosure that meets or exceeds IPS4, NEMA/UL Type 12 is required.

Certifications

See the Product Certification link at rok.auto/certifications for Declarations of Conformity, Certificates, and other certifications details.

Certification (1)	Value
cULus (2)	UL Listed, certified for US and Canada.
CE	European Union 2014/30/EU EMC Directive, compliant with: EN 61800-3; PowerFlex 750-Series AC Drive, Emissions and Immunity European Union 2006/42/EC Machinery Directive: EN ISO 13849-1; Safety Function EN 60204-1; Safety Function EN 62061; Safety Function EN 61800-5-2; Safety Function
RCM	Australian Radiocommunications Act, compliant with: EN 61800-3; categories C2 and C3
Functional Safety	Certified by TÜV Rheinland for Functional Safety: Up to SIL 3, according to EN 61800-5-2, and IEC 61508, and SIL CL3 according to EN IEC 62061; up to Performance Level PLe and Category 4, according to EN ISO 13849-1; when used as described in this PowerFlex 750-Series Safety Reference Manual, publication 750-RM001.
UKCA	UK 2016 No. 1091 EMC Regulations, compliant with: EN 61800-3; PowerFlex 750-Series AC Drive, Emissions and Immunity UK 2008 No. 1597 Supply of Machinery (Safety) Regulations: EN ISO 13849-1 Safety Function EN 60204-1; Safety Function EN 62061; Safety Function EN 61800-5-2; Safety Function

(1) When product is marked, refer to Product Certifications website, rok.auto/certifications for Declarations of Conformity Certificates.
(2) Underwriters Laboratories Inc. has not evaluated the Safe Off, Safe Torque Off, or Safe Speed Monitor options for functional safety.

CE Conformity

CE Declarations of Conformity are available online at: rok.auto/certifications.

The 20-750-S1 Safe Speed Monitor option module is in conformity with the essential requirements of the 2006/42/EC Machinery Directive and the 2004/108/EC and 2014/30/EU EMC Directive when installed and maintained in accordance with the instructions contained in this document. The following standards have been applied to demonstrate conformity:

Machinery Directive (2006/42/EC)

- EN ISO 13849-1 Safety of machinery - Safety related parts of control systems - Part 1: General principles for design
- EN 60204-1 Safety of machinery - Electrical equipment of machines - Part 1: General requirements
- EN 62061 Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems
- EN 61800-5-2 Adjustable speed electrical power drive systems - Part 5-2: Safety requirement - Functional

EMC Directive (2004/108/EC and 2014/30/EU)

- EN 61800-3 Adjustable speed electric power drive systems - Part 3: EMC requirements and specific test methods

UKCA Conformity

UK Declarations of Conformity are available online at:
Product Certifications website, rok.auto/certifications.

The 20-750-S1 Safe Speed Monitor option module is in conformity with the essential requirements of the UK 2008 No. 1597 Supply of Machinery (Safety) Regulations, and UK 2016 No. 1091 EMC Regulations when installed and maintained in accordance with the instructions contained in this document. The following standards have been applied to demonstrate conformity:

Supply of Machinery (Safety) Regulations (2008 No. 1597)

- EN ISO 13849-1 Safety of machinery - Safety related parts of control systems - Part 1: General principles for design

- EN 60204-1 Safety of machinery - Electrical equipment of machines - Part 1: General requirements
- EN 62061 Safety of machinery - Functional ssafety of safety-related electrical, electronic and programmable electronic control systems
- EN 61800-5-2 Adjustable speed electrical power drive systems - Part 5-2: Safety requirement - Funcational

EMC Regulations (2016 No. 1091)

- EN 61800-3 Adjustable speed electric power drive systems - Part 3: EMC requirements and specific test methods

History of Changes

This appendix contains the new or updated information for each revision of this publication. These lists include substantive updates only and are not intended to reflect all changes. Translated versions are not always available for each revision.

750-RM001B-EN-P, April 2010

Change
Clarified SLS Reset behavior in Safe Limited Speed with Enabling Switch Monitoring Mode
Changed the order of the last two steps in the procedure to remove a safe speed condition and resume normal run operation.
Added parameter numbers where they were missing in the text
Added additional information to fault code 3, MP Out Flt.
Corrected ratings for SS and SLS outputs

750-RM001C-EN-P, December 2010

Change
Changed references from the PowerFlex 750-Series AC Drives User Manual to the new PowerFlex 750-Series AC Drives Programming Manual, publication 750-PM001.
Added Frame 8 drive details.
Parameter numbers added to diagrams for greater clarity
Terminology section expanded.
Updated the PFD and PFH Data section with additional attributes and values,
Updated the Safety Reaction Time section with Frame 8 data.
Updated the Set Safety Enable Circuitry section with PowerFlex 753 and PowerFlex 755 details.

750-RM001D-EN-P, September 2011

Change
Updated the PFD and PFH Data section with Frame 9 values.
Updated the Safety Reaction Time section with Frame 9 data.
EMC Core Kit required when installed in Frame 8 and larger drives.
Indicated shielded conductors required

750-RM001E-EN-P, January 2012

Change
Automatic Device Configuration section added

750-RM001F-EN-P, February 2012

Change
Drive Frames 1 and 10 added
PFD and PFH for 20-year Proof Test Interval table updated
Environmental Specifications added.
Compliance clarified under CE in Certifications section.

750-RM001G-EN-P, February 2016

Change
Improved the example wiring diagrams for slave mode, multi-axis cascaded systems.
Revised Environmental Specifications to now include 477 A rating and information about using an IP54 rated enclosure

750-RM001H-EN-P, February 2017

Change
With this revision, references to DriveExecutive™ and DriveExplorer™ software were replaced with Studio 5000 Logix Designer® application and Connected Components Workbench™ software.
Added Safe Speed Monitor option module compatibility with PowerFlex 755T drive products.
Added safety specifications (including PFD and PFH values) for PowerFlex 755T drive products.
Added safety reaction time specifications for PowerFlex 755T drive products.
Updated Parameter Configuration Options table with new software applications
Updated jumper setting figures and added figure for PowerFlex 755T drive products
Added table to clarify drive and feedback module compatibility.
Added feedback jumper settings and DIP switch settings
Added IMPORTANT statement with reference to Safe Operating Stop
Updated examples in Chapter 11
Updated Environmental Specifications table

750-RM001I-EN-P, August 2019

Change
Updated PFD and PFH definitions in the Abbreviations and Definitions table.
Updated PFD and PFH Definitions section.
Added rows for MTTFDyears and DCavg% data to PFD and PFH for PowerFlex 753 and PowerFlex 755 Drives table and PFD and PFH for PowerFlex 755T Drive Products table. Also added columns for Frames 13, 14, and 15.
Replaced the Encoder and Encoder Considerations sections with Requirements for Single and Dual Encoder Systems section. The new section describes Single Encoder, Dual Encoder, and Single Encoder with PM Synchronous Motor requirements.
Changed Set P125 in the Understanding Commutation from "any available feedback device" to "the feedback device must be the primary encoder."
Revised the introductory material in the Installation and Wiring chapter to add ATTENTION and IMPORTANT advisories about the operation of this device.
Added Remove Power to the System section.
Updated Access the Control Pod section.
Updated the Set the Safety Enable Jumper section to describe the Safety Jumper IN fault and how to avoid HW Enbl Jmpr Out fault.
Added that only one safety option module may be installed at a time to the Install the Safe Speed Monitor Option Module section.
Removed obsolete 845T and 845H encoders and replaced with 847T and 847H encoders in the Compatible Encoders section.
Updated Additional Resources in Compatible Encoders table.
Updated Standards and Safety Ratings in the General Specifications table to show card certifications when used with the PowerFlex 755, and when used with the PowerFlex 755T.
Updated Certifications table to show latest directive number.

750-RM001J-EN-P, February 2021

Change
Added IMPORTANT statement to Power Supply Requirements indicating safety option must have dedicated power supply.
Added Environmental Pollution Degree Description (EN 61800-5-1) table to Appendix A.

750-RM001K-EN-P, March 2022

Change
Updated name of PFD to PFDavg.
Added PowerFlex 755TS drives to Conventions section.
Added PowerFlex 755TS Products with TotalFORCE Control Installation Instructions, publication 750-IN119 to Additional Resources table.
Added PFDavg and PFH for PowerFlex 755TS Drive Products table to Safety Data section.
Added PowerFlex 755TS drives to Safety Reaction Time table.
Added PowerFlex 755TS drive information to Parameter Configuration Options table.
Added PowerFlex 755TS Drive Jumper Location illustration to Set the Safety Enable Jumper section.

750-RM001L-EN-P, October 2022

Change
Added UKCA certification information to the Certification table in Appendix A.
Added UKCA Conformity information to Appendix A.

750-RM001M-EN-P, June 2023

Change
Updated safety jumper information for the PowerFlex 755TS drive.

Notes:

Numerics

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Notes:

Rockwell Automation Support

Use these resources to access support information.

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

Documentation Feedback

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

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.

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