Installation and Operating Manual

MiS210 Safety Module

Unidrive M

Original Instructions

For the purposes of compliance with the EU Machinery Directive 2006/42/EC, the English version of this manual is the Original Instructions. Manuals in other languages are Translations of the Original Instructions.

Documentation

Manuals are available to download from the following locations:
http://www.drive-setup.com/ctdownloads

The information contained in this manual is believed to be correct at the time of printing and does not form part of any contract. The manufacturer reserves the right to change the specification of the product and its performance, and the contents of the manual, without notice.

Warranty and Liability

In no event and under no circumstances shall the manufacturer be liable for damages and failures due to misuse, abuse, improper installation, or abnormal conditions of temperature, dust, or corrosion, or failures due to operation outside the published ratings. The manufacturer is not liable for consequential and incidental damages. Contact the supplier of the drive for full details of the warranty terms.

Environmental Policy

Control Techniques Ltd operates an Environmental Management System (EMS) that conforms to the International Standard ISO 14001.

Further information on our Environmental Policy can be found at:
http://www.drive-setup.com/environment

Restriction of Hazardous Substances (RoHS)

The products covered by this manual comply with European and International regulations on the Restriction of Hazardous Substances including EU directive 2011/65/EU and the Chinese Administrative Measures for Restriction of Hazardous Substances in Electrical and Electronic Products.

Disposal and Recycling (WEEE)

When electronic products reach the end of their useful life, they must not be disposed of along with domestic waste but should be recycled by a specialist recycler of electronic equipment. Control Techniques products are designed to be easily dismantled into their major component parts for efficient recycling. The majority of materials used in the product are suitable for recycling.

Product packaging is of good quality and can be re-used. Large products are packed in wooden crates. Smaller products are packaged in strong cardboard cartons which have a high recycled fibre content. Cartons can be re-used and recycled. Polythene, used in protective film and bags for wrapping the product, can be recycled. When preparing to recycle or dispose of any product or packaging, please observe local legislation and best practice.

REACH legislation

EC Regulation 1907/2006 on the Registration, Evaluation, Authorisation and restriction of Chemicals (REACH) requires the supplier of an article to inform the recipient if it contains more than a specified proportion of any substance which is considered by the European Chemicals Agency (ECHA) to be a Substance of Very High Concern (SVHC) and is therefore listed by them as a candidate for compulsory authorisation.

Further information on our compliance with REACH can be found at:
http://www.drive-setup.com/reach

Underwriters Laboratories (UL) Information

The MiS210 Safety Option Module is a cUL Listed accessory to Canadian and US requirements. The UL file reference is: NMMS / 7. E171230.

Registered Office

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SY16 3BE
UK
Registered in England and Wales. Company Reg. No. 01236886.

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Contents

EU Declaration of Conformity (Machinery Directive)

1. Product Model
Integrated Motion Safety Functions and Machinery Safety Functions

MiS210 Option Module

MiS210 Option Module Parameterisation Tool (Safety DLL).

The integrated Motion Safety Functions within the Control Techniques Drives in combination with the Safety Option Module MiS210 comply with the requirements up to SIL 3 and PLe, Cat 3 in accordance with EN 61800-5-2, IEC 61508/ IEC 62061 and ISO 13849-1.

The MiS210 is a programmable device. The programming tool (Parameterisation Tool) is within the scope of the type examination certificate.

2. Name and Address of the Manufacturer
Nidec Control Techniques Ltd, The Gro, Newtown, Powys, SY16 3BE, UK

Registered in England and Wales. Company Reg. No. 01236886
Telephone: 00 44 1686 612300
E mail: marketing.controltechniques@mail.nidec.com
Web: www.controltechniques.com

3. This declaration is issued under the sole responsibility of the manufacturer.

4. Object of the Declaration
MiS210

5. The object of the declaration is in conformity with the relevant European Union harmonisation legislation.
Machinery Directive (2006/42/EC)
Electromagnetic Compatibility Directive (2014/30/EU).

EC type examination has been carried out by the following notified body:

TUV Rheinland	EC type-examination certificate number:
Am Grauen Stein	
51105 Koln	01/205/5720.00/19
Germany	Date of issue: 2019-06-17
	Valid until: 2024-06-17
Notified body identification number: 0035	

The object of the declaration is in conformity with the relevant European Union harmonisation legislation.

6. References to the relevant harmonised standards used

The variable speed drive products listed above have been designed and manufactured in accordance with the following European harmonised standards:

EN 61800-5-2:2017	Adjustable speed electrical power drive systems - safety requirements - functional
EN 61800-5-1:2007+A1:2017 (in extracts)	Adjustable speed electrical power drive systems - safety requirements - electrical, thermal and energy
EN 62061:2005 + AC:2010+A1:2013+A2:2015	Safety of machinery, Functional safety of safety related electrical, electronic and programmable electronic control systems
EN ISO 13849-1:2015	Safety of Machinery, Safety-related parts of control systems, General principles for design
EN 61508 Parts 1 - 7:2010	Functional safety of electrical/ electronic/programmable electronic safety-related systems Part 1: General requirements

7. Signed for and on behalf of:

Person authorised to complete the technical file: P. Knight

DoC authorised by: Conformity Engineer
Jon Holman-White
Director of Research and Development

Date: **15th July 2019**

Place: **Newtown, Powys, UK**

1 Safety information

1.1 Safety of Personnel

Definition of individual target groups:

Personnel involved in projects relating to safe drive systems

Engineers and Technical Staff

Assembly, electrical installation, maintenance and equipment replacement

Plant Electricians and Service Technicians

Start-up, operation and configuration

Engineers and Technical Staff

The MiS210 Safety Module is for use in Safety Related Control Systems, the design of such systems MUST only be done by personnel who are suitably trained and experienced.

1.2 Warnings, Cautions and Notes

> ⚠ **WARNING**
>
> A **Warning** contains information which is essential for avoiding a safety hazard.

> ⚠ **CAUTION**
>
> A **Caution** contains information which is necessary for avoiding a risk of damage to the equipment and motor.

NOTE

A **Note** contains information which helps to ensure correct operation of the product.

In Section 8 Motion Safety Function, there are sections written in red text, these indicate additional warning information to do with a specific functionality.

1.3 Definition of Terms

The term MiS210 Safety Module is used to describe all derivatives of the MiS210 Safety Module product line. If reference is made in this description to a defined derivative, the complete designation is always employed.

The term 'safe' as used in this manual refers in each instance to the assignment of a safe function for applications extending up to PL e, as defined in ISO 13849-1:2008 and/or SIL 3 in accordance with IEC 61508.

The systems software 'Connect' is used for configuration of the MiS210 Safety Module.

Table 1-1 Other Applicable Documents

Description	Reference
Configuration of the MiS210 Safety Module for standalone applications with the 'Connect' program.	Section 4 of this document and 'Connect' context help text.
Validation report for implemented PLC program and parameters.	Safety inspection with approval record.
Approval.	TÜV certificate for product modules MiS210 Safety Module.

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Read the relevant manuals carefully before installing and commissioning the MiS210 Safety Module. Compliance with all documentation is essential for fault free operation, and to safeguard cover in the event of a warranty claim.

Throughout this manual, technical standards are referred to by their international designations (e.g. IEC 61800-5-2 and ISO 13849-1). To comply with European Union law, the EN versions should be applied (e.g. EN 61800-5-2 and EN ISO 13849-1), which are identical to the corresponding international standards in their technical content.

1.4   Terms and Abbreviations

Table 1-2   Terms and Abbreviations

Abbreviation	Description
1oo2	1 Out Of 2
AC	Alternating Current
Black Channel	A black channel is a protocol that operates in the application layer of a network and so is independent of specific network characteristics, in safety applications mechanisms such as CRCs and dual packet transmission ensures the integrity of the data.
CCF	Common Cause Failures
CFUNID	ConFiguration Unique IDentification
CLK	Clock
DC	Direct Current
DC_{avg}	Diagnostic Cover level on demand
ECHA	European Chemical Agency
EEPROM	Electrically Erasable Programmable Read-Only Memory
ELV	Extra Low Voltage
EMC	Electromagnetic Compatibility
EMS	Environmental Management System
EN	European standard
EU	European Union
FIT	Failure in Time
HSW	Health and Safety at Work
IO	Input Output
IP20	Protection class for enclosures
ISO	International Organization for Standardization
MSF	Motion Safety Functions
MTBF	Mean Time Between Failures
$MTTF_d$	Mean Time To Failure in the dangerous direction
OCPUNID	Output Connection Point owning Unique IDentification
OSSD	Output Signal Switch Device
OUNID	Originator Unique IDentification
PC	Personal Computer
PDS(SR)	Power Drive System suitable for use in Safety-Related applications
PELV	Protected Extra Low Voltage
PFH	Probability of Failure per Hour
PES	Programmable Electronic System

Abbreviation	Description
PL	Performance Level
PLC	Programmable Logic Control
PSU	Power Supply Unit
REACH	Registration, Evaluation, Authorization and restriction of Chemicals
SBC	Safe Brake Control
RPI	Requested Packet Interval
SCID	Safety Configuration IDentification
SD	Safe Direction
SELV	Safety Extra Low Voltage
SES	Safe Emergency Stop
SGL	Safe Guard Locking
SGM	Safe Guard Monitoring
SIL	Safety Integrity Level
SLA	Safely Limited Acceleration
SLP	Safely Limited Position
SLS	Safely Limited Speed
SNN	Safety Network Number
SOS	Safe Operating Stop
SRP/CS	Safety Related Parts of a Control System
SS	Safe Stop (1 and 2)
SSI	Synchronous Serial Interface
STO	Safe Torque Off
TUNID	Target Unique IDentification
TÜV	German Technical Inspections Organization

1.5   Intended Use

The MiS210 Safety Module is a configurable safety controller used in the manufacture of safety trip circuits and other safety functions. This module is designed for the following uses:

- In EMERGENCY STOP equipment.
- As a safety components as defined in EC Machinery Directive 2006/42/EC.
- As a PES for risk reduction as defined in IEC 61508.
- In safety power circuits in accordance with IEC 60204-1.
- As a PES for functional safety as defined in IEC 62061.
- As an SRP/CS as defined in ISO 13849.
- As a device for producing the safety functions defined in IEC 61800-5-2.

C E The MiS210 Safety Module is a safety component as defined in Annex IV of the EC Machinery Directive 2006/42/EC. It was developed, designed and produced in strict accordance with the above directive, and with the EC EMC Directive 2004/108/EC.

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1.6   General Safety Instructions

WARNING

- To avoid personal injury and damage to equipment, all work on this device must be carried out by personnel who have been trained in the technical aspects of electrical engineering.
- Each appropriately skilled person must be familiar with the operating instructions.
- Each appropriately skilled person must, as a minimum requirement, have an in-depth knowledge of the National Health and Safety at Work (HSW, i.e. accident prevention) specifications and legislation.
- Use of these devices is restricted to their intended use, in accordance with the previous itemised list. Due compliance with the figures and data listed in Table 10-1 is mandatory.
- The contents of this installation manual provides the detailed information on all of the MiS210 functions and the installation procedure. Some details can be found in the 'Connect' context help, but this manual is the master for the device. Detailed knowledge and understanding of these aspects is vitally necessary prior to first time installation and/or modification of equipment functions or device parameters.
- Commissioning / Start-Up is only permitted on condition that the EMC directive is followed. On the basis of EMC test specifications IEC 55011:2007 + A2:2007 and IEC 61000-6-2:2005.
- For storage and transport, due compliance is required with the conditions defined in IEC 60068-2-6 in relation to the figures given in section 10.
- Compliance with the wiring and connection instructions in the 'Installation' chapter is mandatory.
- The applicable safety specifications must be observed in respect of this application.
- The configured monitoring functions and their parameters and links must be verified through the use of a validation report.
- Implementation of this module must be agreed and matched to the requirements of the relevant commissioning body.
- Never install or commission damaged products. Please report all instances of damage immediately to Nidec Control Techniques Ltd.
- Never open the housing and/or modify in any way.
- The inputs and outputs for standard functions, and/or the digital and analogue data transmitted by communication modules must never be used for safety-related applications.

1.7   Electrical Safety - General Warning

The voltages used in the drive can cause severe electrical shock and/or could be lethal. Extreme care is necessary at all times when working with or adjacent to the drive. Specific warnings are given at all relevant places in this manual.

1.8   System Design and Safety of Personnel

Only functions which are explicitly described as safety functions may be used to ensure the safety of personnel, i.e. no other functions of the drive or its option modules must be used for safety-related functions.

The only safety function provided in the Unidrive M is Safe Torque Off and this is utilized by the MiS210 Safety Module.

The Safe Torque Off function has been approved by TÜV Rheinland as meeting the requirements of the following standards, for the prevention of unexpected starting of the drive:

- IEC 61800-5-2:2007 SIL 3
- ISO 13849-1:2008 PL e

The Safe Torque Off function may be used in a safety-related application. The system designer is responsible for ensuring that the complete system is safe and designed correctly according to the relevant safety standards.

The design of safety-related systems requires specialist knowledge. To ensure that a complete control system is safe, it is necessary for the whole system to be designed according to recognized safety principles. The use of individual sub systems such as drives and option modules with safety functions, which are intended for safety-related applications, does not in itself ensure that the complete system is safe. It is the responsibility of the designer of the end product or application to ensure that it is safe and in compliance with the relevant regulations. Any application examples given in this guide are for illustration only and do not purport to represent complete solutions.

1.9 Environmental Limits

Instructions in this Safety Manual regarding transport, storage, installation and use of the MiS210 Safety Module must be complied with, including the specified environmental limits. MiS210 Safety Module must not be subjected to excessive physical force.

1.10 Compliance with Regulations

The installer is responsible for complying with all relevant regulations, such as national wiring regulations, accident prevention regulations and electromagnetic compatibility (EMC) regulations. Particular attention must be given to the areas of conductors, cable types in particular screening arrangements, the selection of fuses or other protection, and protective earth (ground) connections.

This manual contains instructions for achieving compliance with specific EMC standards.

Within the EU, all machinery in which this product is incorporated must comply with the following directives:

- 2006/42/EC: Machinery Directive.
- 2014/30/EU: Electromagnetic Compatibility.
- 2014/35/EU: Low Voltage Directive.
- 2011/65/EU: Restriction of Hazardous Substances Directive.

1.11 Design of Safe Machinery, Risk Assessment & Safety Standards

The safety features of a machine should be designed at the same time as its intended functions. An initial risk assessment should be carried out, which should be in accordance with the ISO 14121 (ISO 14121) standards (previously 1050). The risk assessment identifies whether safety-related control functions are needed in addition to the inherent safety features of the machine.

The standards currently available for the safety of machinery control systems are ISO 13849-1 and IEC 62061. ISO 13849-1 measures the degree of safety integrity by a "Performance level" with values from a (lowest) to e, while IEC 62061 uses the principles of IEC 61508 to give a SIL (Safety Integrity Level) from 1 (lowest) to 3. Both of these standards allow for the use of complex hardware and software in safety-related control systems.

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1.12   Functional Safety of Electrical Power Drive Systems

Standard IEC 61800-5-2 defines specific MSFs. Some types of MSFs can be carried out by the MiS210 Safety Module in conjunction with the drive. The activation of these functions is carried out through safety features on the machine such as door switches and light curtains, which can be connected directly to the MiS210 Safety Module. If more IO is required the connecting logic can be carried out in a separate safety controller (PLC), which can then be connected to the safe interface of the MiS210 Safety Module (either a physical input or a network input).

1.12.1   Mechanical Brake Control

The drive brake control functions are provided to allow well-coordinated operation of an external brake with the drive. While both drive hardware and software are designed to high standards of quality and robustness, they are not intended for use as safety functions, i.e. where a fault or failure would result in a risk of injury. In any application where the incorrect operation of the brake release mechanism could result in injury, independent protection devices of proven integrity must also be incorporated.

1.13   Responsibilities

It is the responsibility of the machine/equipment designer to ensure the safety of the machine/equipment, including the correct configuration and integration of the MiS210 Safety Module which is required to achieve the necessary safe operation. It is also the responsibility of the machine/equipment designer to ensure that the MiS210 Safety Module meets the requirements of the application, i.e. that the function specified is the correct one for the application and that the integrity data is adequate. Control Techniques are not responsible for:

- The correct configuration of the MiS210 Safety Module into a complete safety-related control system.
- The correct application of the MiS210 Safety Module or a safety-related control system in a machine.

1.14   Avoiding Malfunction during Loss of Zero Volts

To avoid unintended voltage errors at a safe output, the output circuit must always be returned to a 0 V terminal on the MiS210 Safety Module or the drive it is mounted upon.

1.15   Operation and Service

Before installing or removing a module, or disconnecting signal lines, first isolate the module electrically, i.e. the drive should be powered down.

While installing or removing a module, take appropriate precautions to prevent electrostatic discharge on the externally routed terminals and plug connections.

1.16   Transportation / Storage

Instructions regarding transportation, storage and proper handling must be followed. Climate specifications must be observed in accordance with section 10.

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2 MiS210 Safety Module Introduction

2.1 Overview

The MiS210 Safety Module provides motion safety functionality for Control Techniques Unidrive M drives in accordance with the requirements of IEC 61800-5-2. PLCopen Safety part 1 has been used as a guide for the Motion Safety Functions (MSFs) interfaces to give a familiar interface to the User.

The function of the MiS210 Safety Module is to monitor the signals provided at its inputs and to activate its outputs in accordance with the MSF algorithms. Inputs may be directly connected to the MiS210 Safety Module or provided via a safe network. Similarly, outputs may be directly connected or networked.

The MSF algorithms may be selected and configured by the user in accordance with the requirements of their application and up to Pl=e in accordance with ISO 13849-1 and/or SIL 3 in accordance with IEC 61508 and IEC 62061. The Connect PC application is provided to the user for this purpose and allows the configuration to be created and then transferred using a safe mechanism into the MiS210 Safety Module.

The MiS210 Safety Module can be connected to Unidrive-M600, M700, M701 and M702.

Table 2-1   Device Connections

Connections	MiS210
Safe Input Pairs	4
Safe Outputs	2
Pulse Outputs	2
Local Encoders	2
Encoder Power Supply Monitoring	1
Local Encoder Power Supply	1
Drive Encoders	2
Integrated STO	1

NOTE

The MiS210 Safety Module can only be installed in option module slot 3 as this provides the direct connection to the drive STO via the Blade Connector.

Figure 2-1   MiS210 Safety Module Connectors

Blade connector

Module interface connector

Safe Input and Output Connector

Local Encoder Connector
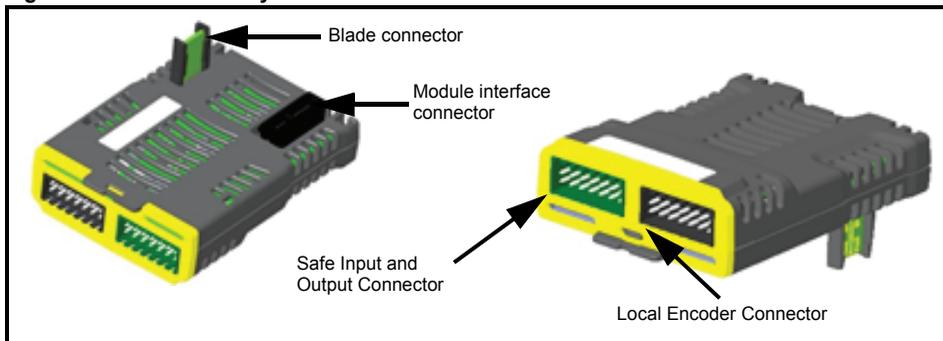
2.2 Configuration

Connect is Control Techniques' graphical PC application for commissioning and monitoring Control Techniques' drives and option modules. The MiS210 Safety Module uses this same application to provide consistency for users who are used to Connect. Connect allows a User to develop a motion safety configuration and transmit, using a black channel, it to the MiS210 Safety Module and then read it back for validation. A Validation Report, which is referred to as a "Sign-Off" report in Connect, is then produced that documents the configuration, see section 7 *Validation* on page 97.

The configuration is saved and protected against power supply failure within the MiS210 Safety Module, it can also be saved on the PC using Connect.

Refer to section 4 *Connect Configuration Tool Introduction* on page 34, for details of how to configure the MiS210 Safety Module.

Once a MiS210 Safety Module has been configured to work on a specific drive, if it is then moved to a different drive, the system must be re validated. The replacement of safety devices requires that the replacement device be configured properly and operation of the replacement device shall be user verified.

2.2.1 Addressing Scheme

The configuration of each MiS210 Safety Module within a system is performed via one of the various communications interfaces available, see section 2.2.3 *Downloading the Configuration* on page 16. The specific interface is hosted by the drive and has a network address to allow the drive to be uniquely identified. The configuration is transferred to and from the MiS210 via a black channel ensuring that the configuration owner and the channel end points are tied together.

On the first connection to the MiS210 Safety Module a robust identification process is enforced which ensures that MiS210 Safety Module and the configuration owner are uniquely identified, independently of network addresses.

2.2.2 Session Management

The MiS210 Safety Module will only allow a single user, identified by a User ID and Password, to open a single session on the MiS210 Safety Module. Should the user then attempt a second login from a different platform using the same login credentials it will be ignored.

If a session is left open but no activity takes place for 30 minutes the session will time out and again a fresh login is required.

There is a facility provided for the User ID and password to be changed, this can be done a maximum of 7 times after the MiS210 Safety Module has been identified with a User ID and password. After this the unit will need to be factory reset. (See section 9.5.4 *Factory Reset* on page 204).

2.2.3 Downloading the Configuration

The MiS210 Safety Module does not contain a communications interface thus configuration is done either via the drive's factory fitted RS-485 connection (at 19200 or 38400 Baud) or via the drive's factory fitted Ethernet port. Networked operation will also be achieved through the drive's factory fitted Ethernet port.

Where network safety critical communications are required, MiS210 Safety Module will only use the recognized safety protocol CIP Safety via the drive's factory fitted Ethernet port.

2.2.4 Testing the Configuration

Once a configuration is downloaded to the MiS210 it is the user's responsibility to test the configuration before producing the Validation Report for printing and signing. (See section 7 *Validation* on page 97) User testing is the means by which all downloads are validated, and signatures should only be considered verified after user testing has taken place.

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2.3   Identification

The MiS210 Safety Module can be identified by the yellow colored front panel bezel. It also contains a label detailing the Name and Serial Number of the module.

Figure 2-2   Example MiS210 Product Label
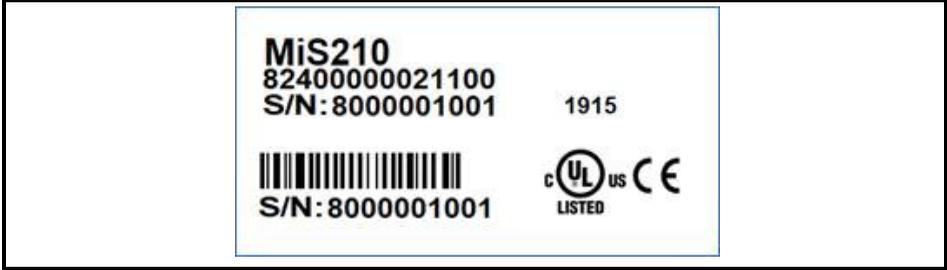
Figure 2-3   Example MiS210 Carton Label
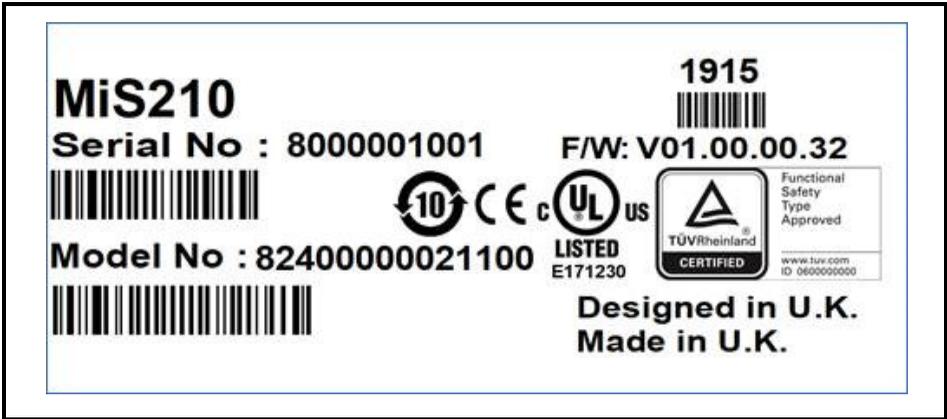
2.4   Items Supplied

The Items Supplied, when a MiS210 Safety Module is purchased are:

• MiS210 Safety Module.

• Front Panel Green IO Connector (CT Part Number 3432-0064).

• Front Panel Black Encoder Connector (CT Part Number 3432-0063).

• MiS210 Instruction Sheet (0478-0515).

Connect is downloadable from the Nidec Control Techniques Ltd. website and the following version is needed.

• Connect (Safety Version) – Version Number 2.13.

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3   Technical Safety Features

The overall architecture is configured as follows: [Sensor] [PES] [Actuator]

Figure 3-1   Overall Architecture
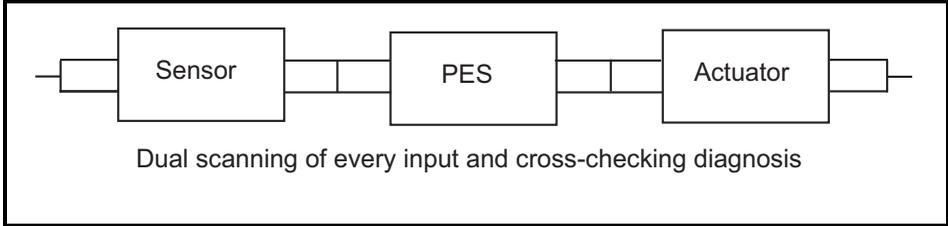
For the MiS210 Safety Module this is shown below in the top level architecture, showing the inputs and the outputs.

Figure 3-2   Top Level Architecture of the MiS210 Safety Module
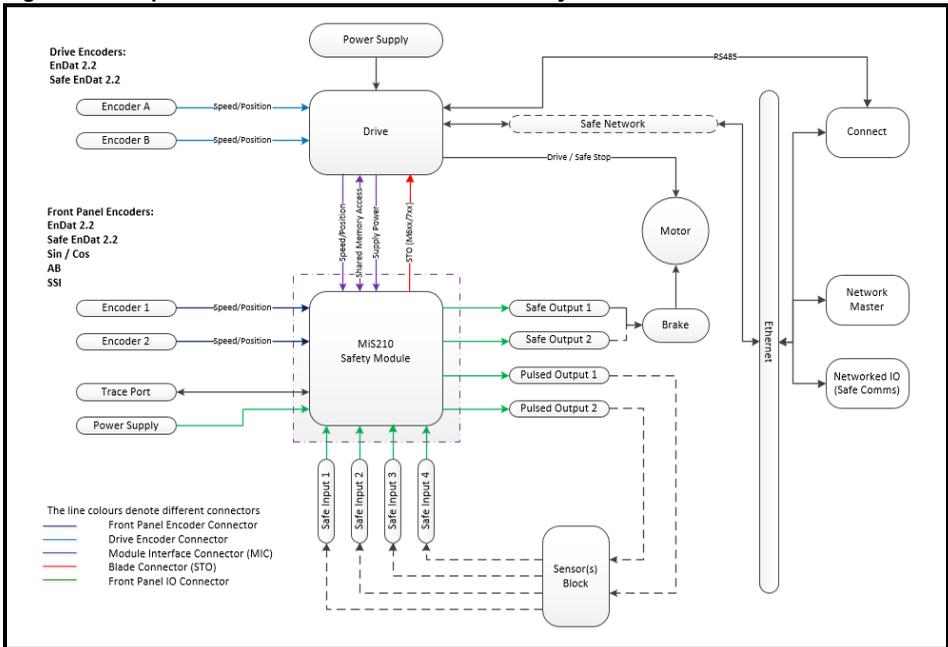
The specific Key Technical Safety Indicators can be found in section 10 *Technical Safety Features* on page 205.

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WARNING

- When using several sensors with different functions (e.g. position indicator, access door plus speed recording) for a safety system, these must be included as an inline circuit in any technical safety assessment of the complete system.
- Due compliance with safety specifications and EMC directives is mandatory
- With regard to the fault exclusions made, reference is made to the Tables listed under D in the Annex to ISO 13849-2.

The resultant maximum possible Performance Levels defined in ISO 13849 remain dependent on the following factors for external components:

- Structure (simple or redundant)
- Detection of faults with a common cause (CCF)
- Diagnosis coverage level on request (DCavg)
- Time until dangerous failure of a channel (MTTFd)

3.1 Digital IO

There are four Local Digital Input Pairs (1oo2 arrangement) providing a method of failure detection of a single input by comparison of the input pair.

There are two Local Outputs that can be wired to external equipment as well as two Pulsed Outputs which are used in conjunction with the Local Inputs.

When fitted on M600, M700, M701 or M702 the Safe Torque Off is routed directly to the drive and removes the torque generated by the motor by disabling the drive power circuitry when a safe state is required. No external wiring is required for this.

3.1.1 Diagnostic Coverage for Inputs

The MiS210 Safety Module has four paired inputs, each input comprises of two input lines, input A and B (paired). The four paired lines are continuously read by the MiS210 Safety Module to determine the state of each input pair.

Table 3-1 Local Digital Input Diagnostics - Default

| MEASURE	DC_{avg}	COMMENT
The test temporarily isolates the input circuitry from the input lines, mimicking a low voltage input – logical zero. The resulting values read by the processor confirm that each input switches to a logic zero. The diagnostic coverage does not incorporate the initial conditioning / protection components.	**99.83 %**	The failure of an internal component will result in either disconnection of the input from the external equipment, short circuit to ground within the MiS210 Safety Module or continuous high or a continuous low, or no effect on operation. In the case of a disconnection or the short circuit to ground or the continuous low the MiS210 Safety Module input will become a logic zero. For all input configurations a continuous low on one input of the pair will always result in the safe state but it will not cause a trip until the other input of the pair becomes high If the input is continuously high the continuous tests will detect the fault and put the MiS210 Safety Module into a safe state.
The paired Inputs are validated against each other. The two channels of the input pair are treated differently, input A is conditioned and passed to the microcontroller, input B is conditioned and inverted and then passed to the microcontroller.		The two signals are compared by the MiS210 Safety Module software and only valid combinations of input A and B are accepted. The inputs are read every 1ms and checked for a valid combination, if there is an invalid combination the outputs will be put in the safe state

The above diagnostics cannot detect short circuits to +24 V or between the inputs thus greater input signal integrity can be achieved by configuring the MiS210 Safety Module to produce pulsed outputs and feed them through to the input pairs. The pulsed outputs are in anti-phase and toggle their value every 1 ms. The MiS210 Safety Module monitors the inputs for pulses, absence of pulses due to the equipment safety device being triggered and when detected the required action taken.

Table 3-2   Local Digital Pulse Input Diagnostics

MEASURE	DC_{avg}	COMMENT
The paired Inputs are validated against the pulsed output phase and each other for the correct state every 1 ms.	**99.99 %**	When used, the two pulsed outputs are in antiphase and the processor checks for the correct phasing at the input pairs. The pulsed inputs toggle each 1 ms. When the pulses are disconnected the microcontroller expects input A to be a zero and input B to be a one at the pin of the microcontroller. Deviations from these patterns are considered as a failure in the input and the MiS210 Safety Module will revert to a safe state.

> ⚠ **WARNING**
>
> - For a technical safety assessment of the input subsystem, manufacturer's data (MTTFd, FIT figures etc.) need to be incorporated.
> - The DC_{avg} figures quoted in Table 3-1 and Table 3-2 need to be applied in a conservative manner, and the information in the comments section need to be accounted for in the safety system.
> - Fault exclusions are permitted in accordance with the applicable standards.
> - If several sensor systems are required to assure proper function of an individual safety function, always merge their partial values correctly in accordance with the selected procedure.
> - Any PSU powering equipment that is connected to the MiS210 Safety Module must be PELV or SELV and referenced to the drive 0V, to guarantee the voltage does not exceed 60 V under working or fault condition. Failure to observe this could cause a loss of the safety function by damage to the digital output circuit.
> - Any external equipment connected to the MiS210 Safety Module inputs must comply with IEC 61131-2.

3.1.2   Diagnostic Coverage for Outputs

The MiS210 Safety Module has three Safe switched Outputs (two Safe Outputs and one Integrated STO), for use in safety related functions. Each output can be controlled individually or grouped.

The operation of each output is continuously tested during operation.

Table 3-3   Local Digital Output Diagnostics

MEASURE	DC_{avg}	COMMENT
The output is monitored checking its state and operability (it is periodically switched low for a period of 500	**99.99 %**	If the output is stuck in operational mode due to a failure within the MiS210 Safety Module the power will be removed resulting in a safe state. Note – Output protection devices are not covered by the diagnostics

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- For applications involving a frequent request for safety disengagement, tests should be carried out at regular intervals. E.g. at the start of every shift or once a week as deemed necessary. In any event a test must be carried out at least once every year.
- Any PSU powering equipment that is connected to the MiS210 Safety Module must be PELV or SELV and referenced to the drive 0V, to guarantee the voltage does not exceed 60 V under working or fault condition. Failure to observe this could cause a loss of the safety function by damage to the digital output circuit.
- Any external equipment connected to the MiS210 Safety Module outputs must comply with IEC 61131-2.
- A range of diagnostic measures have been implemented for the output system. Customers should be aware of the need to incorporate circuit reinforcement elements such as relays, contactors etc. in the disengagement circuit.
- For a technical safety assessment of the output subsystem (when using external elements in the disengagement circuit, e.g. to reinforce the circuit), the manufacturer's specifications (MTTFD, FIT figures etc.) must be used.
- The DC_{avg} figures quoted in the table need to be applied in a conservative manner, and compliance with parameters (see table under 'Comments') needs to be assured.
- Fault exclusions are permitted in accordance with the applicable standards. Compliance with the parameters listed here must be assured at all times.

3.2   Encoders

On the MiS210 Safety Module there are four possible encoder connections, two via the drive (Channel A and Channel B) and two on the MiS210 Safety Module's Front Panel, known as local (Channel 1 and Channel 2). Only certain combinations of encoder are possible and these are detailed in the following tables.

Relative encoders typically provide either a pulse train, or a pulse count. Each pulse represents a measure of distance (angular or linear). The number of pulses between two readings allows the distance moved to be derived and the speed at which the equipment is moving. Additionally acceleration can be derived from multiple readings of the encoder.

Absolute encoders typically provide a value which represents the current position of the equipment the encoder is attached to. Hence by comparing two samples of the positional information, the speed can be derived. Additionally acceleration can be derived from multiple encoder reading.

There is a risk of mechanical shaft failure that cannot be detected, thus a positive shaft connection is essential. In order to gain a better diagnostic coverage the encoder power supplies can be monitored, see section 3.2.1 *Diagnostic Coverage for Encoders* on page 22.

Table 3-4   Local Encoders Only

Primary Encoder		Secondary Encoder		MSFs Not Permitted	Achievable SIL
Type	Location	Type	Location		
Safe Endat 2.2	Channel 1				3
Endat 2.2	Channel 1				2
AB	Channel 1			SLP	1
Sin Cos	Channel 1			SLP	1
SSI	Channel 1				1
Endat 2.2	Channel 1	AB	Channel 2		3
Endat 2.2	Channel 1	SSI	Channel 2		3
Endat 2.2	Channel 1	Sin Cos	Channel 2		3
AB	Channel 1	SSI	Channel 2	SLP	3
SSI	Channel 1	AB	Channel 2		2
Sin Cos	Channel 1	AB	Channel 2	SLP	3
AB	Channel 1	Sin Cos	Channel 2	SLP	2
Sin Cos	Channel 1	SSI	Channel 2	SLP	3
SSI	Channel 1	Sin Cos	Channel 2		2
Sin Cos	Channel 1	Sin Cos	Channel 2	SLP	2
AB	Channel 1	AB	Channel 2	SLP	2
SSI	Channel 1	SSI	Channel 2		2

Table 3-5   Drive Encoders Only

Primary Encoder		Secondary Encoder		MSFs Not Permitted	Achievable SIL
Type	Location	Type	Location		
Endat 2.2	Channel A	–	–		2
Endat 2.2	Channel A	Endat 2.2	Channel B		3

Table 3-6   Encoder Combination (Drive and Local)

Primary Encoder		Secondary Encoder		MSFs Not Permitted	Achievable SIL
Type	Location	Type	Location		
Endat 2.2	Channel A	Endat 2.2	Channel 2		3
Endat 2.2	Channel A	SSI	Channel 2		3
Endat 2.2	Channel A	Sin Cos	Channel 2		3
Endat 2.2	Channel A	AB	Channel 2		3

Channel A is known as P1 on the Drive, and Channel B is known as P2

3.2.1   Diagnostic Coverage for Encoders

The MiS210 Safety Module supports the use of two encoders which may be connected to the MiS210 Safety Module via either the front panel or via the Host Drive, or a combination of the two. In the case where a single Safe Endat 2.2 encoder is to be used only one can be used due to the encoder providing readings from two encoders over the same communications path.

The following table provides a description of the encoder type and a summary of the diagnostic coverage provided by the MiS210 Safety Module. The majority of the diagnostic coverage is provided by the software reading the hardware data and determining the validity of the hardware signals provided.

The operation of each encoder input is continuously tested during operation.

Table 3-7   Encoder Diagnostics

MEASURE	DC_{avg}	COMMENT
SIN COS (Analogue): Two differential analogue signals, each pair being a sinusoid with a 90 degrees phase shift between the signal pairs. The sinusoids provide the encoded position reported by the encoder and the direction of travel. The frequency of the sinusoids is dictated by the rate of movement. The MiS210 Safety Module does not use the magnitude of the signals for calculating the fine position, it counts the number of cycles per 1ms period to extract a value of speed.		
The phase relationship between the two differential signals means that the expression $1 = Sin^2 + Cos^2$ can be used to confirm that the two signals have the correct relationship and are therefore operational. The MiS210 Safety Module performs the trigonometric invariance diagnostic test thus validating the encoder signals.		Loss of both signals will cause a detected failure.
The speed evaluation uses both inputs to determine the speed and direction of the equipment to which the encoder is attached.		Loss of one signal, will result in the reported speed being zero, one or minus one (average of zero), and cause the diagnostic test to fail.
AB: Produces two Phase shifted pulse trains, each pulse indicates a measure of distance, and the direction can be determined from phase relationship between the two pulse trains.		
The differential amplitude of the AB encoder signals is measured.		Loss of both signals will cause a failure.
The speed evaluation uses both inputs to determine the speed and direction of the equipment to which the encoder is attached. Loss of both or one signal will result in the speed measurement producing an average speed of zero.		Loss of one signal, will result in the reported speed being zero, one or minus one (average of zero), and cause the diagnostic test to fail.
SSI: Provide position data, the data length varies and are typically encoded using Gray Code. The MiS210 Safety Module produces a clock which the encoder uses to latch the position and clock out data bits onto the data line. This is a simple serial interface which is driven by the MiS210 Safety Module microcontroller. The protocol used limits the diagnostic coverage that can be achieved.		
The differential amplitude of the encoder clock and data signals are measured.		A loss of signal will cause the MiS210 Safety Module to revert to a safe state.
No data returned		A loss of signal will cause the MiS210 Safety Module to revert to a safe state.
EnDat 2.2: Provide position data, the data length varies depending on the encoder model. The MiS210 Safety Module produces a clock and sends a command. The encoder responds to the command with the required data with a CRC for the data. The data from the EnDat 2.2 encoder depends on the command sent. In normal operation position data is returned from the encoder with encoder health status information and CRC.		
Encoder status data is examined to ensure the encoder is operational.		Encoder status indicating an error will cause the MiS210 Safety Module to revert to a safe state.
The CRC passed with the data is periodically verified, every 16 ms.		An invalid CRC will cause the MiS210 Safety Module to revert to a safe state.

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Safe EnDat 2.2: Provide position data from two internal encoders. The data length varies depending on the encoder model. The MiS210 Safety Module produces a clock and sends a command. The encoder responds to the command with the required data with a CRC for the data. The data from the Safety EnDat 2.2 encoder depends on the command sent. In normal operation position data is returned from the encoder with encoder health status information and CRC.

Encoder status data is examined to ensure the encoder is operational.		Encoder status indicating an error will cause the MiS210 Safety Module to revert to a safe state.
The CRC passed with the data is periodically verified, every 16 ms.		An invalid CRC will cause the MiS210 Safety Module to revert to a safe state.
The encoder provides position from two internal encoders. The primary encoder provides data on every request, whereas the secondary encoder provides data over four cycles. The data is aligned with the first primary encoder reading of the four cycles. The two encoder positions are scaled (if required) and compared.		Failure of the encoder comparison, will cause the MiS210 Safety Module to revert to a safe state.
The Heidenhain specific test looks at the movement of the encoder and compares the read position with a maximum / minimum expected position.		Failure of the Heidenhain test, will cause the MiS210 Safety Module to revert to a safe state.
Overall.	**99.83 %**	

The drive encoder interface accommodates a single encoder type, Endat2.2. The operation of the drive encoder interface is fundamentally different to the local interface. For encoders connected to the local connector the MiS210 Safety Module operates as the encoder interface master, providing the clocks and commands. In the case of the drive encoder interface the drive is the master and provides the encoder clock, and commands. The MiS210 Safety Module performs the same checks as with the local encoder.

Table 3-8   Encoder Specific Tests

Test Name	Description	SIN COS	AB	SSI	ENDAT 2.2	SAFE ENDAT 2.2
Trigonometric Analog Test	Check trigonometric invariance via encoder signal monitoring.	Yes				
Digital Counter Test	One error counter based on simultaneous changes for Sin and Cos signal at the same sample.	Yes	Yes			
Transfer Test	One packet flag is provided in order to guarantee the transfer of data between the encoder and the microcontroller.	Yes	Yes	Yes	Yes	Yes
Comparison Test*	Primary Encoder Value compared with Secondary Encoder Value.	Yes	Yes	Yes	Yes	
Differential Analog Test	Sample of the true amplitude of the Differential Signals to check if is within range.		Yes	Yes		
EnDat CRC	CRC checked protocol, 2 consecutive failures needed to report an error.				Yes	Yes
Heidenhain Test	Specific safety algorithm as specified by Heidenhain.					Yes

* Only if a second encoder is connected

The internal encoder PSU and a single external Encoder PSU can be monitored (Internal means from within the MiS210 Safety Module and external is outside of the MiS210 Safety Module). It is expected that one encoder is power directly from the internal encoder PSU in the MiS210 Safety Module via the local connection. Both the internal and external encoder power supplies can be set at 5 V, 8 V or 15 V and this is configured in Connect. Tests are performed for Over Voltage, Under Voltage as well as a self-test of the monitoring circuits.

Table 3-9 Encoder Power Supply Tests

	Lower Limit	Upper Limit
Internal / External Encoder PSU 5 V	4.38 V	6.07 V
Internal / External Encoder PSU 8 V	7.14 V	9.3 V
Internal / External Encoder PSU 15 V	13.19 V	17.01 V

WARNING

- For applications involving a frequent request for safety disengagement, tests should be carried out at regular intervals. E.g. at the start of every shift or once a week as deemed necessary. In any event a test must be carried out at least once every year.
- Any PSU powering equipment that is connected to the MiS210 Safety Module must be PELV or SELV and referenced to the drive 0 V, to guarantee the voltage does not exceed 60 V under working or fault condition. Failure to observe this could cause a loss of the safety function by damage to the digital output circuit.
- The encoder interface shall comply with the RS-485 electrical standards operating from a supply of 3.3 V.
- The DC$_{avg}$ figures quoted in the table need to be applied in a conservative manner, and compliance with parameters (see table under 'Comments') needs to be assured.
- Fault exclusions are permitted in accordance with the applicable standards. Compliance with the parameters listed here must be assured at all times.

3.2.2 Encoder Mathematics

The MiS210 Safety Module provides safety functions that may require position, speed and/or acceleration information from a variety of encoders. The encoder interface is provided by the microcontroller embedded within the MiS210 Safety Module. The Microcontroller is configured with information from the user when the MiS210 Safety Module is configured using Connect.

Encoder Configuration Parameters

Encoder Parameters : - Encoder Type and Data Format

Encoder Averaging Period : - Selected Average Period of Reported Speed.

Resulting Data Output: -

Position

Speed

Acceleration

BIT Data

The position data will be a positive number indicating the position reported by the encoder and will not be extended to count the number of times the encoder wraps round as the system position changes. Speed and acceleration correct for wrap round.

The speed data representation is in increments per second.

NOTE

- The encoders are sampled at 1 kHz, hence the values are scaled to units relative to a one second interval.

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3.2.2.1   AB or Sin Cos Encoder Interface Rules

AB encoders are relative encoders, with each pulse counted representing a unit of distance.
The microcontroller captures the edges of the pulses on each signal and increments or decrements
a counter dependent on the detected direction. ("A" leading "B" results in an incrementing count).
At power up the encoder counter is set to zero.

> ⚠ **WARNING**
>
> The maximum pulse rate that can be reliably captured is 180 kHz. If this is exceeded,
> then there is a risk of incorrect speed reporting.

Position
1.   The counter which represents the position will wrap at the boundaries

Speed
2.   The speed is the difference between the current encoder reading and the previous encoder
     reading and the sign indicates the direction of movement.
3.   The microcontroller takes account of the wrap condition of the fundamental counter

Acceleration
4.   The acceleration is determined by the difference between the current speed and the previous
     speed then multiplied by 1000000 A positive value indicating acceleration and a negative value
     indicating a deceleration.

3.2.2.2   Digital Position Encoder Interface Rules

There are three types of encoder to be considered the SSI, the EnDat2.2 and the Safe EnDat 2.2
which is a variant of the EnDat 2.2.

These encoders can be used to provide either relative position or absolute position. The MiS210
Safety Module has no knowledge of how the encoder data / system is configured in terms of absolute
or relative position. The system designer must ensure that the design accommodates the mode of
operation appropriately by the selection of the correct encoder and the design of the MSFs.

All of these encoders follow the same method for relative measurements

Each encoder provides a position value which is captured by the microcontroller once every 1 ms.
The MiS210 Safety Module needs to know if the data is gray coded and the data length. These are
set in Connect during the configuration of the Encoders.

Position
1.   The position data is represented in a 64 bit unsigned word.

> ⚠ **WARNING**
>
> The encoder position should not change by more than a third of the encoder range within
> a 1 ms period. This is essential if the MiS210 is to determine direction and speed
> correctly.

Speed
2.   The speed is the difference between the current encoder reading and the previous encoder
     reading and the sign indicates the direction of movement. The Microcontroller takes care of the
     SSI encoder wrap when calculating the speed from the reported position data provided the
     reported position has not progressed by more than a third of the range of movement since the
     last position reading.
3.   The value obtained for the speed is multiplied by 1000 to get the speed in edges per second.

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Acceleration

4. The acceleration is determined by the difference between the current speed and the previous speed then multiplied by 1000000. A positive value indicating acceleration and a negative value indicating a deceleration.

3.2.2.3 Use of Encoders in Absolute Measurement Systems

The MiS210 Safety Module includes motion safety functions that require absolute position information. To achieve this the encoder and system design should comply with the following statements:-

1. For absolute position measurement the range of the encoder must encompasses the full range of movement of the equipment.
2. The encoder position must not wrap within the range of movement of the system.
3. The position reported by the encoder at any point is unique for the entire range of movement.
4. The position reported by the encoder must be repeatable i.e. a given point in the range of motion is always reported as the same position by the encoder, and is true before and after a power cycle.

> ⚠ **WARNING**
>
> If the above is not respected the MiS210 Motion Safety Functions which require absolute position data will not operate correctly.

The MiS210 Safety Module does not distinguish between absolute or relative position. The MiS210 Safety Module will test its configuration to determine if position functions are required, and if so will reject configurations without an EnDat or SSI encoder on the primary channel.

NOTE

Variants of EnDat and SSI encoders provide absolute position, and it is up to the user to ensure an appropriate encoder is attached.

3.2.3 Transmission Delays

The clock signal and the command sent to the encoder are synchronised hence the clock signal can be used directly by the encoder. However the returned data can have a significant transmission delay relative to the transmitted clock. If the interconnecting to the encoder is 100 m away the delay observed between the transmission of the clock and data to the encoder and the receipt at the encoder is in the order of 0.6 μs, and the returned data is observed to have a total delay in the order of 1.2 μs. Hence the alignment of the data returned from the encoder with the clock sent from either the Drive, or the MiS210 can be misaligned by 1.2 μs.

- Excessive Transmission Delay has a detrimental effect on the MiS210 Safety Module's ability to recover the data from the encoder
- The Drive Interface to a EnDat 2.2 encoder requires a baud rate of 500 kHz. Slower rates will cause the drive to trip. At faster rates the MiS210 Safety Module is unable to recover the data.
- The conversion time for the encoder needs to be taken into account when selecting the encoder to be used.

3.2.3.1   Drive Encoder Interface (EnDat 2.2)

The Drive Encoder interface allows the MiS210 Safety Module to snoop the clock and data lines between the encoder and the drive to obtain encoder data. There is a single encoder that is supported using this mechanism, EnDat 2.2. The MiS210 Safety Module listens to the data exchange between the Drive and the encoder and will look at each command the drive sends to the encoder, decode the command and when appropriate snoop the data received from the encoder.

The delays in the data returned from the encoders due to the encoder delay and cable delays **is not** automatically compensated for. Hence cables lengths + encoders which introduce a delay greater than 45% and less than 55% of the clock period should not be used to avoid degradation in the Bit Error Rate. The supported cable lengths can be calculated using the following information and formulae.

Table 3-10   Cable Length Formula Values

Name	Abbreviation	Units
Baud Rate	BR	Bits/second
Encoder delay Clock to data output delay	Dd	ns
Cable propagation delay	Cd	Ns/Meter
Bit time = 1 / Baud rate	Bt	ns
Useable Cable Length	UCL	Meters
Transition Zone	TZ	Meters

$$UCL1 = \frac{(0.45Bt - Dd)}{2Cd}$$

The first useable cable length goes from 0 to UCL1, calculated using the above formula
There is then a Transition Zone where the data at the receiver is transitioning thus the sampling of the data is uncertain

$$TZ1 = \frac{(0.55Bt - Dd)}{2Cd}$$

The first transition zone goes from UCL1 to TZ1 meaning cables between these lengths should not be used.

$$UCL2 = \frac{((0.45Bt + Bt) - Dd)}{2Cd}$$

The second useable cable length goes from TZ1 to UCL2, calculated using the above formula.
There is then a second Transition Zone

$$TZ2 = \frac{((0.55Bt) + Bt) - Dd)}{2Cd}$$

The second transition zone goes from UCL2 to TZ2 meaning cables between these lengths should not be used.

$$UCL3 = \frac{((0.45Bt + 2Bt) - Dd)}{2Cd}$$

The third useable cable length goes from TZ2 to UCL3, calculated using the above formula.

NOTE

- The above is for guidance and does not consider the attenuation effects of the selected cable for the distance intended. In cases where the cable attenuation affects the crossover of the signals the factor of 0.45 should be decreased, and 0.55 increased to ensure the signals have fully transitioned within the usable cable lengths identified.

The drive's encoder update rate can be changed by many factors, so it is not synchronised to the MiS210 1ms evaluation cycle. This means that there is a variation in the sample time of up to 25% and this will be observed as a variation in the speed of up to 25%.

If using a single Drive EnDat 2.2 encoder, set the drive to control safe speeds at least 25% lower than any limit applied by the MiS210 MSFs, and use the Speed Control Tolerance to give a headroom of 25% in SLS and SS.

If using two Drive EnDat 2.2 encoders or a combination of Drive and Local encoders, set the drive to control safe speeds at least 25% lower than any limit applied by the MiS210 MSFs, and use the control tolerance to give a headroom of 25% in SLS and SS. Also set the Encoder Difference Tolerance to accommodate the variation.

The Motion Safety Functions SLS, SSM, SS and SOS must be configured taking account of this 25% tolerance.

If using one or two encoders on the Front Panel this 25% tolerance is not needed, and Front Panel encoders are recommended when more accurate speed monitoring is required.

3.2.3.2   Local Encoder Interface (EnDat 2.2, Safe EnDat 2.2 and SSI)

The MiS210 Safety Module is capable of receiving data from EnDat 2.2, Safe EnDat 2.2 or SSI via its front panel interface at the rates indicated below. The maximum cable length should be limited to 150 M as per the specification for EnDat 2.2 encoders.

Table 3-11   Baud Rate Vs Cable Length

Baud Rate	Safe EnDat 2.2	EnDat 2.2	SSI
1040 kHz	Not available	Not available	31 m
520 kHz	63 m	63 m	63 m
390 kHz	90 m	90 m	90 m
312 kHz	104 m	104 m	104 m
223 kHz	150 m	150 m	156 m
104 kHz	Not available	150 m	383 m

The data exchange between the MiS210 should complete within 1 ms. Hence the maximum duration of the data exchange should be verified using the selected baud rate and the message format.
The total data exchange duration can be calculated using the formulas contained in the tables below.

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Table 3-12   Data Length Analysis

Protocol	Time for Full Position	Time for Complete Data Exchange
EnDat 2.2	$t_{ST} + t_D + 10T + 3T + NtT + 5T + t_{Add}$ where $t_{cal} \leq t_{ST} + t_D/2 + 10T$ $t_{ST} + t_D + t_{cal} + 3T + NtT + 5T + t_{Add}$ where $t_{cal} > t_{ST} + t_D/2 + 10T$	Time for full position + t_m
SSi	tD + T + NtT (tD can't be measured, so a value of 1.25 µs is used)	Time for full position + t_m

Where:

t_{ST} is EnDat start time

t_D is Transmission delay from the front panel to the encoder and back

T is 1/baud rate

T_{cal} is Position calculation time

Nt is Total number of position information bits

t_m is Encoder recovery time

t_{ADD} is Additional data from the Safe EnDat 2.2 / EnDat 2.2 encoder is used during the MiS210 Safety Module configuration checks performed prior operating. The additional information is used to receive the second position from the Safe EnDat 2.2 and is 30 bit times in length. The Additional data is not used by the MiS210 Safety Module during operation when connected to an EnDat 2.2

3.2.4   Cable Attenuation (EnDat 2.2, Safe EnDat 2.2 and SSI)

The attenuation characteristics of the cable reduces the amplitude of the high frequency components of the transmitted data. This has the effect of rounding the edges of the data signals, and reducing the amplitude of the signals that represent alternating 1 s and 0 s. Cable lengths should be minimized as far as possible to reduce these effects, and only suitable cables should be used.

3.2.5   AB and Sin/Cos Encoder Interface

These encoders are connected to the MiS210 Safety Module front panel and provide signals to the MiS210 Safety Module in sympathy with the system they are attached. The effects of cable delays are discounted because the delays on the two signals are equal. However there is a limitation in the signal frequency that can be interpreted by the MiS210 Safety Module

Table 3-13   Maximum Frequency

| Encoder Type	Maximum Frequency of Fundamental
AB	350 kHz
Sin/Cos	350 kHz

The attenuation characteristics of the interface cable used reduces the amplitude of the high frequency components of the transmitted data. This has the effect of rounding the edges of the data signals and reducing the amplitude of the signals that represent alternating 1s and 0s. Cable lengths should be minimized as far as possible to reduce these effects, and only suitable cables should be used.

3.2.6   Process Encoder Values

This aspect of the MiS210 Safety Module allows the data from two separate encoders to be compared, verifying the operation of the primary encoder against the secondary encoder.

Initially taking the difference between the reported positions from the two encoders. Then making sure that the difference does not vary by more than a tolerance.

Figure 3-6   Encoder Position against Actual Position Reported
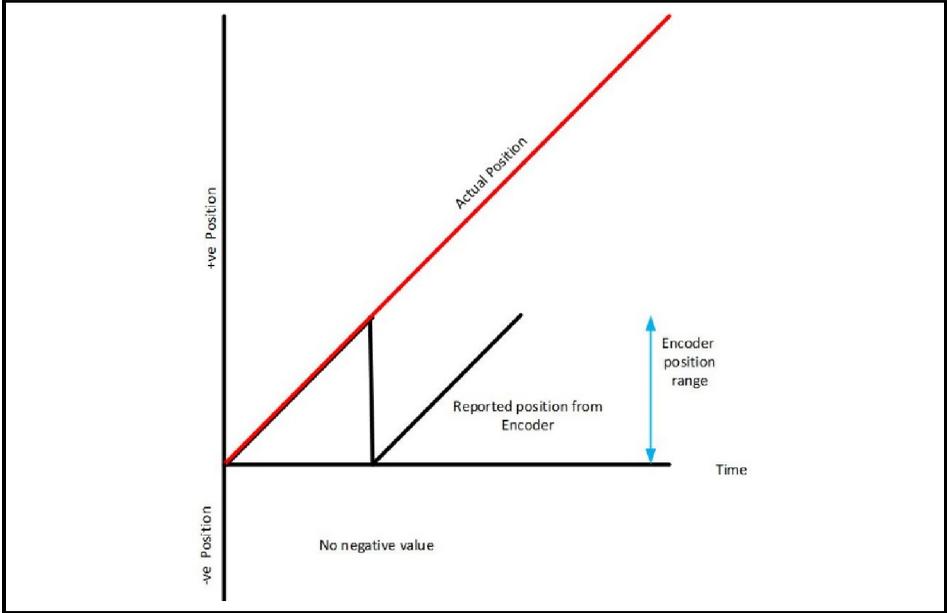
To compare two encoders we need to consider the effect of the two encoders being misaligned, this is shown on the graph below.

Figure 3-7   Encoder Positions from 2 Encoders
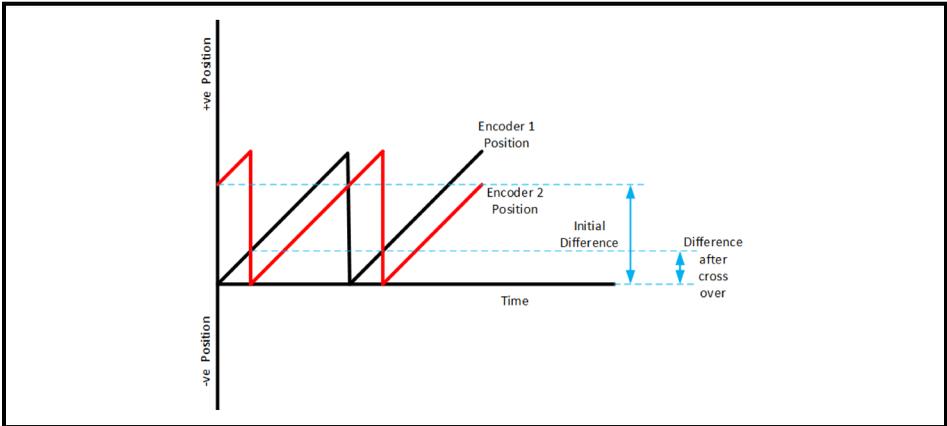
As can be seen there are two valid difference values between the two encoders depending on the relative position of each encoder. This difference value is purely the difference between the two encoders due to the setup, and as one rolls over before the other the difference value changes.

The MiS210 Safety Module evaluates the second expected difference based on a single measurement which obtains the first difference. Then two tests are performed on the encoder positions and only if both tests fail is it logged as a failure.

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3.3 Embedded Microcontroller and Support Devices

The MiS210 Safety Module embedded microcontroller provides the physical platform for the execution of the application software. The selected processor has been assessed in accordance with IEC 61508 and based on the diagnostic features built into the device, it attained a SIL 3 rating when used with an external watchdog device also contained within the MiS210 Safety Module.
The microcontroller hardware provides interfaces to, or internal hardware with the following functions:

1. **Local Inputs**

   Facilitates the reading of the Local Inputs on which the configured safety functions act.

2. **Local Outputs**

   Facilitates the writing of the Outputs based on the analysis performed by the configured safety functions.

3. **Encoder Interface**

   Facilitates the reading of the attached encoders either attached to the front panel of the MiS210 Safety Module or the encoder signal routed through the drive to the MiS210 Safety Module.

4. **Shared Memory Access**

   Manages the communications via the Drive shared memory interface. A variety of protocols and error detection mechanisms are implemented in software, providing safe and secure communication. Via this interface the MiS210 Safety Module can gain access to an attached network and make use of safety protocols.

5. **Data Processing**

   Provides the system manager and scheduler, processes the Encoder and Local Inputs, Motion Safety functions as specified by the users configuration file, and sets the Local outputs.

6. **Storage Functional Block**

   Microcontroller Internal Memory with error detection.

7. **Safety Diagnostics Provides diagnostics for the following diagnostic features:-**

   7.1. Local Inputs – Monitoring and test inject

   7.2. Local Outputs – Monitoring and test inject

   7.3. Encoder Diagnostics – Signal Monitoring, and data validation

   7.4. Power supply – Monitoring and Test Inject

   7.5. Microcontroller Tests and checks – Power on and Continuous self-test.

   7.6. Companion chip monitoring

   7.7. Temperature Monitoring

3.3.1 Diagnostic Coverage Summary

Table 3-14 Diagnostic Coverage Summary

MEASURE	DC_{avg}	COMMENT
In summary, the microcontroller contains two processing units whose operation is continuously compared and should a mismatch in operation be detected, the processor are halted and the MiS210 Safety Module achieves a safe state. The memory which supports the processor has a multibit check code for each location to guard against memory corruption. The peripherals contained on chip are also subject to a varying degree of test – depending on the complexity of the interface, ranging from parity to CRC. To support memory checking / message checking the microcontroller has a built in 64 bit CRC engine which is used continuously verifying programme memory.	99.74 %	This figure considers the embedded microcontroller and the support devices required for operation.

3.4 Response Times

Response time is an important technical safety property and needs to be taken into account with every application / application based or applied safety function.

> ⚠️ **WARNING**
> Particular caution is advisable when using filter functions. Depending on filter length and time, the response time can be extended substantially and this fact should always be taken into consideration when configuring the technical safety functions.
>
> The maximum Drive STO Response time is 20 ms.

The Local Response time is defined to be the time between a change of state of an input at the boundary of the MiS210 Safety Module and corresponding change of state of an output at the boundary.

The MiS210 response time is less than 4 ms, and the cycle time of the MiS210 Safety Module is 1 ms.

The MiS210 Safety Module runs a substantial amount of self-test at both power on and continuously. The complete self-test suite is completed every 16 ms.

When the MiS210 Safety Module enters the commissioning testing state it has a time limit placed on it to prevent the unit being used in a "test" state for an indefinite amount of time. This is set by the user in Connect and is a maximum of 25 days.

3.4.1 Networks

The response time of network communications cannot be given as it will depend upon the specific network in question, size, loading etc.

MiS210 Safety Module should not be used for applications involving CIP Safety where the drive on board Ethernet is less than version, V02.08.00.02.

The MiS210 Safety Module CIP Safety stack, with CIP Product Revision Number V01.01, has been certified as CIP Safety compliant with the following version of the on board Ethernet, V02.08.00.02.

There is no restriction on the Network topology, but the performance of the Black Channel is dependent on the design of the whole network that carries it and predictions about performance cannot be made, and performance could vary.

Any change to the installed system can cause changes to the performance of the Black Channel including addition of or changes to other modules on the network including new firmware versions. If any such changes are proposed then an impact analysis should be performed and if required the Black Channel performance should be retested and the appropriate maintenance control measures applied.

> ⚠️ **WARNING**
> The MiS210 Safety Module should not be used in marine vehicles without permission from the stack licensor, this is a restriction from CIP Safety.
>
> The MiS210 should not be used with multiple PLCs as multicast operation is not supported by the MiS210 Safety Module.

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4.1 Connect Screen Images

When using Connect each page will have context sensitive help to guide the user in setting up the function. The context help in Connect is to aid the user, however the information detailed in this Safety Manual is the Master.
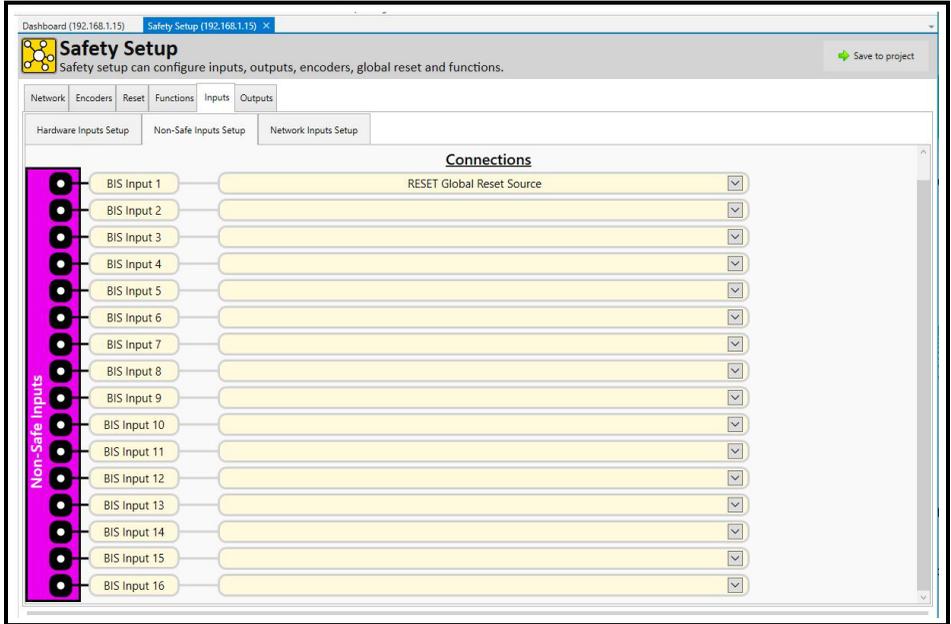
4.1.1 Inputs

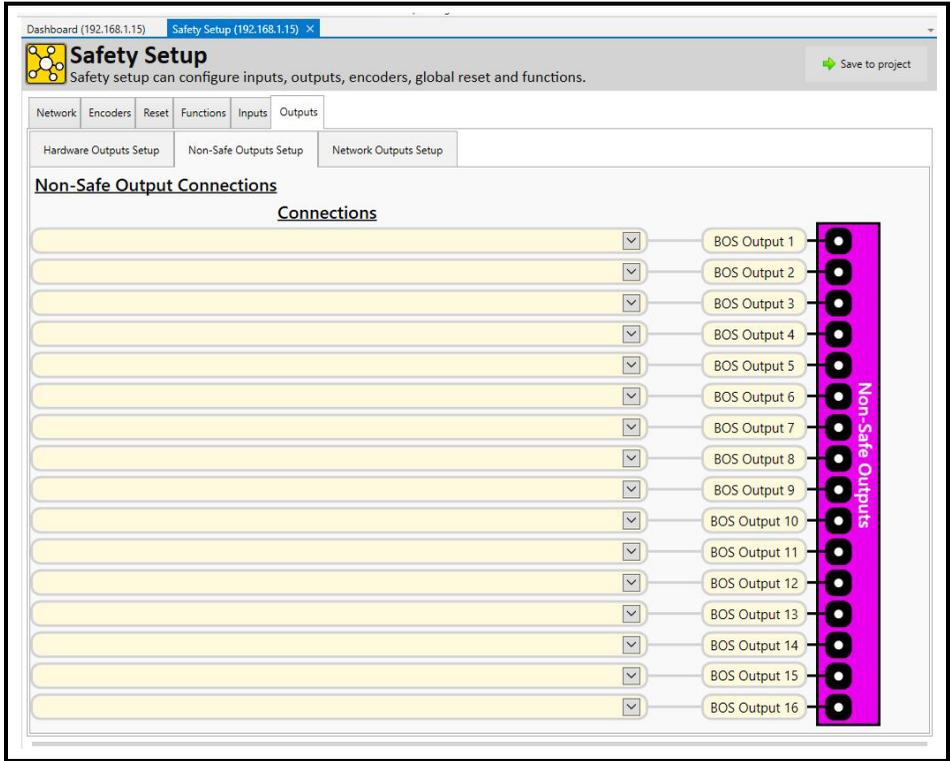The following shows the 4 Hardware Inputs which are fully detailed in section 8.16 *Safe Boolean Hardware Inputs (SHIS)*, the 16 Non Safe Inputs which are fully detailed in section 8.26 *Non Safe Boolean Input (BIS)* and the Network Inputs which are fully detailed in section 8.19 *Safe Boolean Network Inputs (SNIS)* and section 8.21 *Safe Integer Network Inputs: (SINIS)*.

Figure 4-1   Connect Hardware Input Screen
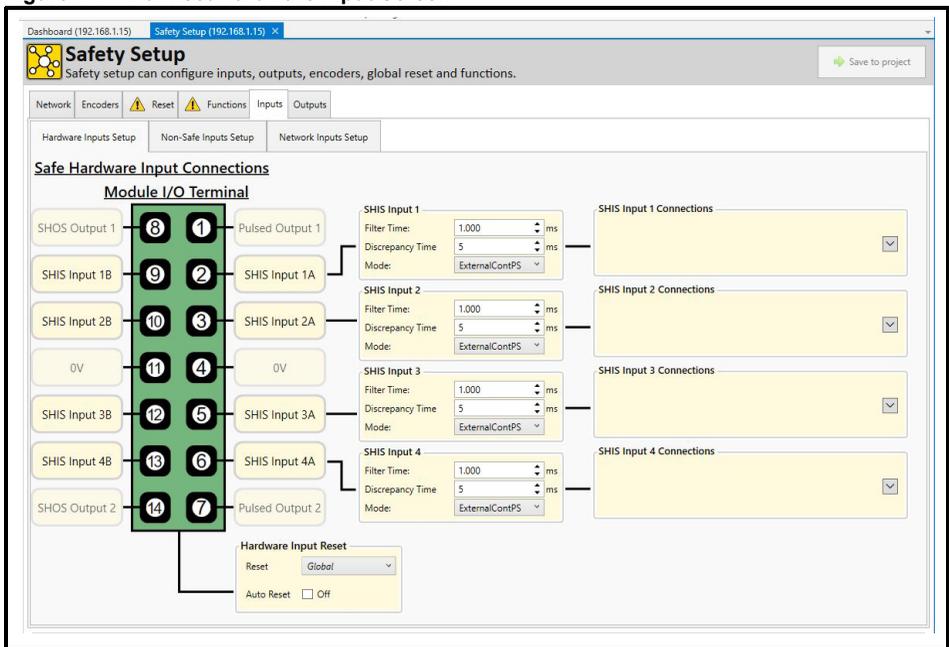
Figure 4-2   Connect Non Safe Input Screen

Figure 4-3   Connect Network Input Screen

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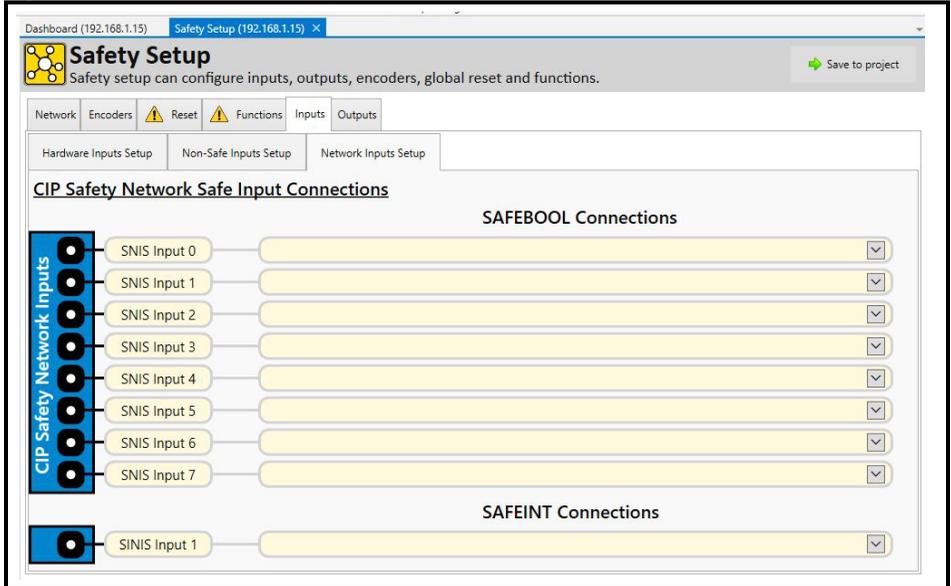
4.1.2 Outputs

The following shows the 2 Hardware Outputs which are fully detailed in section 8.18 *Safe Boolean Hardware Outputs (SHOS)*, the 16 Non Safe Outputs which are fully detailed in section 8.27 *Non Safe Boolean Output (BOS)* and the Network outs which are fully detailed in section 8.20 *Safe Boolean Network Outputs (SNOS)* and section 8.22 *Safe Integer Network Outputs: (SINOS)*.

Figure 4-4   Connect Hardware Output Screen

Figure 4-5   Connect Non Safe Output Screen

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Figure 4-6   Connect Network Output Screen
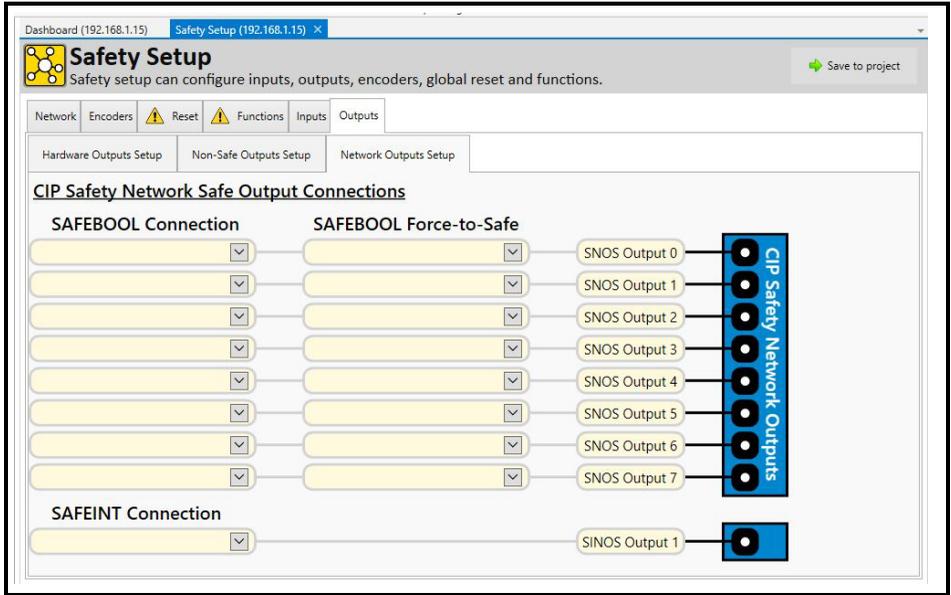
4.1.3 Encoders

The following shows the Encoder set up screens, a maximum of 2 encoders can be connected to the MiS210 from 4 possible options. The 2 encoders are known as the Primary and Secondary encoders. Once an encoder type is selected the possible options for that type will be shown. This is fully detailed in section 8.1 *Encoder Setup*.

Figure 4-7   Connect Encoder Screen
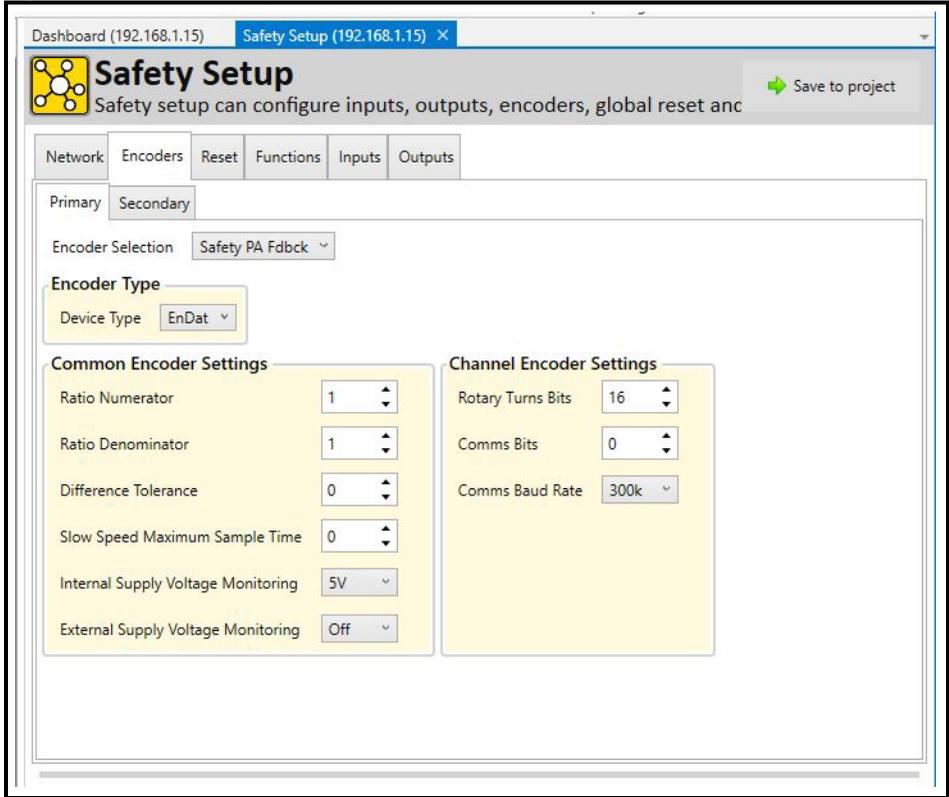
In order to download a configuration to the MiS210 using the drive encoder interface, the offline Connect project and online drive parameters must be synchronized.

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4.1.4 Network

The following shows the Network Settings screen, the only Safe Network available to use is CIP Safety and for this to work the drive must contain the built in Ethernet module (M700 and M702). This is fully detailed in section 8.3 *Safety Network Configuration*.

Figure 4-8   Connect Network Screen
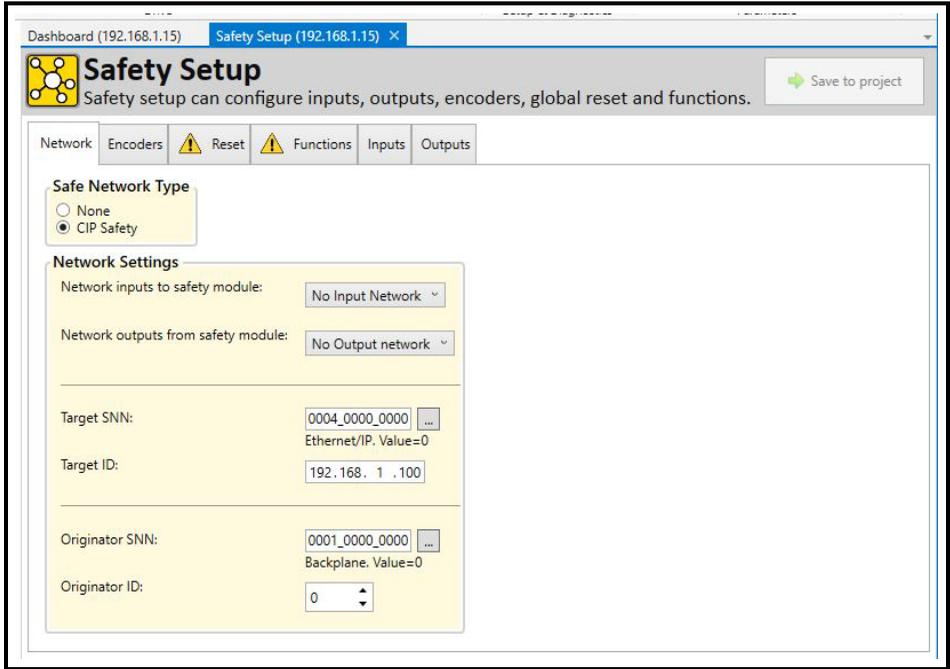
4.1.5 Motion Safety Functions

Each MSF available has its own screen and parameters to set, the one shown below is for STO. To select a MSF you click on its symbol and this opens the options for the selected function. Each of the MSF menus is described in detail in section 8 *Motion Safety Function Details* giving state diagram, settable parameters and timing diagrams.

Figure 4-9   Connect Motion Safety Function Screen
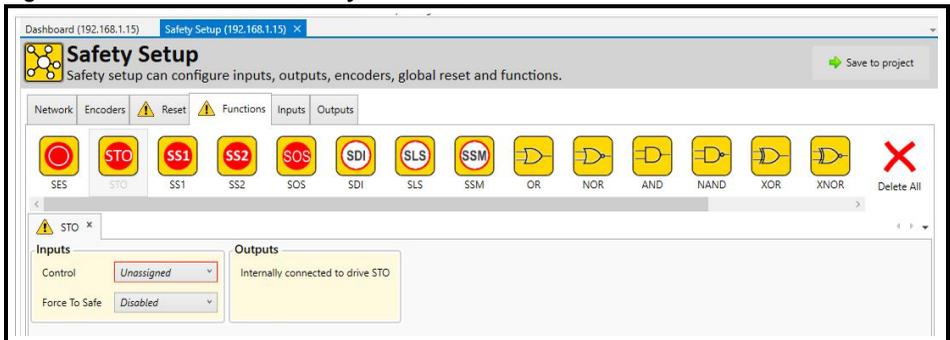
4.1.6 Reset

The following shows the Reset screen, this covers the global reset for the MSFs as well as the Hardware Input reset.

The Hardware Input Reset is detailed fully in section 8.16 *Safe Boolean Hardware Inputs (SHIS)*.

The Global Reset is detailed fully in section 8.2 *Module Configuration & Control*.

Figure 4-10   Connect Reset Screen

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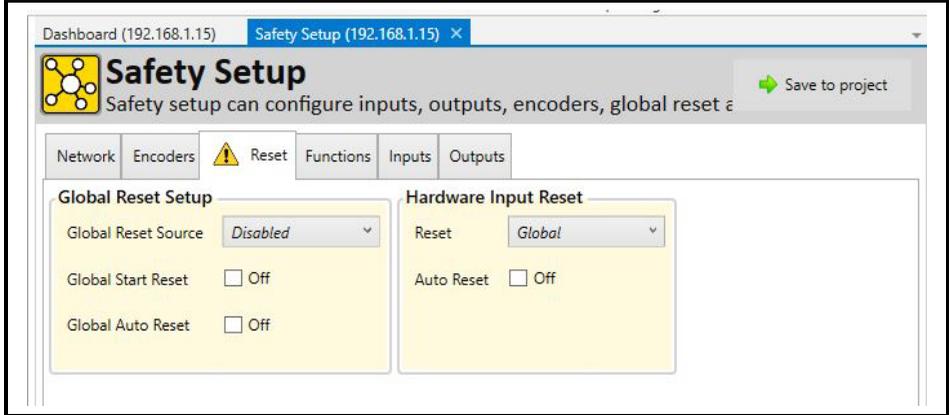
4.2 Connect Basic Workflow

The following workflows depict how to utilise Connect to create a new configuration, modify a configuration, test a configuration, remove a configuration and recover a configuration. These are presented so the user can understand the process of using Connect.

The Safety Function configurations in the workflows below are to illustrate the use of Connect. The workflows should not be considered as solutions to safety requirements, and the designer should create their own solution from the available safety functions setting the parameters for their specific application.

4.2.1 Create a New Configuration

In this workflow it is assumed the MiS210 is unused "out of the box", or the MiS210 has been reset to factory defaults by the user.

Figure 4-11   Scan the Network
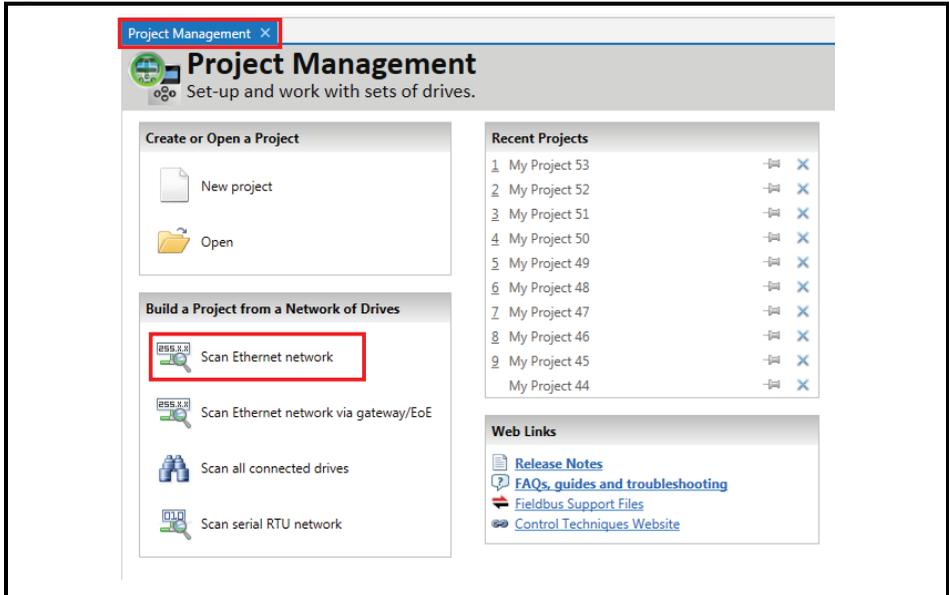
Figure 4-12   Select the MiS210
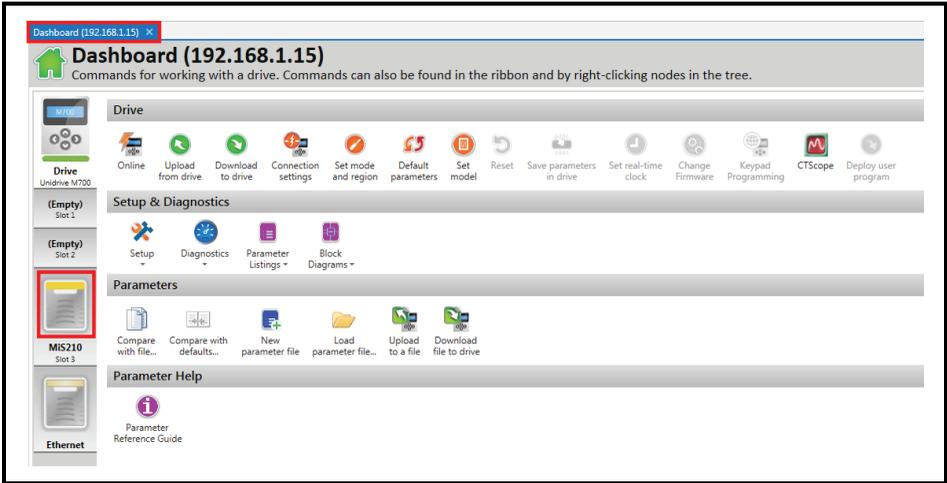
Figure 4-13   Select "Safety Setup"
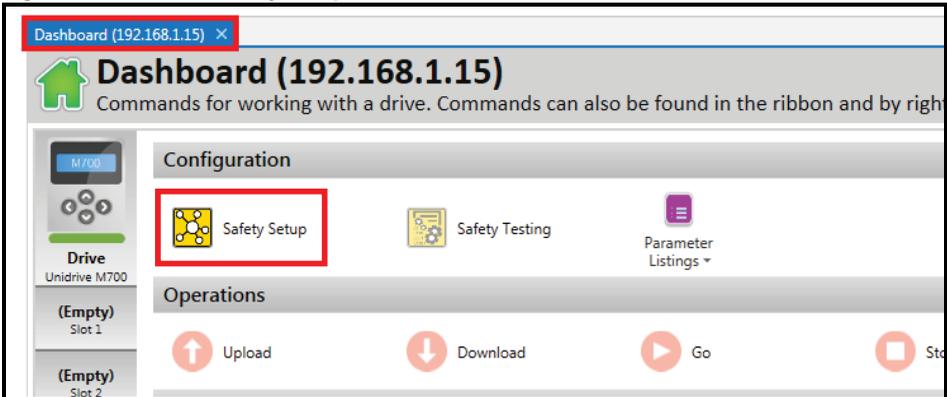
In this workflow SES (Safe Emergency Stop) controlling STO (Safe Torque Off) is illustrated, therefore Network and Encoder functions are not applicable.

Figure 4-14   Configure the Desired Functionality - Network

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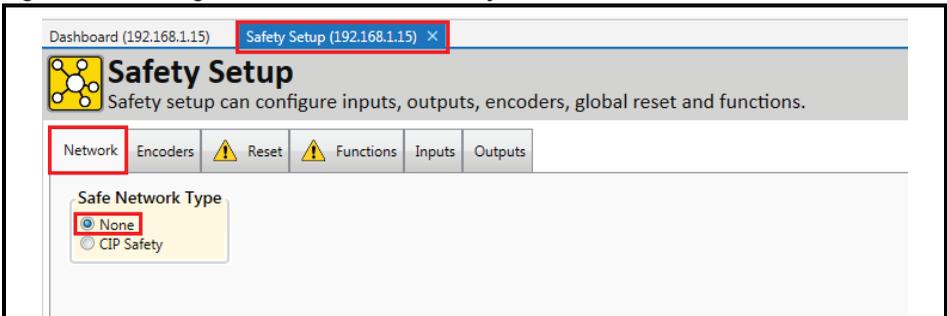
Figure 4-15   Configure the Desired Functionality - Encoders
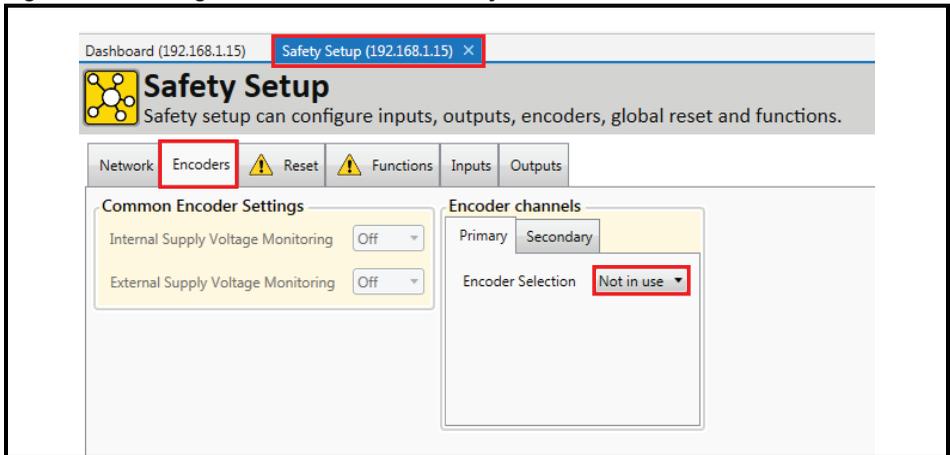
In this workflow BIS Input 1 (Non safe Boolean input) parameter 17.031 (Non Safe Input 1) is mapped by the user to a digital input on the drive (not shown here).

Figure 4-16   Select the Required Input for Reset
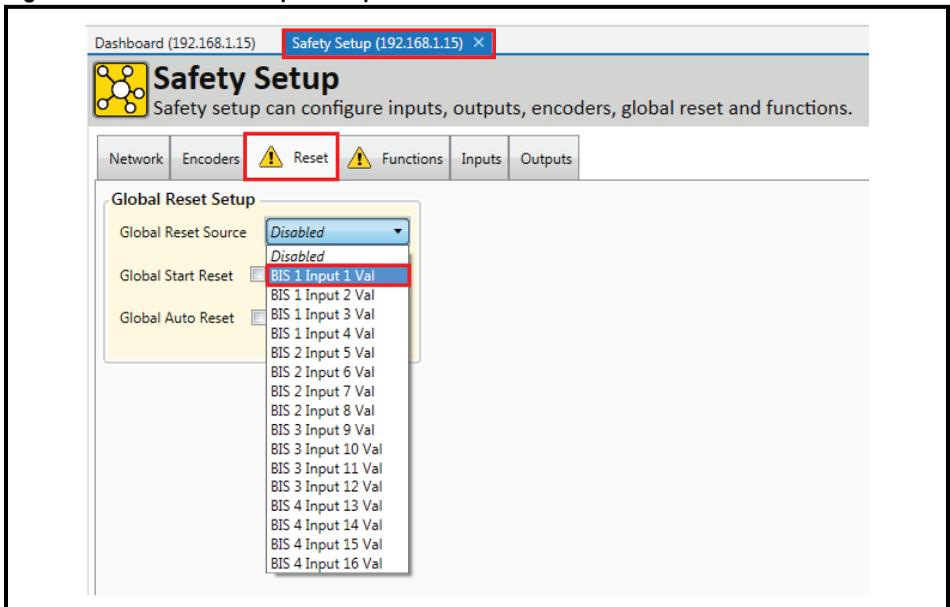
Figure 4-17   Select the "SES" Motion Safety Function
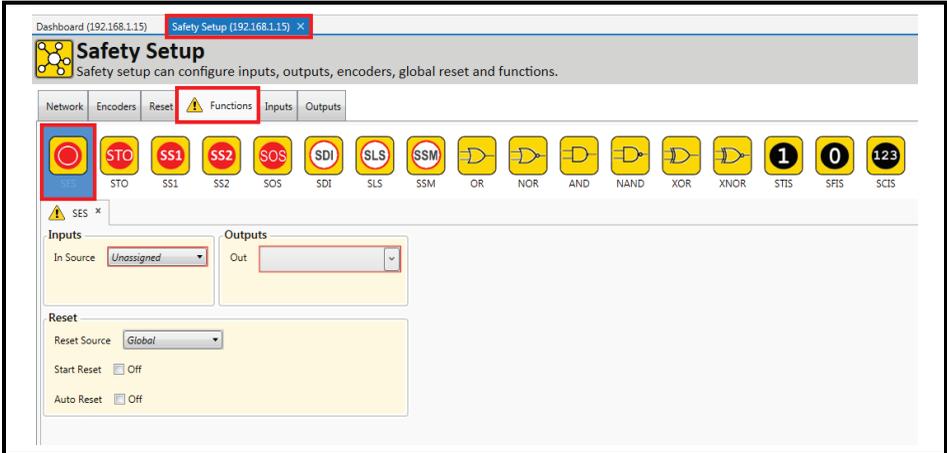
Figure 4-18   Select the "STO" Motion Safety Function
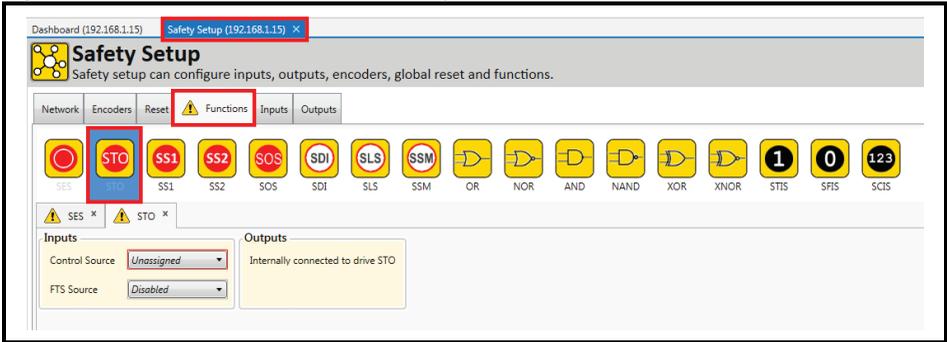
In this workflow. SHIS 1 (Safe Hardware Input 1) is selected as the Input, and STO Control Source as the output.

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Figure 4-19   Configure "SES"
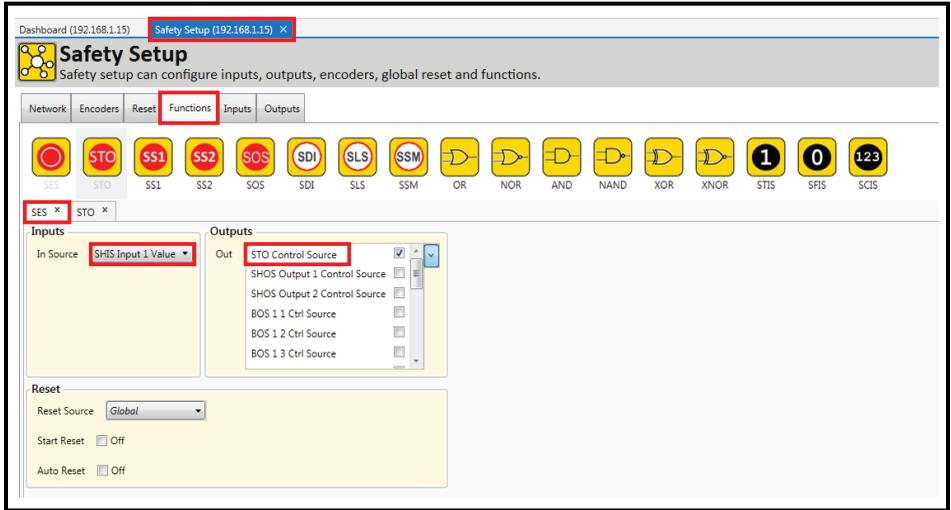
Select "STO", in this workflow it can be seen that the Control Source is by default automatically set up by the selection previously made in the SES output.

Figure 4-20   Configure "STO"
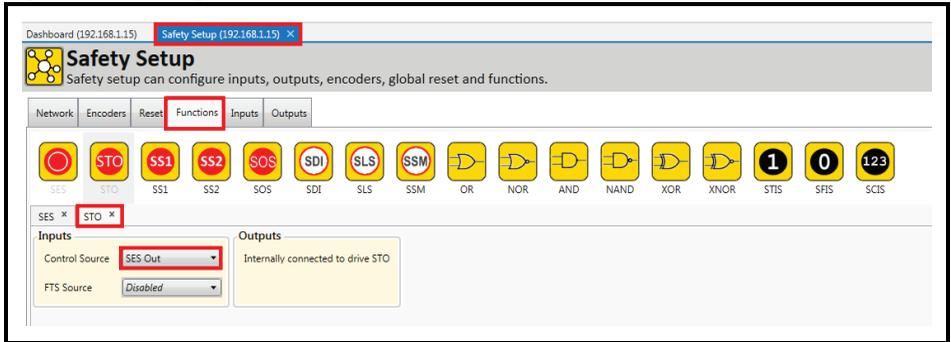
Figure 4-21   Select "Save to Project"
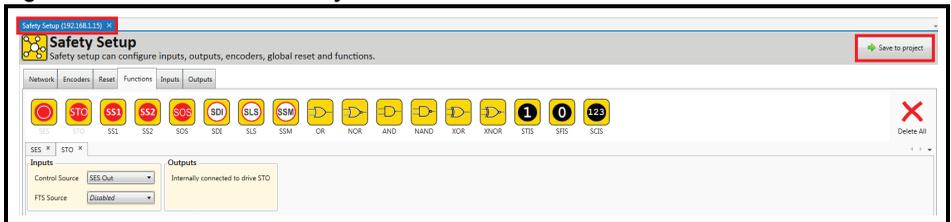
Figure 4-22   Create a Password and Username, then click "Log in"
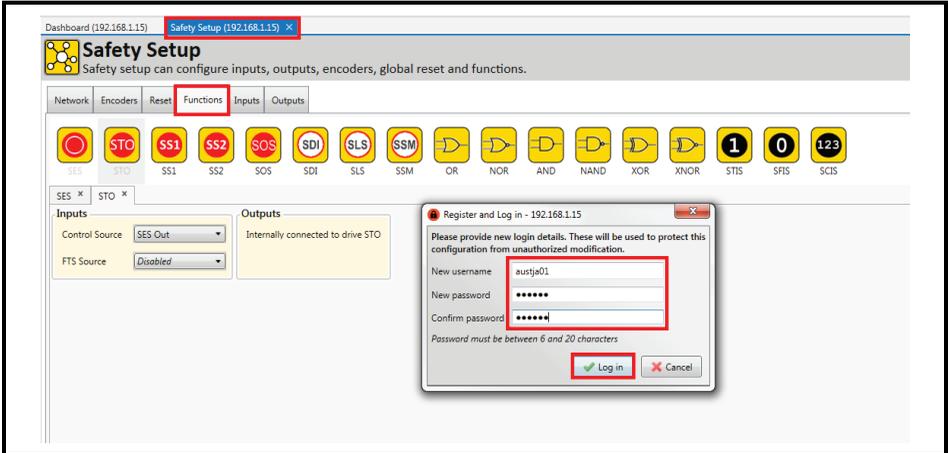
Figure 4-23   Go "Online", then select "Safety Testing"

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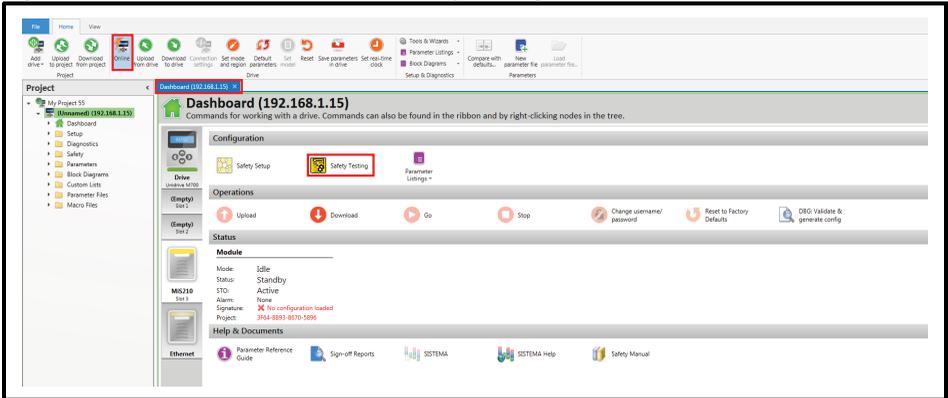
Figure 4-24   Select "Download configuration to module"
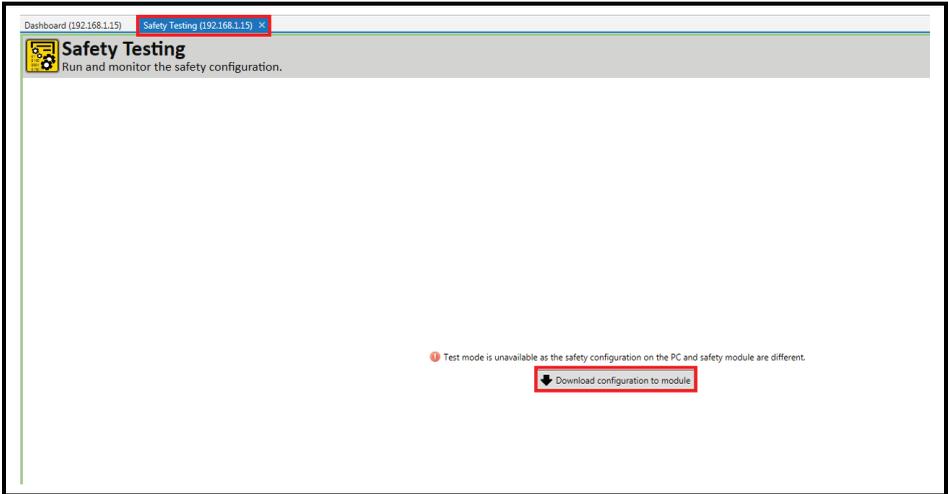
Figure 4-25   Select "Yes"
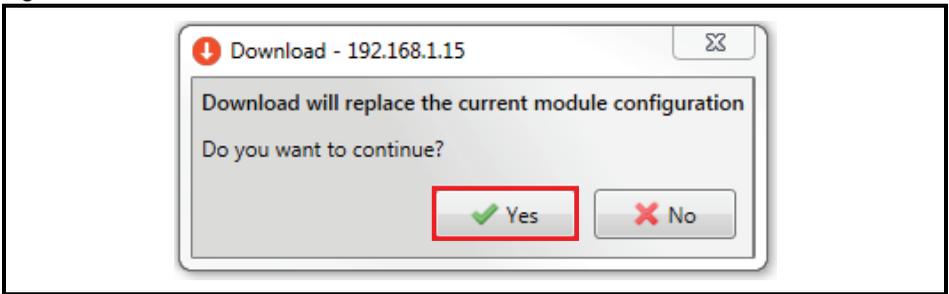
Figure 4-26   Enter Password Previously Assigned when Saving Project
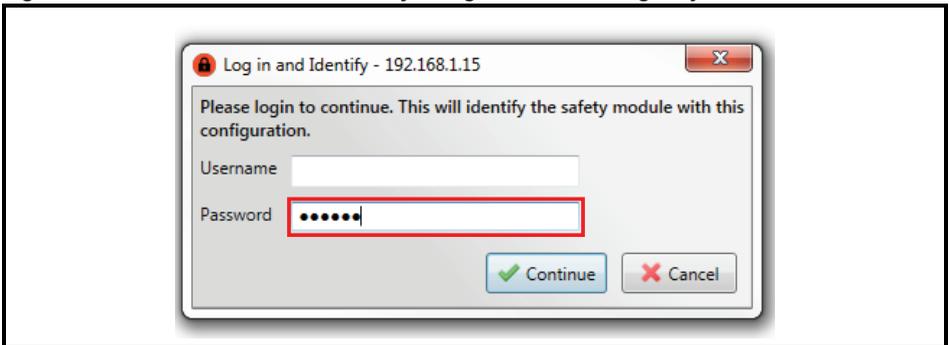
Read the value displayed in menu 17.012 on the drive's display and enter it as prompted, then click "OK".

Figure 4-27   Enter Parameter Value

Figure 4-28   Select "Test"

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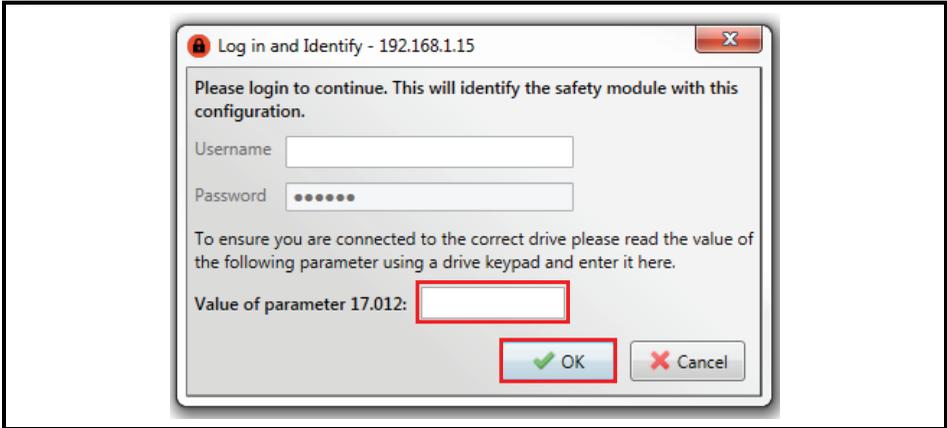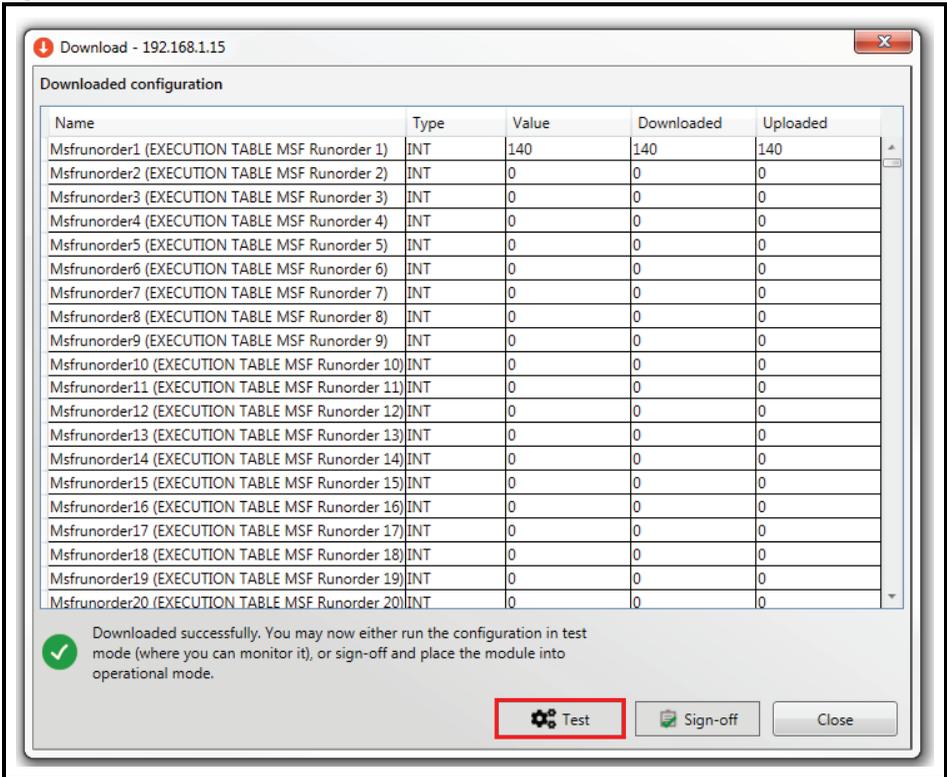
Figure 4-29   Select "Enter Test Mode"
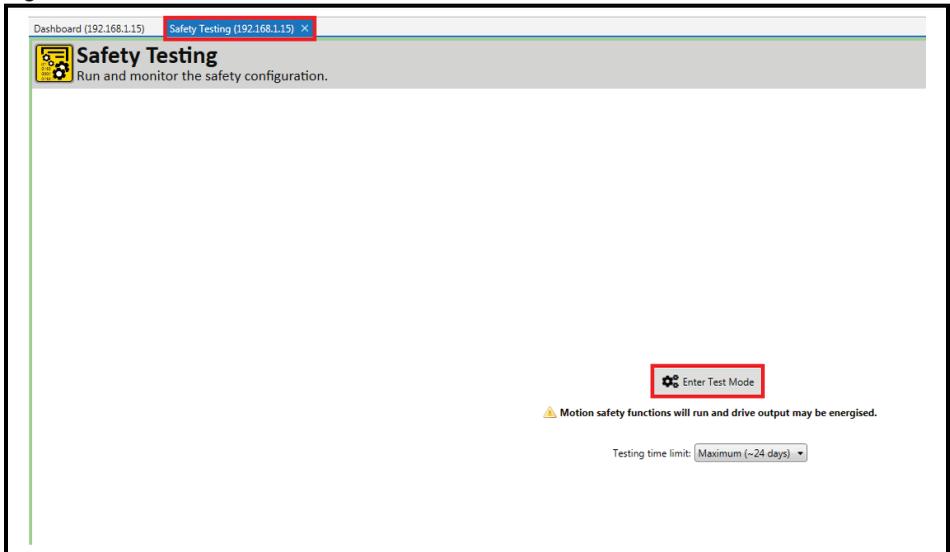
In Test Mode the configuration is running and updating values can be viewed. In this workflow asserting an input on SHIS 1 and instigating a reset on BIS 1 causes the STO to become inactive and therefore allowing the drive to run.

Figure 4-30   In Test Mode
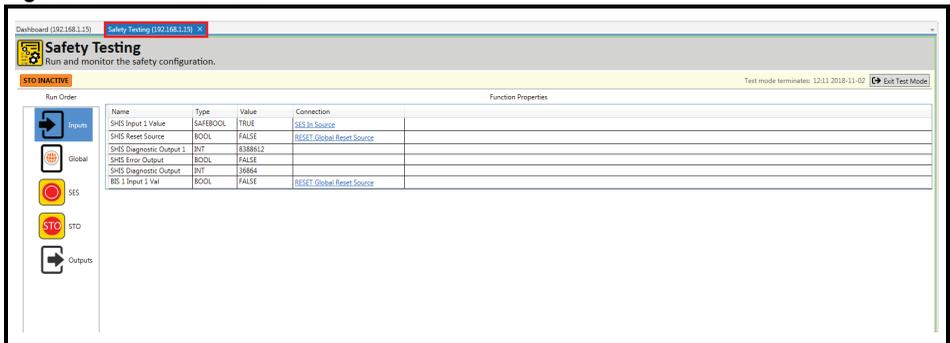
Figure 4-31   Select "Exit Test Mode" and enter Password
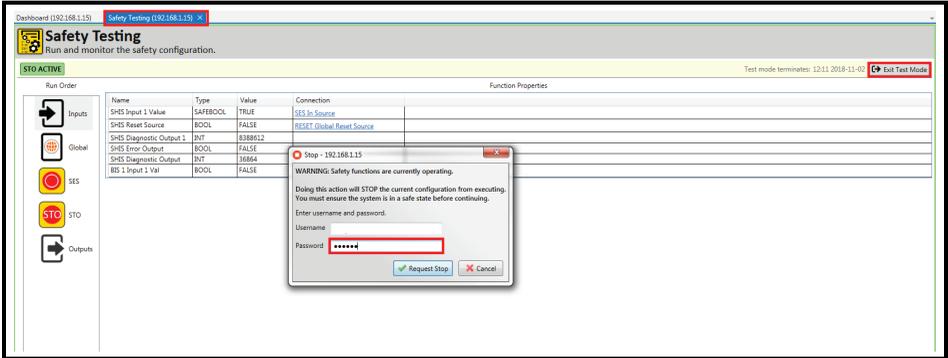
Read the value displayed in menu 17.012 on the drive's display and enter it as prompted, then click "Stop".
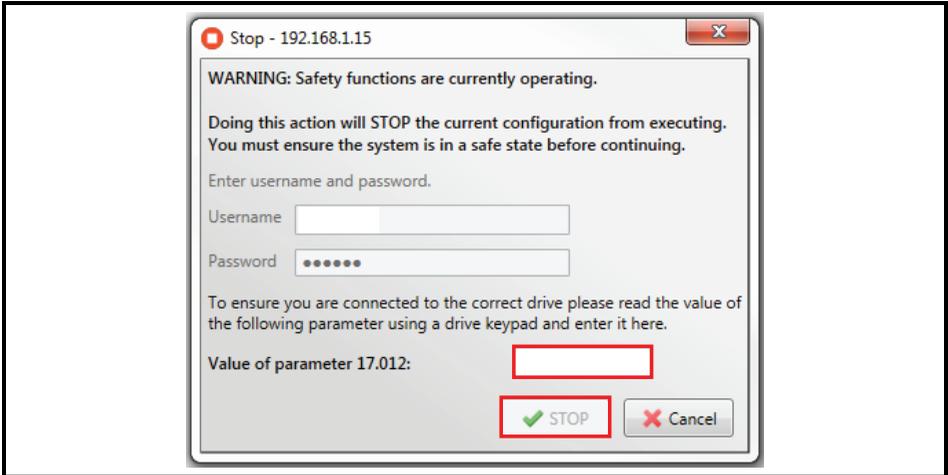
Figure 4-32   Select "Stop"

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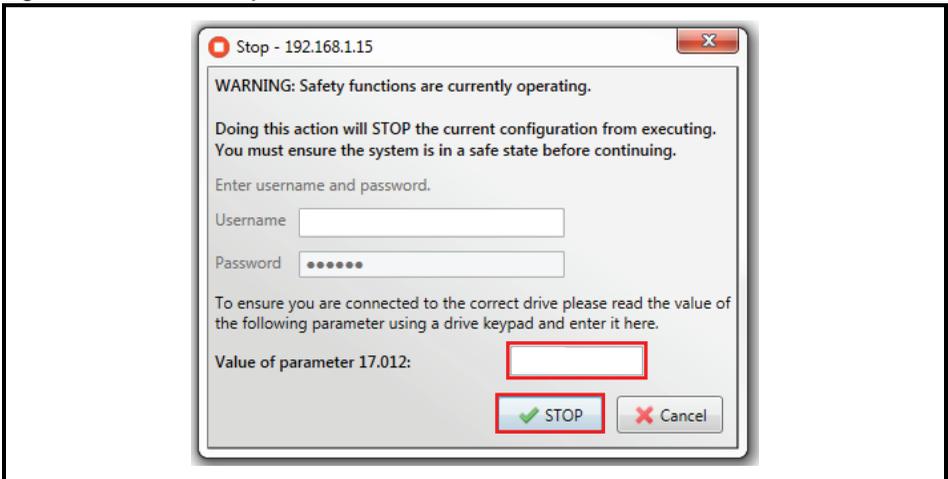
Figure 4-33   Select "Go"
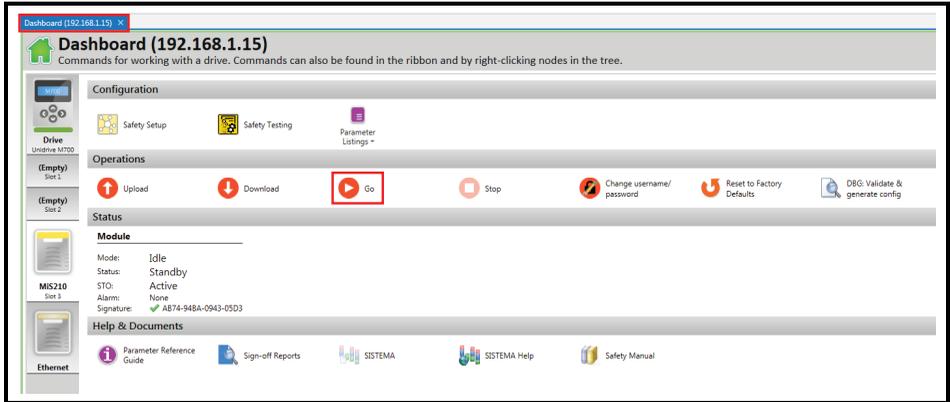
Figure 4-34   Select "Sign off"
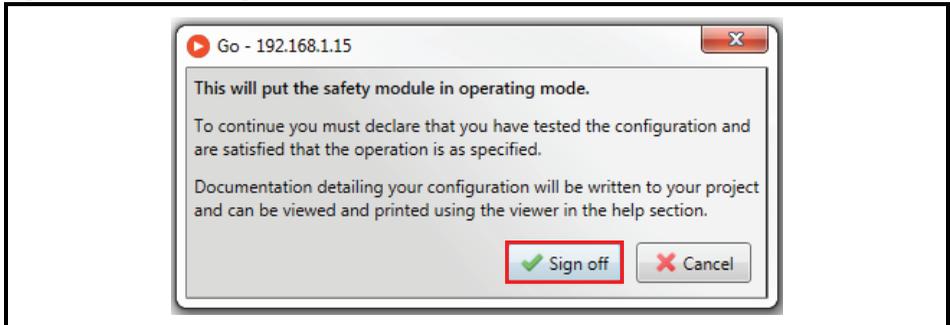
Click on the link to view the sign-off report, then if you have tested and signed off the configuration select "Confirm" to enter operating mode.

Figure 4-35   Confirm the Configuration, select "Confirm"
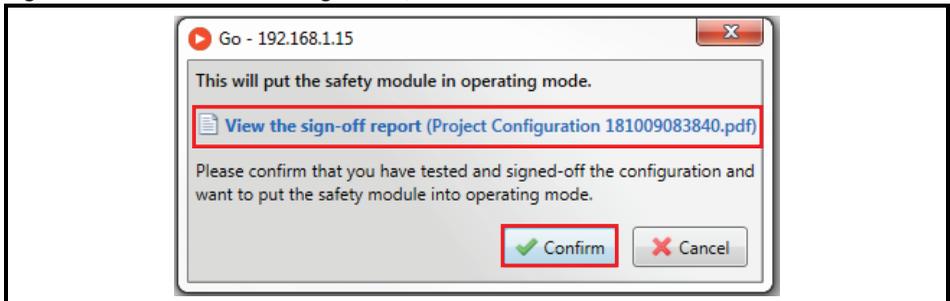
Figure 4-36   The MiS210 is now in Operating Mode, click "Ok"
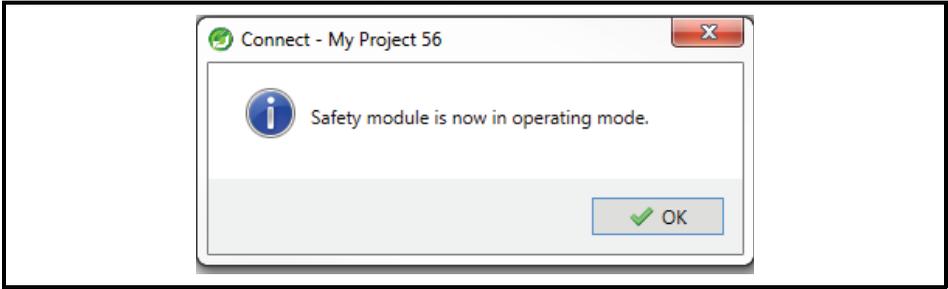
4.2.2   Modify a Configuration

In this workflow an existing Connect project is opened and modified to allow re-configuration of the MiS210.

Figure 4-37   Open an Existing Project

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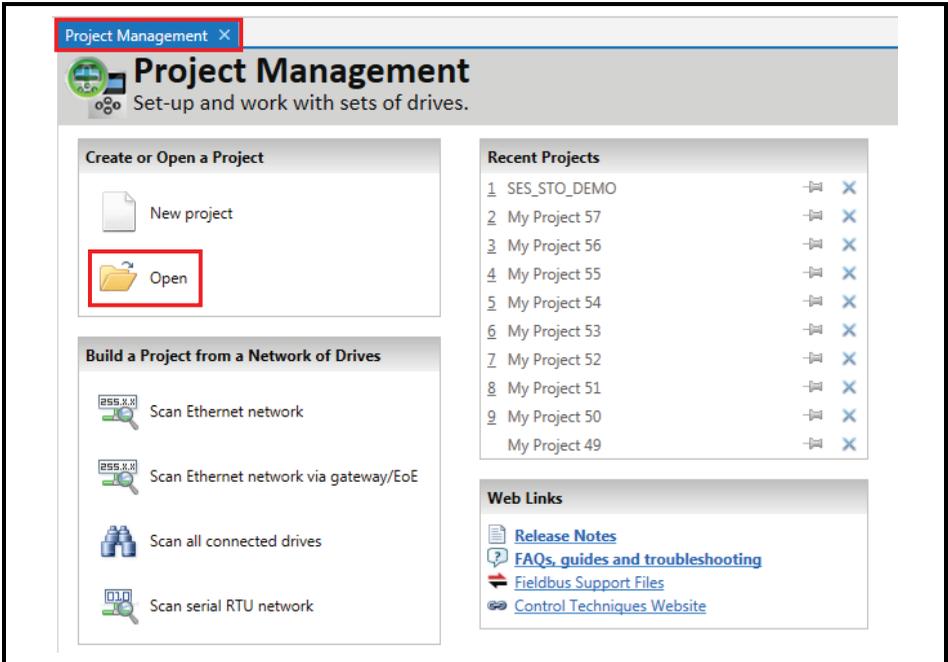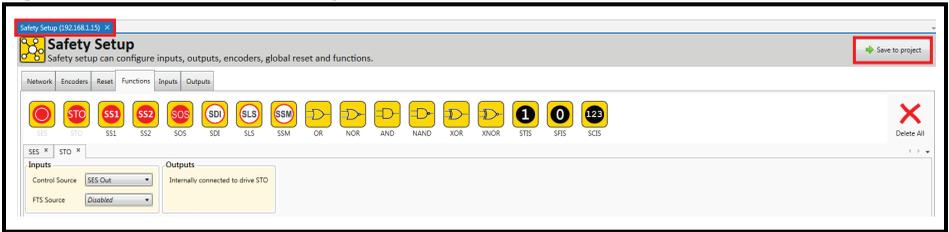
Figure 4-38   Select the MiS210
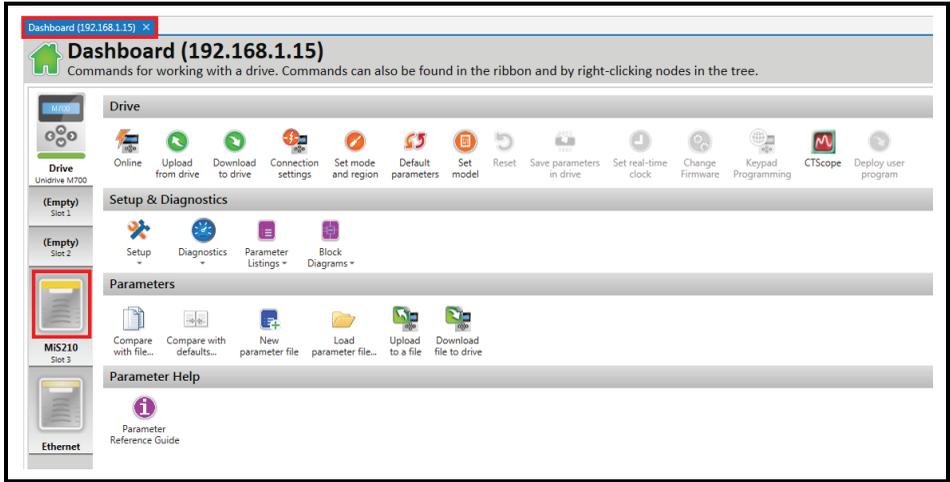
Figure 4-39   Go "Online" and Select "Stop"
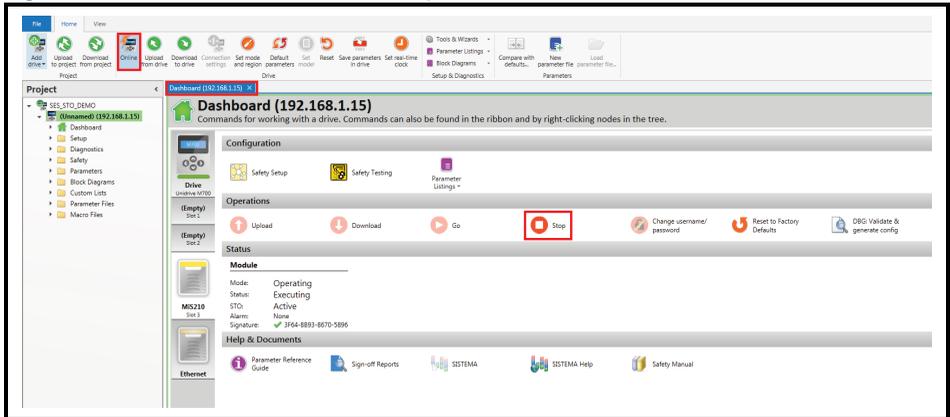
Figure 4-40   Enter Credentials associated with Configuration and Select "Request Stop"
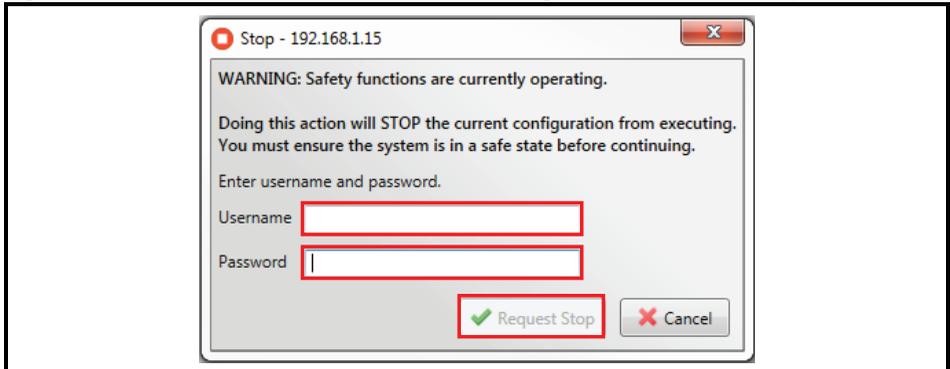
Read the value displayed in menu 17.012 on the drive's display and enter it as prompted, then click "STOP".

Figure 4-41   Enter Parameter Value and Select "Stop"

Figure 4-42   Go "Offline" and select "Safety Setup"

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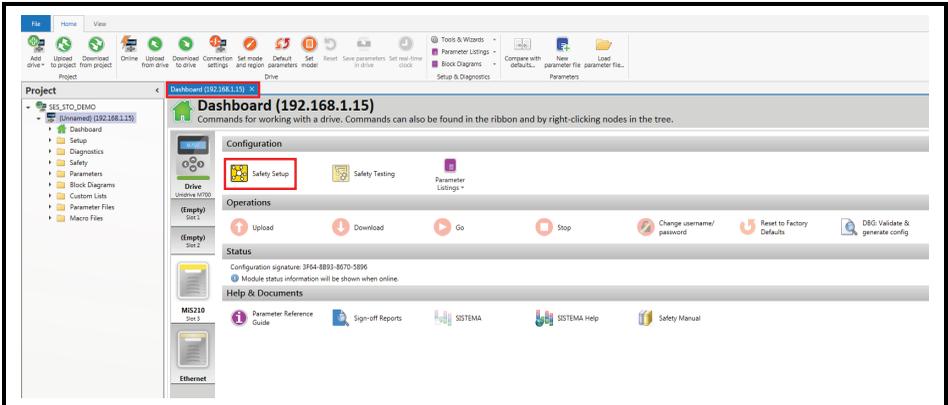
Figure 4-43   Modify the Existing Configuration as Required
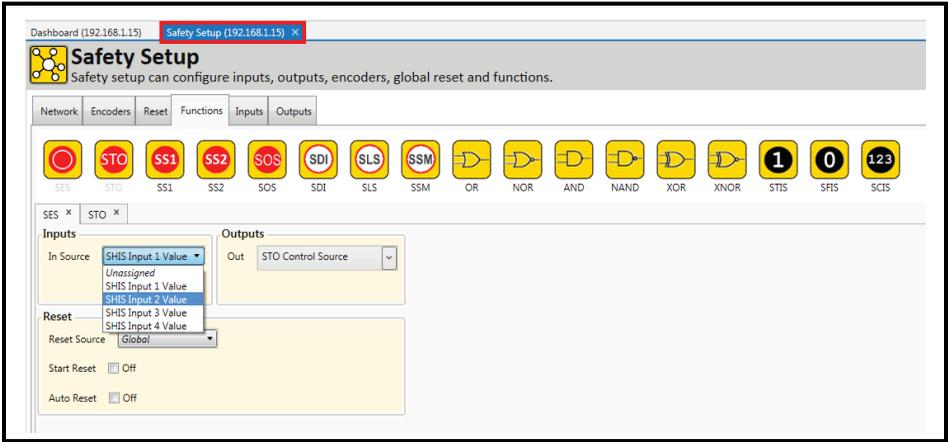
Figure 4-44   Select "Save to Project"

Figure 4-45   Enter Credentials and click "Log in"
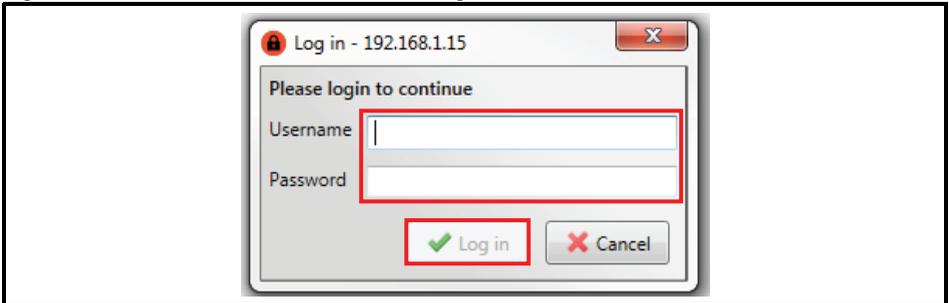
Figure 4-46   Go "Online" and select "Safety Testing"
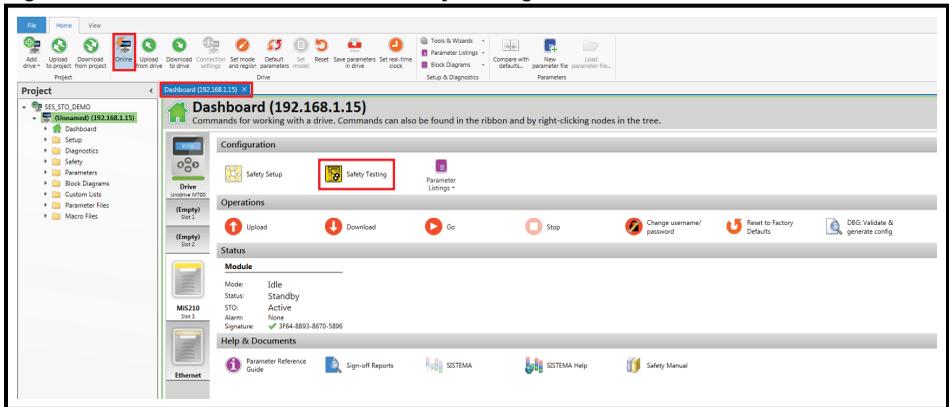
Figure 4-47   Select Download Configuration to Module
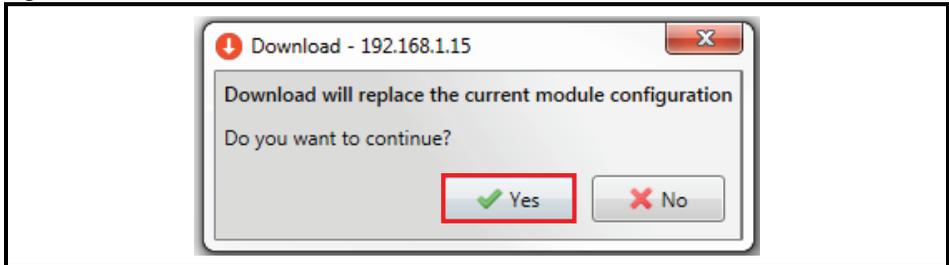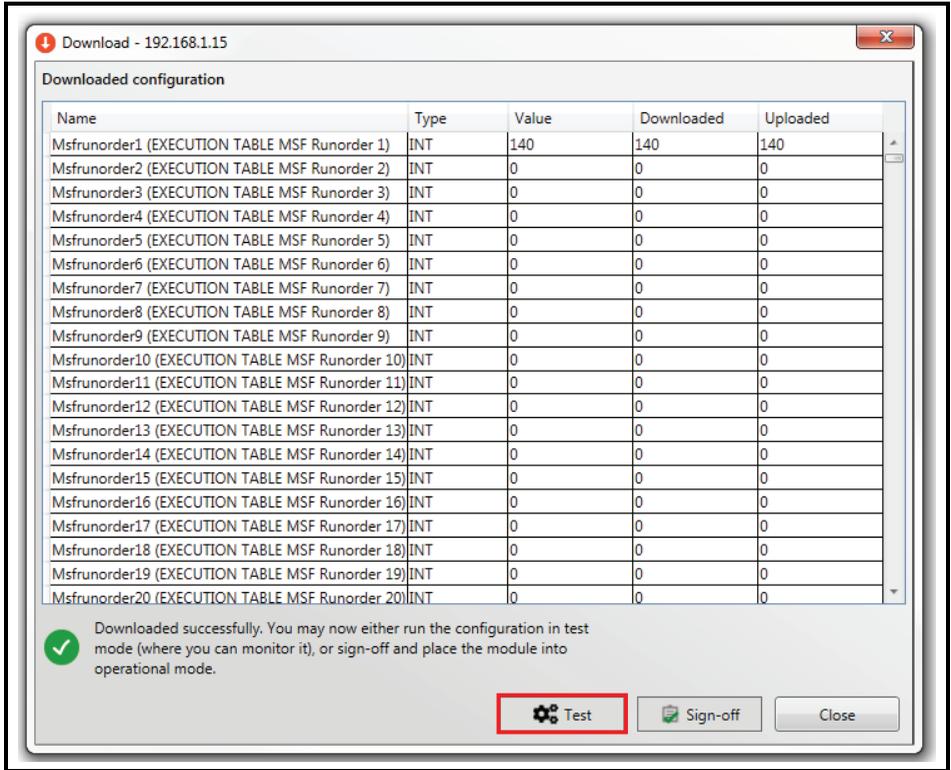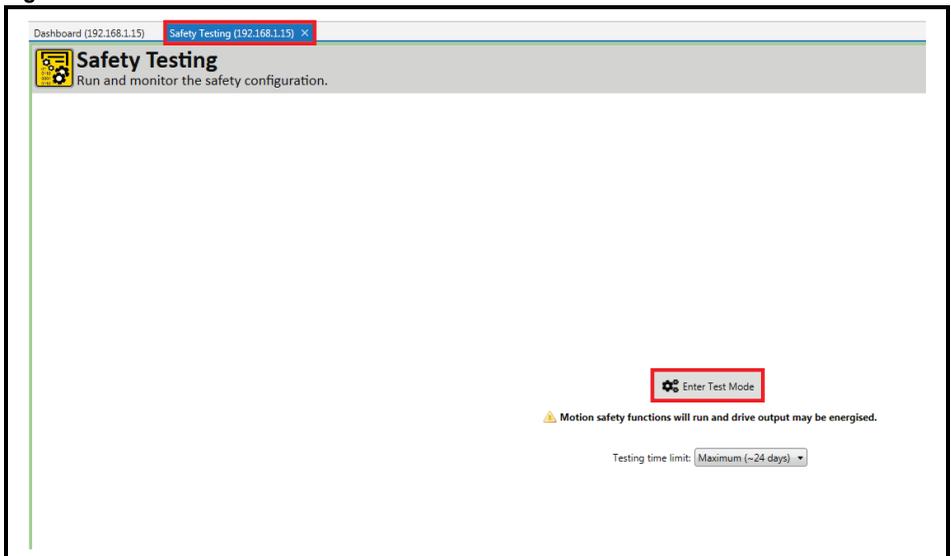

Figure 4-48   Select "Yes"

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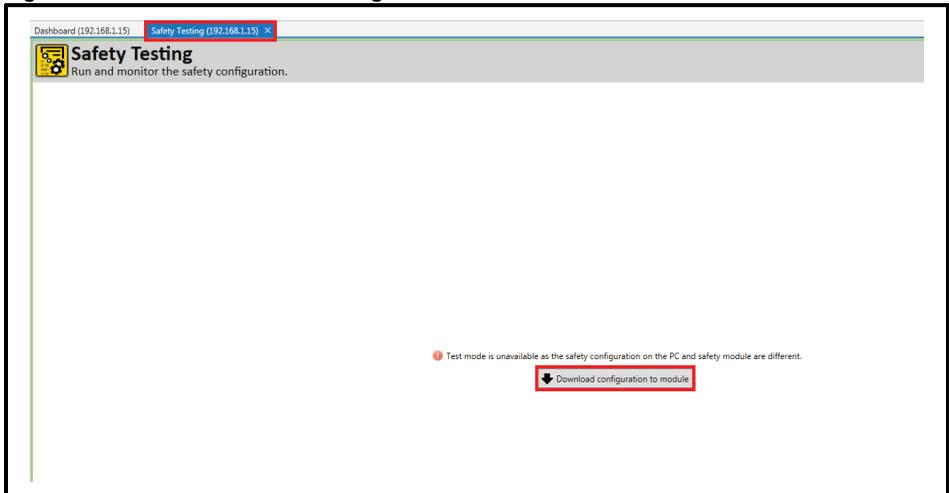
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Figure 4-49   Select "Test"

Figure 4-50   Select "Enter Test Mode"

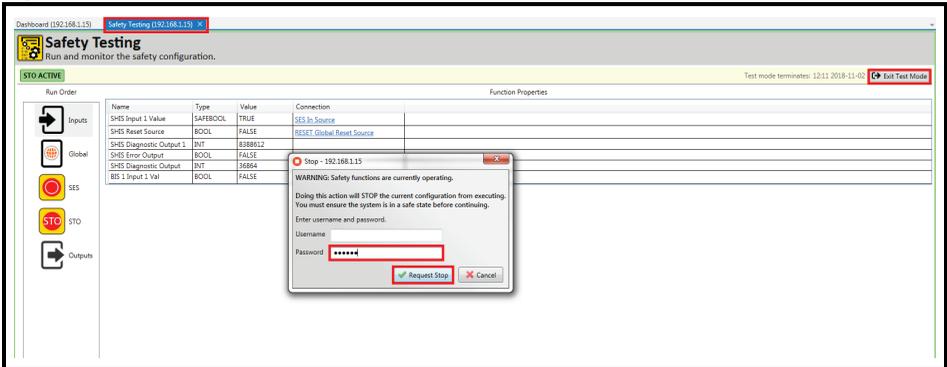
In Test Mode the configuration is running and updating values can be viewed. In this workflow asserting an input on SHIS 2 and instigating a reset on BIS 1 causes the STO to become inactive and therefore allowing the drive to run.

Figure 4-51   In Test Mode
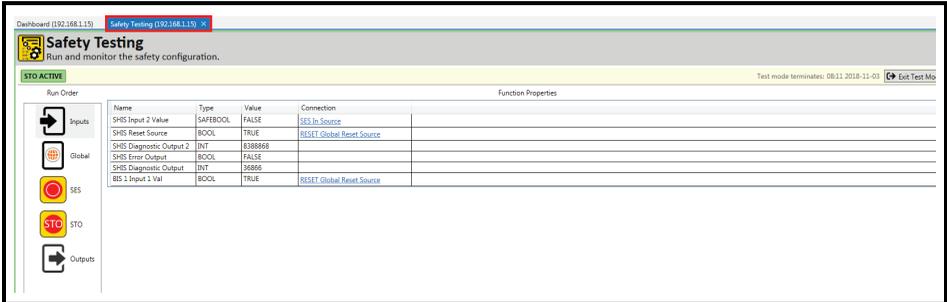
Figure 4-52   Select "Exit Test Mode" enter Credentials then click "Request Stop"

Read the value displayed in menu 17.012 on the drive's display and enter it as prompted, then click "STOP".

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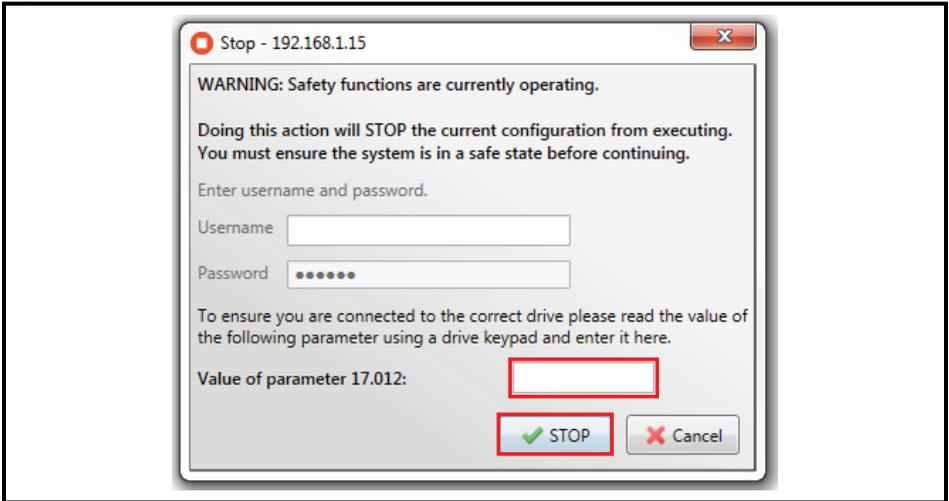
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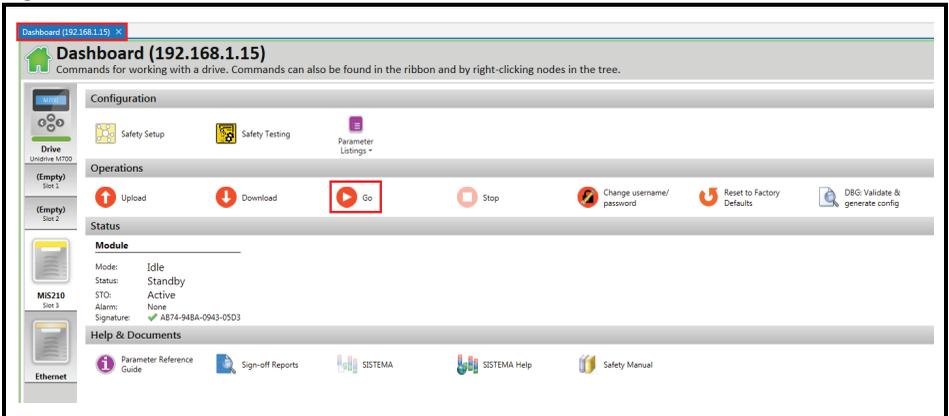Version Control (Amendments)

Figure 4-53   Enter Parameter Value
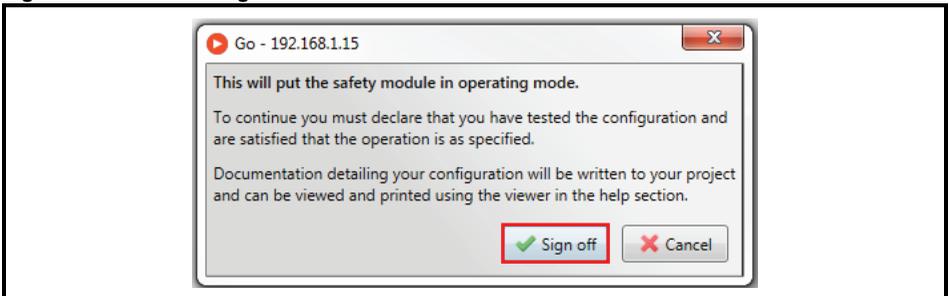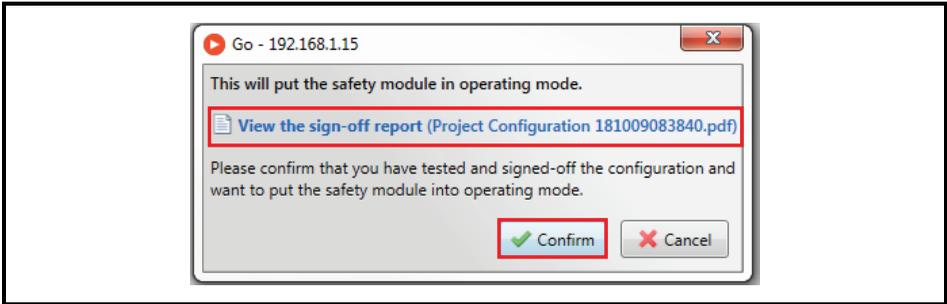

Figure 4-54   Select "Go"

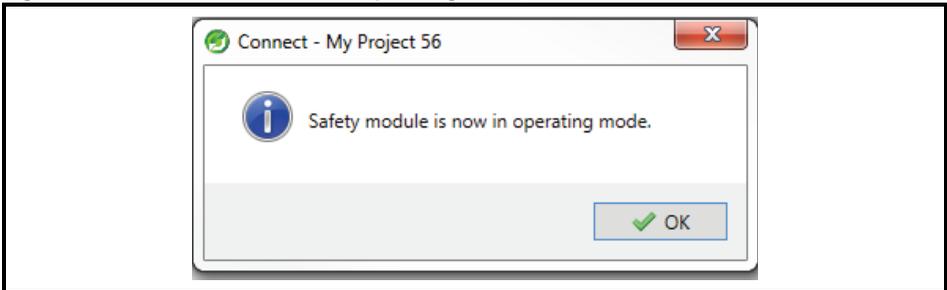**Figure 4-55   Select "Sign off"**

Click on the link to view the sign-off report, then if you have tested and signed off the configuration select "Confirm" to enter operating mode.

Figure 4-56   Confirm the Configuration, select "Confirm"

Figure 4-57   The MiS210 is now in Operating Mode, click "Ok"

4.2.3   Test a Configuration

In this workflow a configuration resident on the MiS210 is tested.
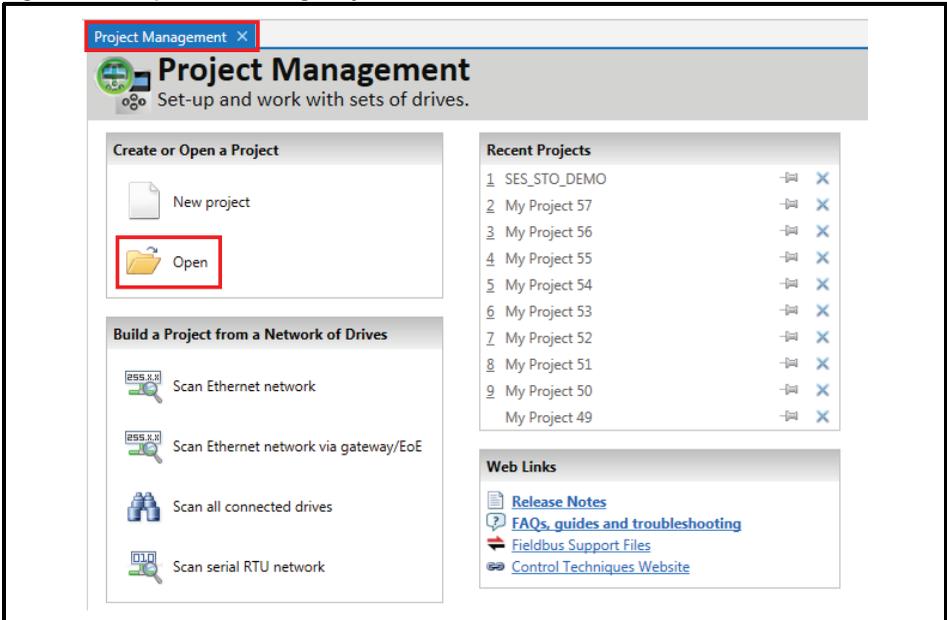
Figure 4-58   Open an Existing Project

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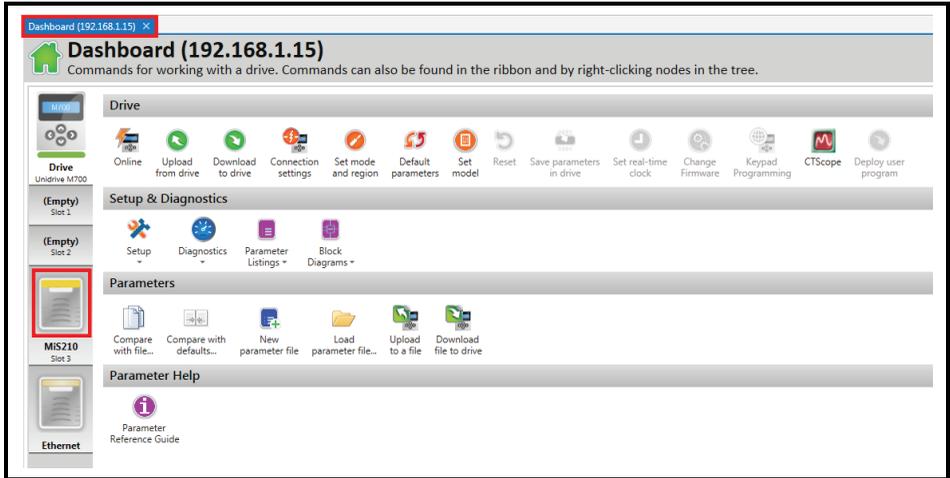Technical Safety Features

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Figure 4-59   Select the MiS210

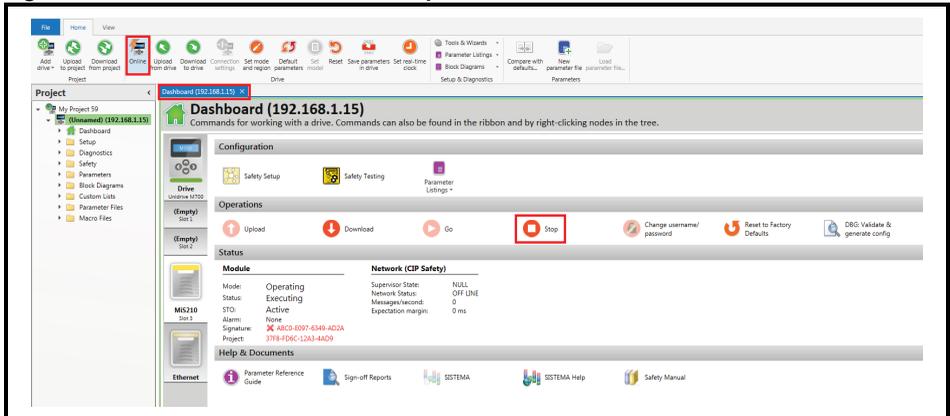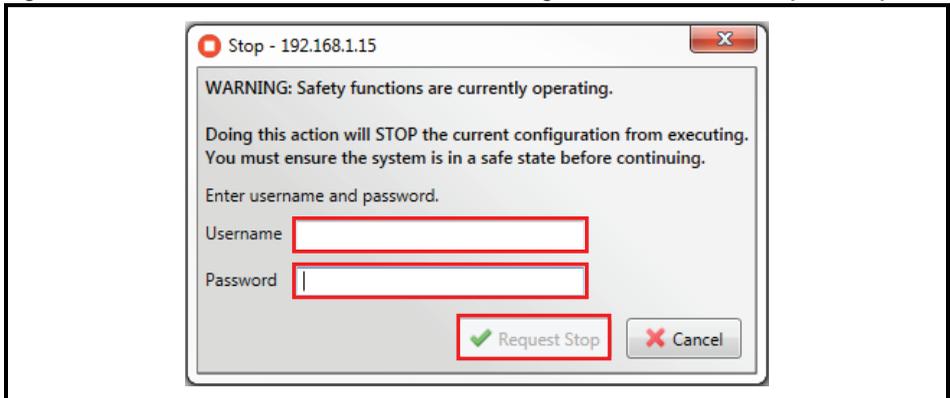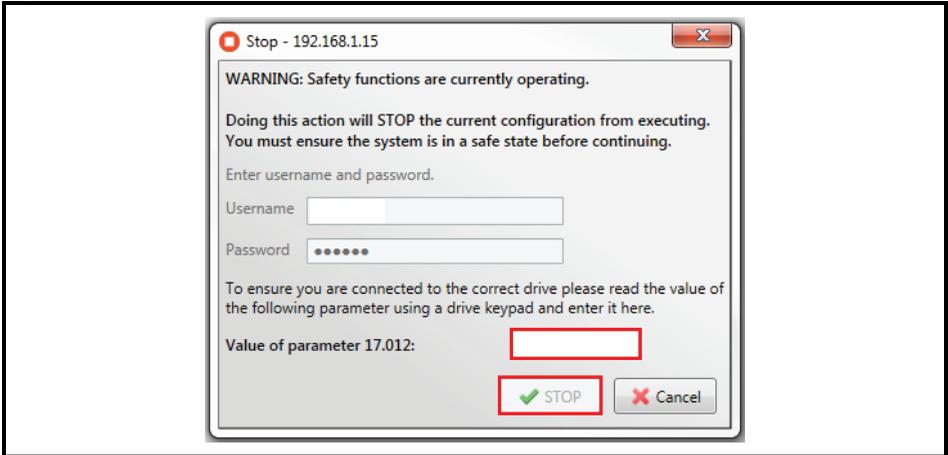**Figure 4-60   Go "Online" and Select "Stop"**

Figure 4-61   Enter Credentials associated with Configuration and Select "Request Stop"

Read the value displayed in menu 17.012 on the drive's display and enter it as prompted, then click "STOP".

Figure 4-62   Enter Parameter Value and Select "Stop"

Figure 4-63   Select "Safety Testing"

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Figure 4-64   Select "Enter Test Mode"

In Test Mode the configuration is running and updating values can be viewed.

Figure 4-65   In Test Mode

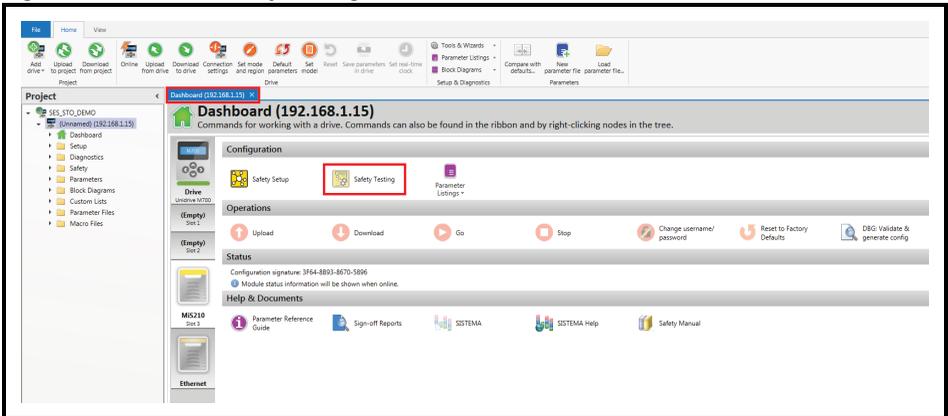**Figure 4-66   Select "Exit Test Mode" enter Credentials then click "Request Stop"**

Read the value displayed in menu 17.012 on the drive's display and enter it as prompted, then click "STOP".

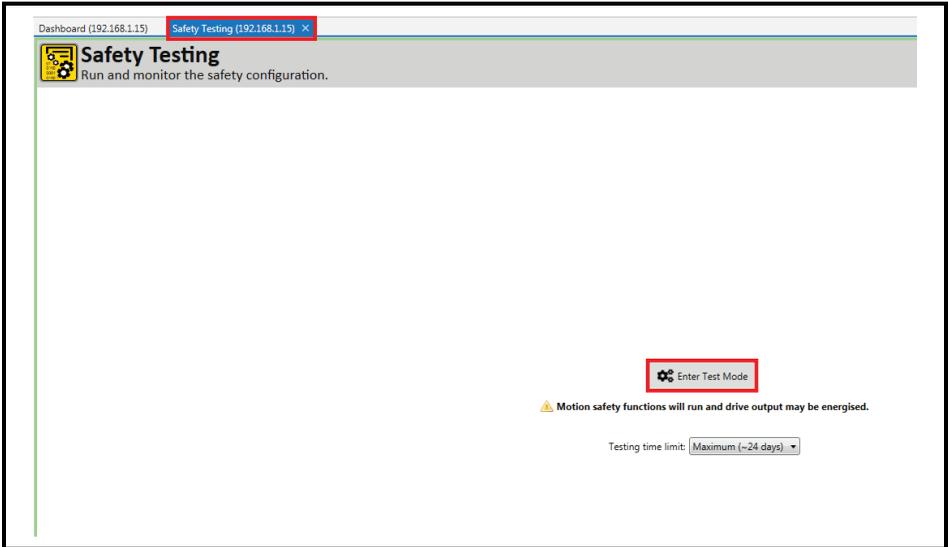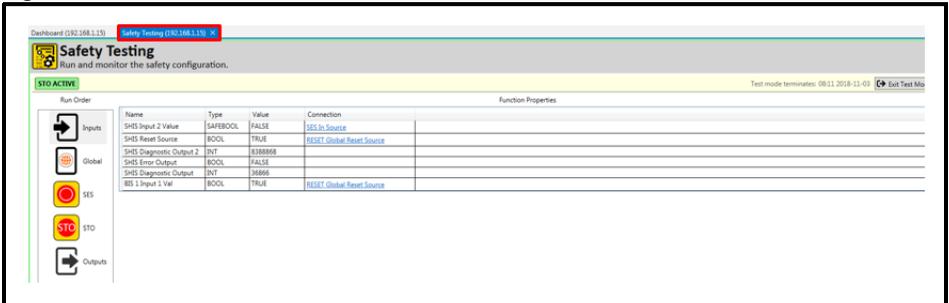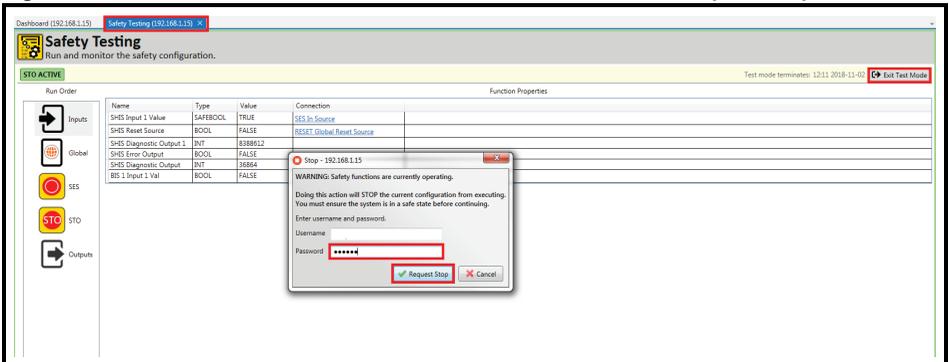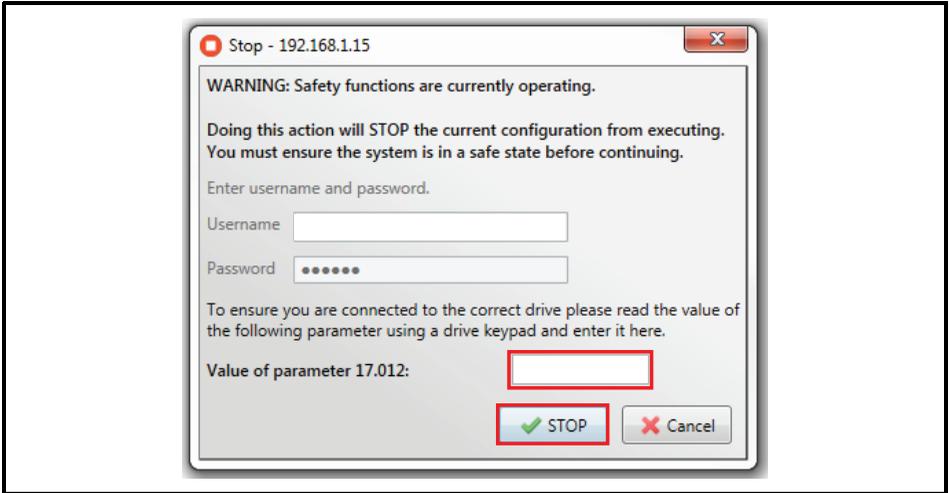**Figure 4-67   Enter Parameter Value**

Figure 4-68   Select "Go"
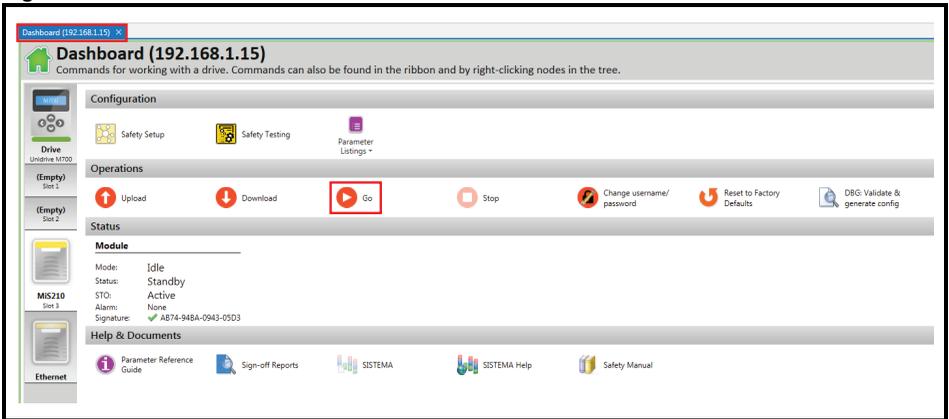
Click on the link to view the sign-off report, then if you have tested and signed off the configuration select "Confirm" to enter operating mode.

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Figure 4-69 Confirm the Configuration, select "Confirm"

Figure 4-70 The MiS210 is now in Operating Mode, click "Ok"
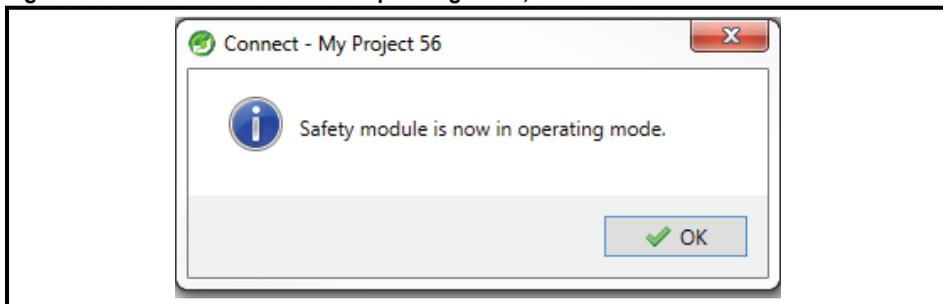
4.2.4 Remove a Configuration

In this workflow an existing configuration is deleted from the MiS210 module. This may be necessary if the user has lost their credentials.

Figure 4-71 Scan the Network
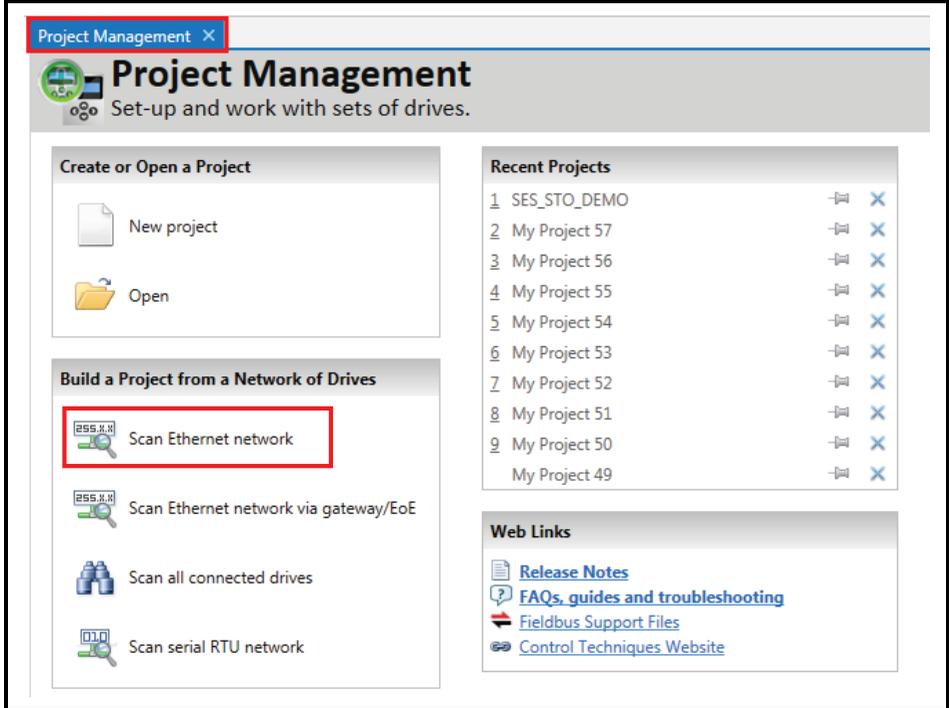
Figure 4-72 Select the MiS210

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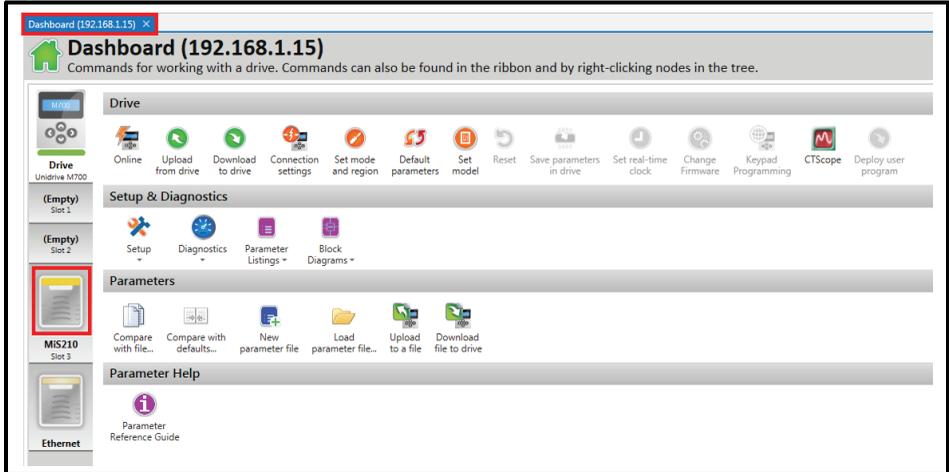
Figure 4-73   Go Online, Select Reset to Factory Defaults

Click yes to confirm that you wish to stop the safety functions and reset the MiS210 to factory defaults.

Figure 4-74   Select "Yes" to Stop the MiS210
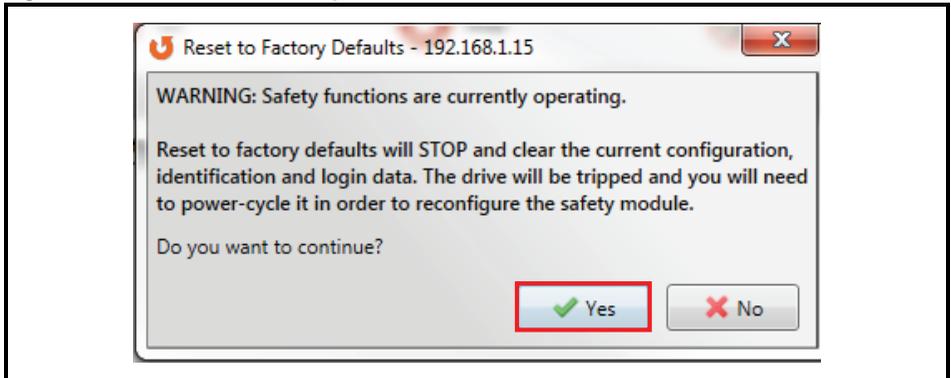

Read the value displayed in menu 17.012 on the drive's keypad and enter it as prompted, then click Reset.

Figure 4-75   Enter Parameter Value and Select "Reset"
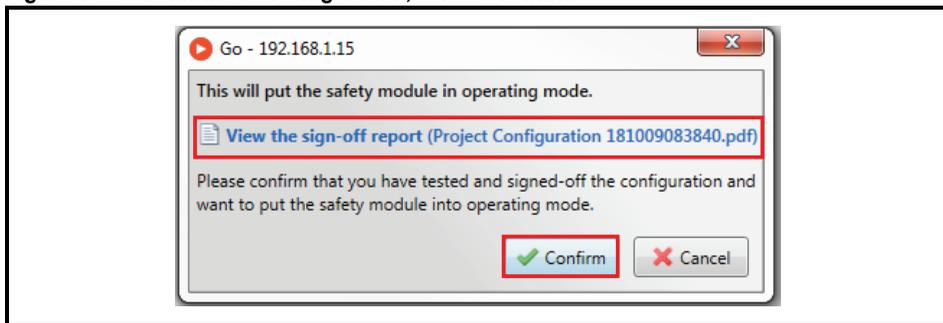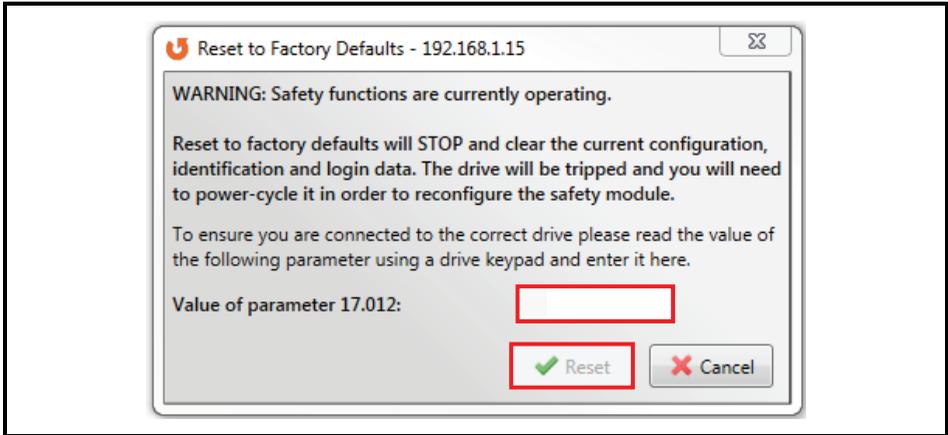

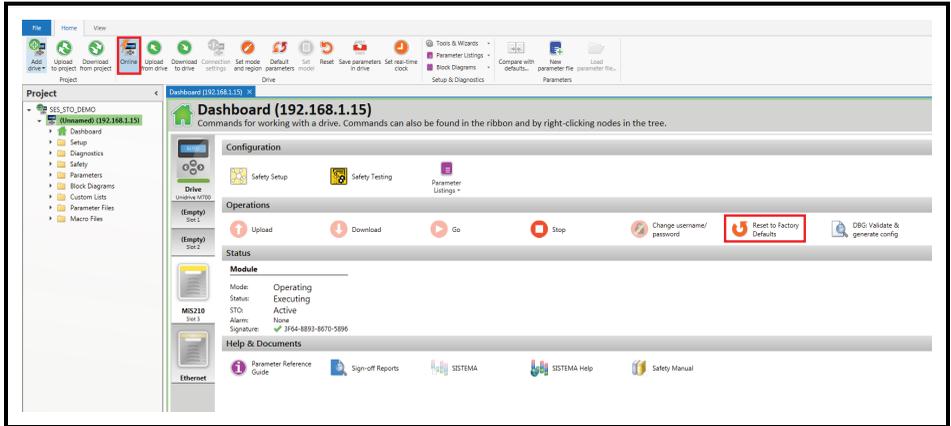The drive must be power-cycled before continuing. Once power-cycled and communications has restored between the MiS210 and Connect, then click Yes.

Figure 4-76   Select "Yes"

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Figure 4-77   Enter New Login Details and click "Continue"

Read the value displayed in menu 17.012 on the drive's keypad and enter it as prompted, then click OK. The MiS210 has now been reset to factory defaults.

Figure 4-78   MiS210 now Reset and Identified click "Ok"
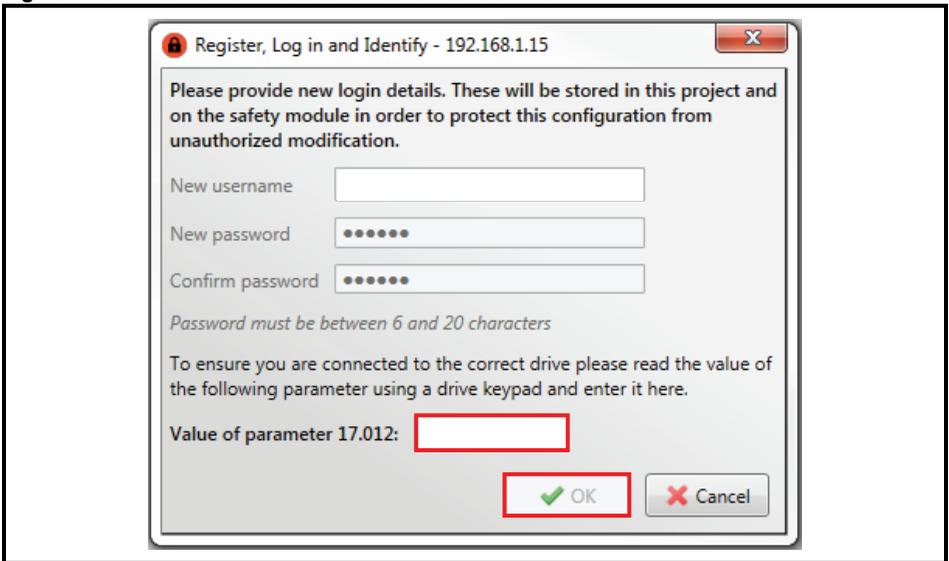
4.2.5 Recover a Configuration

In this workflow we wish to recover an original configuration from the MiS210, the user login details are known but the original Connect project is unavailable.

Figure 4-79   Scan the Network
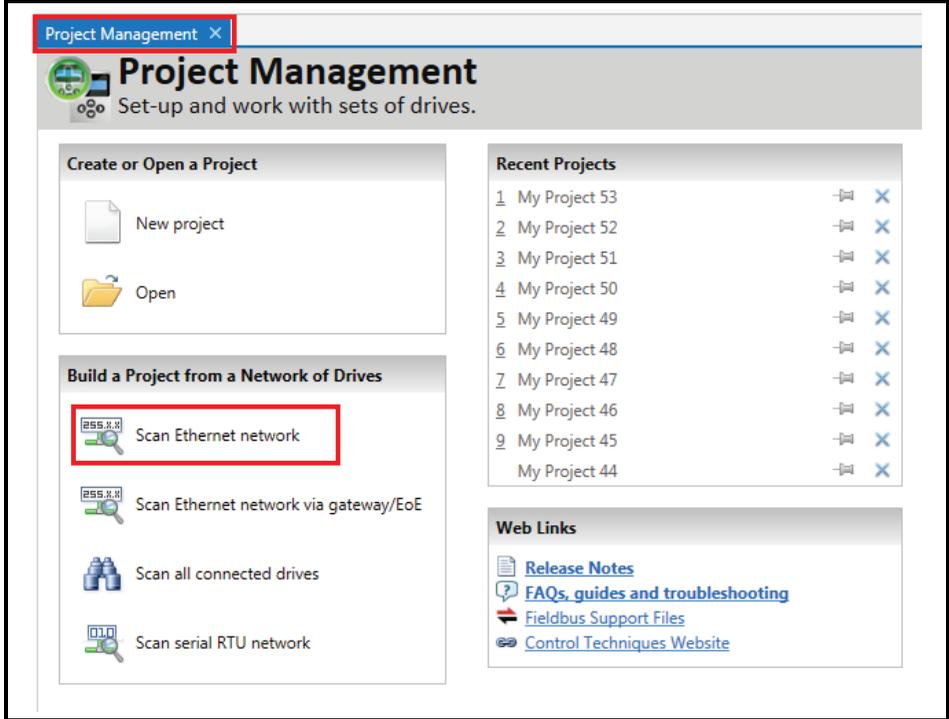
Figure 4-80   Select the MiS210

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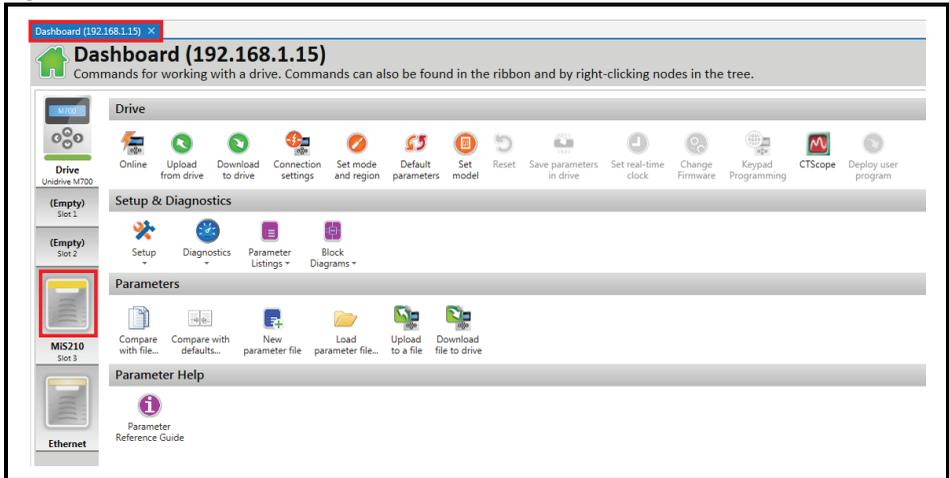
Figure 4-81   Go Online then Select "Stop"

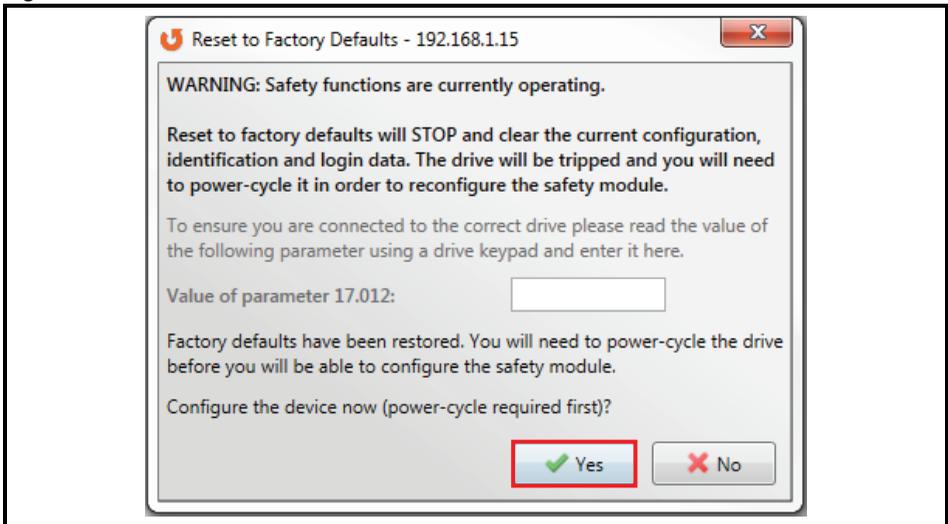**Figure 4-82   Enter existing Credentials and Select "Request Stop"**

Read the value displayed in menu 17.012 on the drive's keypad and enter it as prompted, and then click Stop.
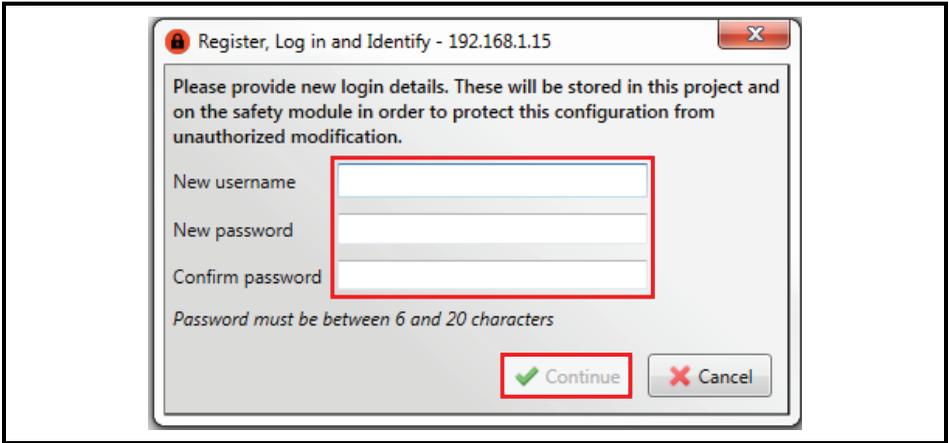
Figure 4-83   Enter Parameter Value and Select "Stop"

Figure 4-84   Select "Upload"

Figure 4-85   Select "Yes"

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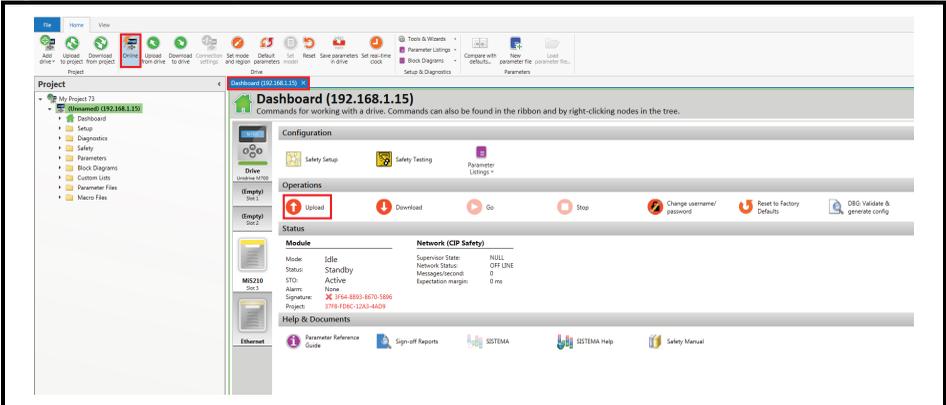
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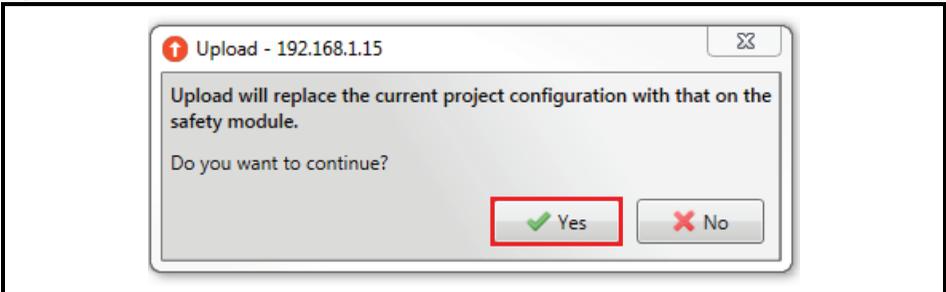
Figure 4-86   Enter New Login Details and then Click "Log In"
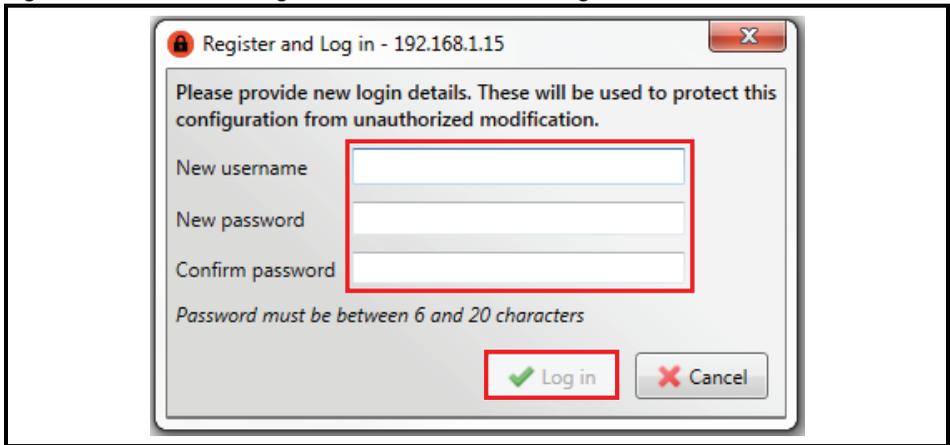
Figure 4-87   Configuration from MiS210 is now loaded into the current Connect project, Click "Close"
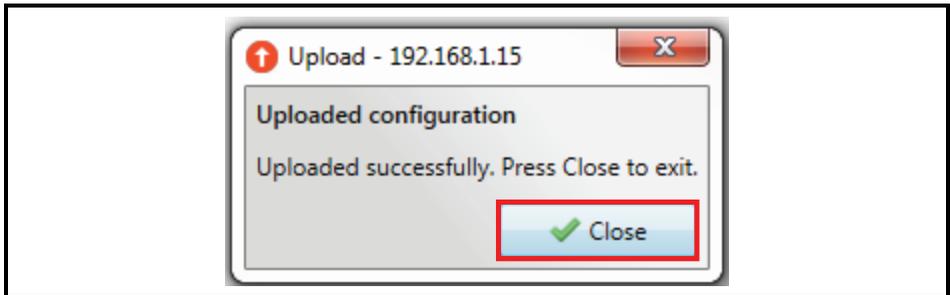
To begin the process of reloading the configuration to the MiS210 see the following steps.

Figure 4-88   Go Online, Select Reset to Factory Defaults
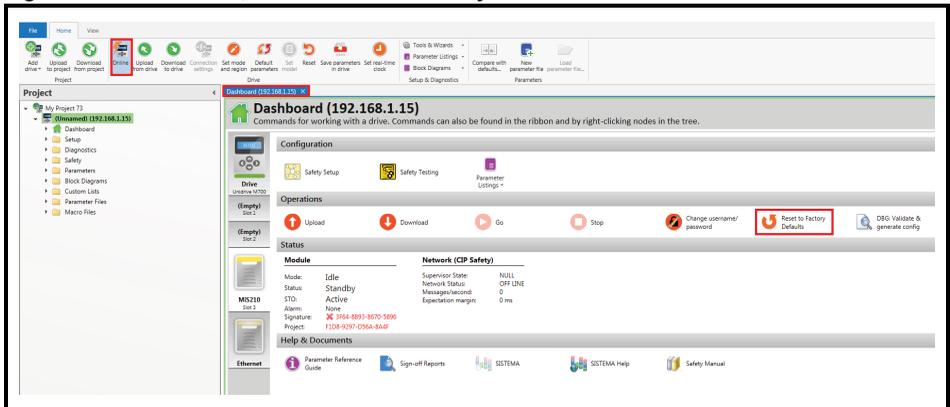
Figure 4-89   Select "Yes"
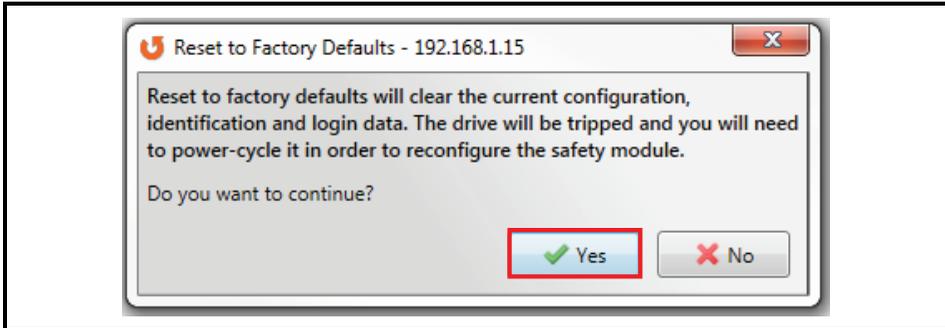
Read the value displayed in menu 17.012 on the drive's keypad and enter it as prompted, then click Reset.

Figure 4-90   Enter Parameter Value and Select "Reset"
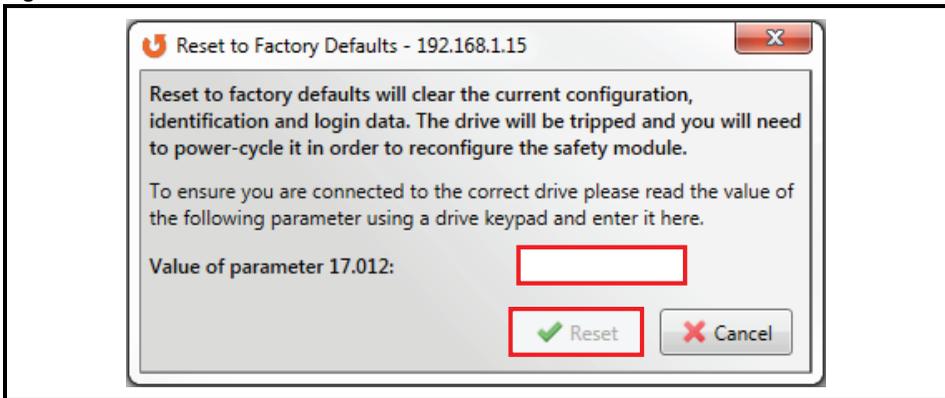
Power cycle the drive, then once communications has been re-established, click "Yes".

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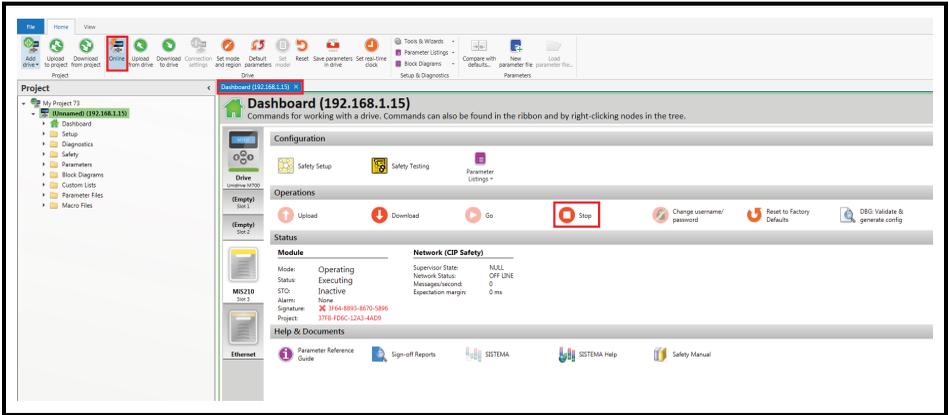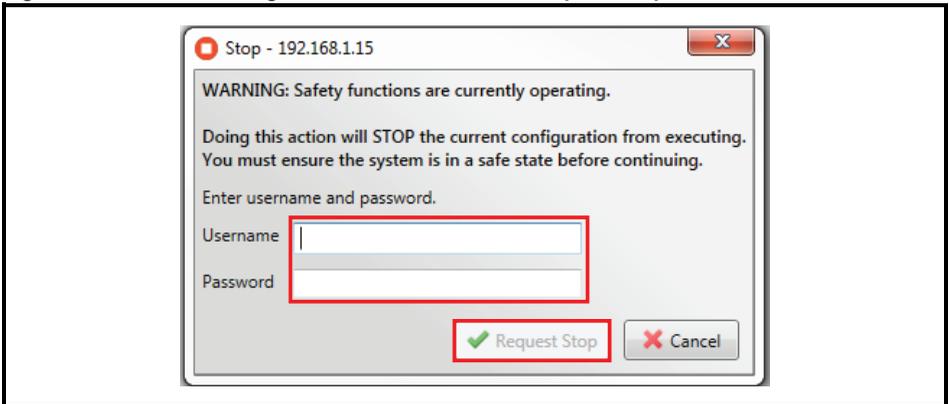Version Control (Amendments)

Figure 4-91   Select "Yes"
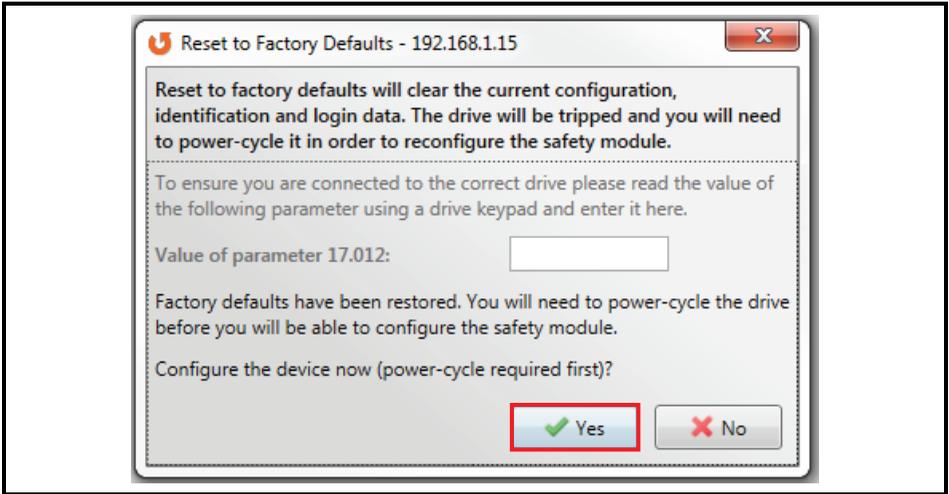
Figure 4-92   Enter New Log In Details and Select "Continue"
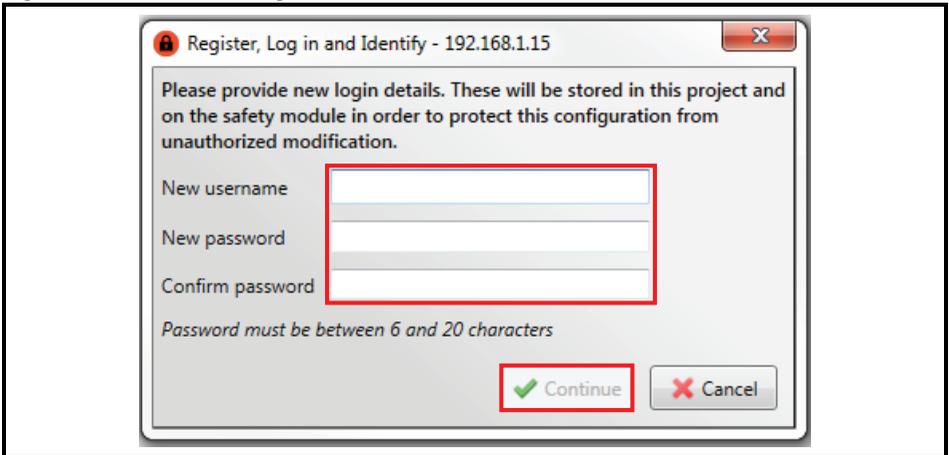
Read the value displayed in menu 17.012 on the drive's keypad and enter it as prompted, and then click OK.

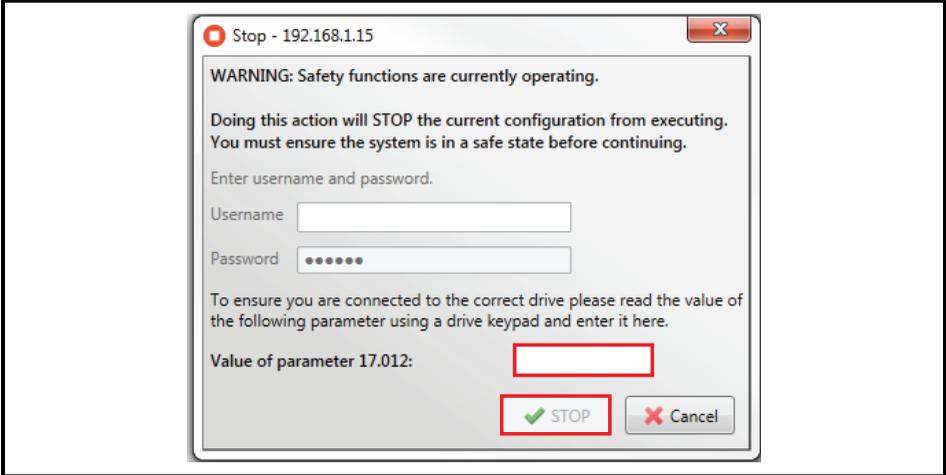**Figure 4-93   Enter New Log In Details and Select "Continue"**
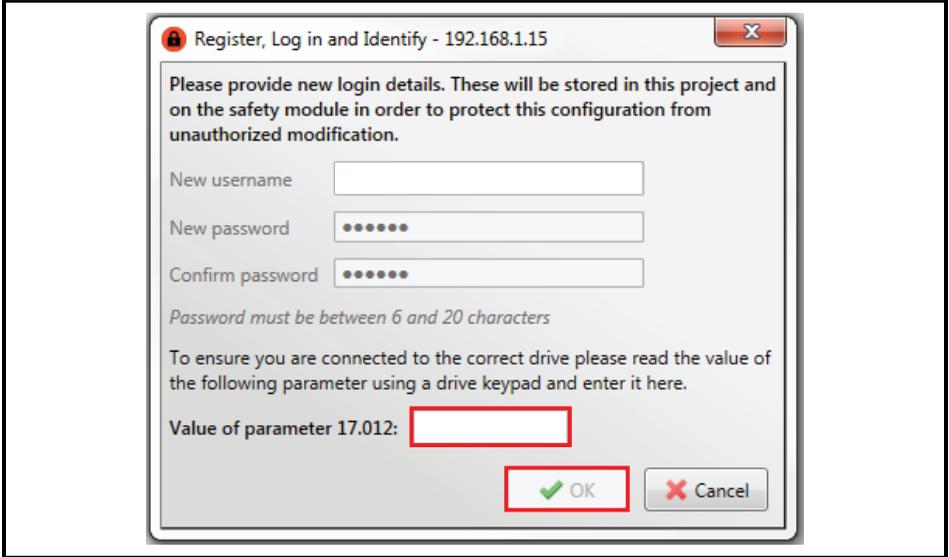
Figure 4-94   Select "Download"
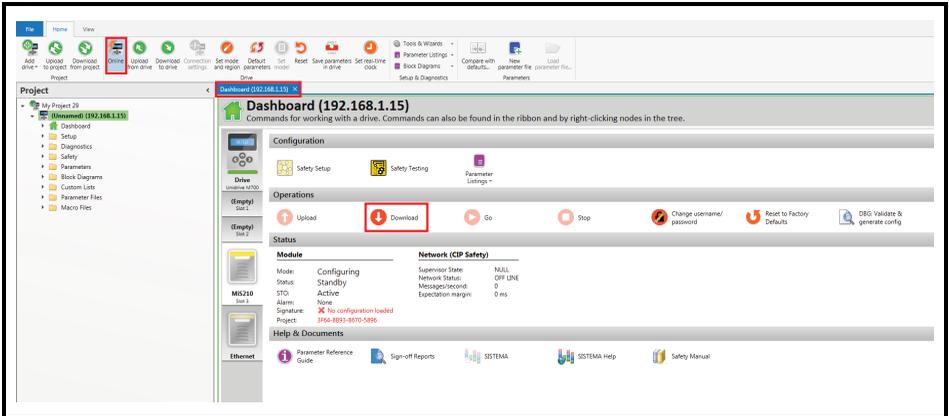
Figure 4-95   Select "Yes" to Confirm Download

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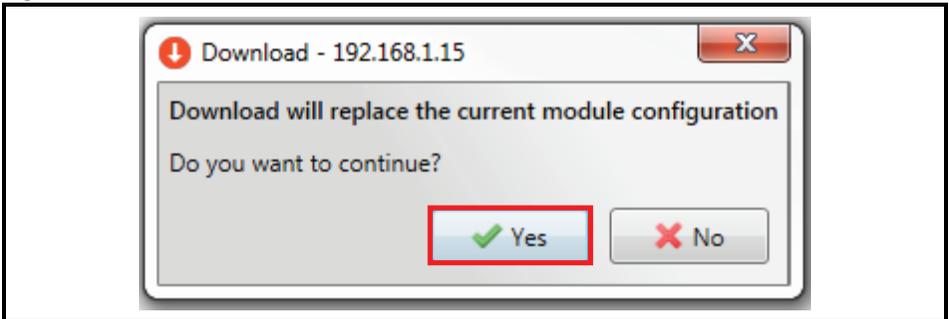
Figure 4-96   Check Details of Download and Select "Sign-off"
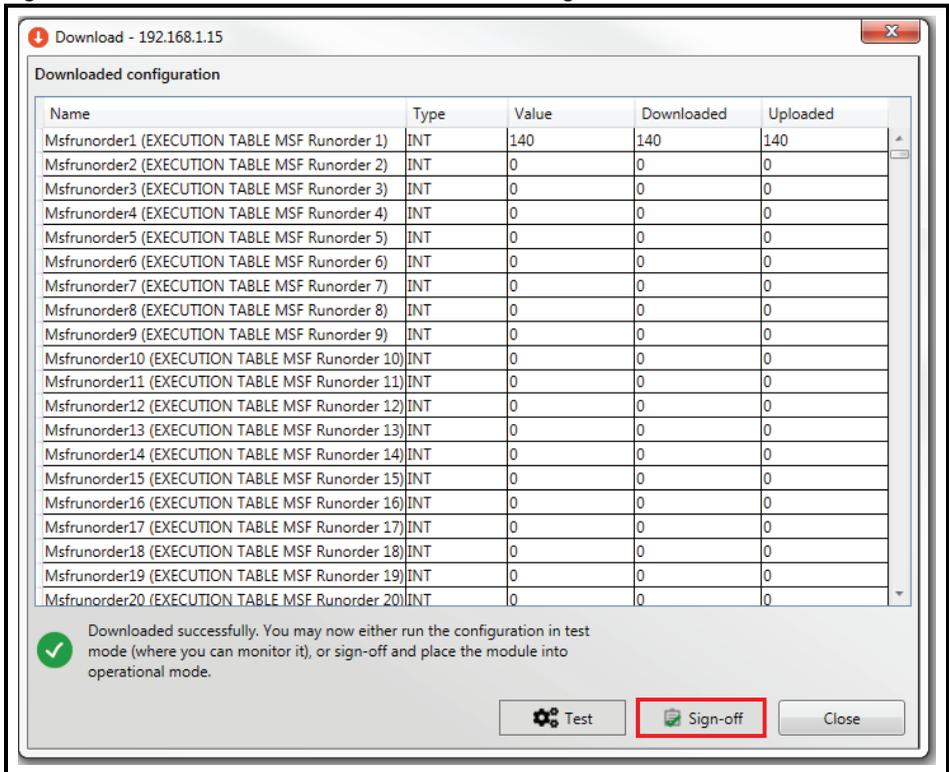
Figure 4-97   Select "Sign-off"
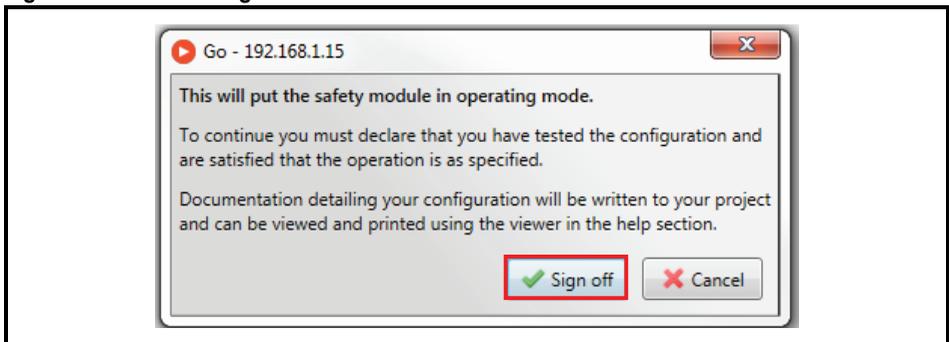
Figure 4-98   Select "Confirm"
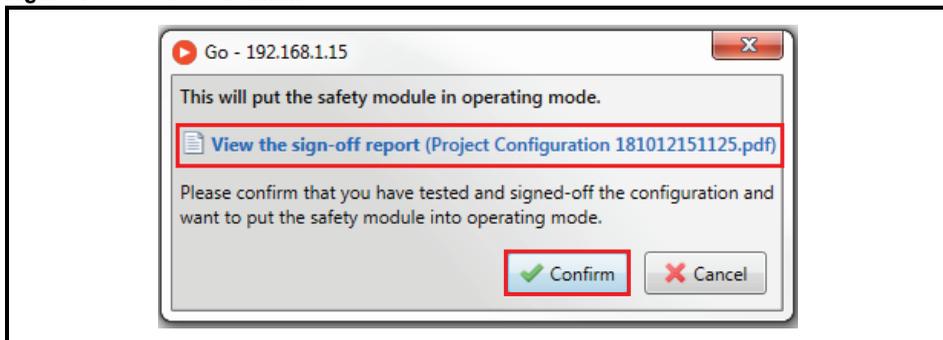
Figure 4-99   MiS210 is now in Operating Mode, Select "OK"

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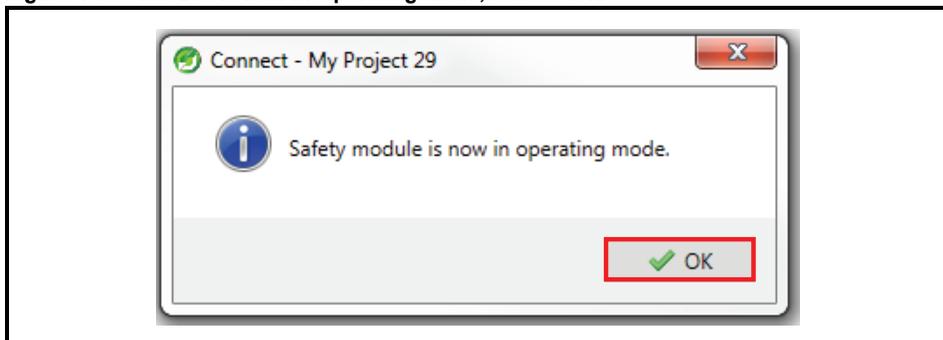
4.3   Configuration – Introduction

The MiS210 Safety Module is a safety controller designed to be attached to a drive as a plug in module. MiS210 Safety Module is safety network capable and can communicate with a single safety device that is a CIP Safety originator. The illustration below shows how the parts of it fit together.

Figure 4-100   MiS210 Safety Module System
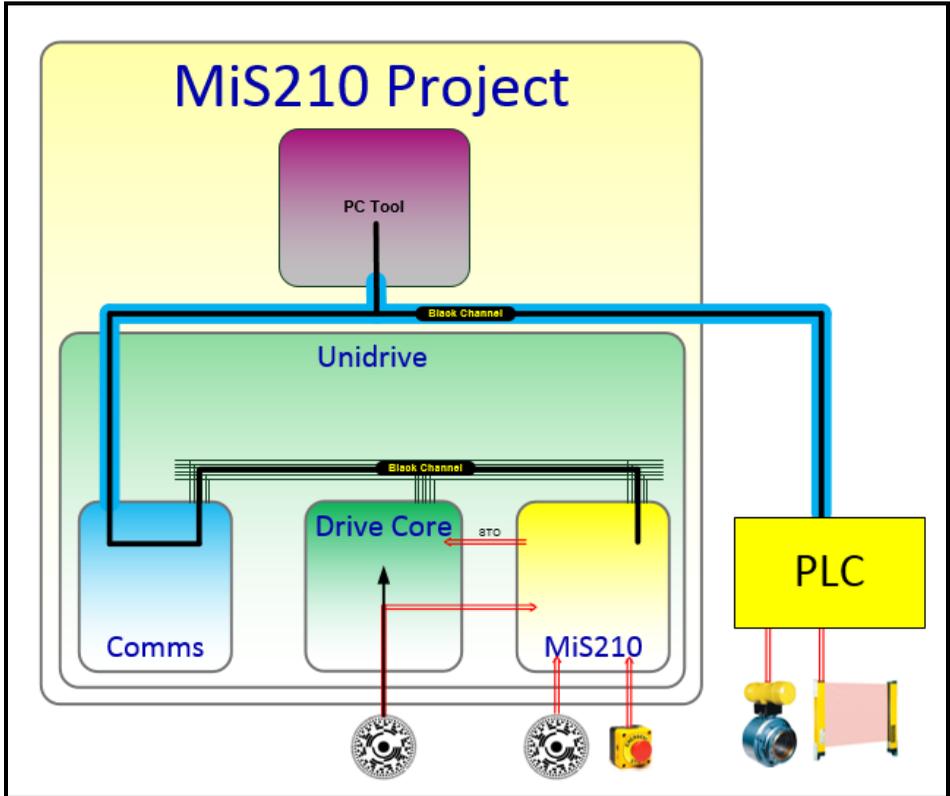
The MiS210 Safety Module implements a configurable safety system, all of the software functions are pre-existing in the firmware and these functions can be turned on and off using Connect.
The functions can then be linked together using source selectors and have functionality determined with attributes.

There are inputs and outputs that cross the boundary of the MiS210 Safety Module and there are also inputs and outputs to functions. To clarify this "Hardware Input/Output", "Network Input/Output" and "STO Output" are used for I/O that crosses the MiS210 Safety Module boundary and "Function Input/Output" is used to describe the inputs and outputs to and from functions.

4.3.1 Input Selectors and Connection Points

To allow the user to make interconnections between function blocks all "Function Outputs" have one or more connection points and all "Function Inputs" have an input selector that is used to select where the function input comes from. Function blocks also have attributes that are set at design time in Connect.

Figure 4-101   Safety Function showing Input Selectors, Attributes and a Connection Point
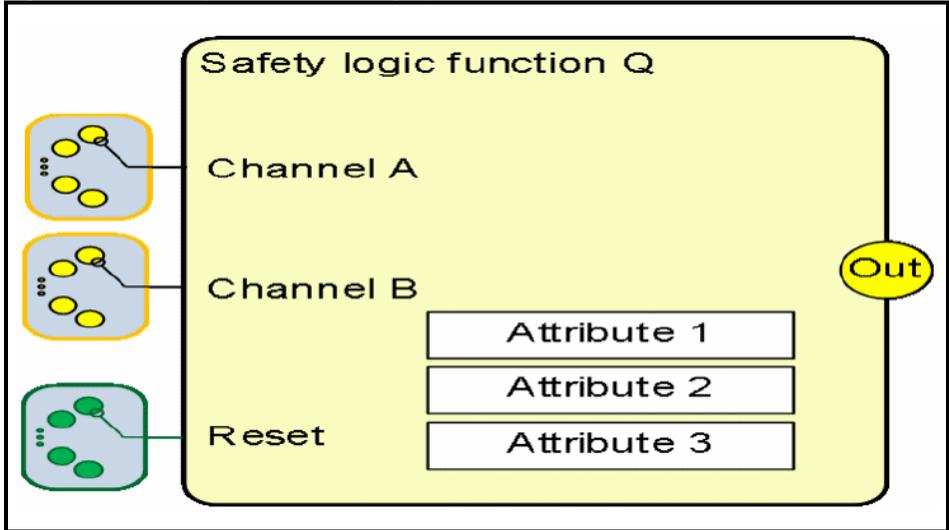
Some functions will have a reset feature, and thus will have an input called Reset and up to 2 attributes called StartReset and AutoReset. These functions will always have at least 1 output which it will hold at safe-state (FALSE) until it is reset. When the function is reset it will evaluate its safety inputs and set its output to TRUE if the safety input state evaluates to operational.

4.3.2 Categories of I/O

A Primary Function Input is one that if its function instance is activated it must be connected to a suitable connection point or set to a constant.

A Primary Function Output is one that its function instance is activated it must be selected by a safe input selector.

A Secondary Function Input is the same as a Primary Function Input except that it may be explicitly disabled.

A Secondary Function Output is the same as a Primary Function Output except that it may be explicitly disabled, by a function attribute. If the connection point is disabled it must not be connected.

Tertiary Function Inputs and Outputs are ones which may be left disconnected.

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4.3.3 Motion Safety Functions

Motion Safety Functions are divided into 3 distinct categories, Input Functions, Logic Functions and Output Functions this is illustrated below.

Figure 4-102   Diagram showing the 3 function categories
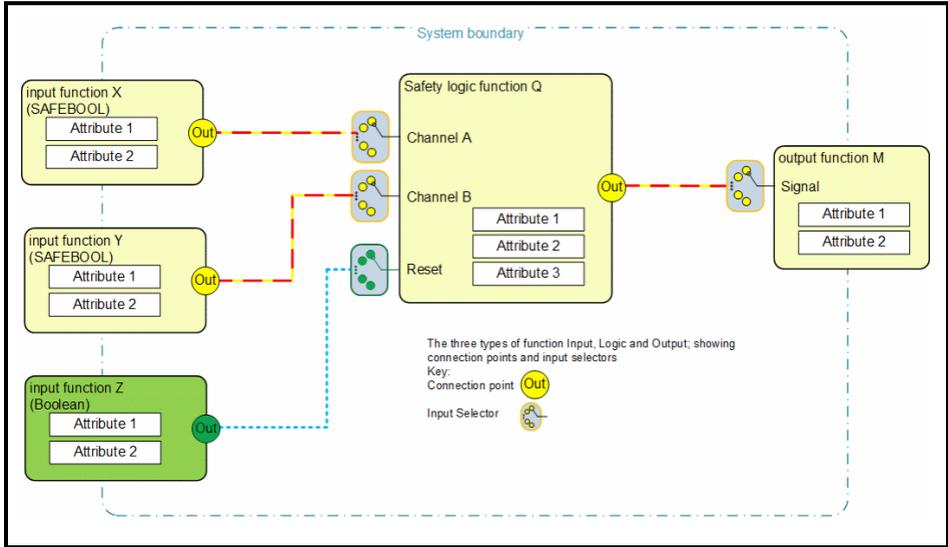
Function Type	Has Input Selector(s)	Has Connection Point(s)	Has Attributes
Input	NO	YES	YES
Logic	YES	YES	YES
Output	YES	NO	YES

All function instances have an activation attribute, if this is FALSE the function is not evaluated and all its attributes and selectors are set to a default value. Any safe outputs that the function has are set to FALSE. If it is TRUE and it is correctly configured the function is evaluated and the outputs set according to its internal algorithm. In Connect the act of selecting a function sets the activation attribute to TRUE.

4.3.4 Diagnostic Codes

Some Motion Safety Functions produce diagnostic codes and these are individually detailed in the menu for each function, see section 8 *Motion Safety Function Details*. Each diagnostic code is 16 bits in length and the top nibble is a bit field with 2 flags and a 2 bit code, the lower 12 bits (11-0) are function dependent.

Bit Number	Value	Description
15	0	Function is Deactivated
	1	Function Activated (state of bits 14-0 undefined)
14	0	No Error Detected
	1	Error Detected (an error may lead to an alarm)
13 & 12	00	Instance operating with single state machine or is in common part of branched state machine, or is in error.
	01	Instance operating in branched part of state machine
	10	Multiple state machines in instance with no common part (no errors are generated by function).
	11	RESERVED

Bit 15	Bit 14	Bit 13	Bit 12	Hex Value	Description
1	0	0	0	0x8	Unbranched state machine in operational state.
1	0	0	1	0x9	Activated, operating with state machine branched (e.g. function has multiple outputs which may be in different states).
1	0	1	0	0xA	Activated, with multiple independent state machines, no errors are generated by this function.
1	0	1	1	0xB	Reserved
1	1	0	0	0xC	Error State (0xD and 0xE would also be error state but never occur as errors are always common to whole instance).

4.3.5 Menus

There are 2 types of menu associated with the MiS210 Safety Module.

4.3.5.1 Module Menu

This is a single menu presented as part of the drive menu system in menu 17 on M600, M700, M701 and M702 drives.

The module menu contains status and diagnostic information for the MiS210 Safety Module none of these parameters are safety relevant and are all visible using Connect and the drive keypad.

Menu	Menu Name	Description
17	Module Menu	This menu is always visible using standard communications and via the keypad. It contains diagnostics, non- safe I /O and message transfer.

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4.3.5.2 Global Menus

These are the menus numbered between 1 and 10, they contain safety relevant data used to set up the module, its encoder access, safety network and function execution order.

Menu	Name	Description
0		Not used
1	Function Execution	This menu contains the list of executed logic functions in the order (starting at 1) determining the execution order. The order is determined by Connect such that there will be no scan delays for any single chain. There is an absolute limit of 100 active logic functions in MiS210 Safety Module. Input and output functions if active are always updated at the start and end respectively of each cycle and they are not included in this list.
2		Not used / Reserved
3	Encoder Set-up	Module encoder set-up, copy of Drive encoder set-up, Encoder selection
4		Not used / Reserved
5		Not used / Reserved
6	Module Configuration	Details for configuring the module (e.g. scan rates, etc.)
7	Network Configuration	Details for configuring the safety network
8		Not used / Reserved
9		Not used / Reserved
10		Not used / Reserved

4.3.6 Safety Configuration System Data Types

The following data types will be supported by the MiS210 Safety Module. Ordinary (non-safe) types are a subset of those defined in IEC 61131 part 3.

Type Name	Description
SAFEBOOL	This safe Boolean type is accepted by safety function safe inputs and is produced as the safe output of safety functions. The values from safe Boolean hardware inputs are of this type and safe hardware outputs accept this type.
SAFEINT	A custom type for representing 32-bit integers that is subject to additional safety checking. Introduction of the type clarifies the fact that the type is safety specific and of course allows type checking as it does for the SAFEBOOL. For certain functions they will also be configurable inputs (variables) for instances where an adjustable speed (or some other) limit is required.
BOOL	The standard IEC61131-3 Boolean data type, provided for things like function reset, diagnostics and monitoring.
INT, DINT	16 & 32 bit signed integers as defined in IEC61131-3, these will be used as constant function attributes (non-configurable inputs).
WORD	A bit field with a width of 16 bits used for diagnostic output only.
Selector	A specialized integer type for function input selection, based on a 32 bit unsigned integer. Values < 1000 are used to represent constants and other features: • 0 is often the default and has a special meaning: selector not set, this is an illegal value in the consistency test and is used to ensure that the designer makes a decision about the function input. • 1 to 999 other values are defined on a per function basis. Values > 999 have a specific decimal format (MMIPP)

5   Installation

5.1   General Installation Notes

Always follow the safety instructions during installation.

The module must be installed in an IP54 or greater rated enclosure.

Route all signal cables separately for activation of digital inputs and contact monitoring purposes.

In all cases separate Non ELV voltages from ELV, SELV and PELV lines, if these voltages are being used in conjunction with this application.

Cable lengths for digital inputs and outputs should not exceed 30 m. Where cable runs exceed 30 m, take appropriate action to exclude the possibility of faults resulting from un-authorized overvoltage levels. Such action may include avoidance of lightning conductors on external wiring, overvoltage ('spike') protection in internal areas, protected cable routing, i.e. shielding.

The encoder PSU cable should be shorter than 30 m and should not leave the building and should not be connected to a distributed power network.

Measures relating to electromagnetic compatibility (EMC).
The MiS210 Safety Module is intended for use in a Unidrive-M600, M700, M701 or M702 environment and complies with the aforementioned EMC requirements provided it is installed as per the instructions in this manual.

> ⚠ **WARNING**
>
> - All signal wires (IO, encoder etc.) connected to the MiS210 Safety Module must be enclosed in shielded cables and the shield of the cable connected to 0 V of the MiS210 Safety Module (via a short wire) **AND** the earthed A frame of the Unidrive. The preferred connection method to the A frame is to remove the outer insulation of the shielded cable and then tie the cable to the A frame with a cable tie so that the exposed shield makes direct contact with the A frame.
> - If there is not a direct connection between the A-frame and one of the drive's 0 V terminals (i.e. not MiS210) then a short wire connection between a 0 V terminal on the drive's IO port and the A-frame must be made. The direct connection between the A-frame and one of the drive's 0V terminals is often provided by a screened cable going to the drive's IO terminals or encoder port.
> - When using an Encoder Power Supply Splitter cable with or without Sin Cos the shielded connector connecting to the encoder cable should be bonded to earth e.g. the backplane the drive is mounted upon.

It is a prerequisite that the entire system and components conforms to the EMC Directive. The user is responsible for the installation and configuration of the MiS210 Safety Module and must be a competent safety engineer as they need to ensure that the function specified in the configuration is correct for the application needs.

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> **⚠ WARNING**
> - Refer to the drive manual for details on power cabling routing and protection.
> - Always use shielded cabling when connecting position/speed sensors. The cable used to transmit signals must be compatible with the RS-485 standard (twisted pair wiring).
> - Ensure that all the inverter technology installed in the vicinity of the module is EMC compliant. Pay careful attention to the cable routing and the processing of shielding for the motor wire and connection of the brake resistor. Always ensure compliance with the installation guidelines of the inverter manufacturer.
> - If the MiS210 is not a new and unused part, any existing configuration should be cleared before the device is used or connected onto a safety network. This can be done by performing a Factory Reset.
> - If the MiS210 is to be connected to a Safety Network, carefully consider implications of mixing different SIL level devices on the Network.
> - Do not update the Drive Firmware while the MiS210 is in Operating or Configuring Mode as this will result in a failure which will require a power cycle.

5.2   Mounting on the Drive

> **⚠ WARNING**
> - The module must be electrically isolated and have a disconnected power supply during installation work.
> - The control circuits are isolated from the power circuits in the drive by basic insulation (single insulation) only. The installer must ensure that the external control circuits are insulated from human contact by at least one layer of insulation (supplementary insulation) rated for use at the AC supply voltage.

5.2.1   M600, M700, M701 and M702

On these drives there are 3 option module slots available. The MiS210 Safety Module can only be connected in slot 3 as this provides the direct connection to the drive Safe Torque Off (STO) through the blade connector. Attempting to fit the MiS210 Safety Module into any other slot may cause physical damage to the module.

The MiS210 Safety Module checks that the Drive Software is greater than V01.16.00, as this is the minimum version that allows the drive encoders to be read.

Drive Date Code must be greater than 1807 to be compatible with the MiS210 Safety Module.

5.2.2 Physical Connection

Place the front of the MiS210 Safety Module under the locating clip on the drive and then push down the blade, refer to MiS210 Instruction Sheet (0478-0515-02).

Figure 5-1 MiS210 Safety Module Fitted to an M700
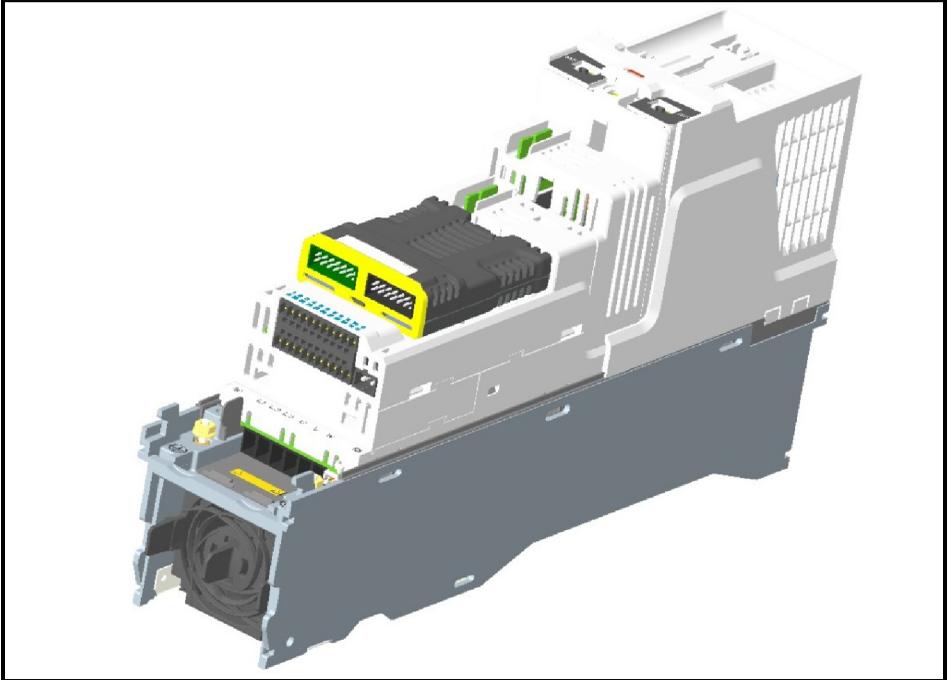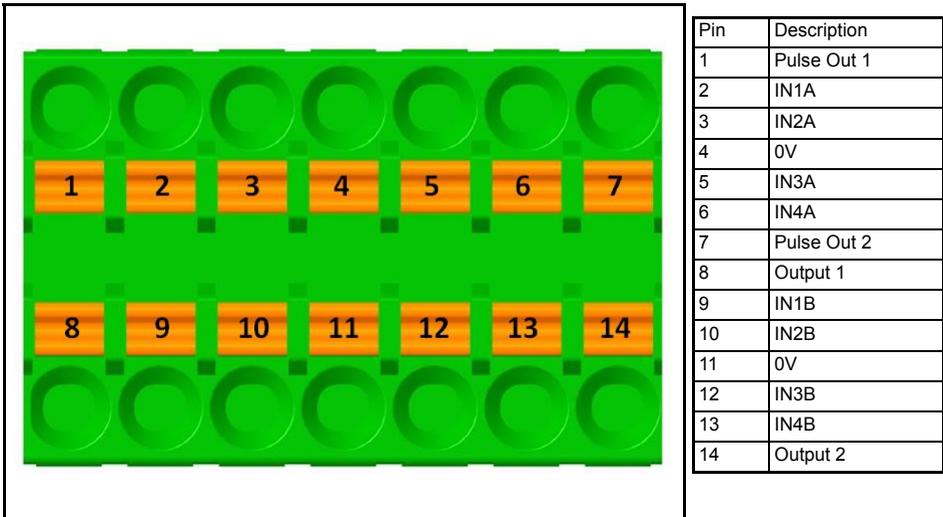
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5.3 Connection of Digital IO

The diagram below shows the digital IO connector for the MiS210 Safety Module.

Figure 5-2   MiS210 Local Digital IO Connector

Pin	Description
1	Pulse Out 1
2	IN1A
3	IN2A
4	0V
5	IN3A
6	IN4A
7	Pulse Out 2
8	Output 1
9	IN1B
10	IN2B
11	0V
12	IN3B
13	IN4B
14	Output 2

The MiS210 Safety Module Inputs and Outputs are classified in IEC 61800-3 2004 +A1:2012 Table 12 as "Ports for process measurement control lines Auxiliary DC Power ports below 60 V", and are configured using Connect. Approved OSSD outputs can be connected without restriction to the inputs. See section 10 *Technical Safety Features* for Key Technical Indicators.

The MiS210 Safety Module Inputs and Outputs do not guarantee surge protection therefore where cables exceed 30 m in length the user shall use screened cable with sufficient shielding effectiveness to prevent disturbance of the signals being conveyed or provide external surge protection.

Since the MiS210 Safety Module is controlling the drive STO directly, this means the STO inputs on the drive terminal are floating. Thus they should be left unconnected. If controlling the STO is not part of the safety system but the user wants to enable the drive they must configure the MiS210 Safety Module so that the STO output is always active.

For details of the diagnostic coverage of the IO see section 3.1 *Digital IO* on page 19.

> **WARNING**
>
> It may be necessary to protect or segregate the wiring because of a short-circuit from the input cable to a DC supply or a signal of > 5 V, which could cause the input to be enabled. Guidance can be found in ISO 13849-2.

5.3.1 Wiring for Input Pair with No Checking

The following diagram shows the wiring for a single pair of Safe Inputs being used without pulse checking.

Figure 5-3   Single Input Pair, No Pulse Checking
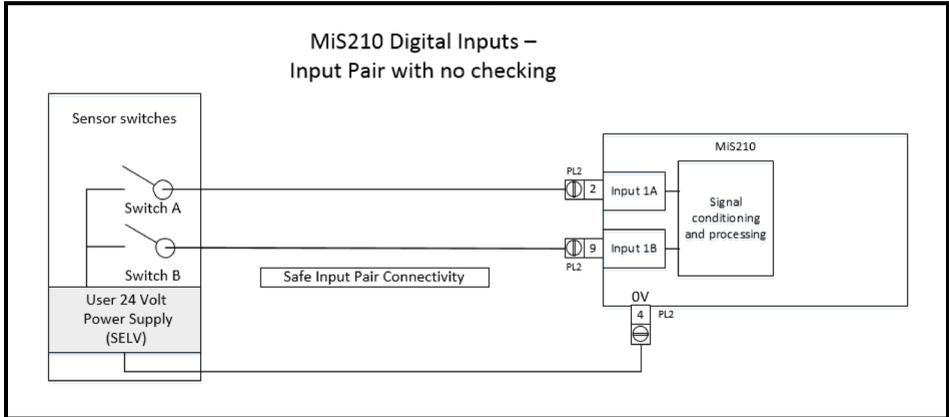
The shield of the cable is not shown, for clarity see section 5.1 *General Installation Notes*.

If multiple pairs are required they are wired in the same manner.

5.3.2 Wiring for Input Pair with Checking

The following diagram shows the wiring for a single pair of Safe Inputs being used with pulse checking. This should be used for safety-related applications outside of the drive system enclosure. PL e compliance with ISO 13849-1:2006 can be achieved as it is possible to exclude the possibility of a short circuit in the wiring between input and associated pulse output, and of a short circuit between the sensor connections.

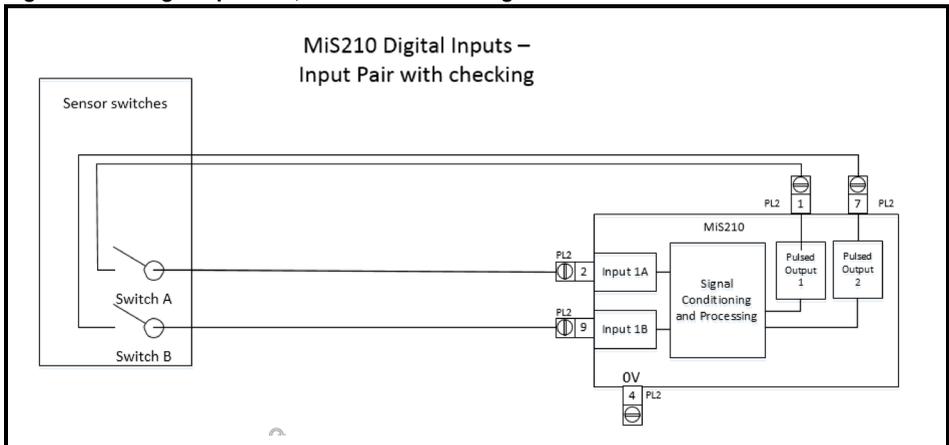**Figure 5-4   Single Input Pair, with Pulse Checking**

The shield of the cable is not shown, for clarity see section 5.1 *General Installation Notes*.

If multiple pairs are required they are wired in the same manner.

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⚠ WARNING	The Pulse Outputs should only be connected to the Safe Inputs of the same MiS210 Safety Module.

5.3.3 Wiring of Output

The following diagram shows the wiring for a single Safe Output. The outputs are tested continuously, and an external wiring fault of a short circuit to +24 V can be detected, the MiS210 Safety Module will disable its outputs however it cannot provide mitigation for the external fault.

Figure 5-5 Single Output

The shield of the cable is not shown, for clarity see section 5.1 *General Installation Notes*.

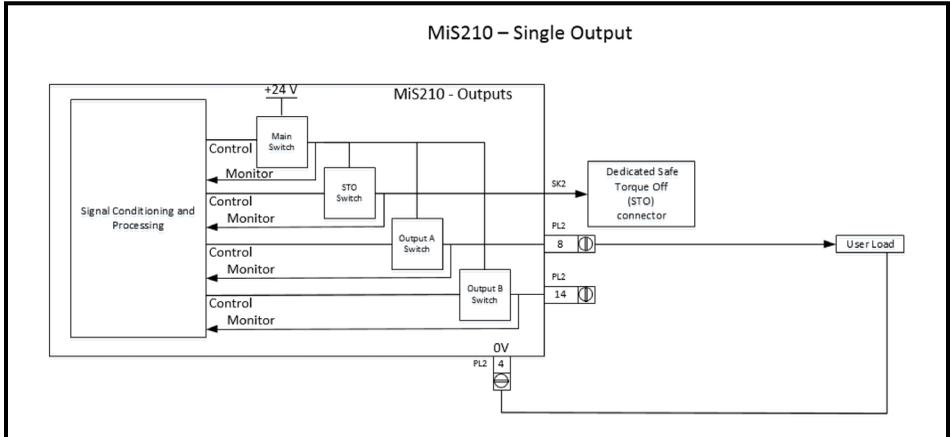If both outputs are required they are wired in the same manner.

For safety applications for cat 3, PL d in accordance with ISO 13849-1:2006, it is required to engage two complementary outputs as a group, thereby activating for example, two external power contactors.

5.4   Connection of Encoder(s) and Encoder Power Supplies

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The MiS210 Safety Module has four possible encoder connections, two on the host drive (A and B) and two on the front panel (1 and 2). Only certain combinations of encoder are possible and these can been seen in section 3.2 *Encoders* on page 21.

WARNING

- The AB and Serial encoders connected must comply with the RS-485 Electrical Specification as the MiS210 Safety Module uses RS-485 transceiver devices that are powered from the internal 3.3 V supply.
- All encoder cables connected to the MiS210 Safety Module should be shielded to protect against EMI.
- Where two encoders are to be used on the same shaft the position reported must have the same sense.

The diagram below shows the encoder connector for the MiS210 Safety Module.

Figure 5-6   MiS210 Local Encoder Connection
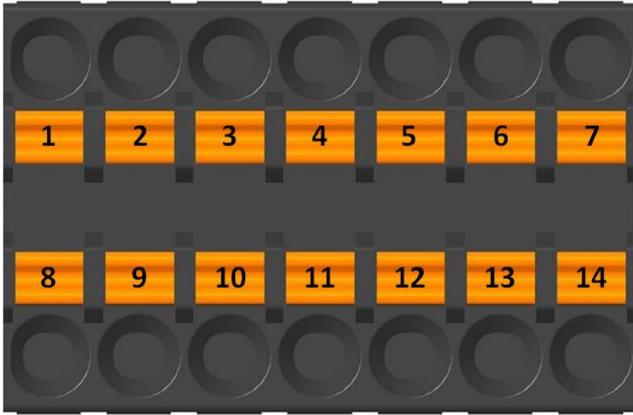
Pin	Description
1	0V
2	Cos1, A1, Data1
3	Sin1, B1, CLK1
4	Cos2, A2, Data2
5	Sin2, B2, CLK2
6	Encoder PSU Output
7	Encoder PSU Input
8	0V
9	Cos1/, A1/, Data1/
10	Sin1/, B1/, CLK1/
11	Cos2/, A2/, Data2/
12	Sin2/, B2/, CLK2/
13	0V
14	0V

5.4.1   Power Supplies

The MiS210 Safety Module is able to provide a power supply for a single encoder (Enc PSU Out) which can be either 5 V, 8 V or 15 V, see section 8.1. When a secondary encoder is in use the MiS210 Safety Module has an additional input on the front panel for monitoring an external power supply (Enc PSU In). Again this supply can be either 5 V, 8 V or 15 V. The encoder supplies are configured using Connect. The two encoders must be powered by separate power supplies to guard against common cause failures.

Table 5-1   Encoder Power Supply Values

Voltage Setting	5 V			8 V			15 V		
	Min	Nom	Max	Min	Nom	Max	Min	Nom	Max
Voltage	4.8 V	5.15 V	5.6 V	7.6 V	8.2 V	8.7 V	13.9 V	15 V	16.1 V
Current (Max)	250 mA			250 mA			200 mA		

The MiS210 Safety Module checks the encoder supplies that are in use and uses the following limits.

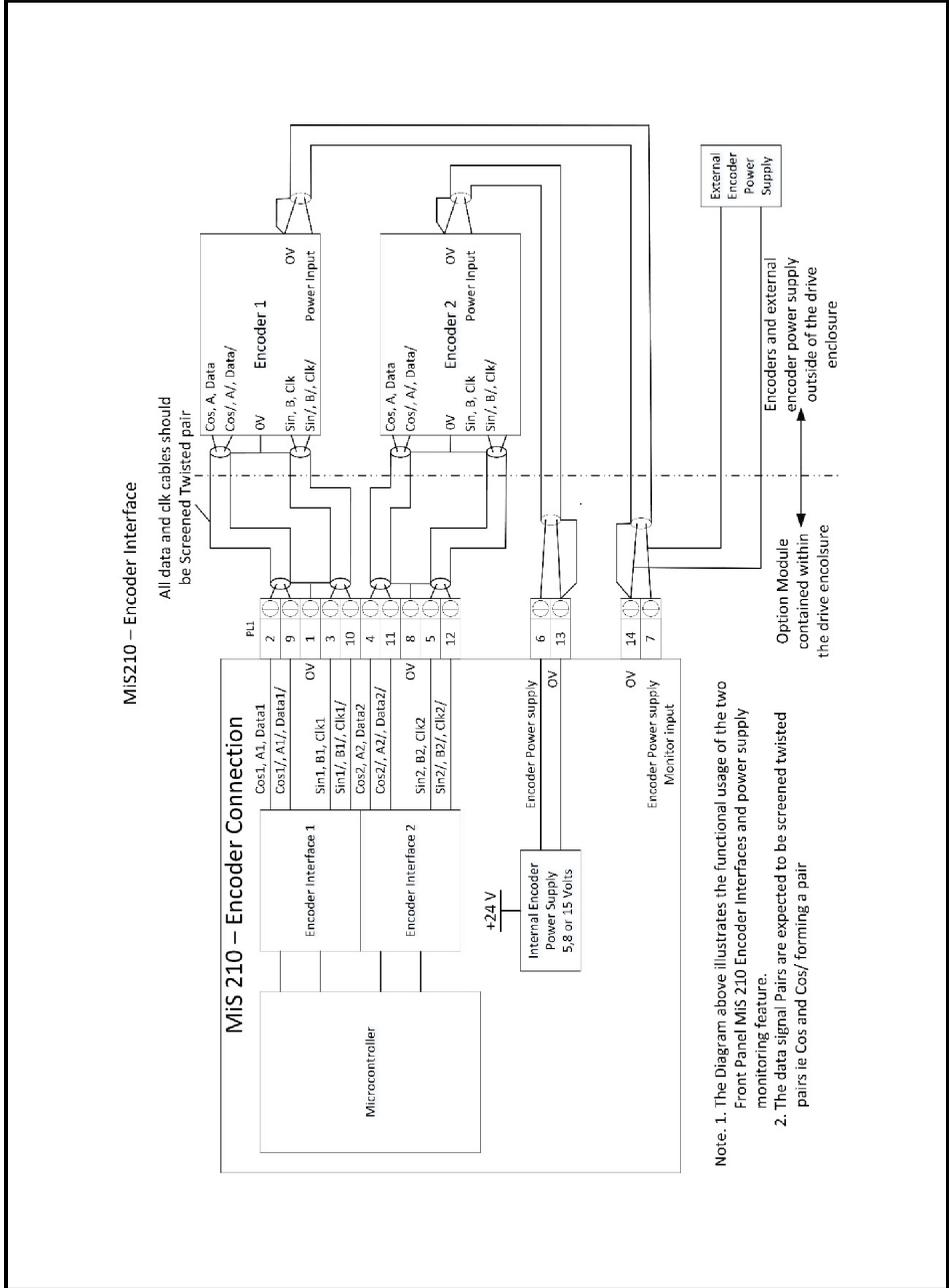**Table 5-2   Encoder Power Supply Monitoring Limits**

Voltage	Lower Limit	Upper Limit
5 V	4.38 V	6.07 V
8 V	7.14 V	9.3 V
15 V	13.19 V	17.01 V

5.4.2   Wiring

The following diagram shows all possible encoder connections, the exact combination of encoders is dependent upon the application and the SIL required.

The encoder(s) selected for use must be configured in the PC tool, Connect. Refer to section 4.1.3, for details of how to configure the MiS210 Safety Module for encoders.

Figure 5-7   Connection of Encoders

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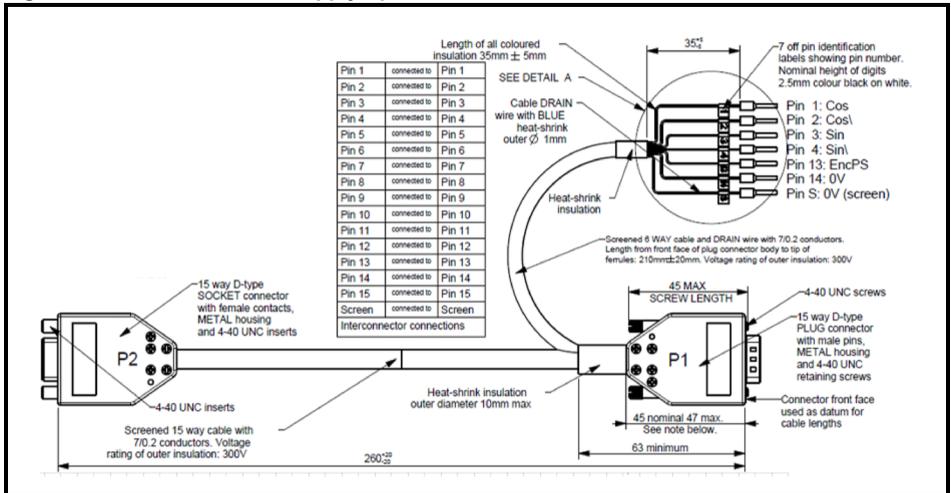
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5.4.3 Cables

If an encoder is used on the drive then depending upon the SIL needed by the application it may be necessary to monitor this power supply. The power supply can be monitored by connecting it to the Local Encoder Connector, as detailed in section 5.4.1 *Power Supplies* on page 91.

Figure 5-8 Encoder Power Supply Splitter
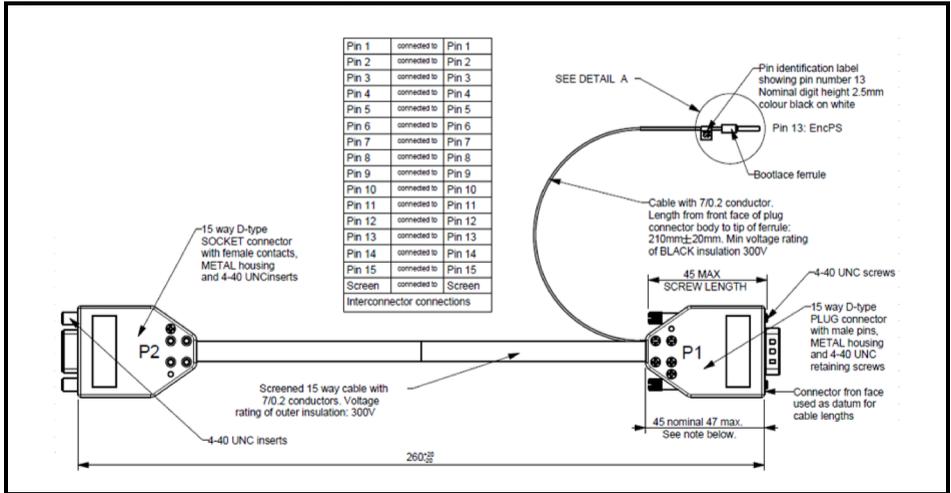
If an EnDat 2.1 with SinCos encoder or a Hiperface with SinCos encoder is used on the drive then the SinCos can be wired to the MiS210 Safety Module with a Sin Cos Splitter Cable and the MiS210 Safety Module will see it as a standard SinCos encoder.

Figure 5-9 Encoder Power Supply Splitter with SinCos

Both types of Splitter Cable can be purchased from Control Techniques Ltd.

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NOTE

The MiS210 Safety Module does not interpolate the Sin Cos signals so only basic relative position is available.

| ⚠ **WARNING**	•	If an external sensor power supply is not routed back through the Local Encoder Connector, any failure of this power supply needs to be incorporated in the fail-safe arrangements for the system as a whole.
	•	Any PSU powering equipment that is connected to the MiS210 Safety Module must be PELV or SELV and referenced to the drive 0V, to guarantee the voltage does not exceed 60 V under working or fault condition. Failure to observe this could cause a loss of the safety function by damage to the digital output circuit.
	•	If the Encoder splitter cables are being used the user must ensure that there is a secondary barrier between the user and the cable and its connector hood.

6   Start Up

The MiS210 Safety Module has 3 modes of operation, IDLE, OPERATING and CONFIGURING and 5 states, STANDBY, EXECUTING, FAILURE and COMMISSIONING (which has 2 sub states TESTING and DOWNLOAD). These are shown in the diagram below.

The MiS210 Safety Module is supplied with no configuration, so when connected and powered up as detailed in section 5 *Installation* on page 85, the unit will enter IDLE Mode and STANDBY state.

Only suitably trained safety personnel should perform the configuration of the MiS210 Safety Module, which is achieved by logging in using Connect, see section 2.2 *Configuration* on page 16.

Refer to section 4 *Connect Configuration Tool Introduction*, for details of how to configure the MiS210 Safety Module.

Figure 6-1   Mode and State Transitions
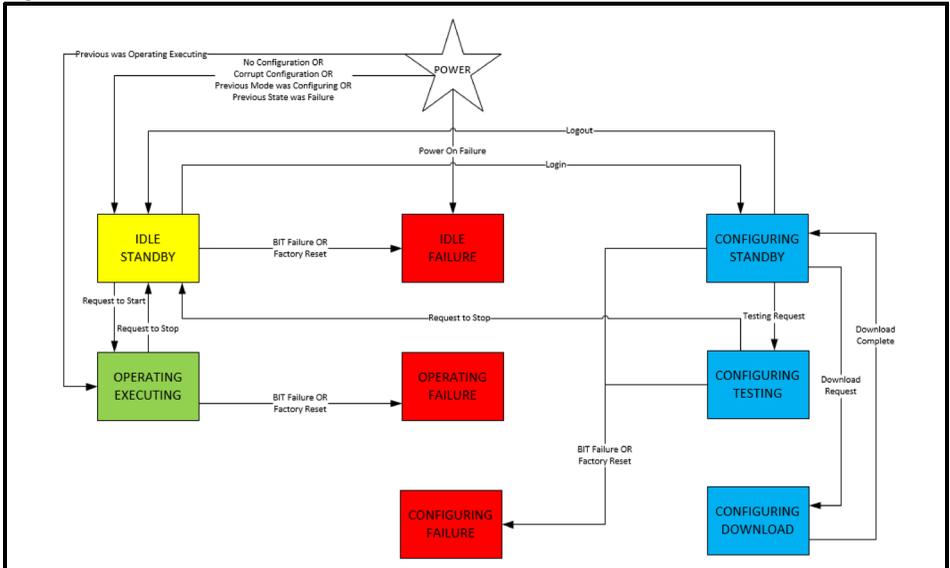
At power on a set of tests is ran on the microcontroller and its peripherals as well as any previously stored configuration. This testing takes a maximum of 150 ms.

All Mode/State transitions that are a request, as shown in the above diagram, are carried out using the Connect PC tool:

Request to Start

Request to Stop

Factory Reset

Login

Logout

Testing Request

Download Request

This means that if the unit has a failure and a power cycle has occurred the user will need to use Connect to put the unit into Operating Mode.

7 Validation

7.1 Overview

It is the user's responsibility to visually ensure that all configuration data was downloaded correctly. This includes the checking of the signature of the transferred data, and the actual configuration. This is the Validation step of the configuration.
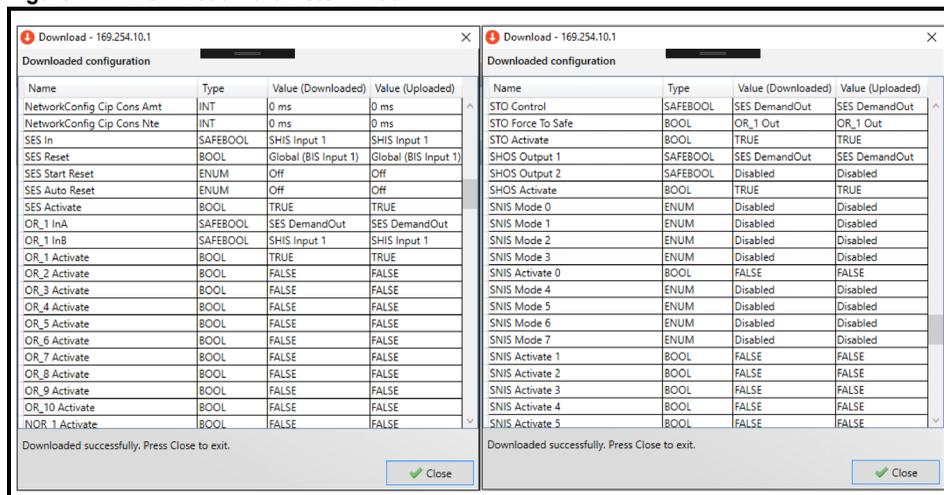
A report is produced by Connect called the Sign-Off report, to assist users in the validation of their safety system. It is a report that details all of the configuration of the MiS210 Safety Module and it is produced as a PDF. This report will be generated automatically every time the user agrees that the configuration downloaded to the MiS210 Safety Module is what they wanted. There is also a Documentation Icon available on the Connect Dashboard at all times, which when selected opens the Documentation Viewer and allows the user to view and/or print the PDF. If multiple versions are available then all will be shown and the user can select the one needed.

7.2 Format

The report is made up of a number of tables that contain all of the configuration details selected by the user or set by default. The first 2 tables cover the Project Name and the Drive Details, the remaining tables are specific to the configuration selected with a table for each of the functions selected. So there will be tables for the Inputs and Outputs (including network IO) and Encoder Selection as well as each Motion Safety Function and Support Functions.

Each table for a function lists the parameter caption and its type and the value that it is set to. The following screen capture shows an example of the pop-up Download Configuration box with the Safe Emergency Stop function, Safe OR and Safe Torque Off activated.

Figure 7-1   Download Parameter Check

The following screen shot is of the functions section of the Sign-Off Report produced by Connect.

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Figure 7-2   Sign-Off Report Sections

> ### 3. Functions
>
> *Safe emergency stop (SES)*
>
> | Name | Type | Value |
> |---|---|---|
> | SES In | SAFEBOOL | SHIS Input 1 |
> | SES Reset | BOOL | Global (BIS Input 1) |
> | SES Start Reset | ENUM | Off |
> | SES Auto Reset | ENUM | Off |
> | SES Activate | BOOL | TRUE |
>
> *Safe OR (OR_1)*
>
> | Name | Type | Value |
> |---|---|---|
> | OR_1 InA | SAFEBOOL | SES DemandOut |
> | OR_1 InB | SAFEBOOL | SHIS Input 1 |
> | OR_1 Activate | BOOL | TRUE |
>
> *Safe torque off (STO)*
>
> | Name | Type | Value |
> |---|---|---|
> | STO Control | SAFEBOOL | SES DemandOut |
> | STO Force To Safe | BOOL | OR_1 Out |
> | STO Activate | BOOL | TRUE |

7.3   Declaration

The final section of the Sign Off Report is the Declaration which provides an area for the signature of the Safety Engineer who designed the system and records the user name, date and time of the reports generation.

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8 Motion Safety Function Details

The following sections contain the details that allow a safety configuration to be built up from individual functions. As they contain safety relevant or safety critical data, protected communications are used and the values can only be changed by an authenticated user from within Connect. A non-authenticated user may view via Connect.

Network Safe I/O cannot be connected directly to the MiS210 Safety Module but should be connected to the PLC module on the safe network and then mapped to the MiS210.

The MiS210 Safety Module will only support the Generic Safety or Generic Safety + Standard profiles which transfers a block of bytes into the module and reads a block of bytes from the module.

Transient diagnostic code behaviour and last alarm code

For those functions that monitor a speed envelope and raise an alarm when the envelope is breached, it is likely that as soon as the alarm is raised the speed envelope breach will only occur for a short period of time because the axis STO will be activated and the speed will drop to zero. Consequently MSF diagnostic parameters will only show the envelope breach diagnostic code for the same short period of time, usually followed immediately by the "wait for reset" diagnostic code, (see the MST timing and state machine diagrams for full details).

The last alarm parameter will show the instance number and diagnostic code from the MSF that caused the current (or last if it has been cleared by a reset) module alarm state.

8.1 Encoder Setup

This section provides set up and indication for the 2 encoder inputs that provide the kinematic information to the MiS210 Safety Module. There are 2 encoder channels the primary channel supplies the kinematic information to any Motion Safety Function (MSF) that needs it, and the secondary channel can provide encoder redundancy to increase the system SIL. The menu also provides information that can be used to test and commission the encoders for safety purposes.

Position:
The basic position unit for the MiS210 Safety Module is the smallest increment of position that can be detected by the encoder, this will cause a change of +/-1 in the Motion Safety Function, and it is called a count.

Speed:
The speed unit for the MiS210 Safety Module is counts/second (counts/s).

Acceleration:
The acceleration unit for the module is counts/s².

There are no kinematic user units in the MiS210 Safety Module.

If 2 encoders are to be used scaling values are able to be set (Encoder Ratio Numerator and Encoder Ratio Denominator) so as encoders with different resolutions can be compared. These values are applied to the secondary encoder in the following way:

Scaled Encoder = (Secondary Encoder Resolution * Encoder Ratio Numerator) / Encoder Ratio Denominator

E.g.

Primary Encoder = 4096 Pulses per Revolution

Secondary Encoder = 1024 Pulses per revolution

To perform the scaling, the denominator is set to 1 and the numerator set to 4.

Scaled Encoder = (1024 * 4) / 1 = 4096

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MONITORING PARAMETERS (Read Only)	
Name	**Description**
MSF Position	The value shown in this 64 bit parameter is the current position, it is fed to any activated MSF that monitors absolute position.
MSF Position per Cycle	The value shown in this 64 bit parameter is the change in current position between the start of previous MSF evaluation cycle and the current one, it is fed to any activated MSF that monitors incremental position. The module will treat motion that produces a count of 0 in this parameter as zero speed, however functions that monitor zero speed can be configured to detect creep at zero speed.
MSF Speed	The value shown in this 64 bit parameter is the current speed in counts/s, it is fed to any MSF that monitors speed.
MSF Acceleration	The value shown in this 64 bit parameter is the current speed in counts/s², it is fed to any MSF that monitors acceleration.
Encoder Error Detected Primary: Secondary:	Contains the first detected current encoder error (both values will report the same error) these are: 0: No Error. 1: Position Comparison Failed. 2: Speed Comparison Failed. 3: Heidenhain Test Failed.
COMMON SETUP ATTRIBUTES (Read/Write)	
Encoder Ratio Numerator	This 16 bit parameter is the numerator for a scaling calculation that allows the primary and secondary encoders to produce a different count for a given change in position. The minimum value is 1. The maximum value is 65536.
Encoder Ratio Denominator	This 16 bit parameter is the denominator for a scaling calculation that allows the primary and secondary encoders to produce a different count for a given change in position. The minimum value is 1. The maximum value is 65536.
Encoder Difference Tolerance	This 16 bit parameter is the maximum position difference that is allowed to build up between the primary and secondary encoders, it allows for a difference in count between the 2 encoder channels, mechanical lags, oscillations, etc.
Internal Encoder Supply Monitoring	Sets the output voltage and consequent monitoring voltage for the safety module's encoder power supply pin. 0: Internal encoder supply & monitoring off. 1: 5 V output and monitoring. 2: 8 V output and monitoring. 3: 15 V output and monitoring.
External Encoder Supply Monitoring	Sets the monitoring voltage for an external encoder power supply 0: External encoder PSU monitoring off. 1: 5 V monitoring. 2: 8 V monitoring. 3: 15 V monitoring.
Encoder Maximum Acceleration for Test	This is a 32 bit value for the Heidenhain Test.

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PRIMARY & SECONDARY SETUP ATTRIBUTES (Read/Write)	
Encoder Source Primary: Secondary:	Selects the encoder source for use with the channel. If MSFs that require kinematic information are in use then the primary encoder must select an encoder source, selecting a secondary encoder may improve the system SIL rating. 0: Not in use. 1: Drive P1 feedback, the module will snoop a compatible encoder connected to the drive P1 encoder channel. 2: Drive P2 feedback, the module will snoop a compatible encoder connected to the drive P2 encoder channel. 3: Safety PA feedback, the module will use a compatible encoder connected to the module's local encoder channel 1. 4: Safety PB feedback, the module will use a compatible encoder connected to the module's local encoder channel 2.
Primary Safe EnDat 2nd Position Bits	This 8 bit parameter is the number of bits of the second position in a safe EnDat encoder. PRIMARY CHANNEL ONLY
Rotary Turns Bits Primary: Secondary:	This 8 bit parameter defines the number of rotary turns bits for the encoder For SinCos and AB Encoders this must be set to 25.
Comms Bits Primary: Secondary:	This 8 bit parameter defines the total number of bits of position information in the communication message from the encoder.
Comms Baud Rates Primary: Secondary:	This parameter is the baud rate selection for the encoder, the code numbers are those used in the drive but not all are supported by the safety module. 0: 100 k — Drive snoop and direct to module 1: 200 k — Drive snoop and direct to module 2: 300 k — Drive snoop and direct to module 3: 400 k — Drive snoop and direct to module 4: 500 k — Drive snoop and direct to module 5: 1 M — Drive snooping only 6: 1.5 M — Drive snooping only 7: 2 M — Drive snooping only 8: 4 M — Not supported

Device Type Primary: Secondary:	This 8 bit parameter defines the encoder connected to the channel, the code numbers are those used in the drive but not all are supported by the safety module.		
	0:	AB	Direct to module only
	1:	FD	Not supported
	2:	FR	Not supported
	3:	AB Servo	
	4:	FD Servo	Not supported
	5:	FR Servo	Not supported
	6:	SC	
	7:	SC Hiperface	Direct to module – SC lines only
	8:	EnDat	Drive snoop and Direct to module
	9:	SC EnDat	Direct to module SC lines only
	10:	SSI	Direct to module only
	11:	SC SSI	Direct to module only
	12:	SC Servo	Direct to module only
	13:	BiSS	Not supported
	14:	Resolver	Not supported
	15:	SC SC	Direct to module only
	16:	Commutation Only	Not supported
	17:	Safe EnDat	Direct to module only
SSI Binary Mode Primary: Secondary:	This 1 bit parameter selects SSI Gray or Binary coded signals. 0: Gray coded. 1: Binary coded.		

8.2 Module Configuration & Control

This section provides set-up and indication for System Alarms and System Resets.

INPUT SELECTORS	
Name	**Description**
Global Reset In Source	Selects the value that will provide the reset source for system wide alarms and the default reset source for motion safety functions. Except when the auto and/or start reset are turned on, a rising edge on the selected value will cause the system function to attempt to leave its system alarm state providing the cause of the system alarm has cleared. **<u>Value of Selector</u>** **0.001**: This selection disables the reset input, in which case the Start and Auto Reset attributes should both be set to on. If Start and/or Auto Reset are used then this decision must be validated and documented. If set to this value without setting both Start and Auto Reset attributes to on, it will not be possible to reset the module and it will remain in safe state. **Valid Output Connector from a non-safe input block:** **<u>Value of Source Selected</u>** **Rising Edge (a change from FALSE to TRUE)**: The system will be reset if the error condition is no longer present. **Falling edge or unchanging TRUE or FALSE**: Does not cause a reset, (a continuous TRUE signal may cause a reset error, see state machine).
ATTRIBUTES	
Global Start Reset	Set the reset behavior at and after system start up until the first valid reset signal is received. **<u>Value</u>** **Off**: No special reset behavior at start up (a reset signal is required at start up). **On**: One-time automatic reset of the function at start up only. A risk assessment on the system must take place and justification provided in the system documentation before this feature is used.
Global Auto Reset	Set the reset behavior after the first valid reset signal is received. **<u>Value</u>** **Off**: No special reset behavior after start up (a reset signal is required). **On**: No reset is required after the first reset (which maybe the automatic start up reset). Note that if this attribute is set, outputs may oscillate between safe and non safe if a motion safety function is moving in and out of an alarm condition, such as when operating close to a boundary condition. A risk assessment on the system must take place and justification provided in the system documentation before this feature is used.
OUTPUTS	
	There are no safety outputs from this menu.
Non-Safe Input Values	A read only packed set of the 16 input bits found in the setup menu.
Non-Safe Output Values	A read only packed set of the 16 output bits found in the setup menu.

The system reset and alarms system is always active, the MSF alarms system is active if there are no global alarms.

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The behavior of the system reset is described by the following state machine diagram:

Figure 8-1   Reset-1 Reset State Machine
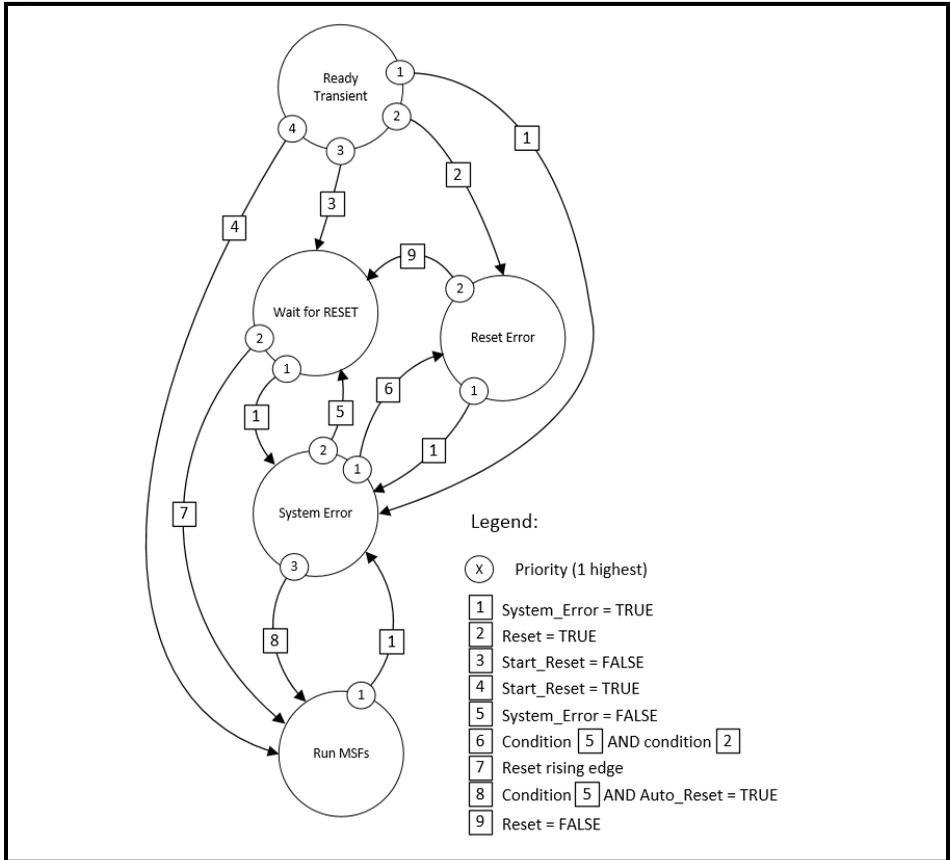
System Alarms

Problems with any of the following will raise a system alarm:

- Drive shared memory
- Safety network (if configured for use)
- Encoders (if configured for use)
- Inputs (if configured for use)
- Drive brown out

Any system error will raise a system alarm which will be held until the system is reset (either manually or automatically according to the configuration). The system will require a reset (which can be automatic) at start up.

MSF Alarms

Many of the MSFs have an error state, most of these error states will cause an alarm. For an alarm to be raised the MSF must be activated and connected. If a deactivated function is called an alarm will always be generated.

SAFEBOOL values encapsulate alarm signals

When an alarm is raised it is propagated through the MSF network in the SAFEBOOL signals passing between functions from input to output. Once an alarm signal reached an output function block the alarm state and check bits are evaluated and if required an alarm is raised and passed up to the MSF alarm and reset system. The structure of the **SAFEBOOL** outputs from MSF is given in the following table:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Reserved					Toggle	Alarm	State
					This bit is set from the LSBit of the 1ms counter, when the SAFEBOOL is written. It is checked for equality with the LSBit of the 1ms counter by the output function and if different an alarm is raised irrespective of the state of the alarm.	This bit contains the alarm flag. If an alarm flag is set when passed into a function it is passed through to the output along with the "First alarm instance number". If the flag set when passed into an output function an alarm is raised.	This bit contains the state of the SAFEBOOL 0 = FALSE 1 = TRUE

MSF Alarm codes

A function can only raise an alarm when it is in error or is waiting for a reset (the function diagnostic code most significant 2 bits will both be set). To support the alarm code indication and storage, MSF alarms will be identified by a code defined by the following 32 bit field:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
i	i	i	i	i	i	i	i	i	i	e	e	e	e	e	e	e	e	e	e	e	e	e	e	0	1	0	0	0	1	0	0
Function instance number										Lowest 14 bits of Function diagnostic code														0x4				0x4			
MSF instance that caused alarm (E.G.: SLS2 => 161)										Function specific alarm code (E.G.: 0xC005 = 00 0000 0000 0101b = 5)														cause group (MSF alarms)				cause block Id (data processing)			

MSF Alarm notification

If any alarm is raised by an MSF in addition to the alarm propagation through the SAFEBOOL described above it is added to a buffer (cleared at cycle start), when the alarm and reset signal system triggers final alarm the oldest alarm code is retrieved and inserted into the MSF alarm code above.

MSF Alarm Action

If a propagated alarm is detected at an output or an alarm is present in the alarm store at the end of the cycle, then the MSF alarm system is activated, the outputs are set to safe state and the main safety switch is opened. To exit this state a reset will be required (although in some circumstances and if configured an automatic reset may occur when the error state clears).

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8.3 Safety Network Configuration

Configuration Ownership

For the MiS210 Safety Module the configuration is downloaded from Connect and therefore as far as the safety network is concerned it is *Tool Owned*. Any *forward open* with configuration data (type 1) received from an originator will be rejected. The OUNID will have to be set up in the Originator to be the same as in the MiS210 Safety Module configuration for connection to be established. When a generic I/O device is selected in the Rockwell PLC, the SCID has to be set manually to match the configuration of the target device. The CFUNID in the MiS210 Safety Module is set to all 0xFFs (Tool owned) so that any attempt to configure it over the network will be rejected. The SCID contains a 32 bit CRC value (called the signature ID), a time stamp (4 bytes) and a date stamp (2 bytes). The time stamp is a 32 bit signed value of ms units which in the plc can be set from 0 to 23 h 59 m 59 s 999ms (0 - 0x05265BFF). The date stamp is the number of days since 1/1/1972.

The MiS210 Safety Module configuration signature is 64 bits and is generated by Connect using 64-bit CRC. This value is stored in the module menu in the drive parameters 006 – 009 as four 16-bit values. For CIPSafety networks, this CRC is used as the Safety Configuration ID (SCID) which consists of a 32-bit CRC (SCCRC) and a Time/Date Stamp (SCTS). The most-significant 32 bits of the MiS210 CRC should be copied into the SCCRC for the device on the PLC (parameters 006 and 007). The time and date for the SCTS are calculated from the lower 32 bits of the MiS210 CRC and presented in parameters 016 to 019 of the module menu. Thus to ensure the SCID in MiS210 matches the SCID in the PLC do the following:

- Copy Parameter 006 into the MSW of the SCCRC in the PLC.
- Copy Parameter 007 into the LSW of the SCCRC in the PLC.
- Copy Parameter 016 into the hours/mins/seconds part of the SCTS in the PLC.
- Copy Parameter 017 into the milliseconds part of the SCTS in the PLC.
- Copy Parameter 018 into the DD/MM part of the SCTS in the PLC.
- Copy Parameter 019 into the YYYY part of the SCTS in the PLC.

When configuring an originator with connection data and the SCID for the target, the connection must be tested and verified. Only then can SCIDs from the target be confirmed.

If you choose to configure safety connections with an SCID=0, you are responsible for ensuring that originators and targets have the correct configurations.

Target ID (TUNID)

The MiS210 Safety Module is considered a Target device and must have a unique identification (TUNID). This ID constitutes a Safety Network Number (SNN) and a NodeID. The SNN is a number in time and date format (2 bytes for date and 4 bytes for time) and the NodeID is the IP address of the target device (4 bytes).

The SNN can be set in 2 ways, automatically, and manually. For the manual setting the date variable is fixed at 0x0004 for EtherNet/IP and the time variable can be set to any number from 1 to 9999(0x0000270F). The date variable is defined as the number of days since 1/1/1972 and the time variable is a value of ms units from 0 to 23 h 59 m 59 s 999 ms (0 - 0x05265BFF). The CIP standard states that computer generated date values between 1/1/2004 (11688) and 5/6/2151 (65534) can be used and values between 1461 and 11687 are Vendor specific. The MiS210 Safety Module will support both methods of setting by allowing the user to set a 48 bit SNN in the configuration setup in Connect. The MS16 bits define the date part and the LS32 bits define the time part. A second window is available to set the IP address (NodeID) of the target to complete the TUNID.

The user should assign SNN numbers for each Safety Network or safety sub-net that are unique system-wide.

The IP Address (NodeID) should be assigned and programmed into the specific fieldbus module being used for the Safety Network before a connection is made to the Safety Network.

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> ⚠️ **WARNING**
>
> • The Automatic method of setting the SNN should only be used when the safety system is not being relied upon.
> • Do not remap the drive option slots as this will cause failures.

Originator ID (OUNID)

On output devices an OCPUNID has to be stored in the Target that matches the OUNID of the PLC to ensure that only one originator can change device outputs. In the MiS210 Safety Module this is set to the OUNID defined in the configuration. Two additional windows are used in the Connect configuration to define the originator SNN and NodeID. For the manual setting of the SNN, the user may wish to set the date variable to 0x0001 which defines a backplane originator. If this is the case the NodeID is not an IP address and so the window used to set the NodeID is not defined as an IP address.

Module Reset and Alarms

In the MiS210 Safety Module a Type 0 reset can be used to reset a motion safety alarm condition. When an alarm is detected the MiS210 Safety Module will set the Manufacturer Specific alarm flag in the exception status attribute (providing alarms have not been disabled by the PLC). The Type 0 reset is only accepted if there is no established IO connection and so the originator must close all connections before the reset is issued. The CIP Safety reset requires a password and for the MiS210 Safety Module this is fixed as "Administrator123" (16 characters).

The exception status attribute can be read from the safety module in Rockwell PLC's by using the message block in the PLC ladder logic. Below is an example of how this can be done:

a. Create MSG_READ tag with MESSAGE type in controller tags tab.
b. Create EXPT_STATUS tag with SINT type, the exception status will be read into this tag.
c. Switch to the Main Routine window of the Main Task.
d. Build the rung with the MSG block as shown below:
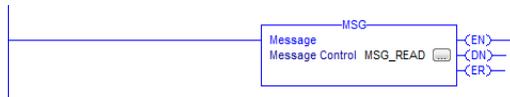
e. Open the MSG block configuration window.

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f.   In the Configuration tab, set the message type to 'CIP Generic'. Set service type to 'Get single attribute'. Fill the class, instance and attribute (i.e. Safety exception status is class 0x39, instance 1, attribute 0x0C). Set the destination element to be 'EXPT_STATUS' as defined in a.
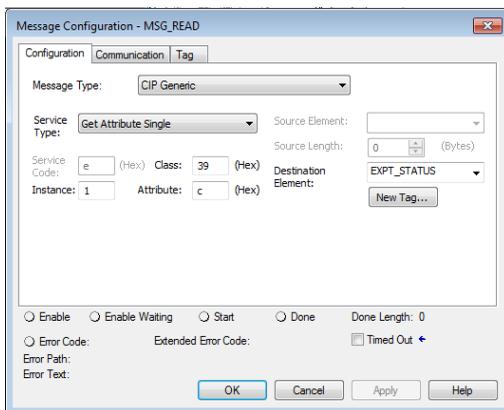
g.   In the Communication tab, set the path to be the MiS210 Safety Module. Also tick the 'Connected' box.

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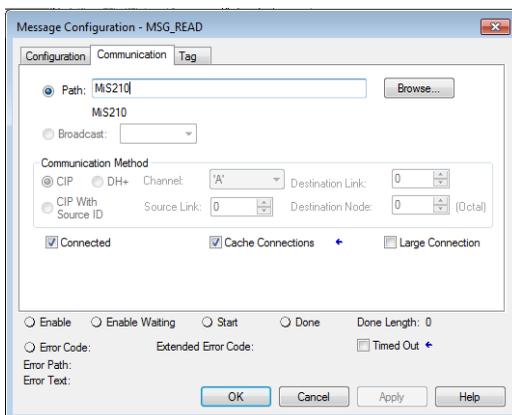
h. Once the program is downloaded and the PLC set to run, the Monitor Tags tab of the controller tags tab will display the Exception status. The Manufacturer Specific alarm is bit 2 of the exception status.
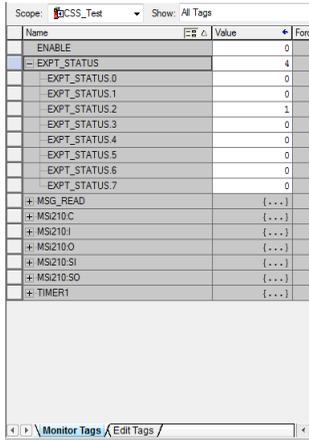
Input and Output Assemblies

Safe data can be passed from the PLC to the MiS210 Safety Module, from the MiS210 Safety Module to the PLC, or in both directions. For each direction an assembly length of up to 20 bytes can be transmitted. Note that an output assembly on the PLC are inputs to the MiS210 Safety Module, and an input assembly on the PLC are the outputs of the MiS210 Safety Module. The assembly lengths set up in the PLC must exactly match the assembly lengths configured in the device. The type of data transmitted for the assembly lengths allowed is defined in the Parameter descriptions below. All integers are 32 bit and are passed as Big Endian (MSByte first). The input assembly instance is fixed at 1000 and the output assembly instance is fixed at 1001. The Null instance required by the safety validator is fixed at 199. The screen shot below indicates a typical setup:
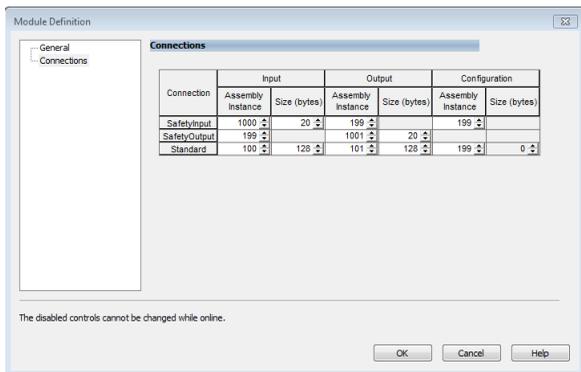
RPI and Timeout Multiplier settings

The MiS210 Safety module does not support RPI settings less than 10 ms. Further to this, if an RPI setting of less than 20 ms is required, then the Timeout multiplier must be set to 2 or greater.

Note that if a Network topology does not allow these minimum values to be set, the PLC values must be set to values that can support the topology, or the topology must be changed to support the system requirements.

Configuration Locking

In CIP Safety systems where the configuration is originator owned it is normal for the Lock Attribute to be set in the target once testing and verification is complete. As the MiS210 Safety Module network configuration is tool owned, the network configuration is automatically locked on downloading a configuration containing Network setup data. The System testing and verification (section 2.2.4 *Testing the Configuration* and section 9 *Diagnostics and Maintenance*) cover the requirements of the CIP Safety Standard.

Name	Description
Safety Network Slot	This is the slot in the drive that is to be used to provide the fieldbus interface between the PLC and the MiS210 Safety Module. (Range 1 – 4)
Safety Network	0 – No Network 1 – CIP Safety
CIP Target SNN	48 Bit SNN for the MiS210 Safety Module
CIP Originator SNN	48 Bit SNN for the PLC
CIP Target NodeID	The MiS210 Safety Module Node ID – the IP address required in the Ethernet Module.
CIP Originator NodeID	The PLC NodeID
CIP Byte Length In	This is the length of assembly required to pass data from the PLC to the MiS210 Safety Module 0 – No data transfer required 1 – One byte (8 Booleans) 2 – Five Bytes (8 Booleans and 1 Integer) 3 – Six bytes (16 Booleans and 1 Integer) 4 – Ten Bytes (16 Booleans and 2 Integers) 5 – Eleven Bytes (24 Booleans and 2 Integers) 6 – Fifteen Bytes (24 Booleans and 3 Integers) 7 – Sixteen Bytes (32 Booleans and 3 Integers) 8 – Twenty Bytes (32 Booleans and 4 Integers)
CIP Byte Length Out	This is the length of assembly required to pass data from the MiS210 Safety Module to the PLC 0 – No data transfer required 1 – One byte (8 Booleans) 2 – Five Bytes (8 Booleans and 1 Integer) 3 – Six bytes (16 Booleans and 1 Integer) 4 – Ten Bytes (16 Booleans and 2 Integers) 5 – Eleven Bytes (24 Booleans and 2 Integers) 6 – Fifteen Bytes (24 Booleans and 3 Integers) 7 – Sixteen Bytes (32 Booleans and 3 Integers) 8 – Twenty Bytes (32 Booleans and 4 Integers)

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8.4 Safe Emergency Stop (SES)

This function tests its single safe input for its state, provides reset functionality and sets the output accordingly. It supports a full manual reset and can be used without other safety logic functions where the MiS210 Safety Module is acting as safety controller. With the STO function it provides the functionality to support an emergency switch off (Emergency Stop Category 0). With other functions it can provide functionality for Emergency Stop Categories 1 and 2.

This function has a single instance within the firmware and it can be activated or deactivated at design time only. Values are available to be read in Test Mode. If values are read from an activated function the current values are returned, if a read is made on a deactivated function the default value is returned.

The following standards are applicable:

Standard	Requirements
IEC 418: 1992	3. Definitions 4.1.12 ... Resetting the control device shall not by itself cause a restart command.
IEC 954-1: 1996	5.4 Manual reset
ISO 12100-2: 2003	4.11.4: Restart following power failure/spontaneous restart
IEC 60204-1, 1997	9.2.2. Stop Functions

Figure 8-2   SES-1 Diagrammatic representation of the SES function

INPUT SELECTORS	
Name	**Description**
SES In Source	Selects the value that will provide the safety demand. This is typically the out value of an input function which in turn connects to a hard wired input pair or network input for the E-Stop. **Value of Selector** **0.000**: This is the default selection, but if the function instance is activated it must be set to select a safe Boolean value. **Valid Output Connector from another Block:** **Value of Source Selected** **TRUE**: No demand for safety-related response, request for operational state (e.g., emergency stop button not engaged). **FALSE**: Demand for safety-related response (e.g., emergency stop button is engaged).
SES Reset Source	Selects the value that will provide the reset source, typically it will be Global Reset but may be connected to any input to control the Reset. Except when the auto and/or start reset are turned on, a rising edge on the selected value will cause the function to attempt to leave its local error state providing the function's inputs evaluate to operational (TRUE). **Value of Selector** **0.001**: This selection disables the reset input, in which case the Auto Reset attribute must be set to on. If this selection is made then this decision must be validated and documented. **0.002**: This is the default selection indicating that the function reset should use the Global Reset (Menu 6). **Valid Output Connector from a non-safe input block:** **Value of Source Selected** **Rising Edge (a change from FALSE to TRUE)**: The function will be reset if the error condition is no longer present. **Falling edge or unchanging TRUE or FALSE**: Does not cause a reset, (a continuous TRUE signal may cause a reset error, see state machine).
ATTRIBUTES	
SES Start Reset	Set the reset behavior at and after system start up until the first valid reset signal is received. **Value** **OFF**: No special reset behavior at start up (a reset signal is required at start up). **ON**: One-time automatic reset of the function at start up only. A risk assessment on the system must take place and justification provided in the system documentation before this feature is used.
SES Auto Reset	Set the reset behavior after the first valid reset signal is received. **Value** **OFF**: No special reset behavior after start up (a reset signal is required). **ON**: No reset is required after the first reset (which maybe the automatic start up reset). A risk assessment on the system must take place and justification provided in the system documentation before this feature is used.
SES Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.

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OUTPUTS	
SES Demand Out	Outputs the safety related response of the function, typically connects to the STO or the SS function. **Value** **TRUE**: No demand for safety related response, request for operational state (e.g. SES In is TRUE, no error and a reset has occurred). **FALSE**: Demand for safety related response, request for safe state. (e.g. SES In is FALSE, error state or reset required).
SES State	RESERVED
SES Error Output	Indicates that the function has detected an error condition. **Value** **TRUE**: Error, check Diagnostic Out for details. **FALSE**: No Error.
SES Diagnostic Out	Diagnostic Fault Code.
SES Ready	Copy of SES Activate.

The function is only active if "SES Activate" has been set at design-time, the behavior description below describes an activated function.

"SES Demand Out" is set to FALSE if the input connected to "SES In Source" is FALSE. "SES Demand Out" can only be set to TRUE if the input connected to "SES In Source" is TRUE and a valid reset has occurred and is still latched. The reset behavior depends on the state of the input connected to "SES Reset Source", "SES Start Reset" and "SES Auto Reset".

An automatic reset is where the function resets when the input connected to "SES In Source" goes to TRUE and "SES Demand Out" will mirror the state of the input connected to "SES In Source" until another error occurs.

If "SES Start Reset" = off AND "SES Auto Reset" = off then a reset signal is required at all times.

If "SES Start Reset" = on AND "SES Auto Reset" = off then a reset signal is required at all times except once only after system start when an automatic reset will be applied.

If "SES Start Reset" = off AND "SES Auto Reset" = on then a reset signal is required only after system start after that and automatic reset will be applied.

If "SES Start Reset" = on AND "SES Auto Reset" = on then a reset signal is never required, an automatic reset will be applied.

The "SES Start Reset" and "SES Auto Reset" shall only be activated if it is ensured that no hazardous situation can occur when the Programmable Electronic System (PES) is started.

Safe Emergency Stop can be used to monitor both single and two-channel emergency stop inputs. The MiS210 Safety Module inputs are all 2 channel with built in discrepancy timers, if single channel is required then the input channels can be connected together.

Figure 8-3   SES-2 State Machine
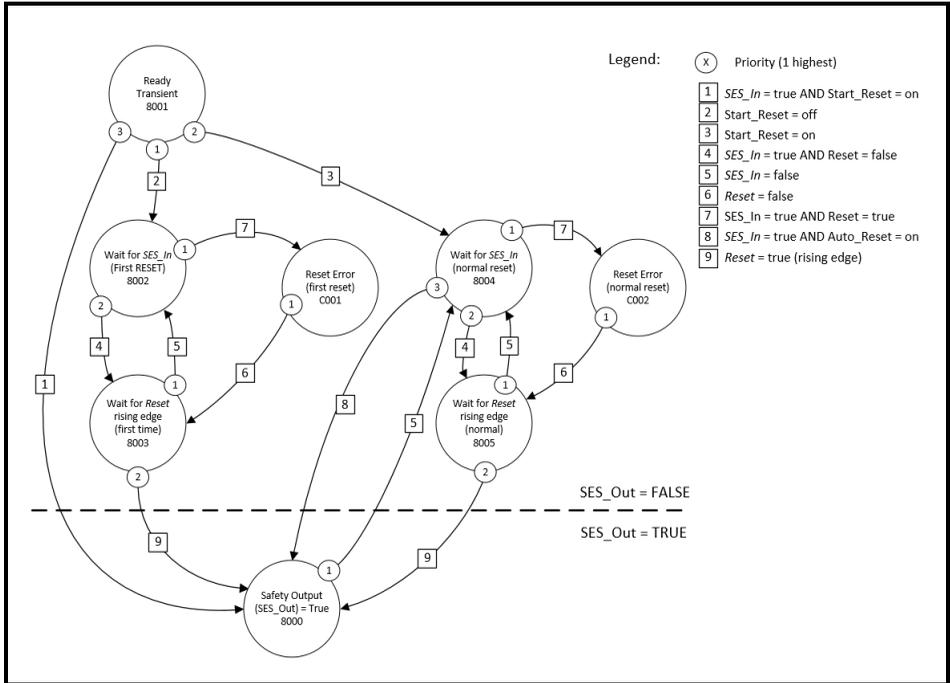
The following Timing diagrams are a walkthrough of a given scenario provided to aid understanding of the state machine diagram, it starts from the first time the function is run. Input functions run as soon as the MSF system is executing, Logic and Output functions run after system reset.

Figure 8-4   SES-3 Timing Diagram with Start Reset OFF and Auto Reset OFF, also shows normal Reset error (0xC002)
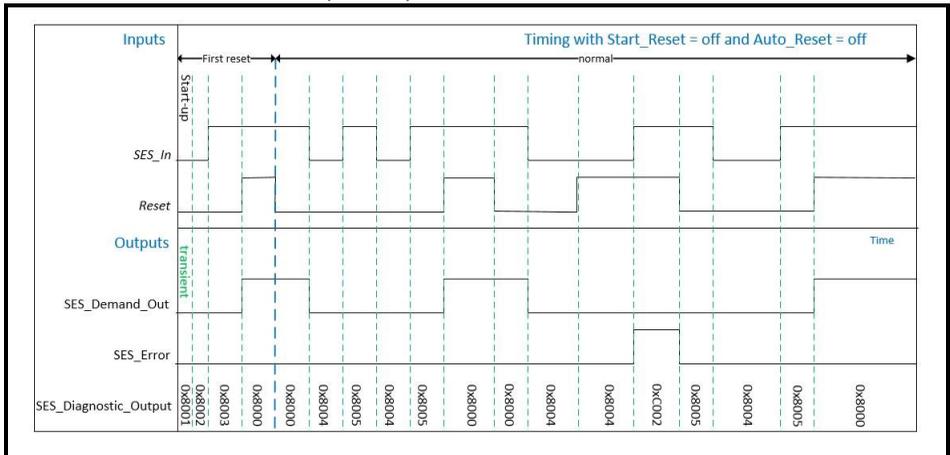
Figure 8-5   SES-4 Timing Diagram with Start Reset ON, also shows normal Reset error (0xC002)
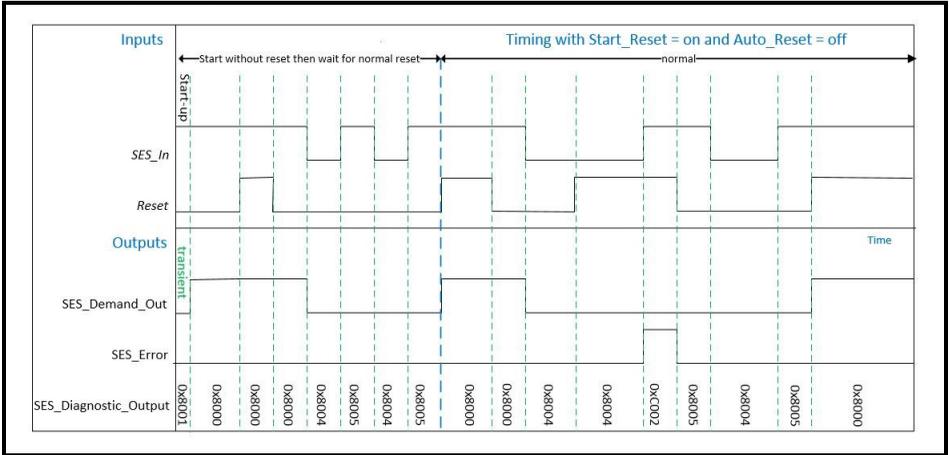
Figure 8-6   SES-5 Timing Diagram with Auto Reset ON, also shows normal Reset error (0xC002)
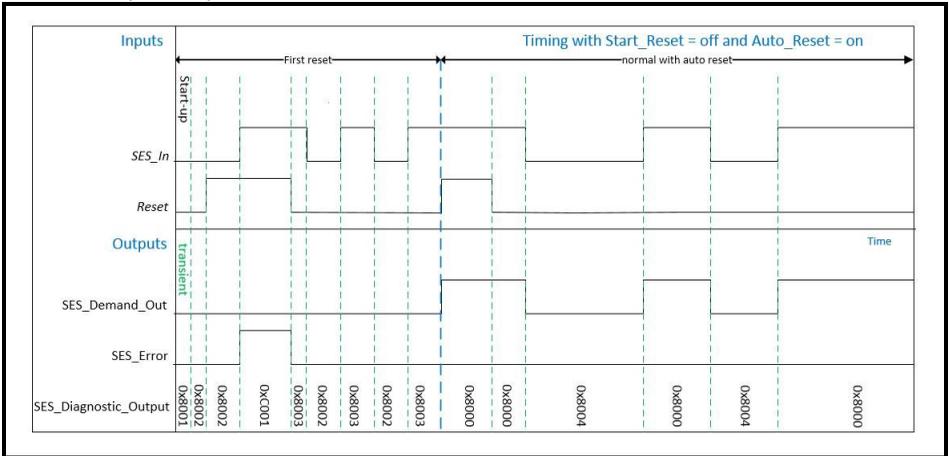
When an error occurs "SES Error Output" is set to TRUE and a diagnostic code is output in "SES Diagnostic Output".

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ERRORS		
SES Diagnostic Output	**State**	**Description**
0xC001	Reset Error (first reset)	During wait for first reset, input connected to "SES Reset Source" signal is TRUE when a rising edge is detected on the input connected to "SES In Source". **In error state** "SES Demand Out" = FALSE "SES Error Output" = TRUE "SES State" = variable
0xC002	Reset Error (normal reset)	During wait for normal reset, SES Reset signal is TRUE when a rising edge is detected on SES In. **In error state** "SES Demand Out" = FALSE "SES Error Output" = TRUE "SES State" = variable
DIAGNOSTICS		
0x8000	Safety Output "SES Demand Out" == TRUE	Input connected to "SES In Source" is TRUE and a reset has occurred. **In this state** "SES Demand Out" = TRUE "SES Error Output" = FALSE "SES State" = variable
0x8001	Ready	Transient state on start-up function moves to one of 0x8000, 0x8002 or 0x8004 depending on state of the input connected to "SES In Source" and "SES Start Reset", see state machine diagram. **In this state** "SES Demand Out" = FALSE "SES Error Output" = FALSE "SES State" = variable
0x8002	Wait for SES In (first reset)	Wait for input connected to "SES In Source" to go to TRUE, state then transitions to 0x8003. **In this state** "SES Demand Out" = FALSE "SES Error Output" = FALSE "SES State" = variable
0x8003	Wait for Reset rising edge (first time)	Wait for the input connected to "SES Reset Source" to go to TRUE, state then transitions to 0x8000. **In this state** "SES Demand Out" = FALSE "SES Error Output" = FALSE "SES State" = variable
0x8004	Wait for SES In (normal reset)	Wait for the input connected to "SES In Source" to go to TRUE, state then transitions to 0x8003. **In this state** "SES Demand Out" = FALSE "SES Error Output" = FALSE "SES State" = variable
0x8005	Wait for Reset rising edge (first time)	Wait for the input connected to "SES Reset Source" to go to TRUE, state then transitions to 0x8000. **In this state** "SES Demand Out" = FALSE "SES Error Output" = FALSE "SES State" = variable

8.5 Safe Stop (SS)

The purpose of this function is to monitor (and possibly initiate by means of a non-safe output) the slowdown of (typically) the host drive and once the drive has stopped or a given time has been exceeded set its demand output to false. Depending on the stop mode, if the axis does not slowdown as required by the Dwell Time and Deceleration attributes or Stop within the time specified in the Stop Time attribute the function will enter an error state and an alarm will be raised, if the function enters error state then a reset is required as the control system is regarded as having lost control.

The function does not provide any form of control for the drive stop it simply monitors that the axis is stopping and or has stopped and sets its output to FALSE once it does or if an error is detected. It does provide an output which can be used to initiate (but not control) the stop when the functions safe input goes false, alternatively the axis control system can use the input signal directly if it has access to it.

The reset does not provide the requirements of a machinery or emergency stop reset, it simply resets the function error state, which occurs after a stop envelope breach after which the function behaves normally.

There are two available instances of this function for the user, contained with SS1 and SS2 in Connect. They can be activated or deactivated at design time only. The function has similarities to that defined in PLCopen Safety part 1 but has significant differences because of the function's direct access to speed feedback.

The following standards are applicable:

Standard	Requirements
IEC 61800-5-2:2007	4.2.2.3 Safe Stop 1, 4.2.2.3 Safe Stop 2, For both safety functions defined in the standard this block can be configured to act either in mode b or c. **Note:** Safe stop 1 is constructed by connecting Safe Stop in series with Safe Torque Off (SS-STO), corresponding to a controlled stop in accordance with stop category 1 of IEC 60204-1 (see section 8.5.1). Safe stop 2 is constructed by connecting Safe Stop in series with Safe Operating Stop and Safe Torque Off (SS-SOS-STO), corresponding to a controlled stop in accordance with stop category 2 of IEC 60204-1 (see section 8.5.2).
IEC 60204-1:2006	9.2.2 Stop Functions – stop category 1: a controlled stop (see 3.11) with power available to the machine actuators to achieve the stop and then removal of power when the stop is achieved; – stop category 2: a controlled stop with power left available to the machine actuators.

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Figure 8-7   SS-1 Diagrammatic representation of the SS function

INPUT SELECTORS	
Name	**Description**
SS In Source	This is the input selector for the function's input. This input controls whether the function monitors a stop or not. **Value of Selector** **0.000**: Default (Illegal will cause a configuration error, this selector must be set by the user) **Valid Output Connector from another Block:** **Value of Source Selected** **TRUE**: The function is not monitoring a stop. **FALSE**: The function is monitoring a stop and if its stop envelope is exceeded the SS demand output is set to FALSE.
SS Reset In Source	This is the input selector for the function's reset input. A rising edge on this input will reset the function following a stop envelope breach error. As this is a serious error (the machine has lost control) there is no auto reset. **Value of Selector** **0.002**: Default, this selection causes the function to use global reset input. **Valid Output Connector from a non-safe input block:** **Value of Source Selected** **Rising Edge (a change from FALSE to TRUE)**: The function will be reset if the error condition is no longer present. **Falling edge or unchanging TRUE or FALSE**: Does not cause a reset, (a continuous TRUE signal may cause a reset error, see state machine).

ATTRIBUTES	
SS Stop Mode	This attribute selects the function's stop mode. **Value** **Rate (0)**: When the input goes FALSE demanding a safe stop, then a dwell timer and deceleration ramp is applied to allow the axis time to come to halt before the function's demand output is set to FALSE. **Note**: This mode will detect an envelope breach during slowdown faster than the time mode. **Time (1)**: When the input goes FALSE demanding a safe stop, then a timer is applied to allow the axis time to reduce speed before the selected level is monitored.
SS Stop Deceleration	The deceleration that the function will use to monitor the rate mode envelope (see SS2 - Rate Envelope Diagram, segment 2), this parameter is not used if the Stop Mode is Time and may be left at default. **Value** Deceleration in encoder counts/s²
SS Dwell Time	This attribute controls the amount of time in milliseconds to be inserted into the Rate Envelope see SS Rate Envelope Diagram), before Deceleration starts to be monitored, this parameter is not used if the Stop Mode is Time and may be left at default. **Value** Time in ms.
SS Stop Time	The time that the function will use to construct the time envelope (see SS Time Envelope Diagram), this parameter is not used if the Stop Mode is Rate and may be left at default. **Value** Time in s.
SS Zero Speed Tolerance	The speed in encoder counts/s that the function will use for its zero speed tolerance **Value** Zero speed tolerance in encoder counts/s.
SS Speed Control Tolerance	This attribute is for setting an upper limit on the amount of dither on the speed feedback which the function allows during slowdown, speed limit and zero speed monitoring. **Note**: Low values in this parameter may cause timing issues.
SS Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.
OUTPUTS	
SS Demand Out	This is the primary safety demand output of the SS function. It is intended for the control of either the STO function or an SOS function so that safe stop 1 and 2 functions can be constructed. It may also be used in other functions that require stop monitoring. If the function is activated it must be connected by means of another function's input selector being set to the parameter number of this output. More than one other input selector can select this output. **Value** **TRUE**: The function is initialized and has detected no errors. **FALSE**: The function is not initialized, OR has detected an error OR is waiting for a reset after an error has cleared.
SS Stop Request	This is a tertiary, non-safe output of the SS function. It provides a signal that could be used to request that the axis stops. **Value** **TRUE**: The axis should stop. **FALSE**: Stop is not requested.
SS State	RESERVED
SS Error Output	Indicates that the function has detected an error condition. **Value** **TRUE**: Error, check Diagnostic Out for details. **FALSE**: No Error.
SS Diagnostic Out	Diagnostic Fault Code.
SS Ready	Copy of SS Activate.

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The function is only active if "SS Activate" has been set at design-time, the behavior description below describes an activated function. For deactivated functions all the outputs are set to false.

The function has 1 Safe output:
SS Demand Out is set to FALSE if the function has not been initialized (this only occurs at start up), if the input is FALSE and the axis has stopped without error, if errors are detected, or if the function is waiting to be reset after an error has occurred.

SS Demand Out is set to TRUE if and only if its safe input is true or its input is FALSE and the axis is stopping without error.

If an error occurs the function will set SS Demand Out to FALSE immediately and it will remain in this state until the source of the error clears and the function is reset.

The function has 1 non-safe output:
This output is provided for convenience and is not to be classed as part of the safety system.

SS Stop Request, when the function SAFEBOOL input goes false this non-safe output goes true and vice versa. For example this parameter can be used by the drive to initiate a stop of the motor.

Errors and Reset:
If an error occurs the function will set SS Demand Out to FALSE and will remain in this state until the source of the error clears. The function must then be reset by means of a rising edge applied to the reset input; there is no auto reset as the monitoring envelope has been breached, indicating that the axis has lost control so intervention is required.

Monitoring types and methods:
Rate Mode: causes the function to monitor the slow down to zero speed using an adjustable dwell time (SS Dwell Time) followed by a segment where the deceleration is monitored (SS Stop Deceleration). If the envelope (the red line in the diagram is crossed by the speed magnitude the function goes to its error state and sets its Demand Output to false immediately. Under the same conditions, this mode will always detect errors at least as fast as Time mode.

Figure 8-8   SS-2 Rate Mode Speed Monitoring Envelope (shown by red line)

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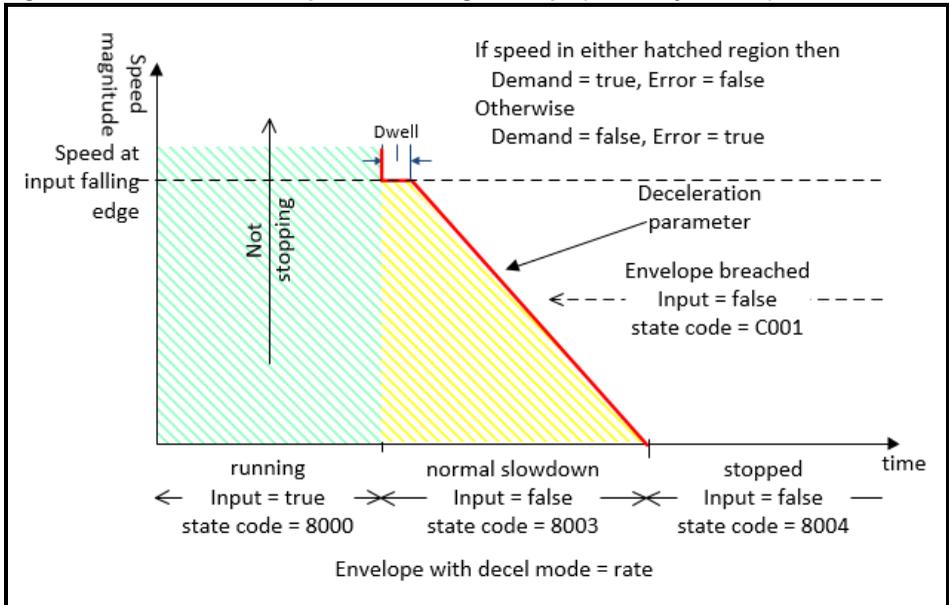
NOTE

Time axis should not be regarded as linear.

Time Mode: causes the function to monitor the slow down to zero speed using an adjustable time (SS Time To Safe Speed). If the envelope (the red line in the diagram) is crossed by the speed magnitude the function goes to its error state and sets its Demand Output to false immediately. In addition, if the axis is detected as accelerating the function moves to the error state immediately. This mode should be used if the deceleration rate is not known, and only a maximum time can be given. See Figure 8-9 *SS-3 Time Mode Speed Monitoring Envelope (shown by red line)*.

Figure 8-9   SS-3 Time Mode Speed Monitoring Envelope (shown by red line)
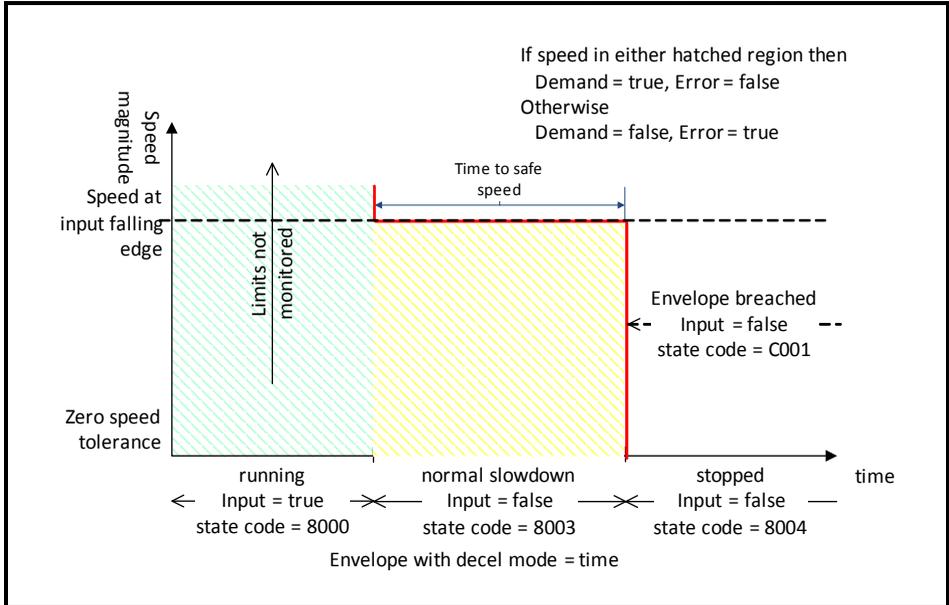
NOTE

Time axis should not be regarded as linear.

Figure 8-10   SS-4 State Machine
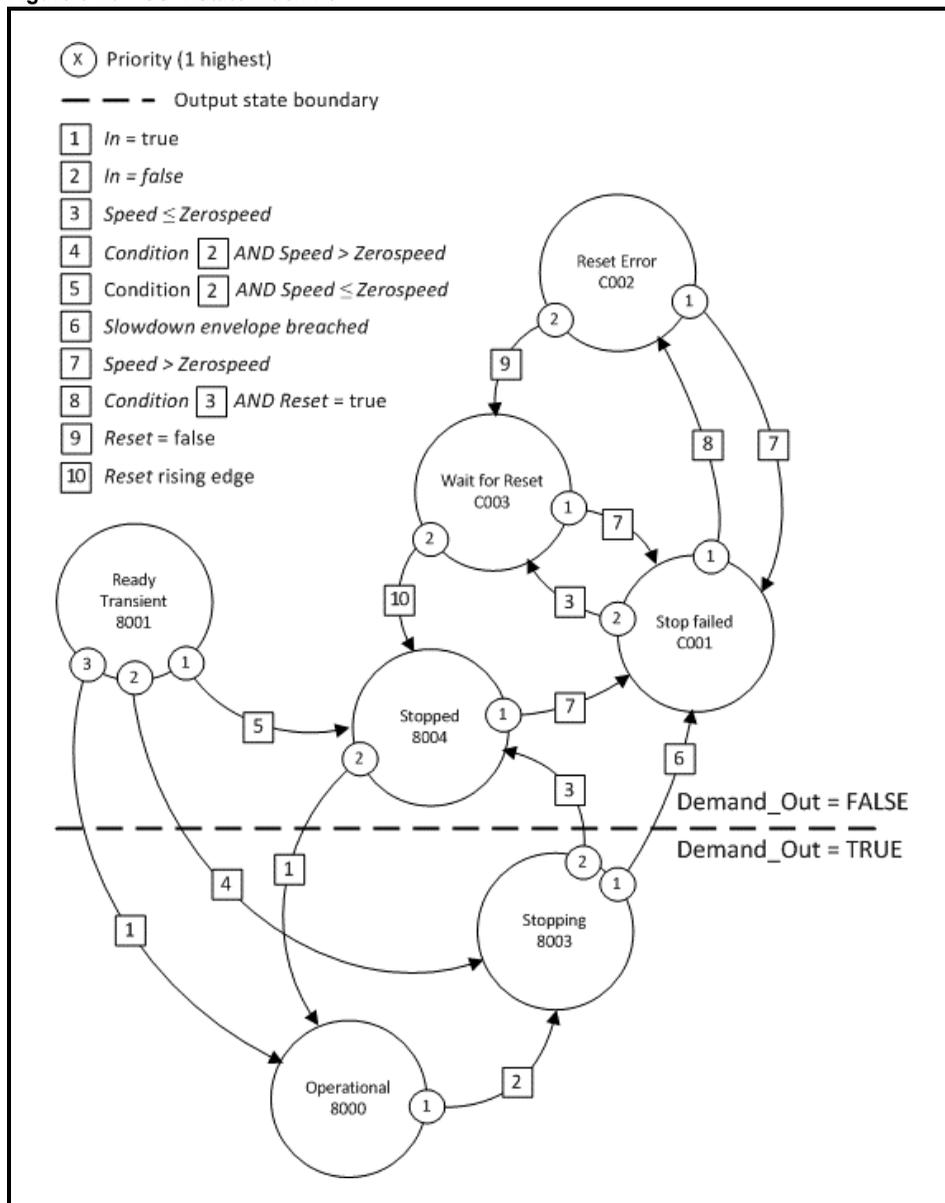
The following Timing diagram is a walkthrough of a given scenario provided to aid understanding of the state machine diagram, it starts from the first time the function is run. Input functions run as soon as the MSF system is executing, Logic and Output functions run after system reset.

Figure 8-11 SS-5 Timing Diagram showing ramp mode envelopes

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ALARMS		
SS Diagnostic Output	**State**	**Description**
0xC001	Stop Failed	Occurs when the axis speed breaches the slowdown envelope or exceeds the zero speed threshold value while the input is FALSE. **In Error State:** Demand Out = FALSE
0xC002	Reset Error	Occurs if the reset signal is high when the C001 error clears. **In Error State:** Demand Out = FALSE
0xC003	Wait for Reset	Occurs after an error state once the error condition has cleared, a rising edge on the error input is required to leave the state. **In This State:** Demand Out = FALSE
DIAGNOSTICS		
0x8000	Operational	Function is operational and not monitoring slowdown or zero speed **To enter this state:** Input = TRUE **In this state:** Demand Out = TRUE
0x8001	Ready	A transient state that occurs for 1 cycle at start up, allows inputs to be checked before any output is set to true. **In This State:** Demand Out = FALSE
0x8003	Stopping	Function is monitoring the slowdown of the axis. **To enter this state:** Input = FALSE **In this state:** Demand Out = TRUE
0x8004	Stopped	Function has detected a stop and sets is output false and is monitoring the speed, if the speed goes above the tolerance speed the function will go to Stop Failed error state and an alarm will be raised. **To enter this state:** Input = FALSE AND axis stopped **In this state:** Demand Out = FALSE

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8.5.1 Safe Stop 1 (SS1)

For the Safe Stop 1 functionality Connect automatically configures a connection between the SS and the STO functions. For a full SS1 implementation SES should also be used as the input to this block. This function uses the Connect STO function so this means that this SS1 is to control the drive that the MiS210 is fitted on via the blade connection.

Figure 8-12   SS1 Diagrammatic representation of SS1

All of the Selectors, Attributes and Outputs related to the SS and STO MSFs are available to be set up for this block within Connect, with the exception of those shown on the diagram above as being specifically configured by Connect.

All of the Errors and Alarms raised by SS and STO MSFs are applicable.

8.5.2   Safe Stop 2 (SS2)

For the Safe Stop 2 functionality Connect automatically configures connections between the SS and SOS functions. For a full SS2 implementation SES should also be used as the input to this block.

Figure 8-13   SS2 Diagrammatic representation of SS2

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All of the Selectors, Attributes and Outputs related to the SS and SOS MSFs are available to be set up for this block within Connect, with the exception of those shown on the diagram above as being specifically configured by Connect.

All of the Errors and Alarms raised by SS, SOS and STO MSFs are applicable.

8.6   Safely Limited Speed (SLS)

The purpose of this function is to monitor the speed of the drive, with various additional checks on acceleration and/or time to reach the safe speed and/or zero speed. When the function is active, if the axis reaches a speed above that defined by the active envelope the SLS output will be set to FALSE, this might be connected to STO to provide a mitigating safety function element. It uses the selected encoder input or inputs to monitor the speed.

This function has a single instances within the firmware and it can be activated or deactivated at design time only. The function has similarities to that defined in PLCopen Safety part 1 but has significant differences because of the function's direct access to speed feedback.

The following standards are applicable:

Standard	Requirements
IEC 61800-5-2: 2007	4.2.3.4 Safely-Limited Speed (SLS) The SLS function prevents the motor from exceeding the specified speed limit.
IEC 60204-1 Ed 5: 2003	9.2.6.3 Enabling control Enabling control (see also 10.9) is a manually activated control function interlock that: a) when activated allows a machine operation to be initiated by a separate start control, and b) when de-activated – initiates a stop function, and – prevents initiation of machine operation.
IEC 954-1: 1996	5.4 Manual reset
ISO 12100-2: 2003	4.11.4: Restart following power failure/spontaneous restart

Figure 8-14   SLS-1 Diagrammatic representation of the SLS function

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INPUT SELECTORS	
Name	**Description**
SLS Speed Limit In Source	This is the input selector for the function's Speed Limit Input. This input controls whether the function monitors for safe speed or not. **Value of Selector** **0.000**: Default (Illegal will cause a configuration error, this selector must be set by the user) **0.001**: Disabled, turns off speed limit monitoring, works in conjunction with SLS Zero speed In Source (equivalent to selecting a permanently TRUE SAFEBOOL value) If this input is disabled the function will not monitor for safe speed. If this input is disabled then SLS Zero Speed In Source **MUST** be enabled. **Valid Output Connector from another Block:** **Value of Source Selected** **TRUE**: The Safe Speed Limit is not monitored and if the Zero speed Input is also TRUE the SLS demand output is set to TRUE. **FALSE**: The Safe Speed Limit is monitored and if its envelope is exceeded the SLS demand output is set to FALSE. **Note**: If the Zero speed Input is FALSE then the Zero Speed Threshold takes precedence and is monitored.
SLS Zero Speed In Source	This is the input selector for the function's zero speed Input. This input controls whether the function monitors for zero speed or safe speed. **Value of Selector** **0.000**: Default (Illegal will cause a configuration error, this selector must be set by the user) **0.001**: Disabled, turns off zero speed monitoring, works in conjunction with SLS Zero speed In Source (equivalent to selecting a permanently TRUE SAFEBOOL value). If this input is disabled the function will not monitor zero speed. If this input is disabled then SLS Speed Limit In Source **MUST** be enabled. **Valid Output Connector from another Block:** **Value of Source Selected** **TRUE**: The Zero Speed Threshold is not monitored and if the Speed Limit Input is also TRUE the SLS demand output is set to TRUE. **FALSE**: The Zero Speed Threshold is monitored and if its envelope is exceeded true the SLS demand output is set to FALSE. **Note**: The Speed Limit Input is ignored if the Zero speed input is FALSE.
SLS Reset In Source	This is the input selector for the function's reset Input. A rising edge on this input will reset the function following an envelope breach error. As this is a serious error (the machine has lost control) there is no auto reset. **Value of Selector** **0.002**: Default, this selection causes the function to use global reset input. **Valid Output Connector from a non-safe input block**: Value of Source Selected. **Rising Edge (a change from FALSE to TRUE)**: The function will be reset if the error condition is no longer present. **Falling edge or unchanging TRUE or FALSE**: Does not cause a reset, (a continuous TRUE signal may cause a reset error, see state machine).
SLS Speed Underride Source	This is the input selector for the function's speed underride input. This input can provide a value to reduce the speed limit below the Safe Speed threshold but not increase the speed limit above the Safe Speed threshold. The value can only be selected from a 32 bit Safety Network input. A 32 bit multiplier is provided so that the input can (if necessary) be scaled up to match the internal 64 bit speed value. The selected value **MUST** be positive. **Value of Selector** **0.001**: Default, this selection disables the Speed Underride Input and the function will use the Safe Speed value as the limit. **Valid Output Connector from another Block:** **Value of Source Selected** **32 bit integer**: A value **transmitted** over a safety network which can be used to underride the fixed safe speed.

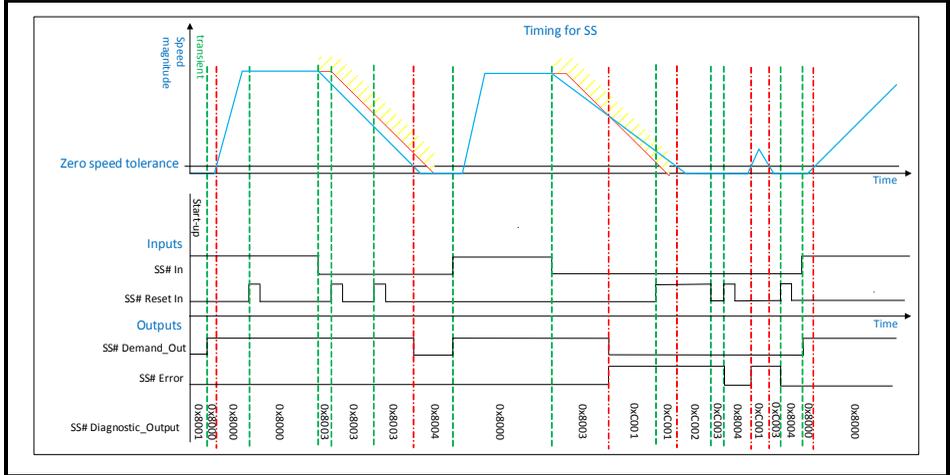| ATTRIBUTES	
SLS Deceleration Mode	This attribute selects the function's deceleration mode. **Value** **Immediate (0)**: When the monitoring inputs (Speed Limit and Zero speed) request speed monitoring the selected level is applied immediately with no ramps or timers **Rate (1)**: When the monitoring inputs (Speed Limit and Zero speed) request speed monitoring, then a dwell timer and deceleration ramp is applied to allow the axis time to reduce speed before the selected level is monitored. Note: This mode will detect an envelope breach during slowdown faster than the time mode. **Time (2)**: When the monitoring inputs (Speed Limit and Zero speed) request speed monitoring, then a timer is applied to allow the axis time to reduce speed before the selected level is monitored.
SLS Safe Speed	The speed that the function will use for its speed limit, unless it is under-ridden by the Speed Underride Input and its multiplier, if this is the case then this parameter acts as an upper limit on the Speed Underride Input. **Value** Safe speed in encoder counts/s
SLS Deceleration 1	The deceleration that the function will use to construct segment 2 of the rate envelope (see Rate Envelope Diagram), this parameter is not used if the Deceleration Mode is Immediate or Time and may be left at default. **Value** Deceleration in encoder counts/s² Minimum value is 1000.
SLS Deceleration 2	The deceleration that the function will use to construct segment 5 of the rate envelope (see Rate Envelope Diagram), this parameter is not used if the Deceleration Mode is Immediate or Time and may be left at default. **Value** Deceleration in encoder counts/s² Minimum value is 1000.
SLS Time To Safe Speed	The time that the function will use to construct segment 2 of the time envelope (see Time Envelope Diagram), this parameter is not used if the Deceleration Mode is Immediate or Rate and may be left at default. **Value** Time in s.
SLS Time To Zero Speed	The time that the function will use to construct segment 4 of the time envelope (see Time Envelope Diagram), this parameter is not used if the Deceleration Mode is Immediate or Rate and may be left at default. **Value** Time in s.
SLS Zero Speed Threshold	The speed in encoder counts/s that the function will use for its zero speed tolerance and standstill monitoring (see Zero speed Behavior Diagram). **Value** Zero speed threshold in encoder counts/s.
SLS Max Standstill Distance	The maximum creep distance (distance relative to the position at which the axis dropped below the Zero Speed Threshold) allowed when zero speed mode is set to position, ignored in speed mode (see Zero speed Behavior Diagram), this parameter is not used if the Zero Speed Mode is Speed and may be left at default. **Value** Distance encoder counts.

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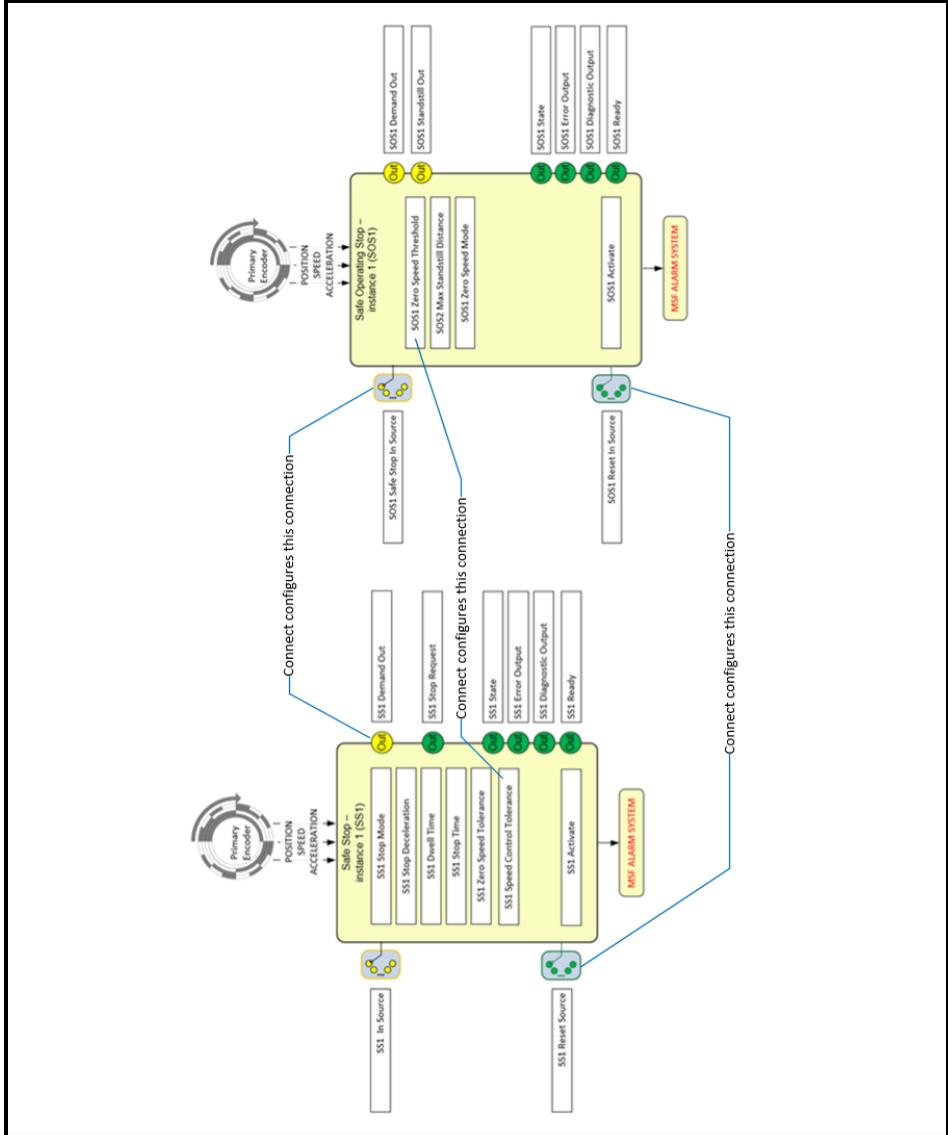|	
SLS Zero Speed Mode	This attribute selects the function's zero speed mode controlling the function behavior at speeds below the Zero Speed Threshold. **Value** **Speed (0)**: When the speed monitoring envelope (see The Envelope Diagrams) is in segment 6 the axis speed is monitored, if it exceeds the Zero Speed Threshold then the SLS Demand Output is set to false. When a slowdown phase is active in time mode then the function checks that the speed does not increase over each cycle. A parameter Speed Control Tolerance is provided to allow small speed control oscillations to be ignored. **Position (1)**: When the speed monitoring envelope (see The Envelope Diagrams) is in segment 6 the axis speed and standstill distances (see Standstill Diagram) is monitored, if either the speed exceeds the Zero Speed Threshold or the Relative position exceeds the Standstill Distance then the SLS Demand Output is set to false.
SLS Dwell Time 1	This attribute controls the amount of time (segment 1) in milliseconds to be inserted into the Rate Envelope before Deceleration1 (Segment 2) starts to be monitored, this parameter is not used if the Deceleration Mode is Immediate or Time and may be left at default. **Value** Time in ms.
SLS Dwell Time 2	This attribute controls the amount of time (segment 4) in milliseconds to be inserted into the Rate Envelope before Deceleration 2 (Segment 5) starts to be monitored, this parameter is not used if the Deceleration Mode is Immediate or Time and may be left at default. **Value** Time in ms.
SLS Speed Underride Multiplier	This attribute works in conjunction with the function's speed underride input. It allows the underride input to be scaled up to match the internal 64 bit speed value. The minimum value is 1.
SLS Speed Control Tolerance	This attribute is for setting an upper limit on the amount of dither on the speed feedback which the function allows during slowdown, speed limit and zero speed monitoring.
SLS Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.
OUTPUTS	
SLS Demand Out	This is the primary safety demand output of the SLS function. It is intended for the control of some mitigating action should control of the axis be lost and the monitored speed is exceeded. The mitigation required depends on the nature of the machine but could include one or more of making STO FALSE, or setting a safe output to FALSE so that some other device can perform an action. If the function is activated it must be connected by means of another function's input selector being set to the parameter number of this output. More than one other input selector can select this output. **Value** **TRUE**: The function is initialized and has detected no errors. **FALSE**: The function is not initialized, OR has detected an error OR is waiting for a reset after an error has cleared.
SLS Safety Active Out	This is a tertiary safety output of the SLS function. It provides a safe signal to indicate if the axis meets the selected monitoring threshold. It might be used (via an output) to release a gate lock or some other device, or it might be connected to another function. If the function is activated its use is optional and it may be left disconnected. More than one other input selector can select this output. **Value** **TRUE**: The function is initialized AND is monitoring a threshold AND there are no errors. **FALSE**: The function is not initialized, OR has detected an error OR is above both of the thresholds.

SLS At Zero Speed Out	This is a tertiary safety output of the SLS function. It provides a safe signal to indicate if the axis is at zero speed. It might be used (via an output) to release a gate lock or some other device, or it might be connected to another function. If the function is activated its use is optional and it may be left disconnected. More than one other input selector can select this output. **Value** **TRUE**: The function is initialized AND is monitoring zero speed AND there are no errors. **FALSE**: The function is not initialized, OR has detected an error OR is above zero speed.
SLS Below Speed Limit Out	This is a tertiary safety output of the SLS function. It provides a safe signal to indicate if the axis is below the safe speed (including any underride). It might be used (via an output) to release a gate lock or some other device, or it might be connected to another function. If the function is activated its use is optional and it may be left disconnected. More than one other input selector can select this output. **Value** **TRUE**: The function is initialized AND is monitoring safe speed AND there are no errors. **FALSE**: The function is not initialized, OR has detected an error OR is above safe speed.
SLS Request Limited Speed	This is a tertiary, non-safe output of the SLS function. It provides a signal that could be used to request that the axis slows to below limited speed. **Value** **TRUE**: The axis should go to below safe speed. **FALSE**: Below safe speed is not requested (but zero speed may be).
SLS Request Standstill	This is a tertiary, non-safe output of the SLS function. It provides a signal that could be used to request that the axis slows to zero speed. **Value** **TRUE**: The axis should go to zero speed. **FALSE**: Below safe speed is not requested (but limited speed may be).
SLS State	RESERVED
SLS Error Output	Indicates that the function has detected an error condition. **Value** **TRUE**: Error, check Diagnostic Out for details. **FALSE**: No Error.
SLS Diagnostic Out	Diagnostic Fault Code.
SLS Ready	Copy of SLS Activate.

The function is only active if "SLS Activate" has been set at design-time, the behavior description below describes an activated function. For deactivated functions all the outputs are set to false.

The function has 4 Safe outputs:

SLS Demand Out is set to FALSE if the function has not been initialized (this only occurs at start up), if errors are detected, or if the function is waiting to be reset after an error has occurred, otherwise it is set to TRUE. If an error occurs the function will set SLS Demand Out to FALSE and it will remain in this state until the source of the error clears and the function is reset.

SLS Active Out is set to FALSE if the function has not been initialized (this only occurs at start up) or the axis is operating with no speed limitation or there is an error or, the function is waiting to be reset after an error has occurred, otherwise it is set to TRUE.

SLS At Zero Speed Out is set to FALSE if the axis is above zero speed otherwise it is TRUE, this applies even when an error exists.

SLS Below Speed Limit Out is set to FALSE if the axis is above safe speed otherwise it is TRUE, this applies even when an error exists.

NOTE

If it is required to have a Zero Speed or Below Speed Limit signal that goes false with error then AND the signal with Active Out.

The function has 2 non-safe outputs:
These 2 outputs are provided for convenience and are not classed as part of the safety system.

SLS Request Limited Speed, when the function is monitoring for safe speed, or a slowdown to it, this output is true; it can be used by the drive to initiate a slowdown to limited speed and hold the axis that condition. There are many ways to do this and its use is left to the user.

SLS Request Standstill, when the function is monitoring for zero speed, or a slowdown to it, this output is true; it can be used by the drive to initiate a slowdown to zero speed and hold that condition. There are many ways to do this and its use is left to the user.

Errors and Reset:
If an error occurs the function will set SLS Demand Out to FALSE and will remain in this state until the source of the error clears. The function must then be reset by means of a rising edge applied to the reset input; there is no auto reset as the monitoring envelope has been breached, indicating that the axis has lost control so intervention is required.

Monitoring types and methods:
The SLS function provides 2 speed thresholds (Below Safe Speed or Zero Speed) that can be either chosen at design-time or dynamically selected by the Speed Limit and Enable inputs. Of the two, Zero Speed monitoring takes precedence and is discussed first.

Zero Speed Monitoring is on if the Enable Input is false, in which case the Speed Limit input is ignored. Zero speed monitoring has two modes in the simplest (Speed Mode) it checks that the axis speed is below the zero threshold (given in SLS Zero Speed Threshold) and (allowing for slowdown if selected - see Decelerations Modes below) if it is not sets all its outputs to false and enters a latched error state, it will allow the axis to creep and so should not be used if this is a risk. Speed Mode is illustrated by the upper graph in Figure 8-16 *SLS-3 Zero Speed Monitoring (only positive limits shown), by itself the top graph shows the axis slowing, monitoring starting followed by a monitored slow down, below zero speed threshold operation, and envelope breach is detected at about 930 s*.

The second mode (Position Mode) also checks speeds but adds a position check too so that the axis cannot creep more than a given distance (given in SLS Max Standstill Distance). The axis position is grabbed when the axis falls below the zero speed threshold and the subsequent position is monitored. Position Mode is illustrated by both graphs in graph in Figure 8-16 *SLS-3 Zero Speed Monitoring (only positive limits shown), by itself the top graph shows the axis slowing, monitoring starting followed by a monitored slow down, below zero speed threshold operation, and envelope breach is detected at about 930 s*.

Safe Speed Monitoring is on if the Enable Input is true, and the Speed Limit input is true. It checks that the axis speed is below Safe Speed (given in SLS Safe Speed) and (allowing for slowdown if selected - see Deceleration Modes below) if it is not it sets all of its outputs to false and enters a latched error state. This is shown in Figure 8-15 *SLS-2 Safe Speed Monitoring, shows axis slowing, monitoring starting followed by a monitored slow down, below speed limit operation, and envelope breach is detected at about 900 s*.

Figure 8-15   SLS-2 Safe Speed Monitoring, shows axis slowing, monitoring starting followed by a monitored slow down, below speed limit operation, and envelope breach is detected at about 900 s

Figure 8-16   SLS-3 Zero Speed Monitoring (only positive limits shown), by itself the top graph shows the axis slowing, monitoring starting followed by a monitored slow down, below zero speed threshold operation, and envelope breach is detected at about 930 s

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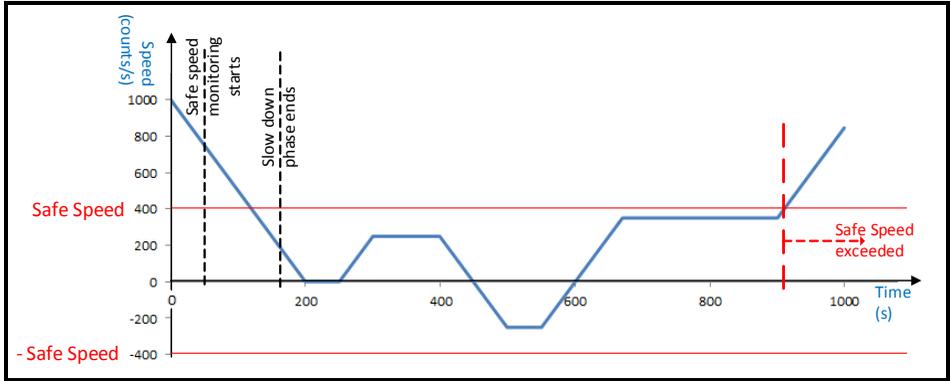
Version Control (Amendments)
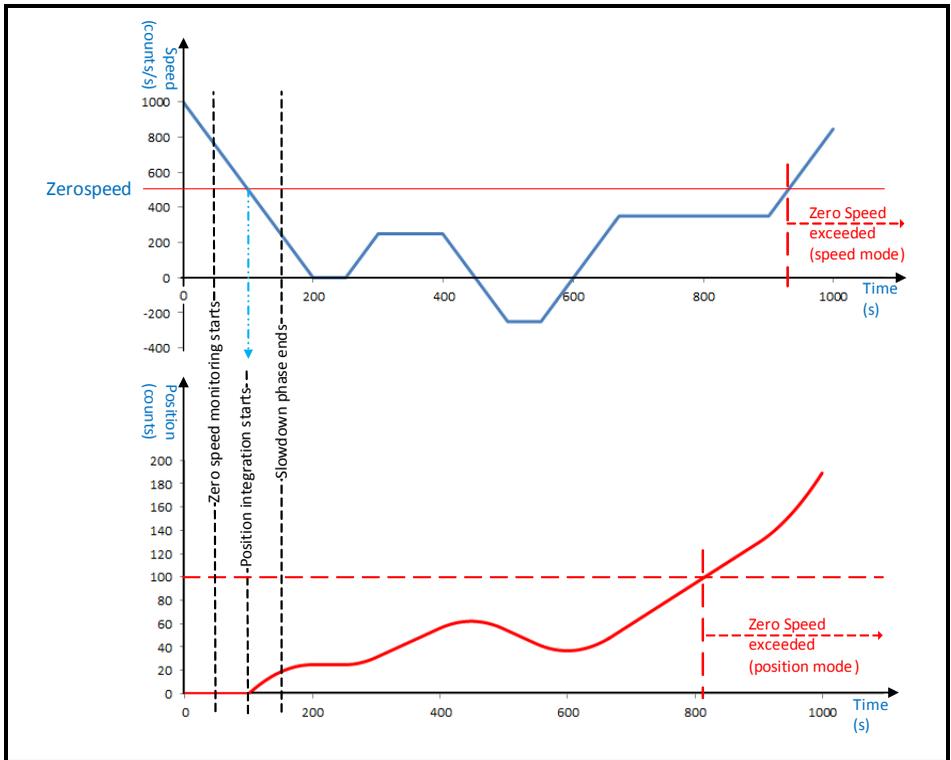
The two graphs in conjunction show speed monitoring with standstill monitoring, zero speed is monitored and used to initialize the standstill position integration, if the allowed displacement occurs (in either direction) then the envelope breach occurs (after about 810 s on the graph).

Deceleration Modes:

The SLS function has 3 different ways to monitor the axis speed when monitoring is requested:

Immediate Mode causes the function to monitor which ever threshold is active immediately allowing no time for the axis to slow down. This mode should be used if the machine control system (not the safety monitoring systems) will slow the machine to the appropriate speed before requesting speed monitoring. See Figure 8-17 *SLS-4 Immediate Mode speed monitoring envelope (shown by red line)*. If the envelope (the red line in the diagram is crossed by the speed magnitude the function goes to its error state and sets it Demand Output to false. This mode should always pick up errors faster than Rate mode, however it cannot monitor the slowdown.

Figure 8-17   SLS-4 Immediate Mode speed monitoring envelope (shown by red line)
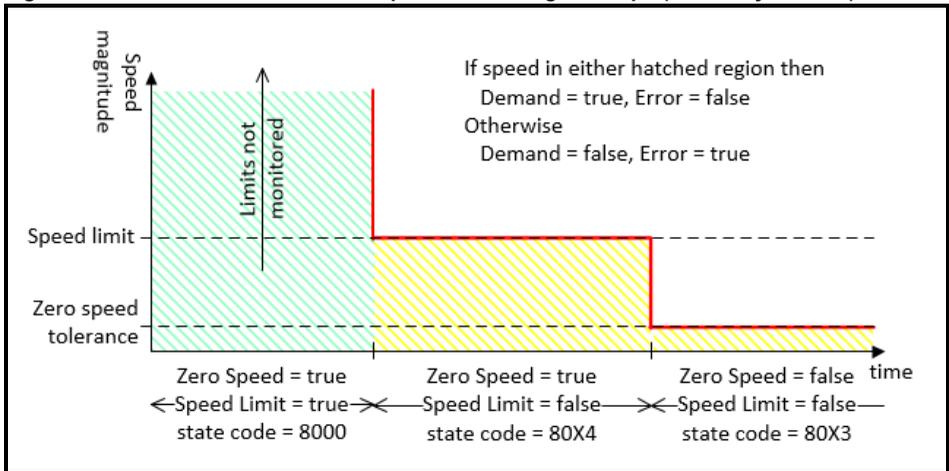
NOTE

The time axis should not be regarded as linear.

Rate Mode: causes the function to monitor which ever threshold is active allowing time for the axis to slow down to one or other threshold by providing an adjustable dwell time (SLS Dwell Time 1 or 2 depending on active threshold) followed by a segment where the deceleration is monitored (SLS Deceleration 1 or 2 depending on active threshold). This mode should be used if the machine control system (not the safety monitoring) will not slow the machine to the active threshold speed before requesting speed monitoring and the deceleration rate is known. See Figure 8-18 *SLS-5 Rate Mode speed monitoring envelope (shown by red line)*. If the envelope (the red line in the diagram) is crossed by the speed magnitude the function goes to its error state and sets its Demand Output to false. This mode should always pick up errors earlier than Timed mode.

Figure 8-18   SLS-5 Rate Mode speed monitoring envelope (shown by red line)
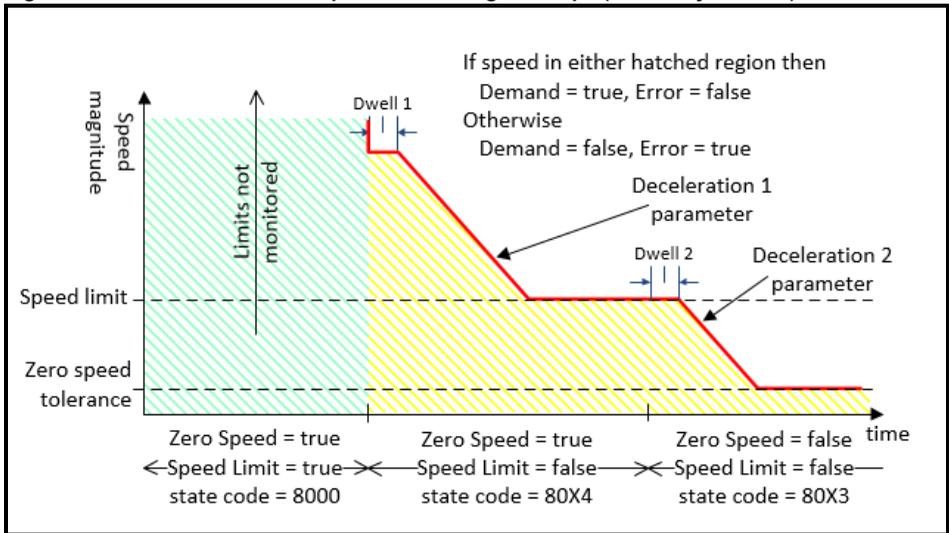
Timed Mode: Causes the function to monitor which ever threshold is active allowing time for the axis to slow down to the selected threshold by providing an adjustable slow down time (SLS Time To Safe Speed or SLS Time To Zero Speed depending on active threshold). This mode should be used if the machine control system (not the safety monitoring system) will not slow the machine to the active threshold speed before requesting speed monitoring and the deceleration rate is unknown or variable, and only a maximum time can be given. See Figure 8-19 *SLS-6 Time Mode speed monitoring envelope (shown by red line)*. If the envelope (the red line in the diagram) is crossed by the speed magnitude the function goes to its error state and sets it Demand Output to false. In addition, if the axis is detected as accelerating the function moves to the error state immediately.

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Figure 8-19   SLS-6 Time Mode speed monitoring envelope (shown by red line)
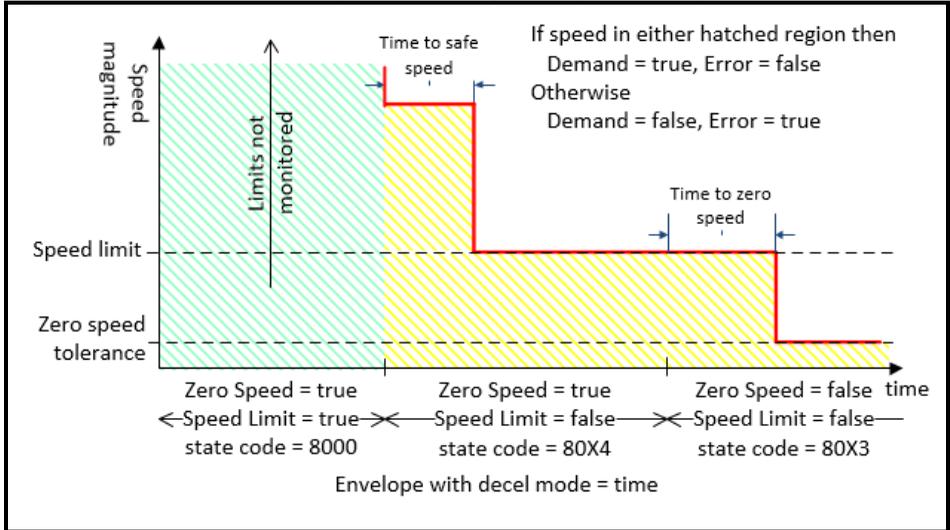
NOTE

The time axis should not be regarded as linear.

Figure 8-20   SLS-7 State Machine

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The following Timing diagram is a walkthrough of a given scenario provided to aid understanding of the state machine diagram, it starts from the first time the function is run. Input functions run as soon as the MSF system is executing, Logic and Output functions run after system reset.

Figure 8-21   SLS-8 Timing Diagram

ALARMS		
SLS Diagnostic Output	**State**	**Description**
0xC0X1	Zero Speed Threshold Exceeded	Occurs when the axis speed exceeds the zero speed threshold value or if configured the standstill distance, whichever comes first. The X in the code is a 4 bit value that can be used to determine in which envelope segment the error occurred (see Figures SLS – 9, SLS-10). **In Error State:** Demand Out = FALSE Safety Active Out =FALSE Below Speed Limit Out = FALSE At Zero Speed Out = FALSE
0xC0X2	Safe Speed Threshold Exceeded	Occurs when the axis speed exceeds the safe speed threshold value. The X in the code is a 4 bit value that can be used to determine in which envelope segment the error occurred (see Figures *SLS* – 9, SLS-10). **In Error State:** Demand Out = FALSE Safety Active Out =FALSE Below Speed Limit Out = FALSE At Zero Speed Out = FALSE
0xC003	Reset Error	Occurs if the reset signal is high when the C0X1 or C0X2 error clears. **In Error State:** Demand Out = FALSE Safety Active Out =FALSE Below Speed Limit Out = FALSE At Zero Speed Out = FALSE
0xC004	Wait for Reset	Occurs after an error state once the error condition has cleared, a rising edge on the error input is required to leave the state. **In This State:** Demand Out = FALSE Safety Active Out =FALSE Below Speed Limit Out = FALSE At Zero Speed Out = FALSE
DIAGNOSTICS		
0x8000	Operational	Function is not monitoring speed and axis may run at full speed. **To enter this state:** Speed Limit In = TRUE Zero speed In = TRUE **In this state:** Demand Out = TRUE Safety Active Out =FALSE Below Speed Limit Out = FALSE At Zero Speed Out = FALSE
0x8001	Ready	A transient state that occurs for 1 cycle at start up, allows inputs to be checked before any output is set to true. **In This State:** Demand Out = FALSE Safety Active Out =FALSE Below Speed Limit Out = FALSE At Zero Speed Out = FALSE

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0x80X3	Monitoring zero speed	Function is monitoring zero speed and axis should be stationary, as defined by the zero speed thresholds and mode attributes. The X in the code is a 4 bit value that can be used to determine in which envelope segment axis is currently in (see Figures *SLS* – 9, SLS-10). **To enter this state:** Speed Limit In = ignored Zero speed In = FALSE **In this state:** Demand Out = TRUE Safety Active Out =TRUE Below Speed Limit Out = TRUE At Zero Speed Out = TRUE
0x80X4	Monitoring safe speed	Function is monitoring the safe speed limit and axis speed should be below the safe speed threshold, as defined by the safe speed threshold and mode attributes. The X in the code is a 4 bit value that can be used to determine in which envelope segment axis is currently in (see Figures *SLS* – 9, SLS-10). **To enter this state:** Speed Limit In = FALSE Zero speed In = TRUE **In this state:** Demand Out = TRUE Safety Active Out =TRUE Below Speed Limit Out = TRUE At Zero Speed Out = FALSE

Figure 8-22   SLS–9 Rate mode segment numbers used in the diagnostic and error codes
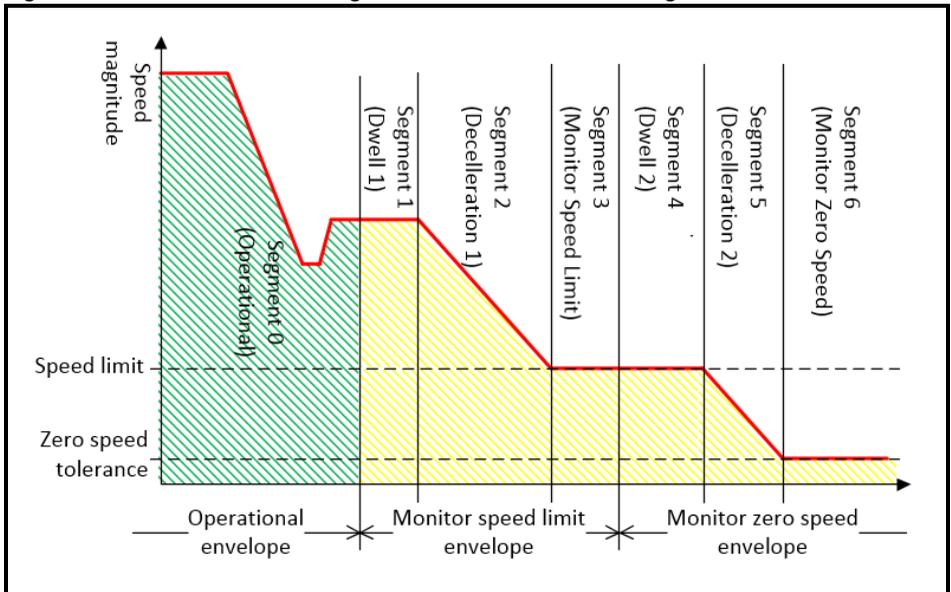
Figure 8-23 SLS–10 Time mode segment numbers used in the diagnostic and error codes (immediate mode is similar but segments 1 and 4 are of 0 width)
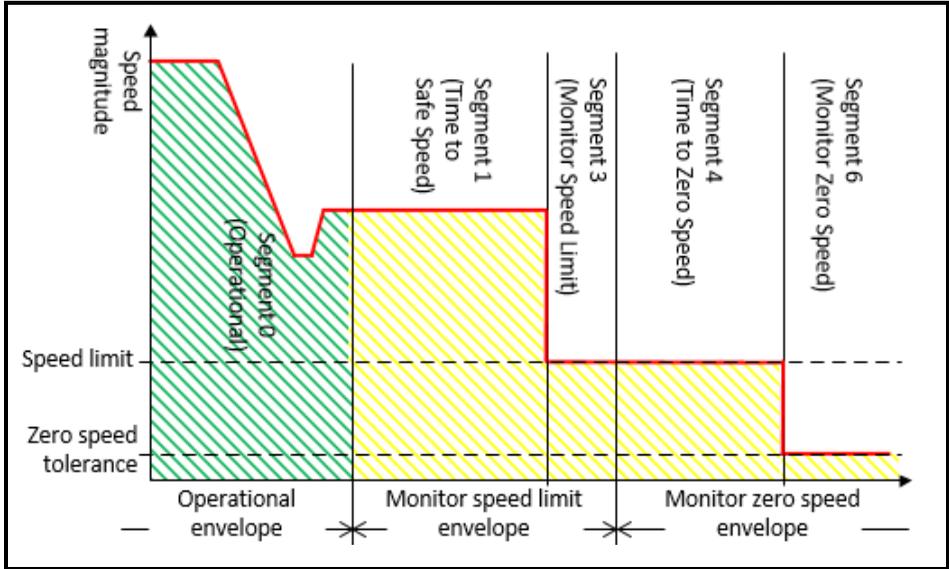
8.7 Safe Operating Stop (SOS)

This function sets its output to TRUE if the input is TRUE, when the input is FALSE it monitors the speed of the axis, and sets its output TRUE if the axis speed is below the zero speed threshold and (optionally) if the axis is not creeping or FALSE otherwise. It uses the selected encoder input or inputs to monitor the speed.

The function is used within Safe Stop 2 (see section 8.5.2) but could be used in other applications where an axis zero speed needs to be monitored.

This function has a single instance available for the user and it can be activated or deactivated at design time only. The function is an implementation of the function briefly described in IEC 61800-5-2:2007.

The following standards are applicable:

Standard	Requirements
IEC 61800-5-2:2017	Section 4.2.3.1 The SOS function prevents the motor from deviating more than a defined amount from the stopped position. The PDS(SR) provides energy to the motor to enable it to resist external forces.
	NOTE
	This description of an operational stop function is based on implementation by means of a PDS(SR) without external (for example mechanical) brakes.
PLC Open	5.2.2.1 Safe Operating Stop (SOS) Ensures that the motor remains stopped by resisting external forces.

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Figure 8-24   SOS-1 Diagrammatic representation of the *SOS* function

Primary
Encoder

POSITION
SPEED
ACCELERATION

Safe Operating Stop –
instance 1 (SOS1)

SOS1 Safe Stop In Source

Out   SOS1 Demand Out

Out   SOS1 Standstill Out

SOS1 Zero Speed Threshold

SOS2 Max Standstill Distance

SOS1 Zero Speed Mode

Out   SOS1 State

Out   SOS1 Error Output

Out   SOS1 Diagnostic Output

SOS1 Reset In Source

SOS1 Activate

Out   SOS1 Ready

MSF ALARM SYSTEM

INPUT SELECTORS	
Name	**Description**
SOS Safe Stop In Source	Selects a SAFEBOOL connection point for the safety signal which will request safe operating stop monitoring. This function will usually be used with the safe stop function and when used with it produces the equivalent of Safe Stop 2. The Primary safe output of the function would usually be connected to the STO function. **Value of Selector** **0.000**: Default (Illegal will cause a configuration error, this selector must be set by the user). **Valid Output Connector from another Block:** **Value of Source Selected** **TRUE**: SOS Function is not monitoring zero speed. **FALSE**: If there is no error, SOS Function is monitoring zero speed.
SOS Reset In Source	This is the input selector for the function's reset Input. A rising edge on this input will reset the following an envelope breach error. As this is a serious error (the machine has lost control) there is no auto reset. **Value of Selector** **0.002**: Default, this selection causes the function to use global reset input. **Valid Output Connector from a non-safe input block:** **Value of Source Selected** **Rising Edge (a change from FALSE to TRUE)**: The function will be reset if the error condition is no longer present. **Falling edge or unchanging TRUE or FALSE**: Does not cause a reset, (a continuous TRUE signal may cause a reset error, see state machine).
ATTRIBUTES	
SOS Zero Speed Threshold	This attribute defines the speed threshold below which the machine is regarded to be stationary. **Attribute Value** The Zero Speed Tolerance specified in the number of encoder counts per second. Default value = 0 The permissible range of values is from 0 to a maximum of 4294967295 counts per second.
SOS Max Standstill Distance	When operating in the position monitoring mode this value is the maximum positive or negative distance from the position read when the function is commanded (SOS Safe Stop In Source = FALSE). If the distance is exceeded the function output, SOS Demand Out = FALSE. All movements within the specified distance relative to the position read when the function is commanded will result in the function output, SOS Out = TRUE. **Attribute Value** The Max Standstill Distance is specified as number of encoder counts. Default value = 0 The permissible range of values is from 0 to a maximum of 4294967295 counts.
SOS Zero Speed Mode	This parameter switches between position and speed modes. In speed (0) mode when SOS Safe Stop In goes to FALSE the axis is monitored for zero speed. In position mode (1) when SOS Safe Stop In goes to FALSE the axis is monitored for both zero speed and standstill. **Attribute Value** **Position**: Monitor the Standstill position. **Speed**: Monitor for zero speed.
SOS Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.

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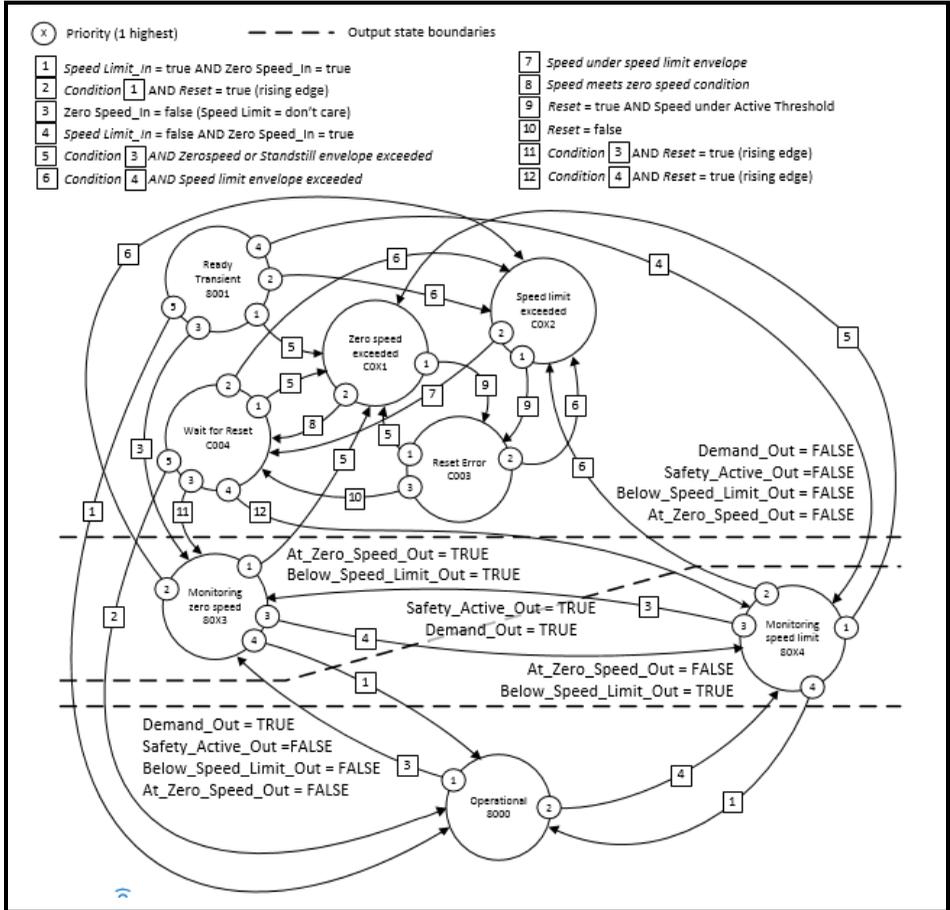| OUTPUTS	
SOS Demand Out	The primary (must be connected) output value of the function provides a signal that should be used to initiate some mitigating action should some unexpected motion in the system be monitored, this could be removal of torque, application of a brake or some other action. **Value SAFEBOOL** **TRUE**: When the Safe Stop Input is true and the function is initialized. When the Safe Stop Input is false and the axis is stopped, and there is no error and the function is initialized. **FALSE**: Any other condition.
SOS Standstill Out	This is a tertiary (can be left unused) output that indicates that the axis is being held at zero speed and there is no error. **Value SAFEBOOL** **TRUE**: When the Safe Stop Input is false and the axis is stopped and has been initialized and there is no error. **FALSE**: Any other condition.
SOS State	RESERVED
SOS Error Out	This output that indicates the commanded SOS has not been able to maintain the minimum speed or if selected, its position within the standstill position range has not been maintained. **Value SAFEBOOL** **TRUE**: Error detected. Minimum speed exceeded or, if selected standstill position exceeded. **FALSE**: No Error detected – No demand for SOS or machine speed or position is within the permissible range.
SOS Diagnostic Out	See diagnostic table for this function for the diagnostic information.
SOS Ready Out	This parameter is a Read Only copy of activate, it is provided for future compatibility with PLCopen.

Functional Description

This function will usually be used with the safe stop function and in this configuration, it produces the equivalent of a Safe Stop 2. The function block uses the selected axis encoder or encoders to monitor the axis speed and or position.

The function has three modes of operation:-

I.   Wait for SOS demand.
II. When an SOS demand is present, and the Zero Speed Mode is speed (1), monitor the axis speed and if the user defined maximum speed is exceeded raise an error.
III. When an SOS demand is present, and the Zero Speed Mode is position (0), monitor the axis speed and the position. If the maximum speed is exceeded or the axis moves beyond the user defined range of movement an error is raised.

Figure 8-25   SOS-2 State Machine

The following Timing diagram is a walkthrough of a given scenario provided to aid understanding of the state machine diagram, it starts from the first time the function is run. Input functions run as soon as the MSF system is executing, Logic and Output functions run after system reset.

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Figure 8-26   SOS-3 Timing Diagram showing the difference between speed and position mode
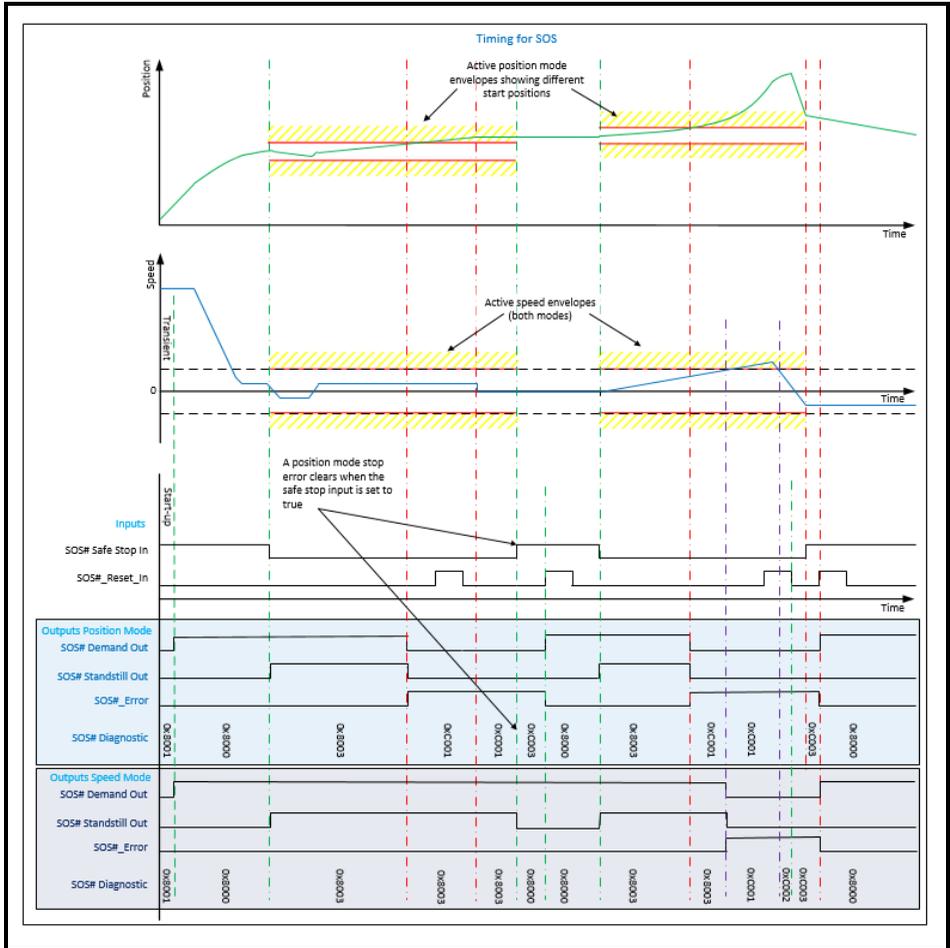
ALARMS		
SOS Diagnostic Output	**State**	**Description**
0xC001	Speed Error	In either mode the detected speed is greater that the speed specified in SOS ZERO SPEED TOLERANCE or excessive creep has been detected in position mode. *In the error state:-* SOS OUT = FALSE SOS STANDSTILL OUT = FALSE
0xC002	Reset Error	The fault has cleared and the system requires a Reset to restart, however the Reset is True hence a rising edge cannot be generated until the reset returns to the False. *In the error state:-* SOS OUT = FALSE SOS STANDSTILL OUT = FALSE

0xC003	Wait for Reset	Occurs after an error state once the error condition has cleared, a rising edge on the error input is required to leave the state. **In This State:** Demand Out = FALSE Standstill Out = FALSE
DIAGNOSTICS		
0x8000	Operational	Following a transition from the Wait For Reset, or Ready, Transient States the function will wait for the demand on the SOS_SAFE_STOP_IN_SOURCE in this state. **To enter this state:** Safe Stop In = TRUE **In this state:** Demand Out = TRUE Standstill Out =FALSE
0x8001	Ready - Transient	This is a transient state on power up. **In this state:** Demand Out = FALSE Standstill Out =FALSE
0x8003	Monitoring Operating Stop	In this state a demand for SOS is present and the SOS is operating correctly with the SOS ZERO SPEED TOLERANCE and the SOS MAXSTANDSTILL DISTANCE not exceeded. **To enter this state:** Safe Stop In = FALSE **In this state:** Demand Out = TRUE Standstill Out =TRUE

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8.8   Safe Speed Monitoring (SSM)

The purpose of this function is to monitor the speed of the drive, and set an output true if the axis speed is below the monitoring speed or false otherwise. It uses the selected encoder input or inputs to monitor the speed.

This function has a single instance within the firmware and it can be activated or deactivated at design time only. The function is an implementation of the function briefly described in IEC 61800-5-2:2007.

The following standards are applicable:

Standard	Requirements
IEC 61800-5-2: 2007	4.2.3.14 Safely Speed Monitor (SSM) The SSM function provides a safe output signal to indicate whether the motor speed is below a specified limit.

Figure 8-27   SSM-1 Diagrammatic representation of the SSM function

INPUT SELECTORS	
Name	**Description**
SSM Speed Underride Source	This is the input selector for the function's speed underride input. This input can provide a value to reduce the speed limit below the Safe Speed threshold but not increase the speed limit above the Safe Speed threshold. The value can only be selected from a 32 bit Safety Network input. A 32 bit multiplier is provided so that the input can (if necessary) be scaled up to match the internal 64 bit speed value. The selected value **MUST** be positive. **Value of Selector** **0.001**: Default, this selection disables the Speed Underride Input and the function will use the Safe Speed value as the limit. **Valid Output Connector from another Block:** **Value of Source Selected** **32 bit integer**: A value transmitted over a safety network which can be used to underride the fixed safe speed.

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ATTRIBUTES	
SSM Safe Speed	The speed that the function will use for its speed limit, unless it is under ridden by the Speed Underride Input and its multiplier. If this is the case, then this parameter acts as an upper limit on the Speed Underride Input. **Value** Safe speed in encoder counts/s.
SSM Speed Underride Multiplier	This attribute works in conjunction with the function's speed underride input. It allows the underride input to be scaled up to match the internal 64 bit speed value. The minimum value is 1.
SSM Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.
OUTPUTS	
SSM Out	This is the primary safety output of the SSM function. It provides a SAFEBOOL value that will typically be used as an input to another function in a design with multiple functions, however it can be connected directly to an output function if required. If the function is activated it must be connected by means of another function's input selector being set to the parameter number of this output. More than one other input selector can select this output. **Value** **TRUE**: The function is initialized and the axis speed is below or equal to the safe speed value. **FALSE**: The function is not initialized, OR and the axis speed is above the safe speed value.
SSM Ready	Copy of SSM Activate.

The function is only active if "SSM Activate" has been set at design-time, the behavior description below describes an activated function. For deactivated functions the outputs are set to false.

The function has 1 Safe output:
SSM Out is set to FALSE if the function has not been initialized (this only occurs at start up), or if the function detects that the axis speed is above the safe speed, otherwise it is set to TRUE.

Figure 8-28   SSM-2 Illustration of output state with axis speed
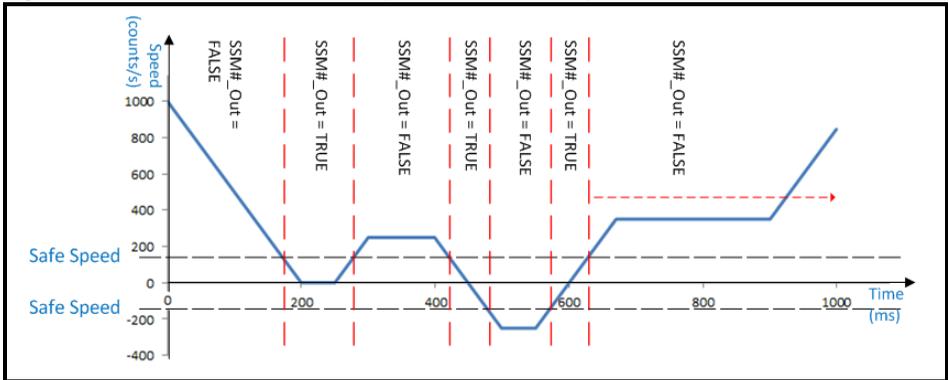
Errors, Reset and Diagnostics:

This function will not raise an error and does not have a reset input.

The function has no state and no significant time based behavior.

There are no error or diagnostic codes.

8.9 Safe Direction (SDI)

This function tests the encoder signals and sets its output to TRUE if the axis is moving in the selected direction, otherwise the output is set to FALSE. An integrator allows a configurable amount of motion in the opposite direction if required.

This function has two instances within the firmware and they can be activated or deactivated at design time only.

Warning: The function does not set its output to FALSE until any motion in the opposite direction to the requested direction exceeds the Opposite Direction Tolerance value. Once this value is exceeded the output will not return to TRUE until an equivalent amount of motion of motion in requested direction occurs.

The following standards are applicable:

Standard	Requirements
IEC 61800 -5-2: 2017	Clause 4.2.4.11 Safe Direction (SDI) The SDI function prevents the motor shaft from moving in the unintended direction.

Figure 8-29   SDI-1 Diagrammatic representation of the SDI function

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ATTRIBUTES	
Name	**Description**
SDI Direction	The direction to be monitored. **Value** 0 – Forward, select for motion with increasing position feedback 1 – Reverse, select for motion with decreasing position feedback.
SDI Opposite Distance Tolerance	The accumulated distance in encoder counts that the axis is allowed to travel in the direction opposite to that selected.
SDI Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.
OUTPUTS	
SDI Out	This is the primary safety output of the SDI function. It provides a SAFEBOOL value that will typically be used as an input to another function in a design with multiple functions, however it can be connected directly to an output function if required. If the function is activated it must be connected by means of another function's input selector being set to the parameter number of this output. More than one other input selector can select this output. **Value** **TRUE**: The function is initialized and the axis speed is travelling in the required direction. **FALSE**: The function is not initialized, OR and the axis speed is traveling or has travelled too far in the opposite direction.
SDI State	RESERVED
SDI Accumulator	The accumulated opposite direction motion in counts if this value exceeds SDI Opposite Direction Tolerance the output SDI Out is set to FALSE.
SDI Ready	Copy of SDI Activate.

The function is only active if "SDI Activate" has been set at design-time, the behavior description below describes an activated function. For deactivated functions, the outputs are set to false.

The function uses the sign of speed in encoder counts per ms to determine the direction. The following checks are done:

1. If the speed is indicating motion in the requested direction and the opposite distance accumulator is 0 then the function output is set to TRUE.

2. If the speed is indicating motion in the requested direction, the Tolerance Reached Flag in State is FALSE and 0 < Accumulator < Opposite Tolerance Distance is TRUE then the function output is set to TRUE and the accumulator value is reduced by the magnitude of the distance moved per cycle or to zero whichever is the larger.

3. If the speed is indicating motion in the requested direction, the Tolerance Reached Flag in State is TRUE and 0 > Accumulator is TRUE then the function output is set to FALSE and the accumulator value is reduced by the magnitude of the distance moved per cycle.

4. If the speed is indicating motion in the requested direction, the Tolerance Reached Flag in State is TRUE and 0 >= Accumulator TRUE then the function output is set to TRUE and the accumulator value is clamped to 0 and the Tolerance Reached Flag is set to FALSE.

5. If the speed is indicating motion in the opposite direction and Accumulator >= Opposite Tolerance Distance is TRUE and the Tolerance Reached Flag in State is FALSE then the function output is set to FALSE, the accumulator value is clamped to the value of Opposite Tolerance Distance and the Tolerance Reached Flag in State is set to TRUE.

6. If the speed is indicating motion in the opposite direction and Accumulator < Opposite Tolerance Distance is TRUE and the Tolerance Reached Flag in State is FALSE then the function output is set to TRUE and the accumulator value is increased by the magnitude of the distance moved per cycle.

7. If the speed is indicating motion in the opposite direction and the Tolerance Reached Flag in State is TRUE then the function output is set to FALSE and the accumulator value is clamped to Opposite Tolerance Distance.

Once the Opposite Tolerance Distance is exceeded the output will only return to true once the axis travels Opposite Tolerance Distance in the correct direction. But position oscillations of amplitude less than Opposite Tolerance Distance will be ignored.

Figure 8-30   SDI-2 Graph of SDI function set for forward direction with a maximum reverse distance of 200 counts
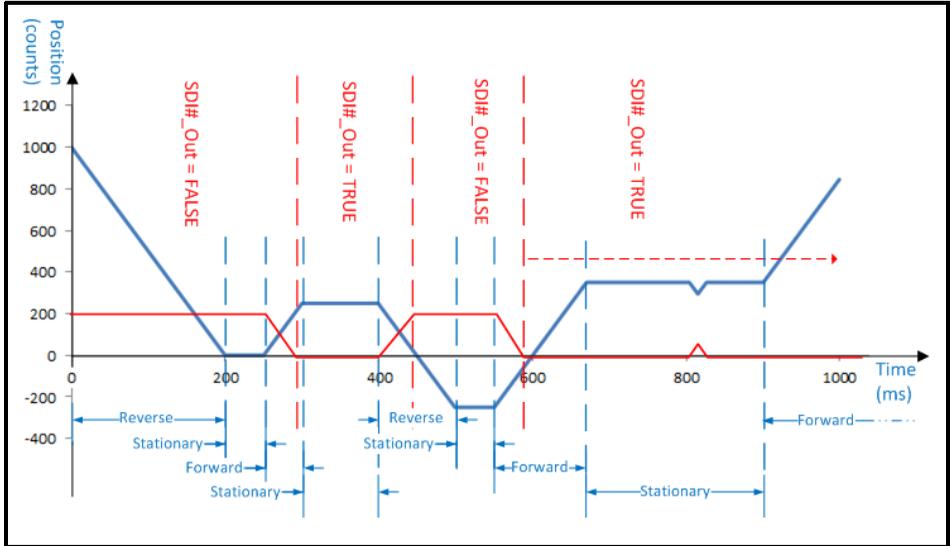
Figure 8-30 showing that a short excursion (at time 800) in the opposite direction can be tolerated if required, and the equivalent forward motion required to clear the accumulated opposite motion. The accumulator value over time is shown as a solid red line.

The function has 1 Safe output:
SDI Out is set to FALSE if the function has not been initialized (this only occurs at start up), or if the function detects that the axis moving in the wrong direction (given the tolerance described above), otherwise it is set to TRUE.

Errors, Alarms, Reset and Diagnostics:
The function raises no errors and has no state machine or diagnostic codes. The function does not raise alarms. The opposite direction accumulator is visible in commissioning mode for diagnostic and commissioning purposes.

8.10   Safe OR (SOR)

This logic function tests its two safe inputs for their state, applies a logical OR and sets the output accordingly. There are eight available instances of this function for the user. Each can be activated or deactivated at design time only. Values are available to be read in Test Mode, if values are read from an activated function the current values are returned, if a read is made on a deactivated function the default value is returned.

Warning: A maximum of eight logic functions (SOR, SNOR, SXOR, SXNOR, SAND, SNAND) are allowed per configuration.

Figure 8-31   SOR-1 Diagrammatic representation of the SOR function

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INPUT SELECTORS	
Name	**Description**
SOR In A Source	Selects the safety signal that needs to be ORed with the value connected to "SOR In B Source". **Value of Selector** **0.000**: This is the default selection, but if the function instance is activated it must be set to select a safe Boolean value. **Value of Source Selected** **TRUE**: the meaning of the signal depends on the system. **FALSE**: the meaning of the signal depends on the system.
SOR In B Source	Selects the safety signal that needs to be ORed with the value connected to "SOR In A Source". **Value of Selector** **0.000**: This is the default selection, but if the function instance is activated it must be set to select a safe Boolean value. **Value of Source Selected** **TRUE**: the meaning of the signal depends on the system. **FALSE**: the meaning of the signal depends on the system.
ATTRIBUTES	
SOR Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.
OUTPUTS	
SOR Out	Outputs the safety related response of the function. **Value** **FALSE**: Demand for safety related response, request for safe state. **TRUE**: No demand for safety related response, request for operational state.
SOR Ready	Copy of SOR Activate.

The function is only active if "SOR Activate" has been set at design-time, the behavior description below describes an activated function.

Truth Table for SOR function		
SOR In A	*SOR In B*	SOR Out
FALSE	FALSE	FALSE
FALSE	TRUE	TRUE
TRUE	FALSE	TRUE
TRUE	TRUE	TRUE

The function raises no errors and has no state machine or diagnostics.

8.11   Safe NOT OR (SNOR)

This logic function tests its two safe inputs for their state, applies a logical NOR and sets the output accordingly. There are eight available instances of this function for the user. Each can be activated or deactivated at design time only. Values are available to be read in Test Mode, if values are read from an activated function the current values are returned, if a read is made on a deactivated function the default value is returned.

Warning: A maximum of eight logic functions (SOR, SNOR, SXOR, SXNOR, SAND, SNAND) are allowed per configuration.

Figure 8-32   SNOR-1 Diagrammatic representation of the SNOR function

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INPUT SELECTORS	
Name	**Description**
SNOR In A Source	Selects the safety signal that needs to be NORed with the value connected to "SNOR In B Source". **Value of Selector** **0.000**: This is the default selection, but if the function instance is activated it must be set to select a safe Boolean value. **Value of Source Selected** **TRUE**: the meaning of the signal depends on the system. **FALSE**: the meaning of the signal depends on the system.
SNOR In B Source	Selects the safety signal that needs to be NORed with the value connected to "SNOR In A Source". **Value of Selector** **0.000**: This is the default selection, but if the function instance is activated it must be set to select a safe Boolean value. **Value of Source Selected** **TRUE**: the meaning of the signal depends on the system. **FALSE**: the meaning of the signal depends on the system.
ATTRIBUTES	
SNOR Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.
OUTPUTS	
SNOR Out	Outputs the safety related response of the function. **Value** **FALSE**: Demand for safety related response, request for safe state. **TRUE**: No demand for safety related response, request for operational state.
SNOR Ready	Copy of SNOR Activate.

The function is only active if "SNOR Activate" has been set at design-time, the behavior description below describes an activated function.

Truth Table for SNOR function		
SNOR In A	*SNOR In B*	SNOR Out
FALSE	FALSE	TRUE
FALSE	TRUE	FALSE
TRUE	FALSE	FALSE
TRUE	TRUE	FALSE

The function raises no errors and has no state machine or diagnostics.

8.12   Safe Exclusive OR (SXOR)

This logic function tests its two safe inputs for their state, applies a logical XOR and sets the output accordingly. There are eight available instances of this function for the user. Each can be activated or deactivated at design time only. Values are available to be read in Test Mode, if values are read from an activated function the current values are returned, if a read is made on a deactivated function the default value is returned.

Warning: A maximum of eight logic functions (SOR, SNOR, SXOR, SXNOR, SAND, SNAND) are allowed per configuration.

Figure 8-33   SXOR-1 Diagrammatic representation of the SXOR function

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INPUT SELECTORS	
Name	**Description**
SXOR In A Source	Selects the safety signal that needs to be XORed with the value connected to "SXOR In B Source". **Value of Selector** **0.000**: This is the default selection, but if the function instance is activated it must be set to select a safe Boolean value. **Value of Source Selected** **TRUE**: the meaning of the signal depends on the system. **FALSE**: the meaning of the signal depends on the system.
SXOR In B Source	Selects the safety signal that needs to be XORed with the value connected to "SXOR In A Source". **Value of Selector** **0.000**: This is the default selection, but if the function instance is activated it must be set to select a safe Boolean value. **Value of Source Selected** **TRUE**: the meaning of the signal depends on the system. **FALSE**: the meaning of the signal depends on the system.
ATTRIBUTES	
SXOR Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.
OUTPUTS	
SXOR Out	Outputs the safety related response of the function. **Value** **FALSE**: Demand for safety related response, request for safe state. **TRUE**: No demand for safety related response, request for operational state.
SXOR Ready	Copy of SXOR Activate.

The function is only active if "SXOR Activate" has been set at design-time, the behavior description below describes an activated function.

Truth Table for SXOR function		
SXOR In A	*SXOR In B*	SXOR Out
FALSE	FALSE	FALSE
FALSE	TRUE	TRUE
TRUE	FALSE	TRUE
TRUE	TRUE	FALSE

The function raises no errors and has no state machine or diagnostics.

8.13   Safe Exclusive NOT OR (SXNOR)

This logic function tests its two safe inputs for their state, applies a logical XNOR and sets the output accordingly. There are eight available instances of this function for the user. Each can be activated or deactivated at design time only. Values are available to be read in Test Mode, if values are read from an activated function the current values are returned, if a read is made on a deactivated function the default value is returned.

Warning: A maximum of eight logic functions (SOR, SNOR, SXOR, SXNOR, SAND, SNAND) are allowed per configuration.

Figure 8-34   SXNOR-1 Diagrammatic representation of the SXNOR function

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INPUT SELECTORS	
Name	**Description**
SXNOR In A Source	Selects the safety signal that needs to be XNORed with the value connected to "SXNOR In B Source". **Value of Selector** **0.000**: This is the default selection, but if the function instance is activated it must be set to select a safe Boolean value. **Value of Source Selected** **TRUE**: the meaning of the signal depends on the system. **FALSE**: the meaning of the signal depends on the system.
SXNOR In B Source	Selects the safety signal that needs to be XNORed with the value connected to "SXNOR In A Source". **Value of Selector** **0.000**: This is the default selection, but if the function instance is activated it must be set to select a safe Boolean value. **Value of Source Selected** **TRUE**: the meaning of the signal depends on the system. **FALSE**: the meaning of the signal depends on the system.
ATTRIBUTES	
SXNOR Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.
OUTPUTS	
SXNOR Out	Outputs the safety related response of the function. **Value** **FALSE**: Demand for safety related response, request for safe state. **TRUE**: No demand for safety related response, request for operational state.
SXONR Ready	Copy of SXNOR Activate.

The function is only active if "SXNOR Activate" has been set at design-time, the behavior description below describes an activated function.

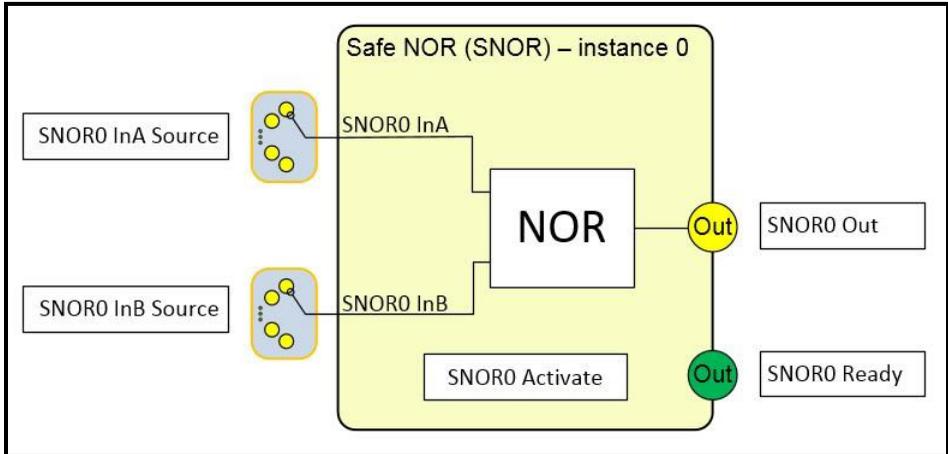| Truth Table for SXNOR function		
SXNOR In A	*SXNOR In B*	**SXNOR Out**
FALSE	FALSE	TRUE
FALSE	TRUE	FALSE
TRUE	FALSE	FALSE
TRUE	TRUE	TRUE

The function raises no errors and has no state machine or diagnostics.

8.14   Safe AND (SAND)

This logic function tests its two safe inputs for their state, applies a logical AND and sets the output accordingly. There are eight available instances of this function for the user. Each can be activated or deactivated at design time only. Values are available to be in Test Mode, if values are read from an activated function the current values are returned, if a read is made on a deactivated function the default value is returned.

Warning: A maximum of eight logic functions (SOR, SNOR, SXOR, SXNOR, SAND, SNAND) are allowed per configuration.

Figure 8-35   SAND-1 Diagrammatic representation of the SAND function

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INPUT SELECTORS	
Name	**Description**
SAND In A Source	Selects the safety signal that needs to be ANDed with the value connected to "SAND In B Source". **Value of Selector** **0.000**: This is the default selection, but if the function instance is activated it must be set to select a safe Boolean value. **Value of Source Selected** **TRUE**: the meaning of the signal depends on the system. **FALSE**: the meaning of the signal depends on the system.
SAND In B Source	Selects the safety signal that needs to be ANDed with the value connected to "SAND In A Source". **Value of Selector** **0.000**: This is the default selection, but if the function instance is activated it must be set to select a safe Boolean value. **Value of Source Selected** **TRUE**: the meaning of the signal depends on the system. **FALSE**: the meaning of the signal depends on the system.
ATTRIBUTES	
SAND Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.
OUTPUTS	
SAND Out	Outputs the safety related response of the function. **Value** **FALSE**: Demand for safety related response, request for safe state. **TRUE**: No demand for safety related response, request for operational state.
SAND Ready	Copy of SAND Activate.

The function is only active if "SAND Activate" has been set at design-time, the behavior description below describes an activated function.

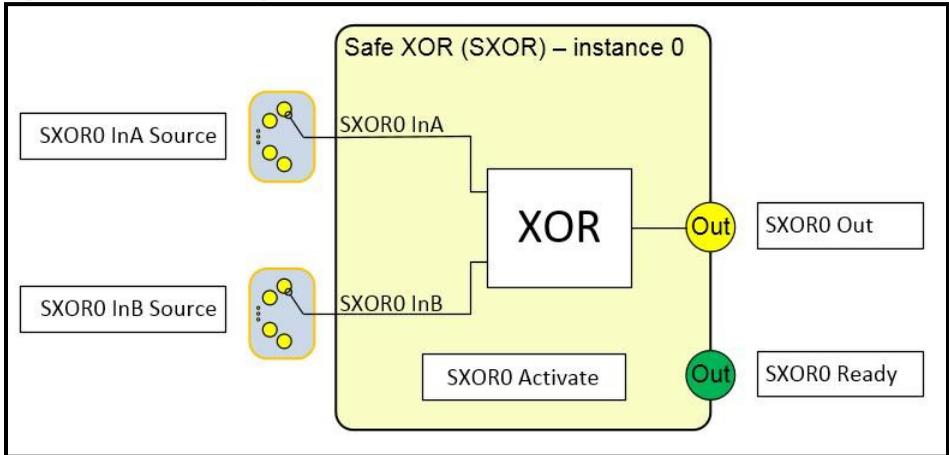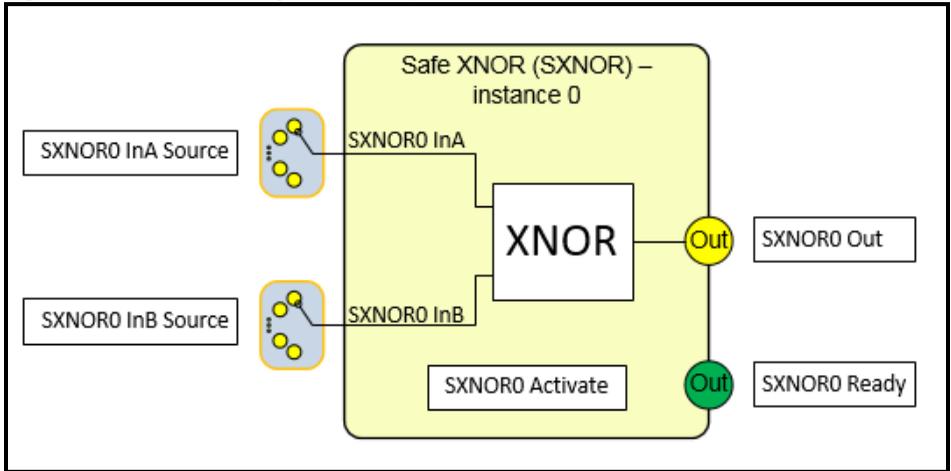| Truth Table for SAND function		
SAND In A	*SAND In B*	SAND Out
FALSE	FALSE	FALSE
FALSE	TRUE	FALSE
TRUE	FALSE	FALSE
TRUE	TRUE	TRUE

The function raises no errors and has no state machine or diagnostics.

8.15   Safe Not AND (SNAND)

This logic function tests its two safe inputs for their state, applies a logical NAND and sets the output accordingly. There are eight available instances of this function for the user. Each can be activated or deactivated at design time only. Values are available to be read in Test Mode, if values are read from an activated function the current values are returned, if a read is made on a deactivated function the default value is returned.

Warning: A maximum of eight logic functions (SOR, SNOR, SXOR, SXNOR, SAND, SNAND) are allowed per configuration.

Figure 8-36   SNAND-1 Diagrammatic representation of the SNAND function

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INPUT SELECTORS	
Name	**Description**
SNAND In A Source	Selects the safety signal that needs to be NANDed with the value connected to "SNAND In B Source". **Value of Selector** **0.000**: This is the default selection, but if the function instance is activated it must be set to select a safe Boolean value. **Value of Source Selected** **TRUE**: the meaning of the signal depends on the system. **FALSE**: the meaning of the signal depends on the system.
SNAND In B Source	Selects the safety signal that needs to be NANDed with the value connected to "SNAND In A Source". **Value of Selector** **0.000**: This is the default selection, but if the function instance is activated it must be set to select a safe Boolean value. **Value of Source Selected** **TRUE**: the meaning of the signal depends on the system. **FALSE**: the meaning of the signal depends on the system.
ATTRIBUTES	
SNAND Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.
OUTPUTS	
SNAND Out	Outputs the safety related response of the function. **Value** **FALSE**: Demand for safety related response, request for safe state. **TRUE**: No demand for safety related response, request for operational state.
SNAND Ready	Copy of SNAND Activate.

The function is only active if "SNAND Activate" has been set at design-time, the behavior description below describes an activated function.

Truth Table for SNAND function		
SNAND In A	*SNAND In B*	SNAND Out
FALSE	FALSE	TRUE
FALSE	TRUE	TRUE
TRUE	FALSE	TRUE
TRUE	TRUE	FALSE

The function raises no errors and has no state machine or diagnostics.

8.16   Safe Boolean Hardware Inputs (SHIS)

This function block reads the 4 dual channel hardware input values into 4 Read Only SAFEBOOLs that are updated once per cycle with the hardware input state before the MSFs are run.
Each SAFEBOOL (called a value) can be used as the value source for an input selector belonging to another function.

The following standards are applicable to the input hardware.

Standard	Requirements
IEC 61131-2:2007	Programmable controllers Part 2: Equipment requirements and tests.

Figure 8-37   SHIS-1 Diagrammatic representation of the Hardware Inputs

INPUT SELECTORS	
Name	**Description**
SHIS Reset Source	Selects the value that will provide the reset source, typically it will be Global Reset but may be connected to any input to control the Reset. Except when the auto and/or start reset are turned on, a rising edge on the selected value will cause the function to attempt to leave its local error state providing the function's inputs evaluate to operational (TRUE). **Value of Selector** **0.001**: This selection disables the reset input, in which case the Auto Reset attribute must be set to on. If this selection is made then this decision must be validated and documented. **0.002**: This is the default selection indicating that the function reset should use the Global Reset (Menu 6). **Value of Source Selected** **Rising Edge (a change from FALSE to TRUE)**: The function will be reset if the error condition is no longer present. **Falling edge or unchanging TRUE or FALSE**: No effect, (a continuous TRUE signal may cause a reset error).

ATTRIBUTES	
SHIS HW In Discrepancy Time	Sets the maximum discrepancy time in ms that an input pair is allowed to be discrepant before the input is regarded as faulty and an input error is raised. The discrepancy time extends the response time of the safety module.
SHIS HW In Mode	Sets the input mode of the dual channel input to one of: Disabled (0): The 2 input channels are marked as not used and the output must not be physically connected. The input must not be used in the configuration and, will not generate an alarm. ExternalContPS (1): The 2 input channels must be sourced from a continuous 24V power supply they will only be checked for faults internal to the MiS210 Safety Module. InternalPulsedPS (2): In this mode the 2 input channels must be wired to the pulsed output terminal, the pulses will then appear on the input terminals and so both internal and external circuit can be checked for faults. OSSD (3): Compatible with safety devices that for test purposes produce notched outputs with OSSD timings. The input will ignore notches. In this mode the 2 input channels can only be checked for faults internal to the MiS210 Safety Module.
SHIS HW In Filter Time	The 2 input channels are individually passed through an averaging filter with a sliding window of the length given in this parameter. Using the filter will introduce a delay into the response time. Minimum Value is 8 which is equivalent to 1 ms.
SHIS Auto Reset	Set the reset behavior after the first valid reset signal is received. **Value** **OFF**: No special reset behavior after start up (a reset signal is required). **ON**: No reset is required after the first reset (which maybe the automatic start up reset). A risk assessment on the system must take place and justification provided in the system documentation before this feature is used.
SHIS Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.
OUTPUTS	
SHIS Value	4 Boolean values representing the state of the 4 input pairs after filtering and discrepancy timing has been processed. **Value** **TRUE**: if and only if both channels of the input after filtering are in the true. **FALSE**: if either input channel is false.
SHIS State	RESERVED
SHIS HW Diagnostic Output	4 Hardware Diagnostic values.
SHIS Error Output	Indicates that the function has detected an error condition. **Value** **TRUE**: Error, check Diagnostic Out for details, if any enabled input is discrepant. **FALSE**: No Error.
SHIS Diagnostic Output	Diagnostic Fault Code.
SHIS Ready	Copy of SHIS Activate.

The function is only active if "SHIS Activate" has been set at design-time (if not active all HW inputs are disabled), in addition individual hardware inputs may be disabled individually which case their output values cannot be used in the configuration and they do not raise errors or alarms.
The behavior description below describes a single enabled input in an activated function.

The 2 input channels "SHIS HW In Ch A" and "SHIS HW In Ch B" on each input pair are filtered using moving average filters. The values after filtering are passed to the equivalence and discrepancy block and "SHIS HW In" is evaluated and passed to the output value and logic section.
The discrepancy status for each input is passed to a set of parameters. No logic is applied at this stage and there is no state machine.

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Function Logic – Common

If an input is in use its "HW In Discrepant" input error will generate an Alarm, which will set all the MiS210 Safety Module outputs to FALSE, this is irrespective of the state of the rest of the configuration and is because the input can no longer be trusted. The SHIS function will require a reset before the system can set any of its outputs to operational again. If one or more inputs cause a discrepancy alarm, a corresponding bit is set in bits 8-11 (Y in the diagrams and tables below) of the diagnostic word and bits 0-7 contain the alarm code. Y is held until the function is reset. The bits are:

Input	bits 8-11 (Y)	Description
1	8	Input 1 caused the last discrepancy error
2	9	Input 2 caused the last discrepancy error
3	10	Input 3 caused the last discrepancy error
4	11	Input 4 caused the last discrepancy error

Function Logic – Per Input

The SHIS function supports 4 input pairs. They share common Discrepancy Error and Reset states as above, but each input has its own Per Input state machine and while there is no alarm present the input state codes are packed into bits 0 – 7 of the common diagnostic code. Bits 0 – 3 (W in the diagrams and tables below) indicates the state of the 4 input channels and bits 4 – 7 (X in the diagrams and tables below) indicate any discrepant but not timed out inputs. The bits are:

Input	bits 4-7 (X)	Description
1	4	Input 1 is discrepant but not timed out.
2	5	Input 2 is discrepant but not timed out.
3	6	Input 3 is discrepant but not timed out.
4	7	Input 4 is discrepant but not timed out.
Input	**bits 0-3 (W)**	**Description**
1	0	0 if channel A and channel B of Input 1 are both on otherwise 1.
2	1	0 if channel A and channel B of Input 2 are both on otherwise 1.
3	2	0 if channel A and channel B of Input 3 are both on otherwise 1.
4	3	0 if channel A and channel B of Input 4 are both on otherwise 1.

"SHIS HW In" is TRUE if "SHIS HW In Ch A" and SHIS HW In Ch B" are not discrepant otherwise it is FALSE.

"SHIS Value" is set to FALSE if "SHIS HW In" is FALSE. "SHIS Value" can only be set to TRUE if "SHIS Value" is TRUE and there is no latched discrepancy error waiting to be cleared.

The reset can only occur if no input is discrepant.

An automatic reset is where the function resets when "SHIS HW In" goes to TRUE and does not require a reset signal of any kind, there is no separate start reset.

The reset functionality is not intended to replace that found in functions such as SES, and when such a function is correctly incorporated into a configuration then it may be reasonable to allow the inputs to automatically reset, however "SHIS Auto Reset" shall only be activated if it is ensured that no hazardous situation can occur when the programmable electronic system (PES) is started.

Figure 8-38   SHIS-2 State Machines with and without Auto Reset
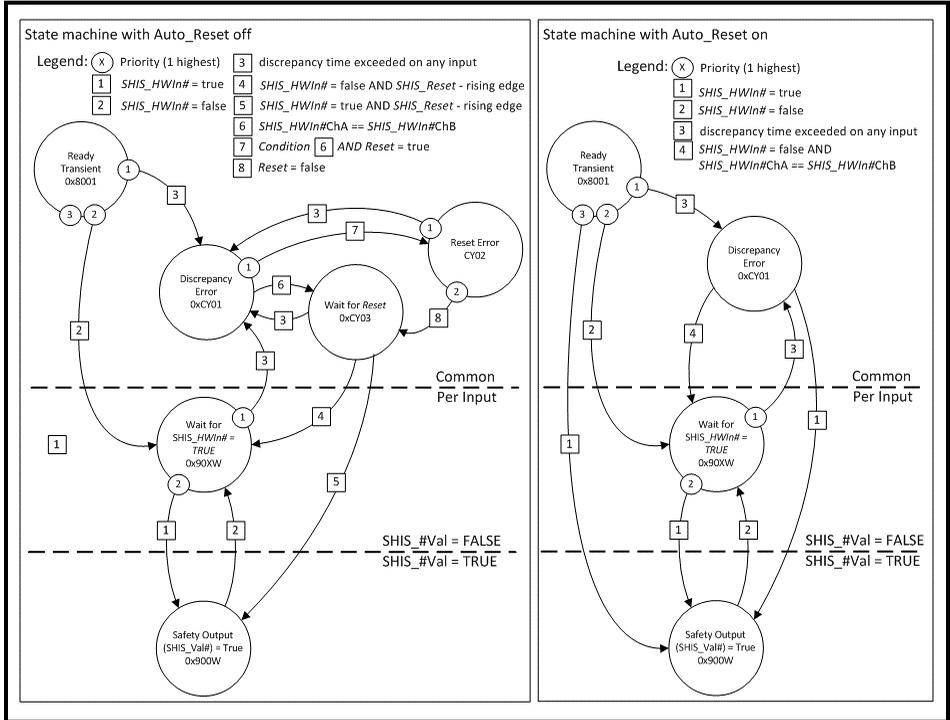
W, X and Y are bit patterns indicating input status (see above tables and timing diagrams).
These diagrams represent 4 separate state machines, one for each input with some states common to all 4.

NOTE

Discrepancy errors from state 0x8001 should only occur if the discrepancy time is set to zero and the input channels are discrepant at start up, these transitions are not shown in the timing diagrams below.

The following Timing diagrams are a walkthrough of a given scenario provided to aid understanding of the state machine diagram, it starts from the first time the function is run. Input functions run as soon as the MSF system is executing, Logic and Output functions run after system reset.

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Figure 8-39 SHIS-3 Timing Diagram for input 1 (all other inputs disabled) with Auto Reset OFF, showing 3 discrepancy errors

Figure 8-40 SHIS-4 Timing Diagram for input 2 (all other inputs disabled) with Auto Reset ON, showing 3 discrepancy errors

The function detects one kind of error an input discrepancy, which always invoke an alarm. This occurs when a pair of input channels are discrepant for more than the given time and the corresponding input is enabled. When an error occurs "SHIS Error" is set to TRUE and a diagnostic code is output, an alarm is also raised.

In addition to the common diagnostic output, there are 4 separate Hardware Diagnostic outputs indicating the state of each channel in accordance with the values defined in the table below.

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ALARMS		
SHIS Diagnostic Output	**State**	**Description**
0xCY01	Discrepancy Error	One or more of the inputs (indicated by bits in nibble Y) has been discrepant for longer than its allowed time. **In this error state** "SHIS Value" = FALSE "SHIS Error Output" = TRUE "SHIS Alarm" = TRUE (An alarm will be raised) "SHIS State" = variable
0xCY02	Reset Error	When the CY01 state cleared the reset input was high, so the reset rising edge cannot be detected and the function cannot be reset. **In this error state** "SHIS Value" = FALSE "SHIS Error Output" = TRUE "SHIS Alarm" = FALSE "SHIS State" = variable
0xCY03	Wait for Reset Rising Edge	Wait for "SHIS Reset" to go to TRUE, state then transitions to one of 0xCY01, 0x90XW or 0x900W. **In this state** "SHIS Value" = FALSE "SHIS Error Output" = FALSE "SHIS Alarm" = FALSE "SHIS State" = variable
DIAGNOSTICS		
0x8001	Ready	Transient state on start-up function the state transitions to one of 0xCY01, 0x90XW or 0x900W.depending on state of "SHIS In" and "SHIS Start Reset". **In this State** "SHIS Value" = FALSE "SHIS Error Output" = FALSE "SHIS Alarm" = FALSE "SHIS State = variable
0x90XW	Safety Output (SHIS Value) = FALSE	"SHIS HW In" is FALSE and a reset has occurred (if required). W indicates the output bit states. X indicates inputs that are discrepant but not timed out. **In this state:** "SHIS Value" = TRUE, "SHIS Error Output" = FALSE "SHIS Alarm" = FALSE "SHIS State" = variable
0x900W	Safety Output (SHIS Val) = TRUE	"SHIS HW In" is TRUE and a reset has occurred (if required). W indicates the output bit states. See table above. **In this state:** "SHIS Value" = TRUE, "SHIS Error Output" = FALSE "SHIS Alarm" = FALSE "SHIS State" = variable

SHIS HW Diagnostic Output (4 of)	Description
0x00800004	Input Channel A = 1 and Input Channel B = 0.
0x00800104	Input Channel A = 0 and Input Channel B = 1.
0x00800404	Input Channel A & B = 1 and Previously were Not OK.
0x00800604	Input Channel A & B = 0 or 1 and Previously were OK.
0x00801404	Input Channel A & B = 0 and Previously were Not OK.
0x00C00104	Input Channel A & B = 0 or 1 and Discrepancy Counter Expired.
0x00810004	Input Channels A & B are Equal and Have Toggled.
0x00810104	Input Channels A & B are Equal and Have not toggled and were previously OK.
0x00810204	Input Channels A & B are Equal and Have not toggled and were previously NOK.
0x00810404	Input Channel A = 1 & Input Channel B = 0 and previously OK (Possible Fault).
0x00810604	Input Channel A = 0 & Input Channel B = 1 and previously OK (Switch Open).
0x00811404	Input Channel A = 1 & Input Channel B = 0 and previously Not OK (Possible Fault).
0x00811604	Input Channel A = 0 & Input Channel B = 1 and previously Not OK (Switch Open).
0x00810804	Inputs A & B are Not Equal and Have Not Toggled and were previously NOK.
0x00C10104	Input Channels A & B are different or not toggling and Discrepancy Counter Expired.

8.17 Safe Torque Off (STO)

Warning: This function controls the blade connector that interfaces directly with the Certified Safe Torque Off (STO) circuitry in the drive. It is the safety engineer's responsibility to check that the drive supports the blade connector.

If supported by the drive, this function causes the drive to disable its power output so that the motor and load will exhibit whatever behavior is dictated by the load torque. The appropriate drive user guide must also be referred to determine the electrical and timing characteristics of the STO circuitry in the drive.

There is a single instance in the firmware and it can be activated or deactivated at design time only. Values are available to be read in Test Mode, if parameters are read from an activated function the current values are returned, if a read is made on a deactivated function the default value is returned.

The following standards are applicable:

Standard	Requirements
IEC 61800-5-2	4.2.2.2 Safe torque off (STO) 6. Requirements for design and development of a PDS(SR) (SIL level).
IEC 60204-1	3.56 Uncontrolled Stop. 9.2.2 Stop functions (stop category 0).
ISO 13849-1	PL level.
IEC 62061: 2005	6. Design and integration of the safety-related electrical control system (SRECS).
IEC 61508	General design standard for Functional Safety.

Figure 8-41   STO-1 Diagrammatic representation of the STO function

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INPUT SELECTORS	
Name	**Description**
STO Ctrl Source	Selects the value that will provide the safety control signal for the STO. This will typically be the output parameter of a function such as SES or SLS. Alternatively it can be connected directly to an input function which in turn connects to a hard-wired input pair or network input (this allows the STO to be controlled directly by another safety device). <u>**Value of Selector**</u> **Valid Output Connector from another Block:** <u>**Value of Source Selected**</u> **TRUE**: No demand for safe torque off, operational state (e.g., emergency stop button not engaged, axis running at safe speed, etc.). **FALSE**: Demand for safe torque off (e.g., emergency stop has been engaged, safely limited speed has detected speed above the active limit, etc.).
STO FTS Source	Selects the value that can set the STO to FALSE but only set it to TRUE if "STO Ctrl Source" is also TRUE. (Force to Safe - FTS). The input is normally disabled (selector value 1), but if in use it must select a non-safe input from menu 91. <u>**Value of Selector**</u> **Valid Output Connector from Non-Safe Input Block:** <u>**Value of Source Selected**</u> **TRUE**: A normal signal (i.e. not part of the safety system) requesting drive operational state (no safe torque off) this signal cannot override the "STO Ctrl Source" signal. **FALSE**: A normal signal (i.e. not part of the safety system) demanding safe torque off).
ATTRIBUTES	
STO Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. <u>**Value**</u> **TRUE**: function will be executed. **FALSE**: function is deactivated.
OUTPUTS	
STO State	RESERVED
STO Diagnostic Out	Diagnostic Fault Code.
STO Ready	Copy of STO Activate.

The STO function is only active if "STO Activate" has been set at design-time, the behavior description below describes an activated function.

If "STO FTS Source" is set to disabled then "STO FTS" is not used and has no effect.

Hardware STO Demand is set to FALSE when the input selected by "STO Ctrl Source" is FALSE OR ("STO FTS Source" is not set to disabled AND "STO FTS" is FALSE), the hardware STO circuitry in the host drive will respond by preventing the connected motor from producing any significant torque after a delay of no less than 1 ms and no greater than 20 ms.

Hardware STO Demand is set to TRUE when the input selected by "STO Ctrl Source" is TRUE AND ("STO FTS Source" is set to disabled OR ("STO FTS Source" is not set to disabled AND "STO_FTS" is TRUE)), the hardware STO circuitry in the host drive will respond by allowing the connected motor to produce significant torque after a delay of no less than 1ms and no greater than 20 ms.

STO Function has no error state and no reset.

NOTE

The STO function alone does not support the reset functionality required by standards such as: IEC 418: 1992, IEC 954-1: 1996, ISO 12100-2: 2003, IEC 60204-1, 1997, etc. If such a machine reset is required, then either it must be handled externally to the safety module or a safety module function such as SES (which provides such a reset) should be used to control the STO function.

Figure 8-42   STO-2 State Machine
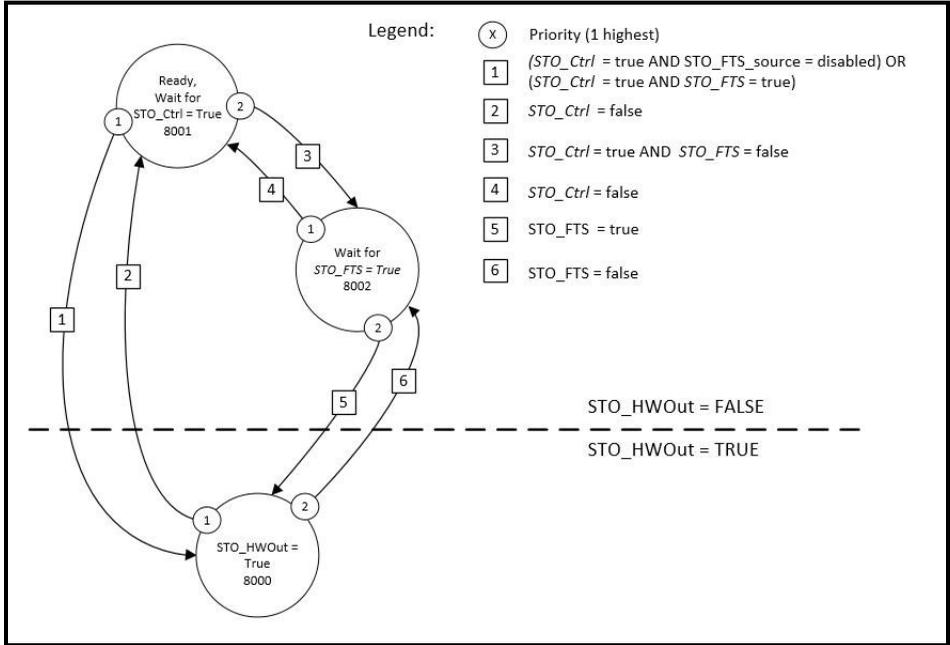
The following Timing diagram is a walkthrough of a given scenario provided to aid understanding of the state machine diagram, it starts from the first time the function is run. Input functions run as soon as the MSF system is executing, Logic and Output functions run after system reset.

Figure 8-43   STO-3 Timing Diagram

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The diagnostic codes are listed below.

DIAGNOSTICS		
SES Diagnostic Output	State	Description
0x8000	STO Hardware Demand = True	The input connected to "STO Ctrl Source" is TRUE and STO_FTS is TRUE. Drive STO circuitry allows the motor to produce torque. **In this state** "STO State" = 1
0x8001	Ready, Wait for "STO Ctrl"	STO Ctrl is FALSE. Drive STO circuitry prevents the motor from producing torque. **In this state** "STO State" = 0
0x8002	Wait for STO_FTS	Wait for STO FTS to go to TRUE. Drive STO circuitry prevents the motor from producing torque. **In this state** "STO State" = 0

8.18 Safe Boolean Hardware Outputs (SHOS)

This function controls the two SAFEBOOL hardware outputs fitted to the MiS210 Safety Module. It does not have a SAFEBOOL output connection as the function acts directly on the hardware outputs, a selected input value of FALSE will cause the hardware output into its low state, while a value of TRUE will give the high state.

There is a single instance in the firmware and it can be activated or deactivated at design time only.

The following standards are applicable to the output hardware:

Standard	Requirements
IEC 61131-2:2007	Programmable controllers. Part 2: Equipment requirements and tests.

The following standards may be applicable when the outputs are used to control an STO circuit, other standards may be applicable when the outputs are used to control other safety functions:

Standard	Requirements
IEC 61800-5-2	4.2.2.2 Safe torque off (STO). 6. Requirements for design and development of a PDS(SR) (SIL level).
IEC 60204-1	3.56 uncontrolled stop. 9.2.2 Stop functions (- stop category 0 :)
ISO 13849-1	PL level
IEC 62061:2005	6. Design and integration of the safety-related electrical control system (SRECS).
IEC 61508	General design standards for Functional Safety.

Figure 8-44   SHOS-1 Diagrammatic representation of the Hardware Outputs

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INPUT SELECTORS	
Name	**Description**
SHOS Ctrl Source	Selects the value that will provide the safety control signal for the hardware output. This will typically be the output of a function. Alternatively it can be connected directly to an input function value parameter which in turn connects to a hard-wired input pair or network input (this allows the output to be controlled directly by another safety device). **Value of Source Selected** **TRUE**: No demand for safe state (HIGH). **FALSE**: Demand for safe state (LOW).
SHOS FTS Source	Selects the value that can set the output to FALSE but only set it to TRUE if the "SHOS Ctrl Source" input value is also TRUE. The input is normally disabled (selector value 1), but if in use it must select a non-safe input. **Value of Source Selected** **TRUE**: A normal signal (i.e. not part of the safety system) requesting drive operational state (no safe torque off) this signal cannot override the "SHOS Control" signal. **FALSE**: A normal signal (i.e. not part of the safety system) demanding safe torque off).
ATTRIBUTES	
SHOS Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.
OUTPUTS	
STO State	RESERVED
SHOS Diagnostic Output	Diagnostic Fault Code.
SHOS Ready	Copy of SHOS Activate.

The SHOS function is only active if "SHOS Activate" has been set at design-time, in addition individual hardware outputs may be disabled individually by setting the selector to disabled. The behavior description below describes a single enabled output in an activated function.

The hardware safety demand signal "SHOS HW Out" is set to FALSE when "SHOS Ctrl" is FALSE OR ("SHOS FTS Source" is not set to disabled AND "SHOS FTS" is FALSE), the hardware circuitry in the safety module will respond setting the output to its low state after a delay of no more than 1 ms.

If "SHOS FTS Source" is set to disabled, then "SHOS FTS" is not evaluated and has no effect.

"SHOS HW Out" is set to TRUE when "SHOS Ctrl" is TRUE AND ("SHOS FTS Source" is set to disabled OR ("SHOS FTS Source" is not set to disabled AND "SHOS FTS" is TRUE), the hardware circuitry in the safety module will respond setting the output to its high state after a delay of no more than 1 ms.

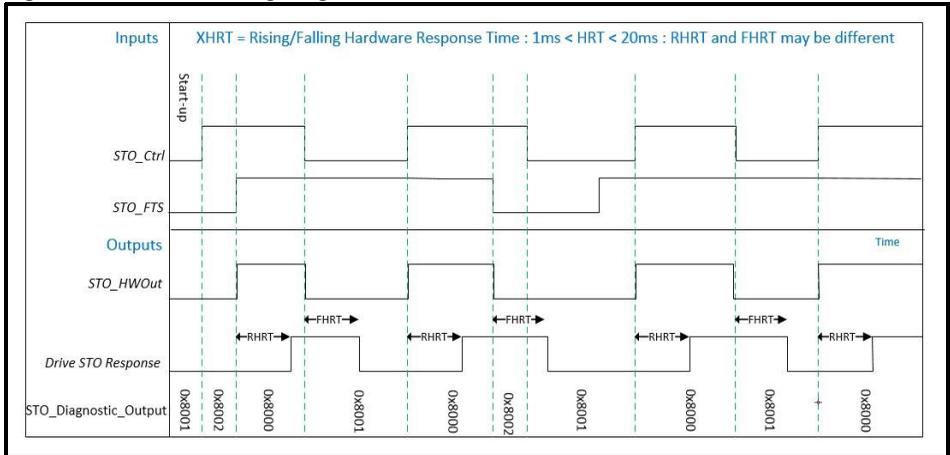SHOS Function has no error state and no reset.

NOTE

The SHOS function alone does not support the reset functionality required by standards such as: IEC 418: 1992, IEC 954-1: 1996, ISO 12100-2: 2003, IEC 60204-1, 1997, etc. If such a machine reset is required then either it must be handled externally to the safety module or a safety module function such as SES (which provides such a reset) should be used to control the SHOS function.

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Function Logic – Per Output

The SHIS function supports 2 outputs. They share a common Ready state as above but each output has its own Per Output state machine and the input state codes are packed into bits 0 to 7. Bits 0 – 3 (W in the diagrams and tables below) indicates state of the 2 output channels (0 = TRUE - as with PLC open diagnostic codes) and bits 4 – 7 (X in the diagrams and tables below) indicate any outputs forced to safe (1 = forced to safe).

Output	bits 4-7 (X)	Description
1	4	Output 1 is forced to safe.
2	5	Output 2 is forced to safe.
	6 & 7 not used = 0	
Input	**bits 0-3 (W)**	**Description**
1	0	0 if output 1 is on (TRUE).
2	1	0 if output 2 is on (TRUE).
	2 & 3 not used = 0	

Figure 8-45   SHOS-2 State Machines, represents 2 state machines, one for each output with the Ready state common to both
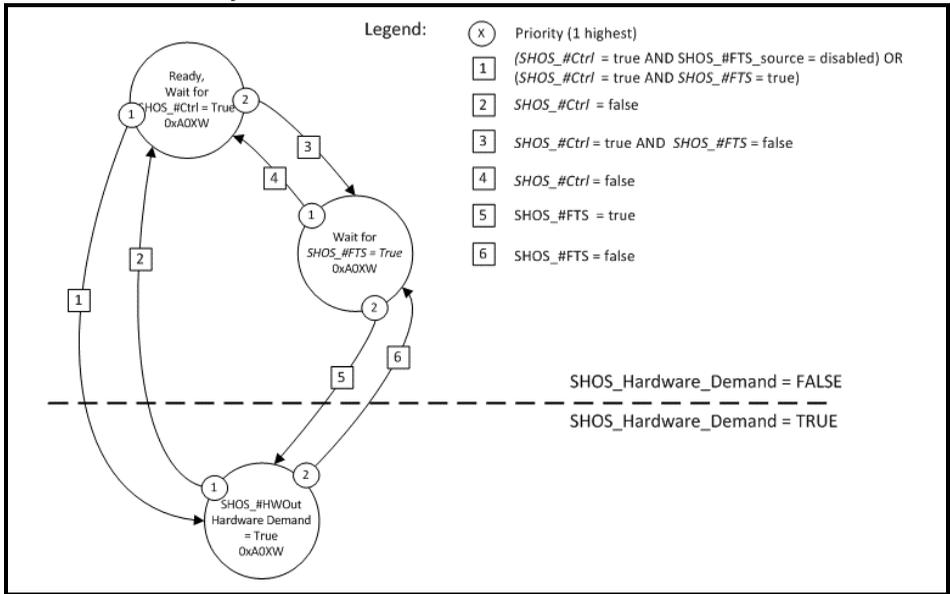
The following Timing diagram is a walkthrough of a given scenario provided to aid understanding of the state machine diagram, it starts from the first time the function is run. Input functions run as soon as the MSF system is executing, Logic and Output functions run after system reset.

Figure 8-46   SHOS-3 Timing Diagram for Output 1
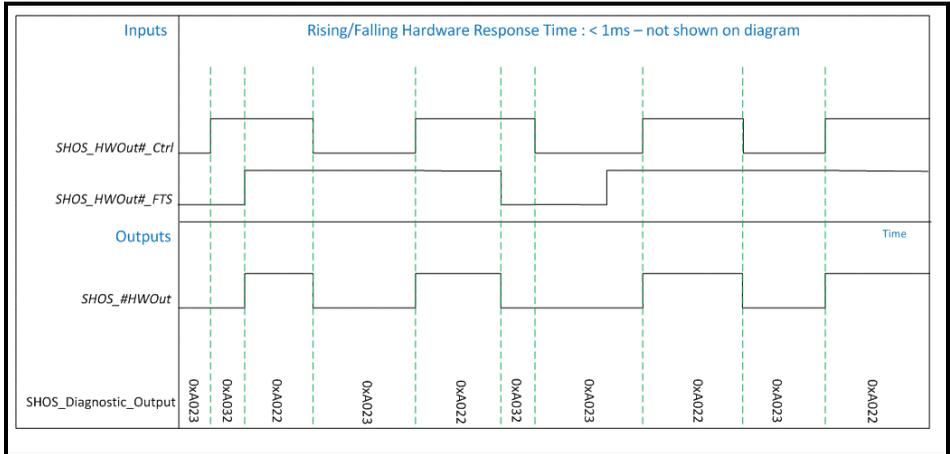
The diagnostic codes are listed below, X and W are as described in the table before the State Diagram.

DIAGNOSTICS		
SHOS Diagnostic Output	**State**	**Description**
0xA0XW	Ready, Wait for SHOS Ctrl	The input connected to "SHOS Ctrl Source" is FALSE. **In this state:** "SHOS HW Out" = FALSE
0xA0XW	Wait for SHOS FTS	Wait for SHOS FTS to go to TRUE. X indicates the outputs in this state. **In this state:** "SHOS HW Out" = FALSE
0xA0XW	SHOS HWOut = True	SHOS Ctrl is TRUE and SHOS FTS is TRUE W indicates the output bit states. **In this state:** "SHOS HW Out" = TRUE

Examples of the diagnostics.

There are 2 bits allocated for each input channel in the lowest 2 nibbles of the diagnostic word, bits 0&4 are for Output 1, bits 1&5 are for Output 2.

Looking at a configuration that is just using Output 1:

State	Hex Diagnostic	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Init (not shown)	0xA000	0	0	0	0	0	0	0	0
Ready	0xA010	0	0	0	1	0	0	0	0
Wait For FTS	0xA001	0	0	0	0	0	0	0	1
Output On	0xA011	0	0	0	1	0	0	0	1

Looking at a configuration that is just using Output 2:

State	Hex Diagnostic	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Init (not shown)	0xA000	0	0	0	0	0	0	0	0
Ready	0xA020	0	0	1	0	0	0	0	0
Wait For FTS	0xA002	0	0	0	0	0	0	1	0
Output On	0xA022	0	0	1	0	0	0	1	0

8.19   Safe Boolean Network Inputs (SNIS)

Each instance of this function block represents a set of 4 SAFEBOOL inputs transmitted over a network, the MiS210 Safety Module can handle up to 4 bytes of network SAFEBOOL inputs using a function instance for each 4 bits, (a total of 32 bits). Each function has 4 SAFEBOOL output connection points each of which represents one of the network inputs, no configuration is required and there is a mode attribute that allows individual bits to be turned on and off. If an input bit is enabled then it must be connected and if it is disabled it must not be connected. The function has a set of non-safe outputs, also following the network input states that can be used as sources for non-safe function inputs.

There are eight instances in the firmware and they can be activated or deactivated at design time only.

Figure 8-47   SNIS-1 Diagrammatic representation of the Network Inputs

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ATTRIBUTES	
Name	**Description**
SNIS Mode	The Mode of the Network input bit (this allows individual bits to be disabled – but they may still be passed in by the network). Possible values for each mode parameter is: 0, disabled – the input bit is not in use and is held false. 1, enabled – the input bit is in use and follows the network bit.
SNIS Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.
OUTPUTS	
SNIS State	RESERVED
SNIS Value	The state of the associated bit in the assembly. For instance 1, x= 0, Network Byte = 0 of which bits (0 to 3) map to parameters 051 to 054. For instance 2, x= 1, Network Byte = 0 of which bits (4 to 7) map to parameters 151 to 154. For instance 3, x= 2, Network Byte = 5 of which bits (0 to 3) map to parameters 251 to 254. For instance 4, x= 3, Network Byte = 5 of which bits (4 to 7) map to parameters 351 to 354. For instance 5, x= 4, Network Byte = 10 of which bits (0 to 3) map to parameters 451 to 454. For instance 6, x= 5, Network Byte = 10 of which bits (4 to 7) map to parameters 551 to 554. For instance 7, x= 6, Network Byte = 15 of which bits (0 to 3) map to parameters 651 to 654. For instance 8, x= 7, Network Byte = 15 of which bits (4 to 7) map to parameters 751 to 754.
SNIS Ready	Copy of SNIS Activate.

The function is only active if "SNIS Activate" has been set at design-time. The behavior description below describes a single enabled input in an activated function instance.

The output value (SNIS Value) will follow the state of the value passed in from the network.

The function raises no errors and has no state machine or diagnostics and network errors are global.

Network Diagnostics are output to the MiS210 Safety Module menu.

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8.20 Safe Boolean Network Outputs (SNOS)

Each instance of this function block represents a set of 4 SAFEBOOL outputs to be transmitted over a network, the MiS210 Safety Module can handle up to 4 bytes of network SAFEBOOL outputs using 2 function instances for each byte, (a total of 32 bits). Each function has 4 SAFEBOOL input selectors each of which represents one of the network outputs. Network configuration is done globally via Menu 7 and there are no attributes related to the network setup in this function. The input selectors allow individual bits to be enabled or disabled. If an output bit is enabled then it must be connected and if it is disabled it must not be connected.

There are eight instances in the firmware and they can be activated or deactivated at design time only.

Figure 8-48   SNOS-1 Diagrammatic representation of the Network Outputs

INPUT SELECTORS	
Name	**Description**
SNOS Ctrl Source	The selector for the SAFEBOOL parameter containing the value "SNOS Ctrl" to be transmitted over the safe network. This will typically be the output parameter of a function. Alternatively it can be connected directly to an input function value parameter which in turn connects to a hard-wired input pair or network input (this allows the output to be controlled directly by another safety device). For instance 1, the values selected by parameters 001 to 004 go to Network Byte 0 bits 0–3. For instance 2, the values selected by parameters 101 to 104 go to Network Byte 0 bits 4 –7. For instance 3, the values selected by parameters 201 to 204 go to Network Byte 5 bits 0–3. For instance 4, the values selected by parameters 301 to 304 go to Network Byte 5 bits 4–7. For instance 5, the values selected by parameters 401 to 404 go to Network Byte 10 bits 0–3. For instance 6, the values selected by parameters 501 to 504 go to Network Byte 10 bits 4–7. For instance 7, the values selected by parameters 601 to 604 go to Network Byte 15 bits 0–3. For instance 8, the values selected by parameters 701 to 704 go to Network Byte 15 bits 4–7. **Value of Selector** **0.000**: none - the default not allowed in a finished configuration. **Value of Source Selected** **TRUE**: No demand for safe state (HIGH). **FALSE**: Demand for safe state (LOW).
SNOS FTS Source	The selector for the Boolean (1 bit) parameter that can force the output state to false. The input is normally disabled (selector value 1), but if in use it must select a non-safe input from menu 91. For instance 1, the values selected by parameters 031 to 034 go to Network Byte 0 bits 0–3. For instance 2, the values selected by parameters 131 to 134 go to Network Byte 0 bits 4–7. For instance 3, the values selected by parameters 231 to 234 go to Network Byte 5 bits 0–3. For instance 4, the values selected by parameters 331 to 334 go to Network Byte 5 bits 4–7. For instance 5, the values selected by parameters 431 to 434 go to Network Byte 10 bits 0–3. For instance 6, the values selected by parameters 531 to 534 go to Network Byte 10 bits 4–7. For instance 7, the values selected by parameters 631 to 634 go to Network Byte 15 bits 0–3. For instance 8, the values selected by parameters 731 to 734 go to Network Byte 15 bits 4–7. **Value of Selector** **0.001**: disabled - the default – FTS is not in use. Otherwise MM.PPP, a valid Boolean parameter. **Value of Source Selected** **TRUE**: A normal signal (i.e. not part of the safety system) requesting drive operational state (no safe torque off) this signal cannot override the SNOS Ctrl signal **FALSE**: A normal signal (i.e. not part of the safety system) demanding output off).
ATTRIBUTES	
SNOS Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.
OUTPUTS	
SNOS State	RESERVED
SNOS Diagnostic Output	Diagnostic Code.
SNOS Ready	Copy of SNOS Activate.

The SNOS function instance is only active if "SNOS Activate" has been set at design-time, in addition individual hardware outputs may be disabled individually by setting the selector to disabled. The behavior description below describes a single enabled output in an activated function.

The network safety demand signal "SNOS HW Out" is set to FALSE when "SNOS Ctrl" is FALSE OR ("SNOS FTS Source" is not set to disabled AND "SNOS FTS" is FALSE), the response of the network and remote device to the demand is dependent on the network setup, this should be factored into the safety system design.

If "SNOS FTS Source" is set to disabled, then "SNOS FTS" is not evaluated and has no effect.

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"SNOS HW Out" is set to TRUE when "SNOS Ctrl" is TRUE AND ("SNOS FTS Source" is set to disabled OR ("SNOS FTS Source" is not set to disabled AND "SNOS FTS" is TRUE), the hardware circuitry in the safety module will respond setting the output to its high state after a delay of no more than 1 ms.

SNOS Function has no error state and no reset.

Function Logic – Per Output

The SNOS function supports 4 outputs, they share a common Ready and Diagnostic output as above but each output has its own Per Output state machine. The diagnostics for each output are packed into bits 0 to 7. Bits 0 – 3 (W in the diagrams and tables below) indicate state of the 4 output channels (0 = TRUE - as with PLC open diagnostic codes) and bits 4 – 7 (X in the diagrams and tables below) indicate any outputs forced to safe (1 = forced to safe).

Outputs a to d represent a group of 4 output assembly bits, either bits 0 to 3 for odd instance numbers or 4 to 7 for even instance numbers.

Output	bits 4-7 (X)	Description
a	Bit 4	= 1 Output a is forced to safe. = 0 Output a is not forced to safe.
b	Bit 5	= 1 Output b is forced to safe. = 0 Output b is not forced to safe.
c	Bit 6	= 1 Output c is forced to safe. = 0 Output c is not forced to safe.
d	Bit 7	= 1 Output d is forced to safe. = 0 Output d is not forced to safe.
Output	**bits 0-3 (W)**	**Description**
a	Bit 0	= 0 if output a is on (TRUE). = 1 if output a is off (FALSE).
b	Bit 1	= 0 if output b is on (TRUE). = 1 if output b is on (TRUE).
c	Bit 2	= 0 if output c is on (TRUE). = 1 if output c is off (FALSE).
d	Bit 3	= 0 if output d is on (TRUE). = 1 if output d is on (TRUE).

Figure 8-49   SNOS-2 State Machine, the diagram represents SNOS with 4 separate state machines one for each output
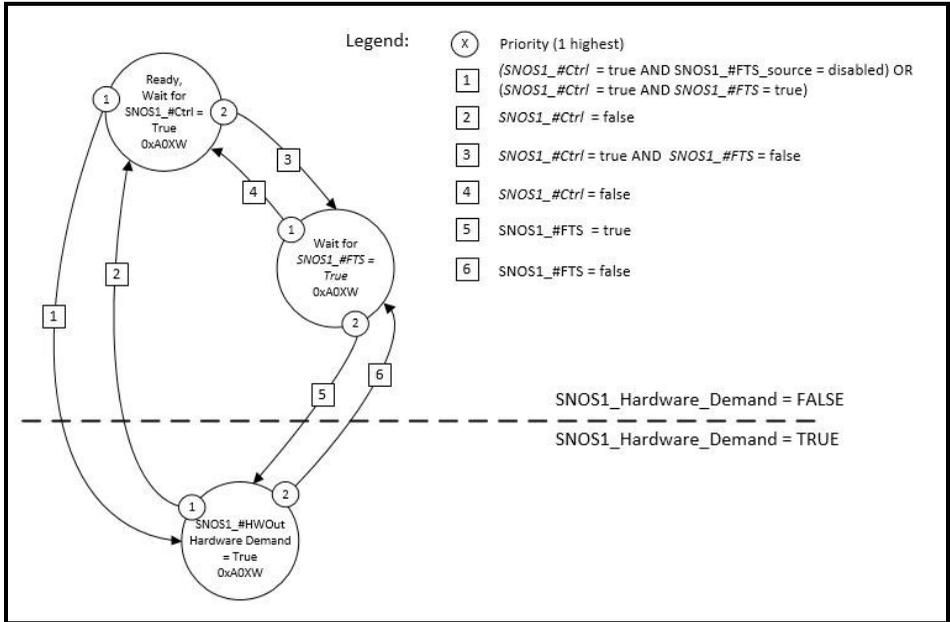
The X & W parts of the diagnostic code are defined in the table above. Because the timing is effectively controlled by the network a timing diagram is not given.

The diagnostic codes for output a (output b to d disabled) are listed below.

DIAGNOSTICS		
SNOS Diagnostic Output	**State**	**Description**
0xA0FF	Initialize	Transient (1 ms) at start up only.
0xA0EF	Ready, Wait for SNOS 1Ctrl	SNOSII 1Ctrl is FALSE. **In this state:** SNOS 1HWOut = FALSE.
0xA0FE	Wait for *SNOS 1FTS*	Wait for SNOSII 1FTS for go to TRUE. **In this state:** SNOS 1HWOut = FALSE. When both outputs are active any outputs in this state are indicated by a bit in W as in the table above.
0xA0EE	*SNOS 1HWOut* = True	SNOS 1Ctrl is TRUE and SNOS FTS is TRUE W indicates the output bit states. See table above this state: SNOS HW Out = TRUE When both outputs are active any outputs in this state are indicated by a bit in X as in the table above.

8.21   Safe Integer Network Inputs: (SINIS)

The single instance of this function block represents a set of 4 SAFEINT inputs transmitted over a network. Each function has 4 SAFEINT output connection points each of which represents one of the network integers, no configuration is required and there is a mode attribute that allows individual output connection points to be turned on and off. If a connection point is enabled, then it must be connected and if it is disabled it must not be connected.

Figure 8-50   SINIS-1 Diagrammatic representation of the Network Inputs

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ATTRIBUTES	
Name	**Description**
SINIS Mode	The Mode of the Network input word (this allows individual words to be disabled – but they may still be passed in by the network) [BIG ENDIAN]. Bytes 1-4 to SINIS 1 Val (86.076). Bytes 6-9 to SINIS 2 Val (86.077). Bytes 11-14 to SINIS 3 Val (86.078). Bytes 16-19 to SINIS 4 Val (86.079). Possible values for each mode parameter is: 0, disabled – the input value is not in use and is held at 0. 1, enabled – the input value is in use and follows the network word.
SINIS Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.
OUTPUTS	
SINIS State	RESERVED
SINIS Value	The value of the corresponding network word, see SINIS Mode description.
SINIS Ready	Copy of SINIS Activate.

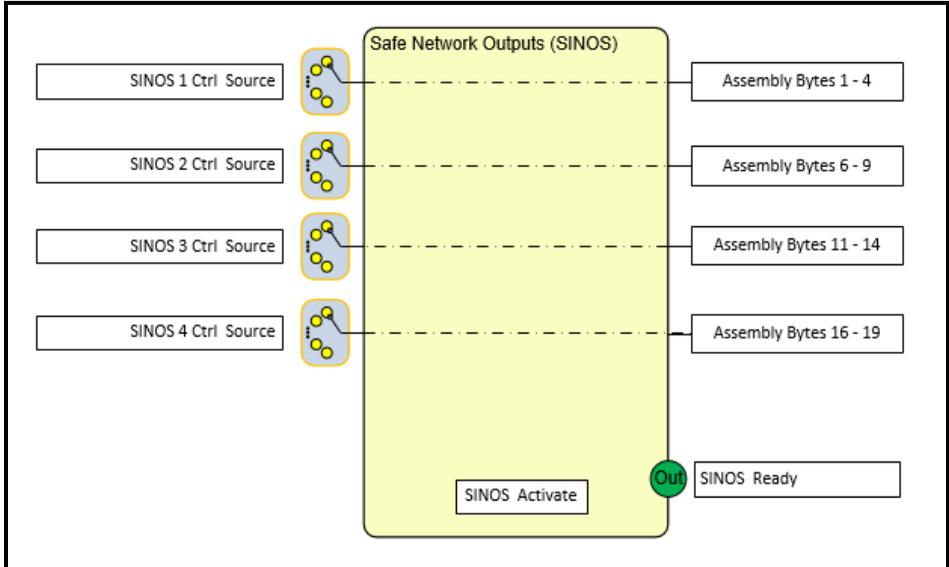The function is only active if "SINIS Activate" has been set at design-time. The behavior description below describes a single enabled input in an activated function. The output value (SINIS Value) will follow the state of the value passed in from the network.

The function raises no errors and has no state machine or diagnostics and network errors are global. Network Diagnostics are output to the MiS210 Safety Module Menu.

8.22   Safe Integer Network Outputs: (SINOS)

The single instance of this function block represents a set of 4 SAFEINT outputs to be transmitted over a network. Each function has 4 SAFEINT input selectors each of which represents one of the network output words. Network configuration is done globally via Menu 7 and there are no attributes related to the network setup in this function. The input selectors allow individual words to be enabled or disabled. If an output is enabled, then it must be connected and if it is disabled it must not be connected.

Figure 8-51   SINOS-1 Diagrammatic representation of the Network Outputs

INPUT SELECTORS	
Name	**Description**
SINOS Ctrl Source	The selector for the INT parameter containing the value to be transmitted over the safe network. This will typically be a confirmatory read-back of an underride value but could be used to monitor other 32 bit values. **Value of Selector** **0.001**: disabled - the default, output will be set to 0. **Value of Source Selected** A 32 bit number.
ATTRIBUTES	
SINOS Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.
OUTPUTS	
SINOS Ready	Copy of SINOS Activate.

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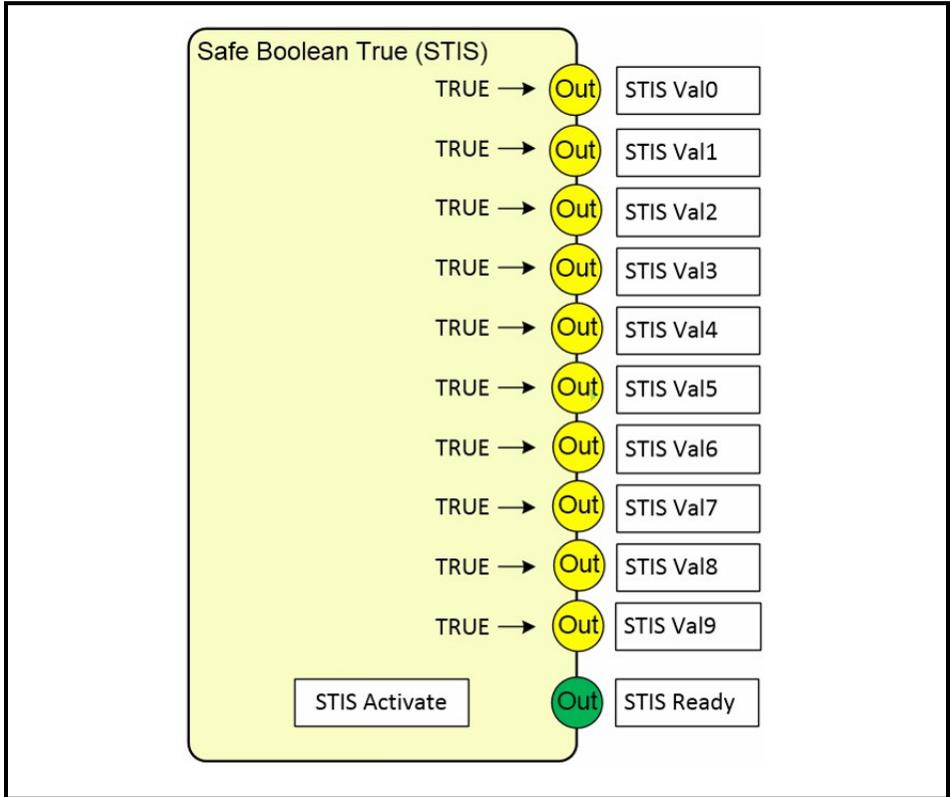
8.23 Safe True (STIS)

The STIS function has no inputs and its 10 safe outputs are always TRUE. It is intended to be used to force SAFEBOOL function inputs or Non-Safe Inputs to TRUE for testing purposes.

Warning: It should be used with extreme care in an operational (i.e. one not being commissioned) and the consistency check in Connect will always warn if this function is used.

Unless the whole function instance is deactivated the output connectors for the instance are always present even if the input is not used. It is not required that any of them should be connected.

No safety standards apply directly to these constants.

Figure 8-52   STIS-1 Diagrammatic representation of STIS

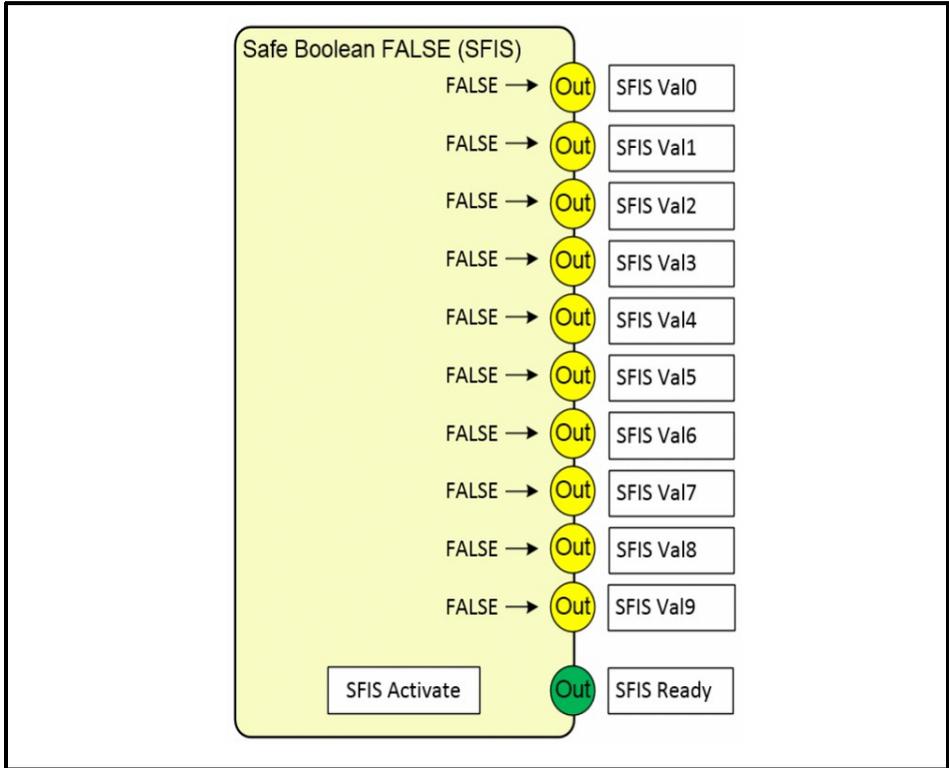| ATTRIBUTES	
Name	**Description**
STIS Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.
OUTPUTS	
STIS Value	Always TRUE.
STIS Ready	Copy of STIS Activate.

8.24 Safe False (SFIS)

The SFIS function has no inputs and its 10 safe outputs are always FALSE. It is intended to be used to force SAFEBOOL function inputs or Non-Safe Inputs to FALSE for testing purposes.

Warning: It should be used with extreme care in an operational (i.e. one not being commissioned) and the consistency check in Connect will always warn if this function is used.

Unless the whole function instance is deactivated the output connectors for the instance are always present even if the input is not used. It is not required that any of them should be connected.

No safety standards apply directly to these constants.

Figure 8-53 SFIS-1 Diagrammatic representation of SFIS

ATTRIBUTES	
Name	**Description**
SFIS Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.
OUTPUTS	
SFIS Value	Always FALSE.
SFIS Ready	Copy of SFIS Activate.

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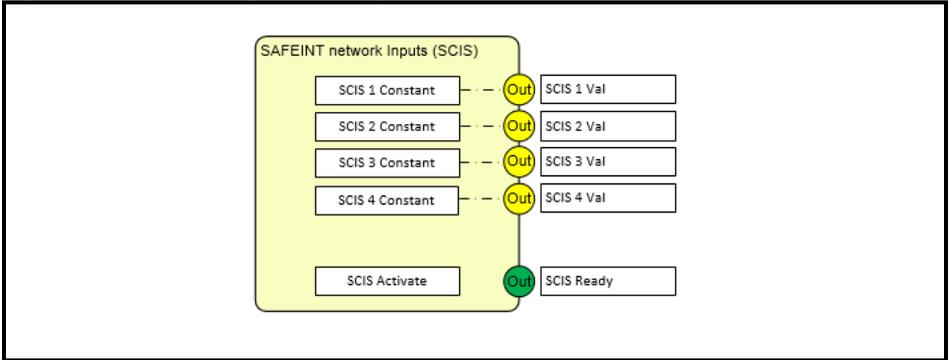
8.25 Safe Constant Integer: (SCIS)

The SCIS function has no inputs and its 4 safe outputs take the integer value stored in the corresponding attribute. It is intended to be used to force SAFEINT function inputs to a given value for testing purposes.

Warning: It should be used with extreme care in an operational system (i.e. one not being commissioned).

Unless the whole function instance is deactivated the output connectors for the instance are always present even if the input is not used. It is not required that any of them should be connected.

No safety standards apply directly to these constants.

Figure 8-54   SCIS-1 Diagrammatic representation of SCIS

ATTRIBUTES	
Name	**Description**
SCIS Constants	Each attribute contains a constant that is placed in the corresponding output value: SCIS 1 Constant (90.051) to SCIS 1 Val (90.076). SCIS 2 Constant (90.052) to SCIS 2 Val (90.077). SCIS 3 Constant (90.053) to SCIS 3 Val (90.078). SCIS 4 Constant (90.054) to SCIS 4 Val (90.079).
SCIS Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.
OUTPUTS	
SCIS Value	Each takes the value of the corresponding attribute, see attribute description.
SCIS Ready	Copy of SCIS Activate.

8.26 Non Safe Boolean Input (BIS)

There are 4 instances of this function and each provides access to 4 non-safe Boolean inputs that are routed through the setup menu. The Boolean inputs are split in 4 banks of 4 inputs (each bank is a function instance, with its own activation input). There are no input selector or attribute parameters.

The state of each input value is updated at the start of every cycle before the motion safety functions are run. Unless the whole function instance is deactivated the output connectors for the instance are always updated even if the input is not used. It is not required that any of them should be connected. The function does not generate errors.
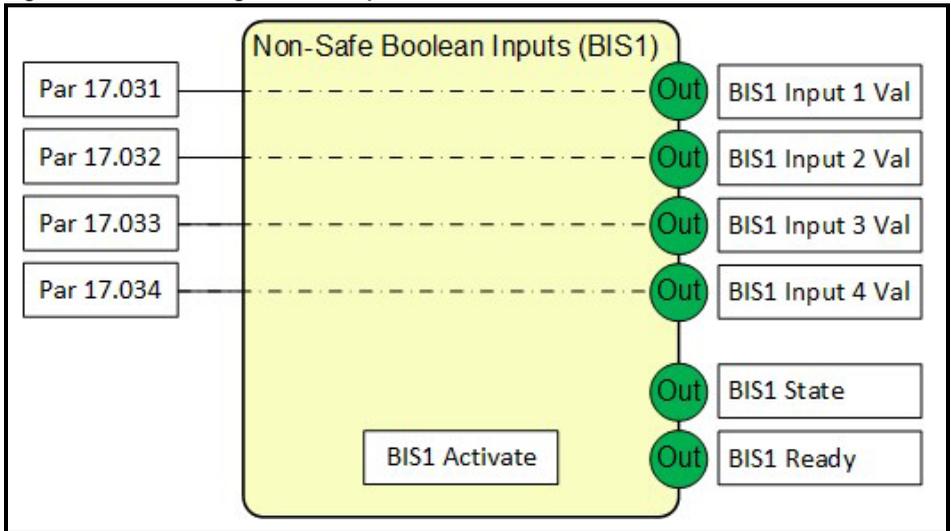
These inputs must not be used to carry any safety signal, they are intended for edge triggered reset signals and other inputs with selectors that can accept a non-safe input.

No safety standards apply directly to these inputs. However, the input may be used as a reset to various functions (which will only respond to a rising edge on the reset input) and in this case these standards are relevant:

Standard	Requirements
IEC 418: 1992	3. Definitions 4.1.12 ... Resetting the control device shall not by itself cause a restart command.
IEC 954-1: 1996	5.4 Manual reset.
ISO 12100-2: 2003	4.11.4: Restart following power failure/spontaneous restart.
IEC 60204-1, 1997	9.2.2. Stop Functions.

There may also be other standards which are indirectly relevant such as those for light curtains Function Interface.

Figure 8-55   BIS-1 Diagrammatic representation of BIS

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BIS is an interface between the non-safe input parameters found in the setup menu and the configurable logic system of the safety module, as such it has no input or control selectors.

ATTRIBUTES	
Name	**Description**
BIS Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.
OUTPUTS	
BIS Value	The state of the associated bit parameter in the setup menu For instance 1, Parameter 17.031 – 17.034 map to Parameters 91.041 – 91.044. For instance 2, Parameter 17.035 – 17.038 map to Parameters 91.141 – 91.144. For instance 3, Parameter 17.039 – 17.042 map to Parameters 91.241 – 91.244. For instance 4, Parameter 17.043 – 17.046 map to Parameters 91.341 – 91.344.
BIS State	RESERVED
BIS Ready	Copy of BIS Activate.

The function is only active if "BIS Activate" has been set at design-time. The behavior description below describes a single enabled input in an activated function instance.

The function raises no errors and has no state machine or diagnostics.

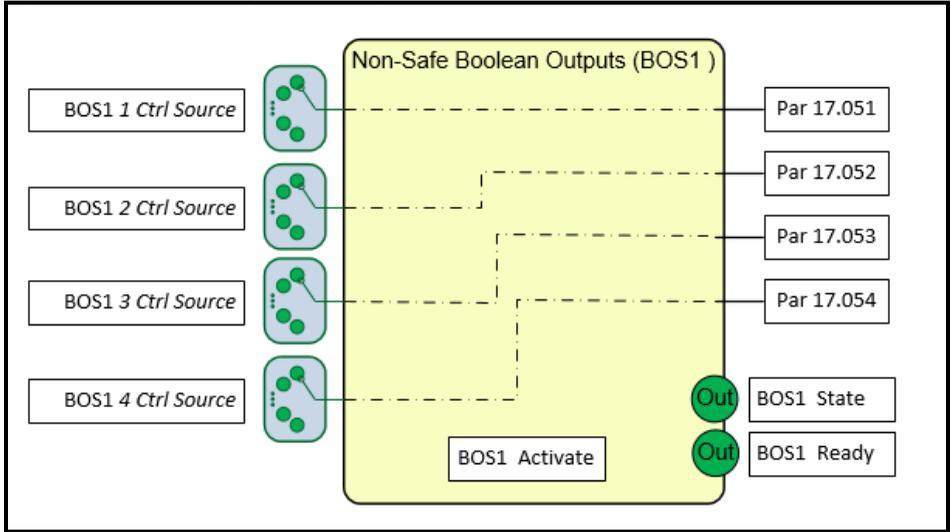## 8.27   Non Safe Boolean Output (BOS)

There are 2 instances of this function and each provides access to 4 non-safe Boolean outputs that are routed through the setup menu. The Boolean outputs are split in 4 banks of 4 inputs (each bank is a function instance, with its own activation input). There are no connection points, attributes or any other setup parameters.

Unless the whole function instance is deactivated the corresponding parameters are always updated even if the input selector is disconnected. It is not required that any of the selectors should be connected. The function does not generate errors.

These outputs must not be used to carry any safety signal, they are intended for monitoring purposes and for initiating actions that the safety module will monitor and react to, for instance the SS function has a non-safe output that on a request for safe state, can be used to request that the drive stops, the output is provided for machine control, and is not part of the safety monitoring function.

No safety standards apply directly to these outputs and they must not be used to control any kind of safety related function or carry any safety related signal.

Figure 8-56   BOS-1 Diagrammatic representation of BOS

INPUT SELECTORS	
Name	**Description**
BOS Ctrl Source	The state of the associated bit parameter in the setup menu For instance 1, the values selected by parameters 031 – 034 go to Parameters 17.051 – 054. For instance 2, the values selected by parameters 131 – 134 go to Parameters 17.055 – 058. For instance 3, the values selected by parameters 231 – 234 go to Parameters 17.059 – 062. For instance 4, the values selected by parameters 331 – 334 go to Parameters 17.063 – 066.
ATTRIBUTES	
BOS Activate	This parameter is used to activate the function. Connect will set this value to true when an MSF is selected. **Value** **TRUE**: function will be executed. **FALSE**: function is deactivated.
OUTPUTS	
BOS State	RESERVED
BOS Ready	Copy of BOS Activate.

The function is only active if "BOS Activate" has been set at design-time. The behavior description below describes a single enabled output in an activated function instance (replace # with the input number).

The function raises no errors and has no state machine or diagnostics.

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9.1 Error Types

Table 9-1   Distinction between Fault and Alarm

TYPE	DESCRIPTION	IMPACT ON SYSTEM	RESET
Non Recordable Fault (NRF)	Serious exception error caused by a function running in MiS210 Safety Module.	All outputs are switched off.	Power Cycle
Recordable Fault (RF)	An issue is detected, in the operation of a test or in a communication.	All outputs are switched off. The failure is stored in the EEPROM and the user is notified via the drive keypad or Unidrive M Connect if it is connected.	Power Cycle
Alarm	The MiS210 Safety module has detected that the inputs are outside the range specified by the motion safety algorithm running.	All outputs are switched off. The system continues running in a cyclic manner to service all requirements of the communication interfaces. The motion safety functions stop operating until the reset is detected.	Configurable Input*

* The Configurable Input refers to the fact that the Reset trigger to clear the alarm is set up by the user in Connect.

9.2 Alarm List

There are two types of alarm that can be raised by the MiS210 Safety Module, System Level and MSF Level. The following table covers the System Level Alarms, these are problems that could affect the entire MSF system and as such stop the MSFs from being ran. These System Alarms are built up of 4 separate alarms and so multiple alarms listed below can be reported at once. System Level Alarms can be configured to automatically reset, this is controlled by the "Global Auto Reset" and "Global Start Reset" (See Section 8.2) attributes.

MSF Level alarms are for an instance, see each individual MSF menu for the MSF Level Alarms that can be produced (Section 10.3) and Section 8.2 for how the alarms are encoded. If an MSF input is connected to the Global attributes for reset, then it will share the System Alarm reset. If auto reset of any MSF is required (and allowed) the auto and start reset attributes belonging to the MSF must be used.

If System and MSF alarms are present the MiS210 Safety Option Module returns the first one that occurred in this order:

1. System Level Alarms (discrepancy, safety network loss, problems with drive comms, brownouts, etc.)
2. MSF Alarms (only if no system level alarms) the first alarm raised in function execution order.

The MiS210 Safety Module reads parameters from the drive on a cyclic basis to determine if any of the following states have occurred: Under Voltage, Brown Out or Restart. This Drive Status is then checked when a MSF is to be ran and if a Brown Out has occurred then an alarm shall be raised putting the outputs into a safe state. The alarm is also stored in the EEPROM and the only way to exit the alarm condition is for the drive to clear the condition and the reset to be triggered.

Table 9-2   Alarm Codes

CODE	MESSAGE	Type
0x00000134	Shared Memory Alive Counter Timed Out	System Alarm
0x00000234	Shared Memory Reports Drive Brown Out	System Alarm
0x00000334	Shared Memory Reports HAP Error	System Alarm
0x00000434	Shared Memory Reports Network Error	System Alarm
0x00000534	Shared Memory Reports Invalid Network Input Data	System Alarm
0x01000034	Encoder 1 Het Block Error	System Alarm
0x02000034	Encoder 1 Endat 2.2 CRC 1 Error	System Alarm
0x03000034	Encoder 1 Safe Endat 2.2 CRC 2 Error	System Alarm
0x04000034	Encoder 1 Endat 2.2 Error 1 Set	System Alarm
0x05000034	Encoder 1 Endat 2.2 Error 2 Set	System Alarm
0x06000034	Encoder 1 Timeout Transaction	System Alarm
0x07000034	Encoder 1 AB or Sin/Cos Counter Error	System Alarm
0x08000034	Encoder Position Mismatch	System Alarm
0x09000034	Encoder Speed Mismatch	System Alarm
0x0A000034	Heidenhain Test Failed	System Alarm
0x0B000034	Encoder 1 Decoded Word Incorrect	System Alarm
0x11000034	Encoder 2 Het Block Error	System Alarm
0x12000034	Encoder 2 Endat 2.2 CRC 1 Error	System Alarm
0x13000034	Encoder 2 Safe Endat 2.2 CRC 2 Error	System Alarm
0x14000034	Encoder 2 Endat 2.2 Error 1 Set	System Alarm
0x15000034	Encoder 2 Endat 2.2 Error 2 Set	System Alarm
0x16000034	Encoder 2 Timeout Transaction	System Alarm
0x17000034	Encoder 2 AB or Sin/Cos Counter Error	System Alarm
0x1B000034	Encoder 2 Decoded Word Incorrect	System Alarm
0x00100034	Input 1 Discrepancy Timeout	System Alarm
0x00200034	Input 2 Discrepancy Timeout	System Alarm
0x00300034	Input 3 Discrepancy Timeout	System Alarm
0x00400034	Input 4 Discrepancy Timeout	System Alarm
0x00001034	User Configuration Changed	System Alarm
0x00010034	MSF Alarm Check Toggle Error	System Alarm
0x??????44	MSF Function Level Alarms (see Section 8.2 and MSF sections)	MSF Alarm

As shown in Section 8.2 the top 10 bits of the alarm code represent the MSF instance number that raised the alarm, the following table maps the code to the MSF.

Table 9-3   MSF Instance Codes

10 BIT VALUE	MOTION SAFETY FUNCTION
14x	Safe Emergency Stop
15x	Safe Stop
16x	Safe Limited Speed
30x	Safe Operating Stop
81x	Safe Boolean Hardware Inputs

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9.3   MiS210 Fault List

The user can see the last fault code reported by the MiS210 Safety Module by viewing Menu 17 Parameter 014 (see section 9.5.3) or the current fault (if there is one) on the Connect dashboard.

RF- Recordable Faults, the fault is stored in internal memory before entering the failure state.

NR – Non Recordable Faults, enters the failure state.

Table 9-4   MiS210 Fault Codes

CODE	MESSAGE	Type
LOCAL INPUTS		
0x00000010	Input Parameter Out Of Range	RF
0x00000020	GPIO Register Failed To Be Updated	NRF
0x00000030	Attempt To Read Inputs When Not Configured	NRF
LOCAL OUTPUTS		
0x00000011	Input Parameter Out Of Range	RF
0x00000021	MSF Tries To Set Un-Configured Outputs	NRF
0x00000031	GPIO Register Failed To Be Updated	NRF
ENCODERS		
0x00000003	Invalid Parameter	RF
0x00000013	No Valid Data To Read	RF
0x00000023	The Encoder Interface Coprocessor Wasn't Loaded Correctly	RF
0x00000033	The Encoder Interface Coprocessor Program 1 Had An Overflow	NRF
0x00000043	The Encoder Interface Coprocessor Program 2 Had An Overflow	NRF
0x00000053	Encoder Interface Coprocessor Program 1 Request Lost Error	NRF
0x00000063	Encoder Interface Coprocessor Program 2 Request Lost Error	NRF
0x00000073	Encoder Interface Coprocessor Program 1 Bus Error	NRF
0x00000083	Encoder Interface Coprocessor Program 2 Bus Error	NRF
0x00000093	Encoder 1 Configuration Error	RF
0x000000A3	Encoder 2 Configuration Error	RF
0x000000B3	Invalid Operation	RF
0x000000C3	Configuration Of Drive Error	RF
0x000000D3	Encoder Combination Error	RF
0x000000E3	PSU Error	RF
DATA PROCESSING		
0x00800004	Process Inputs: A = 1, B = 0	Input Diagnostics
0x00800104	Process Inputs: A = 0, B = 1	Input Diagnostics
0x00800404	Process Inputs: A & B = 1 And Previously Were Not OK	Input Diagnostics
0x00800604	Process Inputs: A & B = 0 Or 1 And Previously Were OK	Input Diagnostics
0x00801404	Process Inputs: A & B = 0 And Previously Were Not OK	Input Diagnostics
0x00C00104	Process Inputs: A & B = 0 Or 1 And Discrepancy Counter Expired	Input Diagnostics
0x00810004	Process Inputs: Valid On state, A & B Toggling and in synch	Pulse Diagnostics
0x00810104	Process Inputs: Valid Off state, both inputs are equal	Pulse Diagnostics
0x00810204	Process Inputs: Both inputs open (not toggling) but in same state	Pulse Diagnostics
0x00810404	Process Inputs: Discrepant with A closed (toggling) and B open (not toggling)	Pulse Diagnostics
0x00810604	Process Inputs: Discrepant with A open (not toggling) an B closed (toggling)	Pulse Diagnostics

CODE	MESSAGE	Type
0x00810804	Process Inputs: Invalid, both inputs open (not toggling) but the state is reversed	Pulse Diagnostics
0x00811404	Process Inputs: A toggling but B is in an unexpected state or B toggling but A is in an unexpected state	Pulse Diagnostics
0x00811604	Process Inputs: A and B toggling but are opposite	Pulse Diagnostics
0x00C10104	Process Inputs: Discrepancy Counter Expired	Pulse Diagnostics
0x00000014	Invalid Attempt To Set Mode And State, Wrong Number Of Flags	NRF
0x00000114	Invalid Mode State Combination	NRF
0x00000214	Login Id Mismatch	NRF
0x00000314	Timestamp Mismatch	NRF
0x00000024	Scheduler Overrun	NRF
0x00000124	Fail State And Network Has Been Shutdown	NRF
0x00000224	Unknown Notification Code Received By Interrupt Handler	NRF
SHARED MEMORY		
0x00000005	Configuration Download Failed	RF
0x00000015	Shared Memory Drive Interface Registers Not Updated Correctly	RF
0x00000025	Serial Communication Access Functions To Drive Failed	RF
0x00000125	Serial Communication Access Function Self Check	NRF
0x00000225	Serial Communication Timeout	RF
0x00000135	Shared Memory Manager Self Check	NRF
0x00000235	Shared Memory Manager Drive Communication Error	NRF
0x00000335	Shared Memory Manager Drive Interface Version Error	RF
0x00000045	Network Error: No HAP Present For Configured Network Slot	RF
0x00000145	Network Error: Receive Queue Full	RF
0x00000245	Network Error: Received Message Too Big	RF
0x00000345	Network Error: Transmit Queue Full	RF
0x00000055	Null Pointer Passed To Shared Memory Configuration	NRF
0x00000155	Network Protocol Unknown	NRF
0x00000255	Network Stack Generated Fail Safe Error During Initialization	NRF
0x00000355	Drive Has Not Allocated Enough Memory For MiS210 HAP	RF
0x00000455	Drive Type Not Correct Or MiS210 Is In Configured Network Slot	RF
0x00000555	Shared Memory Configuration Called While Already Running	RF
0x00000065	Drive Failed To Save NV Data Change From Stack In Allotted Time	RF
0x00xxxx65	Fail Safe Error Generated By The CIPSafety Stack (xxxx = CIPSafety Stack Code)	NRF
STORAGE		
0x00000016	Input Parameter Out Of Range	NRF
0x00000026	EEPROM Command Failed	NRF
0x00000036	Login Block Is Full, Perform A Factory Reset	RF
0x00000046	Read Returns That A Sector Is Empty	RF
SAFETY DIAGNOSTICS		
0x00000017	Self-Test Error During Initialization	NRF
0x00000117	Watchdog Initialization Error	NRF
0x00000317	CRC Check Error During Initialization	NRF
0x00000417	ADC Self-Test Error During Initialization	NRF
0x00000517	Drive Interface Error During Initialization	NRF

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CODE	MESSAGE	Type
0x00000617	Encoder Interface Coprocessor Error During Initialization	NRF
0x00000717	Storage Error During Initialization	NRF
0x00000817	CRC Check Error In Continuous Testing	NRF
0x00000917	Safe Outputs Are Not In Safe State	NRF
0x00000027	Encoder Diagnostic: Error in one or more tests	RF
0x00000127	Encoder Diagnostic: Invalid Parameter Or Configuration	NRF
0x00000227	Encoder Diagnostic: Error During The Read Of ADC Values	RF
0x00000097	Local Input Diagnostics: GPIO Register Failed To Update	NRF
0x00000197	Local Input Diagnostics: Internal Error	NRF
0x000000A7	Local Input Diagnostics: Values Not Updated	RF
0x000000B7	Configuration Not Ready Yet (Shared Memory Still Downloading)	RF
0x000001B7	Consistency Checks Failed	RF
0x000002B7	Stored Configuration Invalid	RF
0x000003B7	Hardware Compatibility Test Failed	RF
0x000007B7	Encoder Configuration Error	RF
0x000000C7	Storage To EEPROM Request Failed	NRF
0x000001C7	Copy Configuration To RAM Failed	NRF
0x000002C7	System Signature Check Failed (Download RPF CRC Check Failed)	NRF
0x000004C7	Encoder Configuration Error	NRF
0x000000D7	Local Output Diagnostics: GPIO Value Not As Expected	RF
0x000001D7	Local Output Diagnostics: Internal Error	NRF
0x000000E7	Power Supply Diagnostics: GPIO Register Failed To Update	NRF
0x000001E7	Power Supply Diagnostics: Internal Error	NRF
0x000002E7	Power Supply Diagnostics: Voltage Read Is Not Within Specified Range	RF
0x000003E7	Power Supply Diagnostics: Circuitry Test Failed	RF
0x000004E7	Power Supply Diagnostics: Threshold Voltage Self-Test Error	RF
0x000005E7	Power Supply Diagnostics: Encoder 5V Self-Test Range Error	RF
0x000006E7	Power Supply Diagnostics: Encoder 8V Self-Test Range Error	RF
0x000007E7	Power Supply Diagnostics: Encoder 15V Self-Test Range Error	RF
0x000008E7	Power Supply Diagnostics: PSU 24V Self-Test Range Error	RF
0x000009E7	Power Supply Diagnostics: PSU 8V Self-Test Range Error	RF
0x00000AE7	Power Supply Diagnostics: PSU 2V5 Self-Test Range Error	RF
0x00000BE7	Power Supply Diagnostics: Threshold Voltage Range Error	RF
0x00000CE7	Power Supply Diagnostics: Encoder 5V Range Error	RF
0x00000DE7	Power Supply Diagnostics: Encoder 8V Range Error	RF
0x00000EE7	Power Supply Diagnostics: Encoder 15V Range Error	RF
0x00000FE7	Power Supply Diagnostics: PSU 24V Range Error	RF
0x000010E7	Power Supply Diagnostics: PSU 8V Range Error	RF
0x000011E7	Power Supply Diagnostics: PSU 2V5 Range Error	RF
0x000000F7	Invalid Drive And Board Type Combination	RF
0x000001F7	Error During Check Configuration	RF
0x000010F7	Temperature Tolerance Error	RF
0x000020F7	Temperature Max Value Error	RF

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CODE	MESSAGE	Type
0x000021F7	Error Accessing Companion Chip	RF
0x000022F7	Synchronization Lost Or Error During Task Execution Of Watchdog	RF
0x000023F7	Lost Synchronization With Watchdog During Operating Or Testing	RF
0x000030F7	Microcontroller Self-Test Error	RF
0x000031F7	Microcontroller Self-Test Error	RF
0x000032F7	Microcontroller Self-Test Error	RF
0x000033F7	Microcontroller Self-Test Error	RF
0x000034F7	Microcontroller Self-Test Error	RF
0x000035F7	Microcontroller Self-Test Error	RF
0x000036F7	Microcontroller Self-Test Error	RF
0x000040F7	Microcontroller Self-Test Error	RF
0x000041F7	Microcontroller Self-Test Error	RF
0x000042F7	Microcontroller Self-Test Error	RF
0x000043F7	Microcontroller Self-Test Error	RF
0x000044F7	Microcontroller Self-Test Error	RF
0x000045F7	Microcontroller Self-Test Error	RF
0x000046F7	Microcontroller Self-Test Error	RF
0x000047F7	Microcontroller Self-Test Error	RF
0x000048F7	Microcontroller Self-Test Error	RF
0x000049F7	Microcontroller Self-Test Error	RF
0x00004AF7	Microcontroller Self-Test Error	RF
0x00004BF7	Microcontroller Self-Test Error	RF
0x00004CF7	Microcontroller Self-Test Error	RF
0x00004DF7	Microcontroller Self-Test Error	RF
0x00004EF7	Microcontroller Self-Test Error	RF
0x00004FF7	Microcontroller Self-Test Error	RF
0x000050F7	Microcontroller Self-Test Error	RF
0x000051F7	Microcontroller Self-Test Error	RF
0x000052F7	Microcontroller Self-Test Error	RF
0x00000019	Microcontroller Self-Test Error	NRF

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9.4   Safety DLL Fault List

Table 9-5   Safety DLL Fault Codes

CODE	MESSAGE	Notes
FUNCTIONS		
0x0FFFFFFE	Access Control – NULL Was Sent As User Name	
0x0FFFFFFF	Session Cleared Successful	
0xFFFFFFFF	Unknown Error	
0x80000002	BC Create Does Not Support Message Type That Was Passed	
0x80000004	CRC Check Failed, Data Block Corrupted	
0x80000008	Log In Information (LID) Do Not Match, Possibly Unauthorized User	
0x80000010	Difference Between Time Stamps Is To Big - Time Out	
0x80000018	Log In Information (LID) Do Not Match, Possibly Unauthorized User Difference Between Time Stamps Is To Big - Time Out	
0x8000001C	CRC Check Failed, Data Block Corrupted Log In Information (LID) Do Not Match, Possibly Unauthorized User Difference Between Time Stamps Is To Big - Time Out	
0x80000014	CRC Check Failed, Data Block Corrupted Difference Between Time Stamps Is To Big - Time Out	
0x8000000C	CRC Check Failed, Data Block Corrupted Log In Information (LID) Do Not Match, Possibly Unauthorized User	
0x80000020	Get System Time returned time smaller or equal to 0.	
0x80000040	Encrypt Or Decrypt Received An Unsupported Data Block (Incorrect Byte Count)	
0x80000080	Decrypt Received Unencrypted Data Block (Block ID = 0)	
0x80010000	CDB Block Is Incorrect. 8001nn00 Bits 16-23 (nn) Are Reserved For Number Of Faults In The Difference List.	
0x80040000	Invalid Login Or Password	
0x80100000	Data Block Is To Big To Calculate Its SHA1	
0x80200000	Command Code Does Not Exist On ECMP Or Parameter List	
0x80800000	Location Out Of Range Of RPF Or CORE DB	
0x81000000	Error In Comparison Process Of CDB Block(S). 81nnnn00 Bits 8-23 Hold FAULT Code From Fault Table	
0xC0000000	One Or More Of Input Pointers Are NULL	
DATABASE		
0x80010000	Serious Database Fault	
0x80020000	Non User Save Parameter In RPF	
0x80040000	Non Existing Menu	
0x80080000	Non Existing Parameter	
0x80100000	Invalid Parameter Format	
0x80200000	Invalid Parameter Value (Too High)	
0x80400000	Invalid Parameter Value (Too Low)	
0x80800000	Duplicated Parameter In RPF	
0x81000000	Fatal Error RPF Cannot Be Read	
0x82000000	Unsupported Size	
0x84000000	Location Out Of Scope Of Database Or RPF	
0x88000000	Empty Parameter Attribute	

CODE	MESSAGE	Notes
0x90000000	Unsupported Size Of Parameter Value	
0xA0000000	Incomplete RPF Configuration	
0xC0000000	Incorrect RAM Location	
VALIDATION RULES		
0x00007530	Problem Outside Of The Rules (Possibly With The Core DB)	
0x00007918	Broken RPF File	
0x00004268	Rule 17	
0x00003E80	Rule 16	
0x00003A98	Rule 15	
0x000036B0	Rule 14	
0x000032C8	Rule 13	
0x00002EE0	Rule 12	
0x00002AF8	Rule 11	
0x00002710	Rule 10	
0x00002328	Rule 9	
0x00001F40	Rule 8	
0x00001F41	Instance Occurs Multiple Times On The Execution List	
0x00001B58	Rule 7	
0x00001770	Rule 6	
0x00001388	Rule 5	
0x00000FA0	Rule 4	
0x00000BB8	Rule 3	
0x000007D0	Rule 2	
0x000007D1	Incorrect Parameter Format In RPF	
0x000007D2	Parameter Value Too Low	
0x000007D3	Parameter Value Too High	
0x000003E8	Rule 1	
0x000003E9	Duplicated Parameter In RPF	
0x000003EA	Incomplete Configuration In RPF	

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9.5 Maintenance

⚠ WARNING	• This device can only be repaired by Nidec Control Techniques Ltd.
	• The warranty is void if the MiS210 Safety Module is opened or modified in any way.
	• Under no circumstances should the Local Connectors on the MiS210 Safety Module be disconnected or reconnected while power is applied to the device, as there is a risk of failure or permanent damage to the connected encoders.

9.5.1 Module Replacement

In order to replace a MiS210 Safety Module the installation description in Section 5 should be followed and then the module should be configured using Connect.

9.5.2 Maintenance Intervals

The MiS210 Safety Module has a life of 20 years and runs a built in test which provides a high degree of diagnostic coverage. The testing of key built in test features is performed at power on, and should be repeated by power cycling the MiS210 at least once a year.

9.5.3 Diagnostic Parameters (Module Menu)

The parameters that are updated by MiS210 Safety Module are all within Menu 17 on M6xx-M7xx, which is the module menu.

If the Module displays Module Failed in Parameter 004, this could be due to a number of things such as the configuration does not match the actual peripherals connected. Also look at Parameters 013 (Last Alarm) and 014 (Last Fault) for further details.

Table 9-6   Module Menu Parameters

Parameter	Name	Description
001	Module ID	502 for MiS210
002	Software Version	
003	Hardware Version	
004	Module Alarm Code	Contain strings that can be displayed on the drive display in the event of certain module conditions 0 – "Module failed" 1 – "Drive firmware" 2 – "Module in Alarm" 3 – "Configuration" (Configuration not valid) 4 – "Module Healthy" 5 – "Read Parameter 15.012" 6 – "Read Parameter 17.012" 7 – "Read Parameter 24.012"
005	Module Trip Code	Contain strings that can be displayed when the module initiates a drive trip 0 – "Healthy" 1 – "Module reset"
006	System Signature Word 3	Bits 48 – 63 of signature displayed in HEX
007	System Signature Word 2	Bits 32 – 47 of signature displayed in HEX
008	System Signature Word 1	Bits 16 – 31 of signature displayed in HEX
009	System Signature Word 0	Bits 0 – 15 of signature displayed in HEX
010	Safety Mode: changes in response to commands and cannot be changed directly	0 – "Idle": In a safe state and waiting for commands 1 – "Operating": monitoring the machine state 2 – "Configuring": can be configured and tested

Parameter	Name	Description
011	Safety State	0 – "Failure": unrecoverable fault must be power cycled 1 – "Standby": starting up or waiting for user instructions 2 – "Executing": monitoring the machine 3 – "Download": waiting for or receiving a configuration 4 – "Test-Comm-On": config mode communications on 5 – "Test-Comm-Off": config mode communications off
012	Round Trip Code	Generated by MiS210 during identification, stopping execution, and setting factory defaults. It must be read by the user and entered into Connect when it asks for a verification code to be entered
013	Last Alarm Code	Contains the last alarm code generated by the MiS210. Alarms cause the MiS210 outputs to go to safe state but they can be reset
014	Last Fault Code	Contains the last fault code generated by the MiS210. Faults cause the MiS210 outputs to go to safe state and cannot be reset, a power cycle is required.
015	Log In Status	0 – "Logged Out" 1 – "Logged In"
016	Time Stamp Coarse	Time stamp parameter hrs:min:sec To be copied into PLC as the part of the Configuration signature.
017	Time Stamp Fine	Time stamp parameter (ms) To be copied into the PLC as part of the Configuration signature.
018	Date Stamp Day/Month	Date stamp Parameter dd.mm To be copied into the PLC as part of the Configuration signature.
019	Date Stamp Year	Date stamp Parameter YYYY To be copied into the PLC as part of the Configuration signature.
020	Safety Network Indication 1	State values of the Safety Supervisor object in CIP Safety 0 – "NULL" – Never seen if network enabled 1 – "SELF TEST" – Module self-test 2 – "IDLE" – Device self-test passed and configured, but no valid data transfer from MiS210 to PLC 3 – "SELF TEST FAULT" – Self test at power up failed 4 – "EXECUTE" Data being transferred from device to PLC 5 – "ABORT" The device has entered a recoverable fault state 6 – "CRITICAL FAULT" The device has entered a non-recoverable fault state and must be power cycled
021	Safety Network Indication 2	Network Status in CIP Safety 0 – "OFF LINE" – No Network communications 1 – "LINK OK" – Device online and connections validated 2 – "ON LINE NO LINK" – Online but no connection yet validated 3 – "Timeout" – One or more connection Timed out 4 – "LINK FAULT" – Connection to Network not possible 5 – "CFRICFR" – Critical Fault and received an Identify Comm Fault Request. Normally used to set a TUNID in a safety device and so should not be seen on the device as the TUNID is set in the configuration.
022	Safety Network Indication 3	0 – "Not used"
023	Safety Network Indication 4	0 – "Not used"
024	Safety Network Indication 5	0 – "Not used"
025	EMPTY	
026	Safety Network Bytes Per Second	The number of received data messages per second from the PLC.
027	Safety Network Expectation Margin	The margin between the latest message received and the set timeout in ms.

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Parameter	Name	Description
028	Safety Network Status Flags	Device internal flags indicating network status Bit 0 – Comms module safety buffer not yet set up Bit 1 – A Fail-Safe error has been generated by the CIP Safety Stack Bit 2 – Connection for receiving data is not yet valid Bit 3 – Connection for sending data is not yet valid Bit 4 – Toggled every time a valid Input message is received Bit 5 – A Reset has been received from the network to reset an Alarm condition.
029 - 030	EMPTY	
031 - 046	None Safe Inputs 1 – 16	Bit Parameters that can be used as non-safe inputs to the motion safety functions. Users must route the required values to these parameters.
047 - 050	EMPTY	
051 - 066	None Safe Outputs 1 - 16	Bit parameters that are written to by the motion safety functions as non safe outputs. Users must route these outputs to the required function.
067 - 069	EMPTY	
070	Command Semaphore	These locations are used to transfer data between Connect and the device when in the executing state.
071	Message Bytes 0-3	
072	Message Bytes 4-7	
073	Message Bytes 8-11	
074	Message Bytes 12-15	
075	Message Bytes 16-19	
076	Message Bytes 20-23	
077	Message Bytes 24-27	
078	Message Bytes 28-31	
079 - 089	EMPTY	
090 - 093	EMPTY	

> **WARNING**
> • The Diagnostic parameters are NOT reliable indicators and cannot be guaranteed to provide accurate information. They should ONLY be used for general diagnostics during commissioning or troubleshooting. Do not attempt to use parameters as operational indicators.

9.5.4   Factory Reset

The MiS210 provides a facility to reset the MiS210 Safety Module to the out of box settings. This can be used to remove the Configuration and identification detail as well as erasing all alarm history.

Connect provides a button to perform a Factory Reset, once pressed the MiS210 Safety Module will display a code on the drive keypad (012 in the table above). This code must be entered into Connect and is sent back to the MiS210 Safety Module to confirm the reset is required.

Once a Factory Reset has occurred the MiS210 Safety Module enters a Failure state and must be power cycled before use.

10 Technical Safety Features

Table 10-1 Key Technical Indicators

KEY TECHNICAL SAFETY INDICATORS	
PL in accordance with ISO 13849:2006	PL e
PFH (High Demand)	9.32×10^{-9} h^{-1}
SIL in accordance with IEC 61508	SIL 3
Partial Proof Test Interval	1 year
Product Life	20 years
Mean Time Between Failures	212983 hours at 50 °C
GENERAL DATA	
Input Connection Type	Green 14 pin socket
Encoder Connection Type	Black 14 pin socket
Wiring for Both Connections	Conductor cross section solid wire: 0.2 mm² - 1 mm² Conductor cross section stranded wire: 0.2 mm² - 1.5 mm² Conductor cross section flexible, with min ferrule without plastic sleeve: 0.25 mm² - 0.75 mm² Conductor cross section flexible, with min ferrule with plastic sleeve: 0.25 mm² - 0.5 mm² Ferrules are recommended and need to be at least 8 mm in length Metric Sizes for Ferrules with plastic sleeves: 0.25 mm² - 0.5 mm²
ENVIRONMENTAL DATA	
Operating Temperature	−20 °C to 40 °C (+55 °C with drive de-rating)
Storage Temperature	−40 °C to 70 °C
Protection Class (IP Rating)	IP 20
Pollution Degree	2
EMC	In accordance with IEC 61326-3-1:2008, IEC 61800-5-2 Ed 2. and IEC 61800-3:2004 + A1:2012
ENCODER DATA	
Maximum Frequency of Incremental Encoders	180 kHz
Maximum Data Clock Frequency for Digital Encoders	Master Mode 500 kHz
Maximum Data Clock Frequency for EnDat 2.2 Drive Snooping	2 MBaud
Encoder Signals	Digital Signals RS-485 transmitters / receivers. Analogue signals for Sin/Cos type 1Vp-p. Max Frequency: 500 kHz (180 kHz for Sin/Cos).
Encoder Power Supply Output	5 V and 8 V at 250 mA max. 15 V at 200 mA max.
Encoder Power Supply Monitoring	5 V, 8 V and 15 V
IO DATA	
Digital Inputs	0-24 V DC inputs as specified in IEC 61131-2 for Type 1 and 3 inputs. Maximum current for a 24 V input is 3 mA.
Digital Outputs	0-24 V DC 100 mA output as specified in IEC 61131-2. Maximum capacitance connected to the output = 10 nF[1]
Pulse Outputs	0-24 V pulses at 500 Hz, 50 % duty cycle.

1. If more capacitance is connected to the output an external pull down resistor should be added (8.2 kΩ per 10 nF) between the output and the 0V of the module.

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11 Version Control (Amendments)

The English version of this Installation and Operating Manual, part number 0478-0480-02, is the original and master version.

Index	Page	Date	Author	Modification
Draft	All	08/02/18	Kate McDougall	First Issue for Safety Team Review
Internal	All	22/02/18	Kate McDougall	For Review by Other Teams Not to go outside of CT
V1.0	All	19/10/18	Kate McDougall	Draft Version for Michelin
V2.0	All	10/04/19	Kate McDougall	Customer Release - CIPSafety Comms

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