# NUM-SAMX
# Safety module for NUM DrivePro

## Instruction manual

(sw release 1.3.0/ 2.3.0/ 4.3.0 - 1.4.0/ 2.4.0/ 4.4.0)

**For NUM-SAMX revision 16#0000000D**

M00069EN-03

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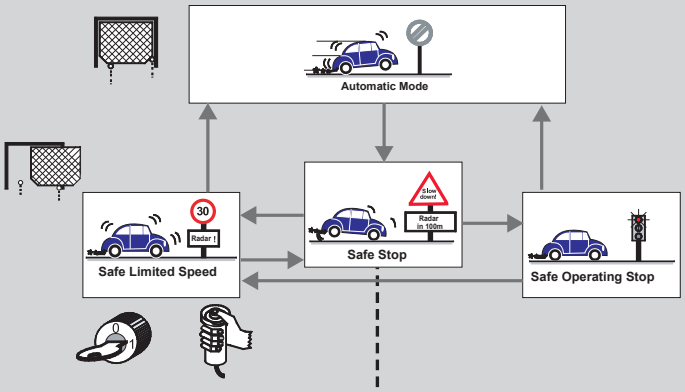


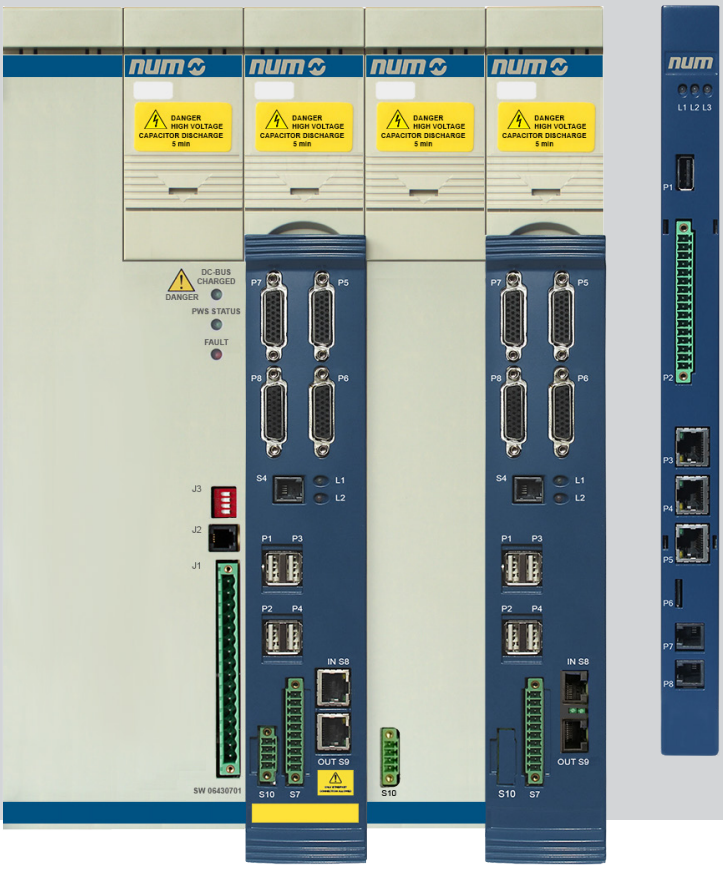


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# 1 Foreword

## 1.1 Notes on the manual

This description is only intended for the use of trained specialists in control and automation technology who are familiar with the applicable national standards. It is essential that the following notes and explanations are followed when installing and commissioning these components.

The responsible staff must ensure that the application or use of the products described satisfy all the requirements for safety, including all the relevant laws, regulations, guidelines and standards.

### 1.1.1 Disclaimer

The documentation has been prepared with care. The products described are, however, constantly under development. For that reason the documentation is not in every case checked for consistency with performance data, standards or other characteristics.

In the event that it contains technical or editorial errors, we retain the right to make alterations at any time and without warning.

No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams and descriptions in this documentation.

### 1.1.2 Trademarks

EtherCAT® and Safety over EtherCAT® are registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

Other designations used in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owners.

### 1.1.3 Patent Pending

The EtherCAT Technology is covered, including but not limited to the following patent applications and patents: EP1590927, EP1789857, EP1456722, EP2137893, DE102015105702 with corresponding applications or registrations in various other countries.

### 1.1.4 Copyright



### 1.1.5 Delivery conditions

In addition, the general delivery conditions of the company NUM apply.

### 1.1.6 Description rules

In the descriptions, when the parameter number is printed with sloped characters, it means that we refer to value stored into the parameter.

## 1.2 Safety instructions

### 1.2.1 Safety Rules

Consider the following safety instructions and descriptions!

Product specific safety instructions are to be found on the following pages or in the areas mounting, wiring, commissioning etc.

### 1.2.2 Disclaimer

All the components are supplied in particular hardware and software configurations appropriate for the application. Modifications to hardware or software configurations other than those described in the documentation are not permitted, and nullify the liability of NUM.

### 1.2.3 Personnel Qualification

This description is only intended for the use of trained specialists in control, automation and drive engineering who are familiar with the applicable national standards.

### 1.2.4 Description of safety symbols

The following safety symbols are used in this operating manual. They are intended to alert the reader to the associated safety instructions.

| Symbol | Meaning of the symbol |
|---|---|
|  | The information “ i ” icon indicates notes on product use. |
|   | The STOP icon indicates a wrong operation which may damage the product or indicates important notes on product use . |
|  | The TRIANGLE icon indicates hazard for human beings and this information is referring to personal damage!<br><br>Whenever one of these icons appear, please beware, use and apply adequate precautions to avoid hazards or damage situations during the drive installation and commissioning operations!<br><br>Please beware, consult chapter 2.5<br>Please beware! Prevent and safety instruction against accidental contact with electrical components. |

## 1.3 Abbreviations and definitions

| Abbreviations | Meaning |
|---|---|
| **Bi-Axes** | Drive for two motors control |
| **BHX, BPX, SHX, SPX BPH, BPG** | NUM axis motor range |
| **CNC IU** | CNC Internal Unit: 0.001mm, 0.01mm, 0.1mm, 0.0001mm etc. See CNC parameter P4N2 on Parameter Manual M00068 |
| **CTMG1100 and CTMTx** | NUMEtherCAT Gateway and modules (see Installation manual M00032) |
| **CTMP6900** | NUMSafe PLC (see Installation manual M00033) |
| **CTMS1904** | NUMSafe input terminal (see Installation manual M00034) |
| **CTMS2904** | NUMSafe output terminal (see Installation manual M00035) |
| **EtherCAT** | Digital bus communication type |
| **EMC** | Electromagnetic Compatibility |
| **EPS** | Electrical Positions Synchronization |
| **E-Stop** | Emergency Stop |
| **EU** | European Union |
| **FSoE** | Fail Safe over EtherCAT |
| **M** | Motor |
| **MASTER** | NUM DrivePro module for TANDEM application |
| **MDLL3** | Power Supply module |
| **MDLUF** | NUM digital drive |
| **Mono-Axis** | Drive for one motor control |
| **NUM DrivePro** | Digital drive module (Power + Control Units) |
| **NUM over EtherCAT** | MDLUF digital bus communication type |
| **NUM-STOX** | Safe Torque Off certified SIL 2 module |
| **NUM-SAMX** | NUM-Safety certified SIL 3 module |
| **PDS** | Power Drive System (line filter + power cable + power supply + drives + power cables + motors) |
| **Quad-Axes** | Drive for four motor control |
| **RJ11/ RJ45** | Type of connector |
| **RTK** | Real Time Kernel |
| **Size x** | Module width (50mm, 100mm, 200mm or 400mm) |
| **SDM** | Safe Direction Monitoring |
| **SLS** | Safely Limited Speed |
| **SLP** | Safe Limited Position |
| **SOS** | Safe Operating Stop |
| **SP** | Drive Standard Performance version |
| **SRP/ECS** | Safety–Related Part Electrical Control System |
| **SS1** | Safe Stop 1 |
| **SS2** | Safe Stop 2 |
| **SSM** | Safe Speed Monitor |
| **STO** | Safe Torque Off |
| | |
| **Safety Failure** | In case a safety limit is disobeyed (for example a Safe Limited Speed is not respected) NUM-SAMX trigger a Safety Failure. The drive reaction depends on the Safety Failure class and the drive parameter setting. See chapter 6.4.9 |
| **Internal diagnostic failure** | It's an internal NUM-SAMX fault that can be due to hardware, software, noise etc. |

## 1.4 Document revisions

| Edition | Evolution Index | Meaning of the major documentation evolution points | See chapter |
|---|---|---|---|
| 12.2024 | 00 | Compliance with Software version 1.00 / 2.00 / 4.00<br>Document creation:<br><br>NUM-SAMX Safety module for NUM DrivePro | - |
| 03.2025 | 01 | Compliance with Software version 1.2.0 / 2.2.0 / 4.2.0 | - |
| 07.2025 | 02 | Correction of NUM SAMX revision index | Cover |
| 01.2026 | 03 | Conversion rule for linear motor parameters S6 | 6.3.1<br>6.3.4 |

## 1.5 How to read the manual

This manual is structured and divided into 11 main sections as indicated here below. We suggest to follow these indicated manual sections.

| | |
|---|---|
| 1 | **Foreword**<br><br>This first section introduces the general notes, the use of the manual about safety instructions and definitions of abbreviations mentioned in the manual. |
| 2 | **General warnings on product use**<br><br>This chapter will contain general warnings on the installation and use of the product, in particular on the dangerous areas around the units that compose it. The safety conditions for switching on the unit will also be indicated. |
| 3 | **Introduction**<br><br>This chapter schematically represents the typical configurations, including the safety devices and modules, which constitute the system architecture, describing the use of the functions. |
| 4 | **Machine safety and related standards**<br><br>This chapter will indicate the reference regulatory standards on machinery safety and, in particular, risk analysis and risk reduction will be described. |
| 5 | **Relevant standards and intended use**<br><br>In this chapter, the relevant standards and their intended use will be indicated as well as the functional safety reliability data of the NUM_SAMX board. |
| 6 | **FSoE I/O, Parameters and Operating modes**<br><br>In this chapter you can consult the general list of parameters and their operating modes, FSoE I/O, in the NUM-SAMX Mono-Axis, Bi-Axis configurations. |
| 7 | **Integration in a FlexiumPro project**<br><br>This chapter will describe adding and addressing devices in a FlexiumPro project and how to add a NUM-SAMX parameter folder. |
| 8 | **NUM-SAMX Measure point MPX list**<br><br>In this chapter the NUM-SAMX Measure points will be listed. It will also explain the meaning of MPX21 which is used to store a value that could be used to better understand the root cause of a safety alarm that has occurred. |
| 9 | **Diagnostics and Maintenance**<br><br>In this last chapter, concerning diagnostics and maintenance, the Status of EtherCAT connector S8, S9 LEDs will be described. |

## 1.6 NUM Agencies

The list of NUM agencies is given on https://www.num.com

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# 2 General warnings on product use

## 2.1 NUM DrivePro with NUM-SAMX - User's informations

Before connecting, operating or adjusting these products, please read the following User's software information:

NUM DrivePro minimum software release version is 1.2.0 / 2.2.0 / 4.2.0

- NUM-SAMX software release version for Mono-Axis drive is 1.1.0.
- NUM-SAMX software release version for Bi-Axes drive is 2.1.0.
- NUM-SAMX software release version for Quad-Axes drive is 4.1.0.
- The NUM DrivePro reaction to the alarms described in this manual could be defined in NUM DrivePro Parameter Manual M00066 for their setup.


NUM declines all responsibility for injury or damage to persons or objects due to incorrect use of this product.


As described in the present document, NUM-SAMX deals with functional safety (as per EN 61800-5-2).
None of the NUM-SAMX safety functions is related to electrical safety; NUM-SAMX does not guarantee electrical insulation.
Even the Safe Torque Off (STO) function does not remove the electrical connection between drive and motor.

Before any intervention on the drive system, and/or connected motors and devices, the system must be powered-off.
After power off, wait at least 5 minutes before carrying out any operation; It's the time needed to discharge the capacitors of the intermediate circuit.

## 2.2 NUM DrivePro with NUM-SAMX unpacking inspection

You are advised to check that you have all the equipment before starting to install the drive.
Please always control the item reference on the package label.

Do not operate if you have recognized a transport damage.
In this case contact immediately NUM.

## 2.3 General drives installation warnings instructions


- All the international, state, regional and local standards must be complied with during the installation and during the use of this product. Only properly qualified personnel having extensive knowledge in servo drive system should install, commission and/or maintain the product.

- To comply with current safety regulations, all wiring and connections must be made in accordance with the electrical diagrams shown in this manual.

  NUM declines all responsibility for injury or damage to persons or objects due to incorrect use of this product.

- During the servomotor installation, always make sure that the connection cable used is the one established in NUM DrivePro Installation manual M00067.
  The use of an incorrect cable leads to the violation of the international standards.

- NUM drives operate correctly only by distribution systems such as “TN, TT”.

- NUM drives to operate correctly must always be equipped with a line filter.
  Please refer to NUM DrivePro Installation manual M00067.

- All the components (PDS, CNC, filter, etc.) must be correctly connected to the cabinet structure. The PDS must be mounted on a earthed unvarnished plate.

  For more detailed information please refer to M00067 or M00027 manuals.

- Use only original NUM cables. The original NUM cables have special characteristics.

- The total length of the power cables used in each PDS must be <400m at 5kHz PWM and < 200m at 10kHz PWM.

- The total length of the cable for the drive digital bus interconnections must comply Ethernet 100Base-TX cabling specification.

- The external braking resistor frame may reach high temperatures in the case of a particularly heavy duty. We therefore suggest to place the braking resistors where they will not be accidentally touched by personnel.

- The line filter frame may reach high temperatures. Therefore to facilitate sufficient air circulation and ensure an adequate heat exchange it is recommended that a minimum clearance of 30mm is left when installing the filter in the electrical cabinet.

  We therefore suggest to place them where they will not be accidentally touched by personnel.

- The line choke frame may reach high temperatures.

  We also suggest to place them where they will not be accidentally touched by personnel.

  To prevent eventual electromagnetic disturbances emitted from the inductance, we suggest that it is placed at least 500mm far from particulary sensitive apparatus, from the digital bus flat cable interconnections or from sensor cables.

## 2.4 Drive switched on condition general warnings


- Before switch on the System cover the energized parts in order to avoid them being touched. Do not touch the electrical components while the system in ON.

- When the drive is switched on, the power components, such as the connectors or braking resistor, are connected to the mains power supply. Be very careful not to touch these components.

- The drive must always be switched off before handling. Wait at least 5 minutes before carrying out any operation, i.e. The time needed for the intermediate circuit capacitors to discharge.

  (Standard EN60204-1).

  A clear warning must be placed on the modules in the relevant language of the country where the equipment is shipped. (Including discharge time)

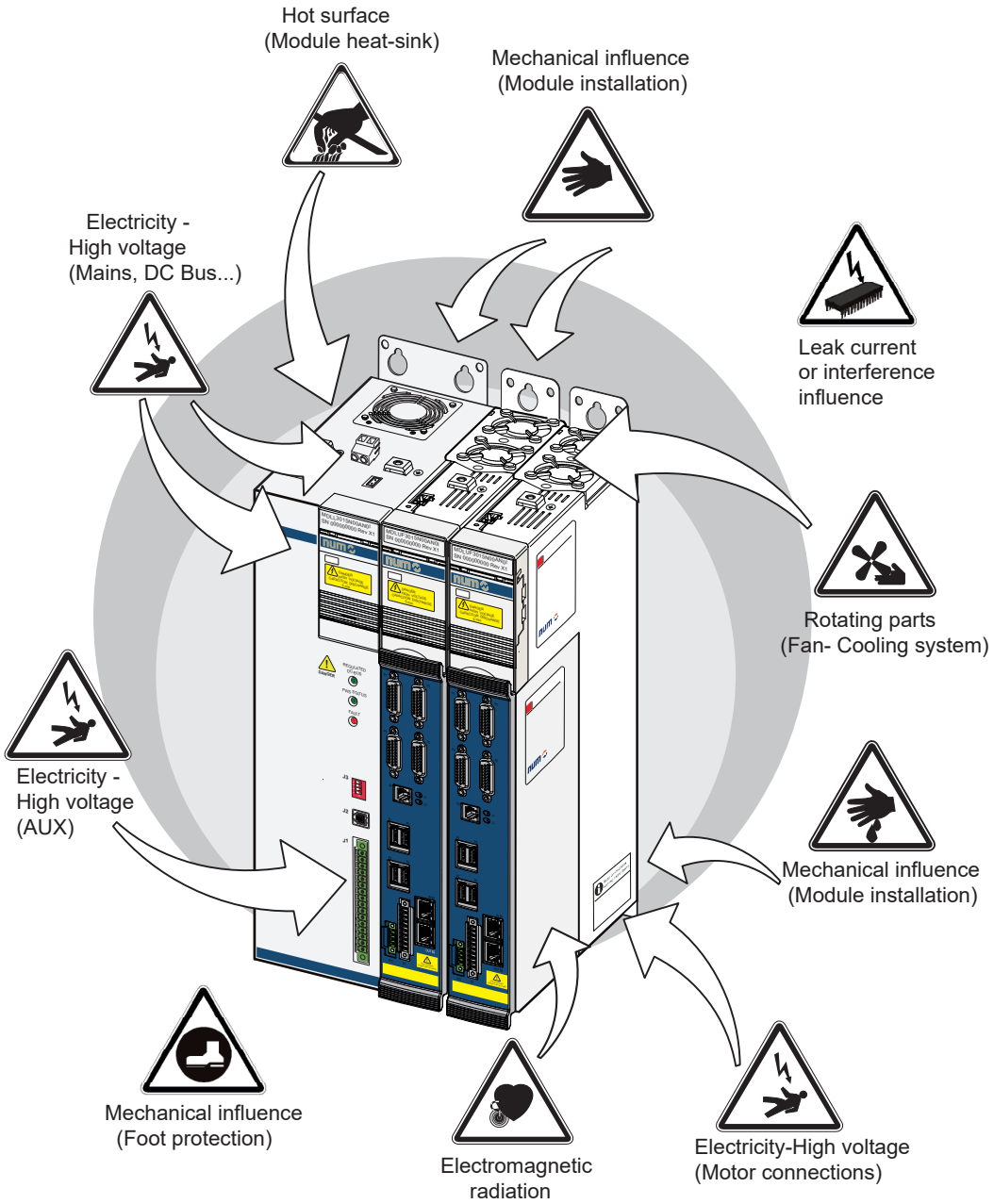
- During operation, the motor can be stopped by disabled or by the start of speed reference control circuits, whilst the drive remains enabled. To avoid sudden restarting of the system and ensure the safety of operating personnel, ensure that the current is cut off directly on the power circuit.

- In the event of an alarm, the drive is fitted with safety devices which can cause the drive or the motor to stop in the following circumstances: mechanical locking of the motor, voltage variations, break in power supply.

- Elimination of the cause of a stoppage can cause sudden, unexpected restarting of the system which can constitute a hazard in certain conditions, in particular for machines or installations which must comply to EN 60204-1, relating to the safety of electrical machines.

  It is therefore important, in these cases, for users to protect themselves against the possibility of sudden restarting by proceeding as indicated above.

## 2.5 View of the hazardous areas around MDLUF units




NUM declines all responsibility for injury or damage to persons or objects due to incorrect use of this product.

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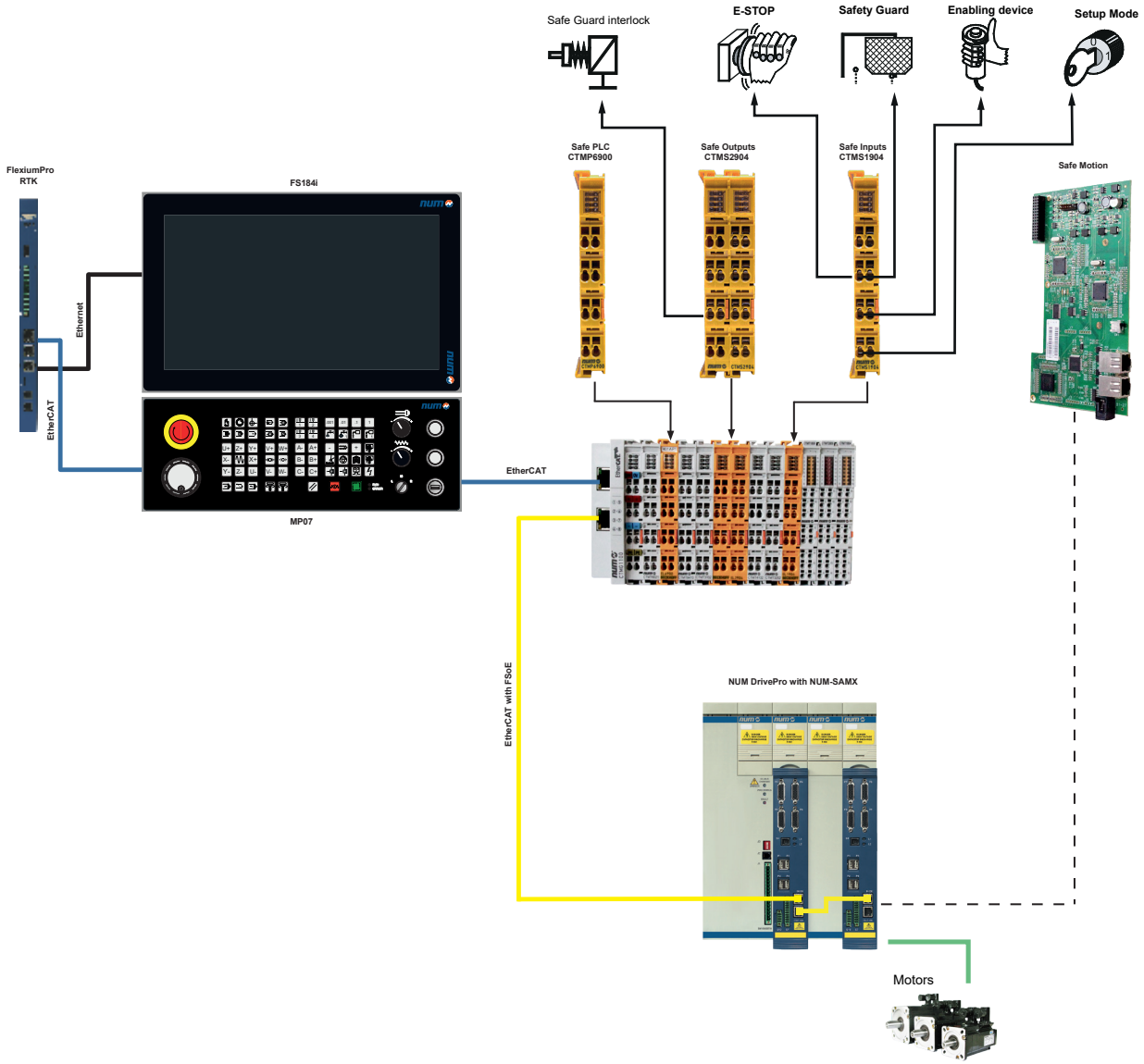
# 3 Introduction

## 3.1 NUMSafe architecture

NUMSafe architecture is typically composed by the following devices:

- FlexiumPro RTK where runs the Flexium PLC and EtherCAT master
- EtherCAT gateway (CTMG1100)
- Safe PLC (CTMP6900 or CTMP1960-2600)
- Safe I/Os (CTMS1904, CTMS2904 and CTMS2912)
- MDLUF with NUM-SAMX option (MDLUF----E-FN0I)
- Synchronous and asynchronous motors with and without (sensorless) feedback sensor.




*NUMSafe architecture*

## 3.2 NUMSafe system components connection

The following system components can be connected to the system through the safe I/Os:

- Emergency Stop control devices
- Push button for unblocking the power amplifier
- Safety guard position switches or outputs of a optical protection device (e.g. Light curtain)
- Push button for safety guard confirmation
- Operating mode switch for selecting setup mode
- Enabling devices for enabling motor movements in setup mode
- Power contacts for switching external loads, if necessary with linked contacts
- Electromechanical safety guard interlocking.

All safety related information are transmitted over the standard EtherCAT connection (FSoE), together with safety related data.

The wiring is reduced to the minimum and the flexibility and scalability is maximized.

## 3.3 NUM-SAMX safety module utilisation

The NUM-SAMX safety module can be used to integrate safety functions for personal protection against dangerous movements into the MDLUF drive positioning controllers. (See note hereunder)

The safety module offers various operating modes for:

- safe monitoring of the motor movement and
- safe removal of the motor power supply.

Thanks to the motion monitoring functions it is possible to leave the motor under power, even with the safety door open or the protective devices deactivated. The usual switch off the power is not required. Time-consuming restart procedures are thus not required. This reduces downtime.

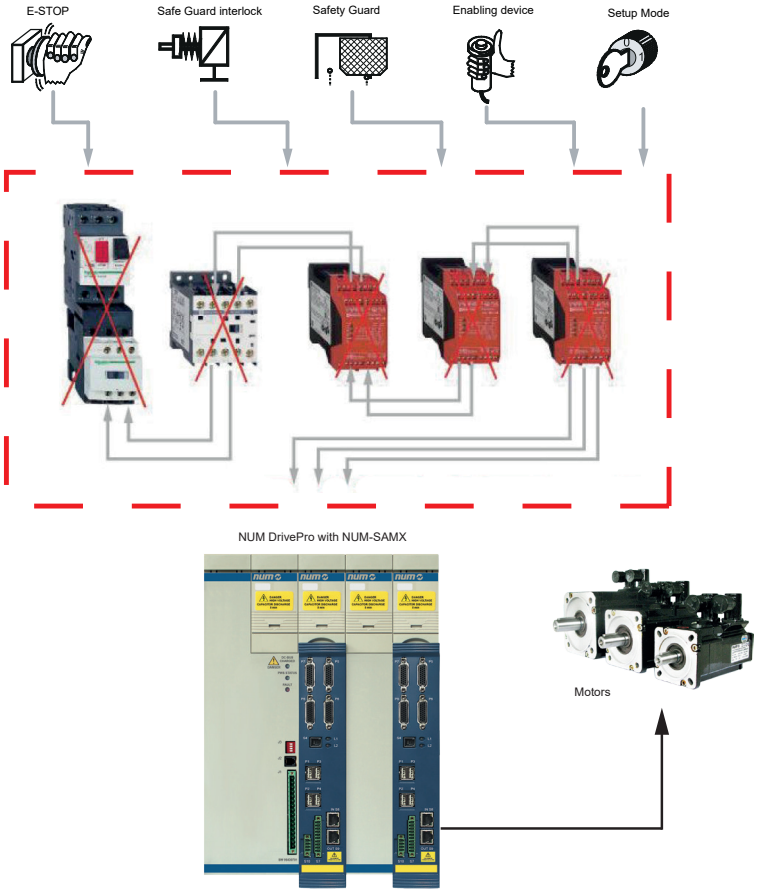
This becomes more important the more frequently entry to the danger area is required.

These safety functions enable the more stringent safety requirements for setup mode required by the machine directive to be met.

The components required in conventional safety engineering can be replaced with the NUM Safe devices. These components include:

- Additional position sensors (one per axis)
- Stop position and speed monitor (one per axis)
- Safety relays (Emergency Stop relays)
- Motor power contactors.

NUM-SAMX module requires the connection of the motor sensor onto the P1...P6 connector MDLUF unit (Refer to M00067 manual for detailed information).
This reduces the costs for components, installation and also the space required for the system. (See figure)




*External versus without NUM-SAMX safety engineering.*

## 3.4 Safety functions

| Safety function | Description | Response time | Applicable for synchronous motors with feedback sensor | Applicable for asynchronous motors with feedback sensor | Applicable for sensorless motors |
|---|---|---|---|---|---|
| **Safe Torque Off (STO)** | When the STO function is activated NUM-SAMX module removes power to the motor, that can cause dangerous rotation (or motion in the case of a linear motor).<br>NUM DrivePro will not provide energy to the motor which can generate torque (or force in the case of a linear motor).<br>The activation of the function is performed by means of the NUM-SAMX Logical Input named **TorqueEn** (False = STO).<br>This function has the highest priority and is performed with the delay defined in parameter *S19*, if value <> 0. | < 50µs | ● | ● | ● |
| **Safe Stop 2 (SS2)** | The SS2 function monitors the motor deceleration rate within set limit (defined by the parameter *S23*) and initiates the Safe Operating Stop (SOS) monitoring function, when the \|motor speed\| is below a specified limit (*S16*).<br>SS2 is triggered by:<br>An Emergency stop request (NUM-SAMX Logical Input nEstop = 0) or safety function (SLS, SLP, SDI) disobeying.<br>The monitoring of the braking ramp can be delayed by means of the parameter *S17* or *S18.* | < 10ms | ● | ● | |
| **Safe Stop 1 (SS1)** | The SS1 function is obtained by enabling STO once the SS2 function is terminated, or initiates the motor deceleration (if configured into drive parameter with V30.5 = 1) and initiates the STO function after an application specific time delay (*S17* or *S18*). See chapter 6.4.10 for details | < 10ms | ● | ● | |
| | | (1) | | | ● |
| **Safe Operating Stop (SOS)** | The SOS function prevents the motor from deviating more than a defined amount from the stopped position.<br>The NUM DrivePro provides energy to the motor in order to resist to external forces.<br>SOS function is activated automatically at the end of a safe stop (SS2) with safety guard opened or activated opening the safety guard.<br>The safety guard interlock (NUM-SAMX Logical Output **InterlockOut**) is released when the \|motor speed\| is below specified limit (parameter *S16*). | < 10ms | ● | | |
| **Safe Speed Monitor (SSM)** | The SSM function provides a safe output signal (NUM-SAMX Logical Output **Speed**) to indicate whether the \|motor speed\| is below a specified limit *S24*. This threshold limit doesn't have relation with the Speed Limits active. | < 10ms | ● | ● | |
| | | (1) | | | ● |
| **Safely-Limited Speed (SLS)** | The SLS function prevents the motor from exceeding specified speed limits. SLS is activated by:<br>• in Automatic Mode if NUM-SAMX parameter *S15* is different from 0<br>• with safety guards opened (NUM-SAMX Logical Input **GuardClsd** = 0) and enabling the NUM-SAMX Logical Input **EnablingDevice** = 1 and selecting one of 4 speed limits (NUM-SAMX parameter *S11...S14*) by means of NUM-SAMX Logical Input **SpdLm1, SpdLm2, SpdLm3, SpdLm4**.<br>• whenever the SLS monitoring functions is disobeyed NUM-SAMX generates a Safety Failure and the SS2 function is triggered (for details see chapter 6.4.8). | < 10ms | ● | ● | |
| | | (1) | | | ● |

| Safety function | Description | Response time | Applicable for synchronous motors with feedback sensor | Applicable for asynchronous motors with feedback sensor | Applicable for sensorless motors |
|---|---|---|---|---|---|
| **Safely-Limited Position (SLP)** | The SLP function prevents the axes from exceeding specified position limit(s). SLP is activated with NUM-SAMX Logical Input **SfPosition** n (n= 0...15) and the specified limits are set by means of the parameter *S32...S63*. Necessary condition before the activation of the SLP is the execution of the Safe Homing Position. Whenever the SLP functions is disobeyed NUM-SAMX generates a Safety Failure and the SS2 function is triggered (for details see 6.4.8).<br>SLP function is foreseen for linear and rotary limited excursion axes application, it is not foreseen for rotary endless application (rotary axes modulo or spindle).<br>In case of use of absolute measure system, the axis travel must not pass through the 0 absolute position of the measure system. | < 10ms | ● | | |
| **Safe Direction (SDM)** | Safety function SDM (safe direction monitoring) is equivalent to safety function SDI of EN 61800-5-2:2007, with direction monitoring.<br>Whenever the SDM functions is disobeyed NUM-SAMX generates a Safety Failure and the SS2 function is triggered (for details see chapter 6.4.8). | < 10ms | ● | | |
| **Safe Cams (SCA)** | The SCA function offers FSoE Inputs that safely report axis position ranges.<br>This function is automatically disposable when Safe Homing has been completed (**SfHomDone** = TRUE). Any fault reaction is foreseen from this function.<br>SCA function is foreseen for linear and rotary limited excursion axes application, it is not foreseen for rotary endless application (rotary axes modulo or spindle).<br>In case of use of absolute measure system, the axis travel must not pass through the 0 absolute position of the measure system. | < 10ms | ● | | |

(1) Response time:

< 100ms on Mono-Axis Drive

< 150ms on Bi-Axes Drive

< 200ms on Quad-Axes Drive


Position related safety functions (SLP, SCA and SOS), Safe Stop functions (SS2) and Safe Direction functions (SDI) **are NOT safely supported** for asynchronous motors.


For asynchronous motors, at any transition from higher Speed to lower Speed assuming an Encoder Fault, a time-out value must be calculated.
The motor in free running mode must reach the lower speed within the time-out value. To calculate the value the maximum |motor speed|, the inertia and the brake distance must be considered.

### 3.4.1 Automatic mode

| | |
|---|---|
| **Automatic mode** | In Automatic mode the Safe Speed Monitor (SSM) could be enabled.<br><br>If the Automatic Mode Speed Limit parameter *S15* is defined > 0, NUM-SAMX in Automatic mode implements the Safe Speed Monitor (SSM) function.<br><br>When the Automatic Mode Speed Limit *S15* is disobeyed, NUM-SAMX generates a Safety Failure and the SS2 function is triggered<br><br>In case *S15* = 0 the Safe Speed Monitor function is disabled. |

### 3.4.2 Other monitoring functions

| | |
|---|---|
| **Temperature monitoring** | The temperature of the NUM-SAMX module is monitored. If the temperature exceeds or falls below the permissible operating range, an Alarm is issued to the Drive Controller.<br><br>The power amplifier is not disabled and the fault reaction under stays the Drive failure reaction setting. |

### 3.4.3 Safety Function Priority

The NUM-SAMX monitors the parameters of the activated safety functions which has been requested by the Safe PLC. In case of parameter violation a Safety Failure is generated and the SS2 function is triggered.

If the braking ramp is not respected NUM-SAMX triggers STO safety function.

The Safe Torque Off has the highest priority. The other safety functions have the same priority:

that means that the NUM-SAMX when requested, or as a consequence to system failures, activates the STO function independently by every other safety function activated before.

### 3.4.4 Muting and suspension of safety functions

It is not possible to exclude the safety functions whenever are activated.

### 3.4.5 Alarm queue managing

NUM-SAMX manages a queue of 3 alarms that could happens as consequence of an alarm condition. The queued alarms are emitted one at time after cancellation of the previous by means of CNC reset command.

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# 4 Machine safety and related standards

## 4.1 Introduction

As a result of automation, demand for increased production and reduced operator physical effort, safety-related part of control system (SRP/CS) of machines play an increasing role in the achievement of overall machine safety.

There are many situations on machines where (SRP/ECS) are employed as part of safety measures that have been provided to achieve risk reduction.

A typical case is the use of an interlocking guard that, when it is opened to allow access to the danger zone, signals the electrical control system to stop hazardous machine operation.

## 4.2 Risk analysis and risk reduction

The SRP/CS shall be designed and constructed so that the principles of EN ISO 12100:2010 and EN ISO 14121-1:2007 are fully taken into account (see Figures 1 and 3).

All intended use and reasonable foreseeable measure shall be considered.

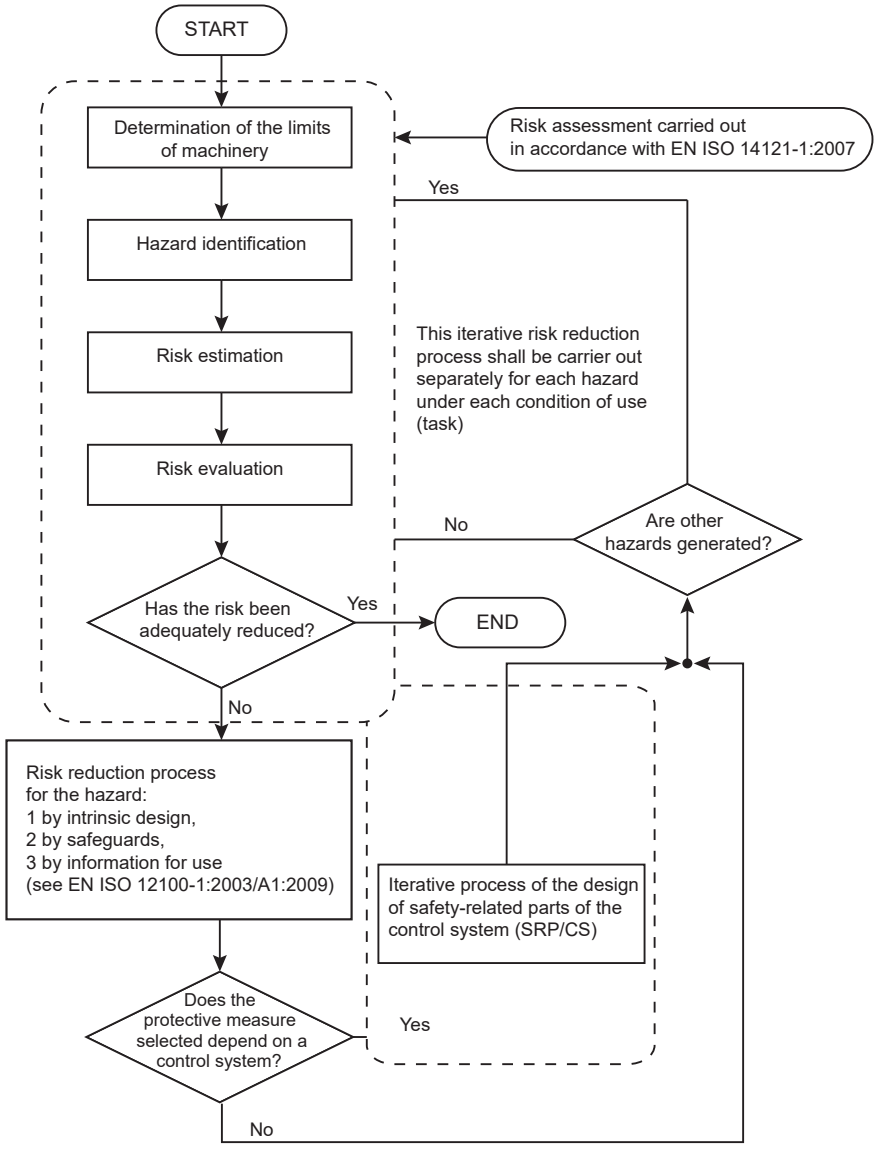


*Figure 1 - Overview of the risk assessment/risk reduction (Taken from EN ISO 13849-1:2015)*

The strategy for risk reduction at the machine is given in EN ISO 12100-1:2003/A1:2009. This strategy covers the whole life cycle of the machine.

The hazard analysis and risk reduction process for a machine requires that hazards are eliminated or reduced through a hierarchy of measures:

- hazard elimination or risk reduction by design (see EN ISO 12100-2:2003/A1:2009);
- risk reduction by safeguarding and possibly complementary protective measures (see EN ISO 12100-2:2003/A1:2009);
- risk reduction by the provision of information for use about the residual risk (see EN ISO 12100-2:2003/A1:2009).

## 4.3 Contribution to the risk reduction by the electrical control system

The design of the SRP/ECS to provide the required risk reduction is an integral subset of the overall design procedure for the machine. The SRP/ECS provides safety function(s) at a PL which achieves the required risk reduction.

In providing safety function(s), either as an inherently safe part of the design or as a control for a safeguard or protective device, the design of the SRP/ECS is a part of the strategy for risk reduction.

EN ISO 13849-1:2015 defines the performance levels in terms of probability of dangerous failure per hour.

Five performance levels (a to e) are set out, with defined ranges of probability of a dangerous failure per hour (see Table 3).

**Table 3 - Performance levels (PL)**

| PL | Average probability of dangerous failure per hour 1/h |
|---|---|
| a | $\geq 10^{-5}$ to $< 10^{-4}$ |
| b | $\geq 3 \times 10^{-6}$ to $< 10^{-5}$ |
| c | $\geq 10^{-6}$ to $< 3 \times 10^{-6}$ |
| d | $\geq 10^{-7}$ to $< 10^{-6}$ |
| e | $\geq 10^{-8}$ to $< 10^{-7}$ |
| Note. Besides the average probability of dangerous failure per hour other measure are also necessary to achieve the PL. | |

From the risk assessment (see EN ISO 14121-1:2007) at the machine, the machine builder shall decide the contribution to the reduction of risk which needs to be provided by each relevant safety function which is carried out by the SRP/ECS(s).

This contribution does not cover the overall risk of the machinery under control, e.g. not the overall risk of a mechanical press, or washing machine is considered, but that part of risk reduced by the application of particular safety functions.

Examples of such functions are the stopping function initiated by using an electro-sensitive protective device on a press or the door-locking function of a washing machine.

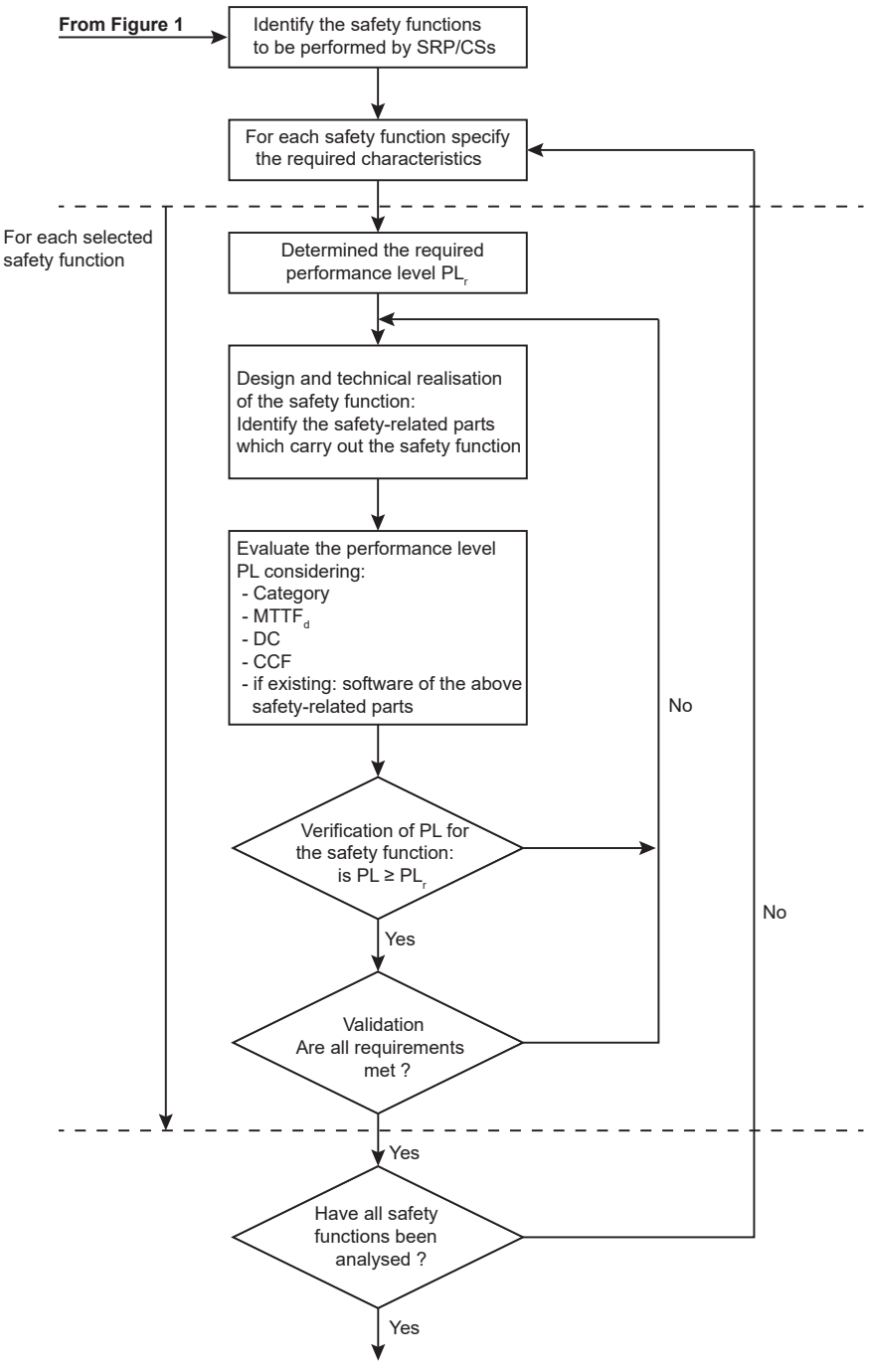


*Figure 3 - Iterative process for design of safety-related parts of control systems (SRP/CS).*

*Taken from EN ISO 13849-1:2015.*


As well being responsible for the risk analysis the machine builder is responsible for validating.

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# 5 Relevant standards and intended use

| | |
|---|---|
| **EN ISO 13849-1:2015** | Safety of machinery<br>Safety-related parts of control systems<br>Part 1: General principles for design |
| **EN ISO 13849-2:2012** | Safety of machinery<br>Safety-related parts of control systems<br>Part 2: Validation |
| **EN 60204-1:2018** | Safety of machinery<br>Electrical equipment of machines<br>Part 1: General requirements |
| EN 61800-5-2:2007 | Adjustable speed electrical power drive systems<br>Functional<br>Part 5-2: Safety requirements Functional |
| EN 61800-3:2004/A1:2012 | Adjustable speed electrical power drive systems<br>Part 3: EMC requirements and specific test methods |
| EN 61800-5-1:2007/A11:2021 | Adjustable speed electrical power drive systems<br>Part 5-1: Safety requirements - Electrical, thermal and energy |
| **EN 60529:1991/A2:2013/AC:2019-02** | Degrees of protection provided by enclosures (IP Code) |

## 5.1 NUM-SAMX Functional safety reliability data

NUM-SAMX is applicable for all applications with synchronous and asynchronous motors for machines where the risk assessment requires additional safety devices.

The reliability parameters of the complete NUM DrivePro power drive system with NUM-SAMX safety module according to IEC/EN 61800-5-2 and EN ISO13849-1/2 are:

| **Safety reliability data** | | |
|---|---|---|
| **Parameter** | **Value** | **Measuring unit** |
| **Type (according to IEC/EN 61800-5-2)** | B | - |
| **Category (according to EN ISO 13849-1/2)** | 3 | - |
| **Architecture (according to IEC/EN 61800-5-2)** | 1002 (D) | - |
| **HFT (according to IEC/EN 61800-5-2)** | 1 | - |
| **MTTFd (of each channel) (according to EN ISO 13849-1/2)** | > 100 | Years |
| **$DC_{agv}$ (according to EN ISO 13849-1/2)** | > 99 | % |
| **SFF (according to IEC/EN 61800-5-2)** | > 99 | % |
| **PFH / $PFH_D$** | 1.48E-09 | 1/h |
| **CCF** | 65 | - |
| **ß factor** | 2 | % |
| **PL (according to EN ISO 13849-1/2)** | e | - |
| **SIL (according to IEC/EN 61800-5-2)** | 3 | - |

The system is suitable for High demand application. The function can be used during normal machine operation with a daily frequency. The Hardware fault-tolerance is equal to 1, because of the 1oo2 (one out of two) architecture.

Since the safety module contains 2 redundant channels, a single failure does not inhibit the safety function.


The use of the safety module for vertical axis is not permitted without additional means.

## 5.2 Fault Exclusion

None

## 5.3 Environmental conditions

Please refer to NUM DrivePro Installation manual M00067 for more detailed informations.

Whenever the safety module is used, the Drive has to be used in a protected environment (min. IP54). The Electrical Cabinet may be applicable for this.

NUM DrivePro must be installed in conformity with the Installation manual M00067.

## 5.4 MDLUF and NUM-SAMX installation and connections

Please refer to NUM DrivePro Installation manual M00067 for more detailed informations.

## 5.5 Inter operations

NUM-SAMX safety module can only be used integrated in NUM DrivePro (MDLUF) Power Drive Systems (PDS). It requires external Safe PLC, input modules and it may require external safe output modules (interlock etc); the communication between such external safe devices is realized by means of FSoE.

NUM DrivePro with NUM-SAMX inter operates with the following devices:

- CNC system: FlexiumPro
- Safe PLC: NUMSafe PLC (CTMP6900, CTMP1960-2600)
- Safe input: NUMSafe input terminal (CTMS1904)
- Safe output: NUMSafe output terminal (CTMS2904, CTMS2912)
- EtherCAT Gateway: NUMEtherCAT Gateway (CTMG1100)
- Safe PLC programming tool: “CODESYS Safety for EtherCAT Safety Module”
- Synchronous and Asynchronous motors with a feedback sensor.
- Synchronous and Asynchronous motors without feedback sensor but with some safety function only.

NUM-SAMX is available for Mono-Axis, Bi-Axes and Quad-Axes MDLUF drives.

### 5.5.1 Compatible feedback sensor

Incremental signal sensor:

- TTL encoder
- sin/cos encoder
- Sick Hiperface encoder with sin/cos signals
- Heidenhain EnDat 2.1 and 2.2 encoder with sin/cos signals
- NUM encoder types: “P”, “Q”, “J”, “K”

Digital sensor:

- Heidenhain EnDat 2.2 encoder without sin/cos signals
- Fagor and Renishaw BISS-C encoder
- Sick Hiperface DSL encoder
- NUM encoder types: “I”, “L”, “3”, “4”, “Y”, “Z”

For the system’s SIL calculation the MTTF declared by the encoder manufacturer has to be taken into account. Please refer to chapter 5.5.2

In case of using Safe encoders, the calculation of the system’s PFH is done by adding the encoder PFH to the NUM-SAMX one.

### 5.5.2 System's SIL / PFH calculation in case of using compatible feedback sensors

$MTTF_{d\ (encoder)} = 2 * MTTF_{encoder}$ (Use encoder manufacturer declared data)

$PFH_{encoder}\ [1/h] = 1 / MTTF_{d\ (encoder)}\ [h]$

$PFH_{NUM\text{-}SAMX}\ [1/h] = 1.28 \cdot 10^{-9}$

$PFH_{tot} = PFH_{NUM\text{-}SAMX} + PFH_{encoder}$

From $PFH_{tot}$ the associated SIL / PL can be directly determined.
(Please refer to chapter 4.3 - Table 3 - Performance levels (PL) )


The calculation must be done considering the motor encoder's MTTF.
Additional direct measure sensor are not involved in the calculation.


Position related safety functions (SLP and SOS), Safe Stop functions (SS2) and Safe Direction functions (SDM) **are NOT safely supported** for asynchronous motors.


For asynchronous motors, at any transition from higher Speed to lower Speed assuming an Encoder Fault, a time-out value must be calculated.
The motor in free running mode must reach the lower speed within the time-out value. To calculate the value the maximum motor speed, the inertia and the brake distance must be considered.

### 5.5.3 Reliability data with NUM sensors

| **NUM sensor type** | MTTF encoder [h] | MTTFd encoder [h] | PFH encoder [1/h] | PFH NUM-SAMX [1/h] | PFH total [1/h] | PL total | Category |
|---|---|---|---|---|---|---|---|
| **P** | 2.17E+06 | 4.34E+06 | 2.30E-07 | 1.28E-09 | 2.32E-07 | d | 3 |
| **Q** | 2.48E+06 | 4.96E+06 | 2.02E-07 | 1.28E-09 | 2.03E-07 | d | 3 |
| **J** | 1.58E+06 | 3.15E+06 | 3.17E-07 | 1.28E-09 | 3.19E-07 | d | 3 |
| **K** | 1.70E+06 | 3.40E+06 | 2.94E-07 | 1.28E-09 | 2.96E-07 | d | 3 |
| **I** | 1.28E+06 | 2.56E+06 | 3.91E-07 | 1.28E-09 | 3.93E-07 | d | 3 |
| **L** | 1.38E+06 | 2.75E+06 | 3.64E-07 | 1.28E-09 | 3.65E-07 | d | 3 |
| **3** | Safe encoder | Safe encoder | 4.00E-08 | 1.28E-09 | 4.17E-08 | d | 3 |
| **4** | Safe encoder | Safe encoder | 4.00E-08 | 1.28E-09 | 4.17E-08 | d | 3 |
| **Y** | 1.27E+06 | 2.54E+06 | 3.94E-07 | 1.28E-09 | 3.95E-07 | d | 3 |
| **Z** | 1.27E+06 | 2.54E+06 | 3.94E-07 | 1.28E-09 | 3.95E-07 | d | 3 |

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# 6 FSoE I/O, Parameters and Operating modes

## 6.1 FSoE I/O for NUM-SAMX Mono-Axis

### 6.1.1 **FSoE Input** (NUM-SAMX Logical Output)

| Type | [Bit] | Bit name | Description |
|---|---|---|---|
| **Input** | [0] | **StandStill** | See chapter 6.5 |
| | [1] | **CutOff** | 0= STO disabled<br>1= STO enabled (see chapter 6.5) |
| | [2] | **InterlockOut** | 0= safety guard opening not allowed<br>1= safety guard opening allowed (see chapter 6.5) |
| | [3] | **Speed** | See chapter 6.5 |
| | [4] | **SfPosActive** | 0= Safe Position Monitoring not active<br>1= Safe Position Monitoring active |
| | [5] | **TestReqrd** | Foreseen for future application |
| | [6] | **SfHomDone** | 0= Safe homing not yet done<br>1= Safe homing done |
| | [7] | **SfCam0** | 0= Axis position outside of safe path 0 limit<br>1= Axis position inside of safe path 0 limit |
| **Input** | [0] | **SfCam1** | 0= Axis position outside of safe path 1 limit<br>1= Axis position inside of safe path 1 limit |
| | [1] | **SfCam2** | 0= Axis position outside of safe path 2 limit<br>1= Axis position inside of safe path 2 limit |
| | [2] | **SfCam3** | 0= Axis position outside of safe path 3 limit<br>1= Axis position inside of safe path 3 limit |
| | [3] | **SfCam4** | 0= Axis position outside of safe path 4 limit<br>1= Axis position inside of safe path 4 limit |
| | [4] | **SfCam5** | 0= Axis position outside of safe path 5 limit<br>1= Axis position inside of safe path 5 limit |
| | [5] | **SfCam6** | 0= Axis position outside of safe path 6 limit<br>1= Axis position inside of safe path 6 limit |
| | [6] | **SfCam7** | 0= Axis position outside of safe path 7 limit<br>1= Axis position inside of safe path 7 limit |
| | [7] | **SfCam8** | 0= Axis position outside of safe path 8 limit<br>1= Axis position inside of safe path 8 limit |
| **Input** | [0] | **SfCam9** | 0= Axis position outside of safe path 9 limit<br>1= Axis position inside of safe path 9 limit |
| | [1] | **SfCam10** | 0= Axis position outside of safe path 10 limit<br>1= Axis position inside of safe path 10 limit |
| | [2] | **SfCam11** | 0= Axis position outside of safe path 11 limit<br>1= Axis position inside of safe path 11 limit |
| | [3] | **SfCam12** | 0= Axis position outside of safe path 12 limit<br>1= Axis position inside of safe path 12 limit |
| | [4] | **SfCam13** | 0= Axis position outside of safe path 13 limit<br>1= Axis position inside of safe path 13 limit |
| | [5] | **SfCam14** | 0= Axis position outside of safe path 14 limit<br>1= Axis position inside of safe path 14 limit |
| | [6] | **SfCam15** | 0= Axis position outside of safe path 15 limit<br>1= Axis position inside of safe path 15 limit |
| | [7] | Unused | |

**SfCam**x inputs are enabled when **SfHomDone** = 1.

### 6.1.2 **FSoE Output** (NUM-SAMX Logical Input)

| Type | [Bit] | Bit name | Description |
|---|---|---|---|
| **Output** | [0] | **TorqueEn** | 0= STO enabled<br>1= STO disabled |
| | [1] | **nE-Stop** | 0= E-Stop enabled → SS2 functions is triggered<br>1= E-Stop disabled |
| | [2] | **GuardClsd** | 0= Safety guard open<br>1= Safety guard closed → Automatic Mode |
| | [3] | **EnablingDevice** | 1= Jog movements are possible at limited Speed |
| | [4] | **SpdLm1** | 1= Speed limit 1 (*S11*) selected |
| | [5] | **SpdLm2** | 1= Speed limit 2 (*S12*) selected |
| | [6] | **SpdLm3** | 1= Speed limit 3 (*S13*) selected |
| | [7] | **SpdLm4** | 1= Speed limit 4 (*S14*) selected |
| **Output** | [0] | **SfPosition0** | 0= Safe position 0 disabled<br>1= Safe position 0 enabled |
| | [1] | **SfHoming** | 1 = Safe homing position reached |
| | [2] | **SfDirPlus** | 1= Movements in position increment direction are allowed |
| | [3] | **SfDirMinus** | 1= Movements in position decrement direction are allowed |
| | [4] | **SfPosition1** | 0= Safe position 1 disabled<br>1= Safe position 1 enabled |
| | [5] | **SfPosition2** | 0= Safe position 2 disabled<br>1= Safe position 2 enabled |
| | [6] | **SfPosition3** | 0= Safe position 3 disabled<br>1= Safe position 3 enabled |
| | [7] | **SfPosition4** | 0= Safe position 4 disabled<br>1= Safe position 4 enabled |
| **Output** | [0] | **SfPosition5** | 0= Safe position 5 disabled<br>1= Safe position 5 enabled |
| | [1] | **SfPosition6** | 0= Safe position 6 disabled<br>1= Safe position 6 enabled |
| | [2] | **SfPosition7** | 0= Safe position 7 disabled<br>1= Safe position 7 enabled |
| | [3] | **SfPosition8** | 0= Safe position 8 disabled<br>1= Safe position 8 enabled |
| | [4] | **SfPosition9** | 0= Safe position 9 disabled<br>1= Safe position 9 enabled |
| | [5] | **SfPosition10** | 0= Safe position 10 disabled<br>1= Safe position 10 enabled |
| | [6] | **SfPosition11** | 0= Safe position 11 disabled<br>1= Safe position 11 enabled |
| | [7] | **SfPosition12** | 0= Safe position 12 disabled<br>1= Safe position 12 enabled |
| **Output** | [0] | **SfPosition13** | 0= Safe position 13 disabled<br>1= Safe position 13 enabled |
| | [1] | **SfPosition14** | 0= Safe position 14 disabled<br>1= Safe position 14 enabled |
| | [2] | **SfPosition15** | 0= Safe position 15 disabled<br>1= Safe position 15 enabled |
| | [3,4,5,6,7] Unused | | |

## 6.2 FSoE I/O for NUM-SAMX Bi-Axes and Quad-Axes

### 6.2.1 **FSoE Input** (NUM-SAMX Logical Output)

| Type | [Bit] | Bit name | Description |
|---|---|---|---|
| **Input** | [0] | **Axn_StandStill** | See chapter 6.5 |
| | [1] | **Axn_CutOff** | 0= STO disabled<br>1= STO enabled (See chapter 6.5) |
| | [2] | **Axn_InterlockOut** | 0= safety guard opening not allowed<br>1= safety guard opening allowed (See chapter 6.5) |
| | [3] | **Axn_Speed** | See chapter 6.5 |
| | [4] | **Axn_SfPosActive** | 0= Safe Position Monitoring not active<br>1= Safe position Monitoring active |
| | [5] | **TestReqrd** | Foreseen for future application |
| | [6] | **Axn_SfHomDone** | 0= Safe homing not yet done<br>1= Safe homing done |
| | [7] | **Axn_SfCam0** | 0= Axis position outside of safe path 0 limit<br>1= Axis position inside of safe path 0 limit |
| **Input** | [0] | **Axn_SfCam1** | 0= Axis position outside of safe path 1 limit<br>1= Axis position inside of safe path 1 limit |
| | [1] | **Axn_SfCam2** | 0= Axis position outside of safe path 2 limit<br>1= Axis position inside of safe path 2 limit |
| | [2] | **Axn_SfCam3** | 0= Axis position outside of safe path 3 limit<br>1= Axis position inside of safe path 3 limit |
| | [3] | **Axn_SfCam4** | 0= Axis position outside of safe path 4 limit<br>1= Axis position inside of safe path 4 limit |
| | [4] | **Axn_SfCam5** | 0= Axis position outside of safe path 5 limit<br>1= Axis position inside of safe path 5 limit |
| | [5] | **Axn_SfCam6** | 0= Axis position outside of safe path 6 limit<br>1= Axis position inside of safe path 6 limit |
| | [6] | **Axn_SfCam7** | 0= Axis position outside of safe path 7 limit<br>1= Axis position inside of safe path 7 limit |
| | [7] | **Axn_SfCam8** | 0= Axis position outside of safe path 8 limit<br>1= Axis position inside of safe path 8 limit |
| **Input** | [0] | **Axn_SfCam9** | 0= Axis position outside of safe path 9 limit<br>1= Axis position inside of safe path 9 limit |
| | [1] | **Axn_SfCam10** | 0= Axis position outside of safe path 10 limit<br>1= Axis position inside of safe path 10 limit |
| | [2] | **Axn_SfCam11** | 0= Axis position outside of safe path 11 limit<br>1= Axis position inside of safe path 11 limit |
| | [3] | **Axn_SfCam12** | 0= Axis position outside of safe path 12 limit<br>1= Axis position inside of safe path 12 limit |
| | [4] | **Axn_SfCam13** | 0= Axis position outside of safe path 13 limit<br>1= Axis position inside of safe path 13 limit |
| | [5] | **Axn_SfCam14** | 0= Axis position outside of safe path 14 limit<br>1= Axis position inside of safe path 14 limit |
| | [6] | **Axn_SfCam15** | 0= Axis position outside of safe path 15 limit<br>1= Axis position inside of safe path 15 limit |
| | [7] | Unused | - |

**Axn_** means **Ax1_** : axis 1 or **Ax2_** : axis 2 or **Ax3_** : axis 3 or **Ax4_** : axis 4.

**Axn_SfCam**x are enabled when **Axn_SfHomDone** = 1.

### 6.2.2 **FSoE Output** (NUM-SAMX Logical Input)

| Type | [Bit] | Bit name | Description |
|---|---|---|---|
| **Output** | [0] | **Axn_TorqueEn** | 0= STO enabled<br>1= STO disabled |
| | [1] | **Axn_nE-Stop** | 0= E-Stop enabled → SS2 functions is triggered<br>1= E-Stop disabled |
| | [2] | **Axn_GuardClsd** | 0= Safety guard open<br>1= Safety guard closed → Automatic Mode |
| | [3] | **Axn_ EnablingDevice** | 1= Jog movements are possible at limited Speed |
| | [4] | **Axn_SpdLm1** | 1= Speed limit 1 (*S11*) selected |
| | [5] | **Axn_SpdLm2** | 1= Speed limit 2 (*S12*) selected |
| | [6] | **Axn_SpdLm3** | 1= Speed limit 3 (*S13*) selected |
| | [7] | **Axn_SpdLm4** | 1= Speed limit 4 (*S14*) selected |
| **Output** | [0] | **Axn_SfPosition0** | 0= Safe position 0 disabled<br>1= Safe position 0 enabled |
| | [1] | **Axn_SfHoming** | 1 = Safe homing position reached |
| | [2] | **Axn_SfDirPlus** | 1= Movements in position increment direction are allowed |
| | [3] | **Axn_SfDirMinus** | 1= Movements in position decrement direction are allowed |
| | [4] | **Axn_SfPosition1** | 0= Safe position 1 disabled<br>1= Safe position 1 enabled |
| | [5] | **Axn_SfPosition2** | 0= Safe position 2 disabled<br>1= Safe position 2 enabled |
| | [6] | **Axn_SfPosition3** | 0= Safe position 3 disabled<br>1= Safe position 3 enabled |
| | [7] | **Axn_SfPosition4** | 0= Safe position 4 disabled<br>1= Safe position 4 enabled |
| **Output** | [0] | **Axn_SfPosition5** | 0= Safe position 5 disabled<br>1= Safe position 5 enabled |
| | [1] | **Axn_SfPosition6** | 0= Safe position 6 disabled<br>1= Safe position 6 enabled |
| | [2] | **Axn_SfPosition7** | 0= Safe position 7 disabled<br>1= Safe position 7 enabled |
| | [3] | **Axn_SfPosition8** | 0= Safe position 8 disabled<br>1= Safe position 8 enabled |
| | [4] | **Axn_SfPosition9** | 0= Safe position 9 disabled<br>1= Safe position 9 enabled |
| | [5] | **Axn_SfPosition10** | 0= Safe position 10 disabled<br>1= Safe position 10 enabled |
| | [6] | **Axn_SfPosition11** | 0= Safe position 11 disabled<br>1= Safe position 11 enabled |
| | [7] | **Axn_SfPosition12** | 0= Safe position 12 disabled<br>1= Safe position 12 enabled |
| **Output** | [0] | **Axn_SfPosition13** | 0= Safe position 13 disabled<br>1= Safe position 13 enabled |
| | [1] | **Axn_SfPosition14** | 0= Safe position 14 disabled<br>1= Safe position 14 enabled |
| | [2] | **Axn_SfPosition15** | 0= Safe position 15 disabled<br>1= Safe position 15 enabled |
| | [3,4,5,6,7] Unused | | |

**Axn**_ means **Ax1**_ : axis 1 or Ax2_ : axis 2 or Ax3_ : axis 3 or Ax4_ : axis 4.

## 6.3 Parameters

### 6.3.1 General list

| Parameter number | Parameter name | Description | Unit | Range of values | Default value |
|---|---|---|---|---|---|
| ***S2*** | **FSoE Address** | Fail Safe over EtherCAT Field Bus address | [ ] | 0 ÷ 65535 | 0 (Set to invalid by default) |
| ***S5*** | **Operational modes** | General Configuration<br>See chapter 6.3.3 | [ ] | 0h ÷ FFFFFFFFh | 0h |
| ***S6*** | **Period by turn (V360)** | = V360 for Rotary motor (1)<br>= V259 • 2000000 / V380 for Linear motor (1) | [ ] | 0 ÷ 4294967295 | 128 |
| ***S7*** | **Absolute resolution by turn (V361)** | = V361 for Rotary motor (1)<br>= V259 • 2000000 / V381 for Linear motor (1) | [ ] | 0 ÷ 4294967295 | 1048576 |
| ***S8*** | **MULTI Coefficient (V306)** | Sensor MULTI coefficient | [ ] | -2147483647 ÷ +2147483647 | 10000 |
| ***S9*** | **DIVI Coefficient (V307)** | Sensor DIVI coefficient | [ ] | 0 ÷ 4294967295 | 512 |
| ***S10*** | **Motor pole pairs number (V257)** | = V257 for sensorless Rotary motor | [ ] | 0 ÷ 4294967295 | 5 |
| ***S11*** | **SLS1 Speed limit** | Safely Limited Speed #1 | [ 1/10 rpm ] or [ $1/10 \frac{2 \cdot Polepitch}{min}$ ] | 0 ÷ 4294967295 | 1000 |
| ***S12*** | **SLS2 Speed limit** | Safely Limited Speed #2 | [ 1/10 rpm ] or [ $1/10 \frac{2 \cdot Polepitch}{min}$ ] | 0 ÷ 4294967295 | 2000 |
| ***S13*** | **SLS3 Speed limit** | Safely Limited Speed #3 | [ 1/10 rpm ] or [ $1/10 \frac{2 \cdot Polepitch}{min}$ ] | 0 ÷ 4294967295 | 3000 |
| ***S14*** | **SLS4 Speed limit** | Safely Limited Speed #4 | [ 1/10 rpm ] or [ $1/10 \frac{2 \cdot Polepitch}{min}$ ] | 0 ÷ 4294967295 | 4000 |
| ***S15*** | **Automatic mode speed limit** | Safely Limited Speed in Automatic Mode | [ 1/10 rpm ] or [ $1/10 \frac{2 \cdot Polepitch}{min}$ ] | 0 ÷ 4294967295 | 10000 |
| ***S16*** | **Motor standstill threshold** | Motor Standstill threshold | [ 1/10 rpm ] or [ $1/10 \frac{2 \cdot Polepitch}{min}$ ] | 0 ÷ 4294967295 | 100 |
| ***S17*** | **Ramp on E-Stop monitoring delay** | Delay time for ramp monitoring in case of E-Stop | ms | 0 ÷ 65535 | 150 |
| ***S18*** | **Ramp on alarm monitoring delay** | Delay time for ramp monitoring in case of Safety Failure. | ms | 0 ÷ 65535 | 150 |
| ***S19*** | **Cutoff delay** | Delay time for power stage/motor torque disabled. | ms | 0 ÷ 65535 | 0 |

| Parameter number | Parameter name | Description | Unit | Range of values | Default value |
|---|---|---|---|---|---|
| *S20* | **Encoder disalignment threshold** | Maximum allowed difference between:<br>- NUM DrivePro sensor counter and NUM-SAMX sensor counter for synchronous motor.<br>- NUM DrivePro motor speed and NUM-SAMX motor speed for asynchronous motor. | [1 motor turn = 65536] for Synchronous motor<br><br>[1 /10 rpm] for Asynchronous motor | 0 ÷ 4294967295 | 1000 |
| *S21* | **Position disalignment threshold for SOS and safe homing** | Position deviation after transition from any mode to Safe Operating Stop (SOS). | CNC IU | 0 ÷ 4294967295 | 100 |
| *S22* | **Safe homing positon** | Definition of Safe Homing position | CNC IU | -2147483647 ÷ +2147483647 | 0 |
| *S23* | **Deceleration ramp** | Definition of Safe Deceleration ramp | $\left[\frac{rpm}{s}\right]$ or $\left[\frac{2 \cdot Polepitch}{min \cdot s}\right]$ | 0 ÷ 4294967295 | 5000 |
| *S24* | **SSM Speed limit** | Safe Speed Limit threshold used to manage NUM-SAMX Logical Output **Speed (Axn_Speed)** | $\left[1/10\ rpm\right]$ or $\left[1/10\ \frac{2 \cdot Polepitch}{min}\right]$ | 0 ÷ 4294967295 | 0 |
| *S32 to S63* | **Safe position n lower / upper limit** | Definition of lower / upper limit position n (n = 0...15) | CNC IU | -2147483647 ÷ +2147483647 | 0 |

(1) Vxxx are NUM DrivePro parameters. Please refer to NUM DrivePro Parameters manual M00066.

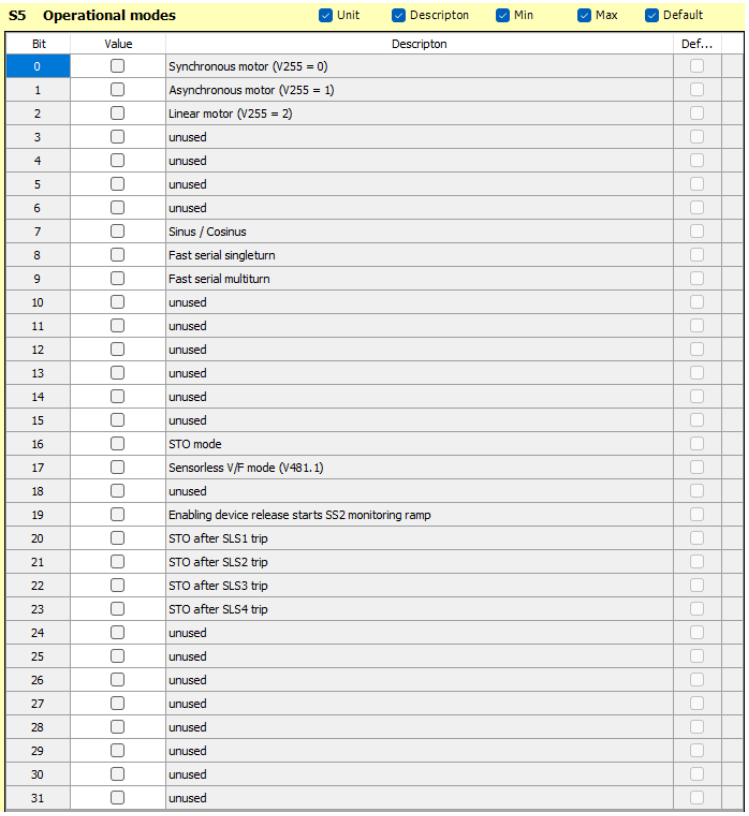
## 6.3.2 FSoE Address

### *S2* FSoE Address

| General | Unit | Range of values | Default value |
|---|---|---|---|
| | [ ] | 0 ÷ 65535 | 0<br>(Set to invalid by default). |
| Description | Fail Safe over EtherCAT Field Bus address.<br>As well as the drive physical address defined by the dip-switches, each NUM-SAMX must be uniquely identified with a FSoE address.<br>Such address create the link with the Safe PLC master of the FSoE protocol.<br>If the NUM-SAMX is installed on a Bi-axes or Quad-Axes drive each axis must have own FSoE address. The FSoE address must be set also in the NUM-SAMX device inside the FlexiumPro Tools (see chapter 7)<br>. | | |
| Note | Address 0 not allowed. | | |

## 6.3.3 NUM-SAMX configuration

### *S5* Operational modes

| General | Unit | Range of values | Default value |
|---|---|---|---|
| | [ ] | 0h ÷ FFFFFFFFh | 0h |
| Description | General Configuration. | | |
| | | | |
| Note |  | | |

S5 Operational modes — Unit, Descripton, Min, Max, Default

| Bit | Value | Descripton | Def... |
|---|---|---|---|
| 0 | ☐ | Synchronous motor (V255 = 0) | ☐ |
| 1 | ☐ | Asynchronous motor (V255 = 1) | ☐ |
| 2 | ☐ | Linear motor (V255 = 2) | ☐ |
| 3 | ☐ | unused | ☐ |
| 4 | ☐ | unused | ☐ |
| 5 | ☐ | unused | ☐ |
| 6 | ☐ | unused | ☐ |
| 7 | ☐ | Sinus / Cosinus | ☐ |
| 8 | ☐ | Fast serial singleturn | ☐ |
| 9 | ☐ | Fast serial multiturn | ☐ |
| 10 | ☐ | unused | ☐ |
| 11 | ☐ | unused | ☐ |
| 12 | ☐ | unused | ☐ |
| 13 | ☐ | unused | ☐ |
| 14 | ☐ | unused | ☐ |
| 15 | ☐ | unused | ☐ |
| 16 | ☐ | STO mode | ☐ |
| 17 | ☐ | Sensorless V/F mode (V481.1) | ☐ |
| 18 | ☐ | unused | ☐ |
| 19 | ☐ | Enabling device release starts SS2 monitoring ramp | ☐ |
| 20 | ☐ | STO after SLS1 trip | ☐ |
| 21 | ☐ | STO after SLS2 trip | ☐ |
| 22 | ☐ | STO after SLS3 trip | ☐ |
| 23 | ☐ | STO after SLS4 trip | ☐ |
| 24 | ☐ | unused | ☐ |
| 25 | ☐ | unused | ☐ |
| 26 | ☐ | unused | ☐ |
| 27 | ☐ | unused | ☐ |
| 28 | ☐ | unused | ☐ |
| 29 | ☐ | unused | ☐ |
| 30 | ☐ | unused | ☐ |
| 31 | ☐ | unused | ☐ |

| Bit | Bit function | Bit value = 0 | Bit value = 1 |
|---|---|---|---|
| 0 | Synchronous motor (V255 = 0) | (1) | Define that the monitored motor is a rotary motor. |
| 1 | Asynchronous motor (V255 = 1) | (1) | Define that the monitored motor is an asynchronous motor. |
| 2 | Linear motor (V255 = 2) | (1) | Define that the monitored motor is a linear motor. |
| 3 | Unused | | |
| 4 | Unused | | |
| 5 | Unused | | |
| 6 | Unused | | |

| Bit | Bit function | Bit value = 0 | Bit value = 1 |
|---|---|---|---|
| 7 | Sinus / Cosinus | (2) | Define that the monitored motor is equipped with a sensor with incremental traces (MDLUF parameter V320.2 = 1 or V320.4 = 1) (4) |
| 8 | Fast serial singleturn | (2) | Define that the monitored motor is equipped with a sensor with Fast Serial communication (MDLUF parameter V320.3 = 1 and V365 = 1) (4) |
| 9 | Fast serial multiturn | (2) | Define that the monitored motor is equipped with a sensor with Fast Serial communication (MDLUF parameter V320.3 = 1) multi-turn (MDLUF parameter V365 > 1) (4) |
| 10 | Unused | | |
| 11 | Unused | | |
| 12 | Unused | | |
| 13 | Unused | | |
| 14 | Unused | | |
| 15 | Unused | | |
| 16 | STO mode | All the NUM-SAMX Logical Input are managed to activate the various safety function. | See chapter 6.3.3.1 for details. (3) |
| 17 | Sensorless V/F mode (V481.1) (4) - available only on axis 1 | | The motor is not equipped with feedback sensor (sensorless). See chapter 6.3.3.2 for details. (3) |
| 18 | Unused | | |
| 19 | Enabling device release starts SS2 monitoring ramp | With Safe Limited Speed (SLS) function active, when “Enabling device” is released, if \|motor speed\| > *S16*, SS2 monitor braking is activated and Alarm 61 Ext 10 (or Ext 110) is issued. | With Safe Limited Speed (SLS) function active, when “Enabling device” is released, if \|motor speed\| > *S16*, SS2 monitor braking is activated but no Alarm is issued as for E-Stop managing. *S17* E-Stop Ramp Monitoring Delay is used in such case. See chapter 6.4.9.1 for details. |
| 20 | STO after SLS1 trip | With SLS1 active, the \|motor speed\| goes over *S11* value, NUM-SAMX goes in Alarm 61 Ext 2 (or Ext 102) and SS2 braking monitoring is activated. | With SLS1 active, the \|motor speed\| goes over *S11* value, NUM-SAMX goes in Alarm 61 Ext 2 (or Ext 102) and STO function is immediately activated. see chapter 6.4.3 for details. |
| 21 | STO after SLS2 trip | With SLS2 active, the \|motor speed\| goes over *S12* value, NUM-SAMX goes in Alarm 61 Ext 2 (or Ext 102) and SS2 braking monitoring is activated. | With SLS2 active, the \|motor speed\| goes over *S12* value, NUM-SAMX goes in Alarm 61 Ext 2 (or Ext 102) and STO function is immediately activated. see chapter 6.4.3 for details. |

| Bit | Bit function | Bit value = 0 | Bit value = 1 |
|---|---|---|---|
| 22 | STO after SLS3 trip | With SLS2 active, the \|motor speed\| goes over *S13* value, NUM-SAMX goes in Alarm 61 Ext 2 (or Ext 102) and SS2 braking monitoring is activated. | With SLS3 active, the \|motor speed\| goes over *S13* value, NUM-SAMX goes in Alarm 61 Ext 2 (or Ext 102) and STO function is immediately activated. see chapter 6.4.3 for details. |
| 23 | STO after SLS4 trip | With SLS4 active, the \|motor speed\| goes over *S14* value, NUM-SAMX goes in Alarm 61 Ext 2 (or Ext 102) and SS2 braking monitoring is activated. | With SLS4 active, the \|motor speed\| goes over *S14* value, NUM-SAMX goes in Alarm 61 Ext 2 (or Ext 102) and STO function is immediately activated. see chapter 6.4.3 for details. |
| 24 | Unused | | |
| 25 | Unused | | |
| 26 | Unused | | |
| 27 | Unused | | |
| 28 | Unused | | |
| 29 | Unused | | |
| 30 | Unused | | |
| 31 | Unused | | |

(1) One and only one of the bits 0,1,2 must be set otherwise Alarm 64 Ext 70 (or Ext 170)

(2) One and only one of the bits 7,8,9 must be set otherwise Alarm 64 Ext 71 (or Ext 171)

(3) One and only one of the bits 16,17 could be set. If both bits are set Alarm 64 Ext 72 (or Ext 172) is issued.

(4) Vxxx are NUM DrivePro parameters. Please refer to NUM DrivePro Parameters manual M00066.

### 6.3.3.1 STO mode

*S5* = 10000h

It is useful with sensorless motors.

NUM-SAMX manages only the Logical Input: **TorqueEn**.

If one of the Logical Inputs **GuardClsd** or **nE-Stop** becomes = 0

or one of the Logical Inputs: **SfHoming**, **SfDirPlus**, **SfDirMinus**, **SpdLm**n becomes = 1

the NUM-SAMX goes in STO mode and an alarm will issue

- Safe Position function is not allowed
- Safe Direction Monitoring function is not allowed
- Logical Output **SfCamx** are disabled,
- Logical Output **StandStill** and **Speed** are now static always FALSE,
- Automatic Mode speed control must be disabled with *S15* = 0 otherwise Alarm 64 Ext 40 (or Ext 140)
- Safe limited speed (SLS) is not allowed.
- Standstill control must be disabled with S16 = 0 otherwise Alarm 64 Ext 33 (or Ext 133)

It behaves like a Safe Torque Off board without axis position and speed surveillance

Using parameters S17 and S18, the user can configure the braking delay in case of Emergency Stop or Alarm to trigger an emergency braking procedure (not supervised) before activating the Safe Torque Off function.

Setting S17=0 and S18=0 will cause an immediate Safe Torque Off in case of Emergency Stop or Alarm.

### 6.3.3.2 Sensorless motor managed in V/f mode

The sensorless V/f mode is only available on motor M1 on Bi-axes or Quad-Axes drive.

When the management of a sensorless motor in V/f mode is activated by means of *S5.17* = 1, only SLS, SSM and STO function are available.

The request of activation of other functions will issue alarms:

- Safe Position function is not allowed;
- Safe Direction Monitoring function is not allowed;
- Logical Output SfCamx are disabled (always false);
- Standstill control must be disabled with S16 = 0 otherwise Alarm 64 Ext 33 (or Ext 133).

The status of the logical outputs is described on chapter 6.5.3

Due to the delay on motor speed computation in NUM-SAMX, this fact must be taken into account in *S17* and *S18* value definition to avoid unexpected Alarm 61 Ext 11 (or Ext 111).

In case of Bi-Axes or Quad-Axes drive the activation of the sensorless motor management could be done on motor M1 only, otherwise Alarm 64 Ext 30 (or Ext 130) will issue.

### 6.3.4 Sensor configuration

#### *S6* Period by turn (V360)

| General | Unit | Range of values | Default value |
|---|---|---|---|
| | [ ] | 0 ÷ 4294967295 | 128 |
| Description | The value of this parameter must be: = V360 for Rotary motor (1)<br>= V259 • 2000000 / V380 for Linear motor (1) | | |
| Note | (1) Vxxx are NUM DrivePro parameters. Please refer to NUM DrivePro Parameters manual M00066 | | |

#### *S7* Absolute resolution by turn S1 sensor (V361)

| General | Unit | Range of values | Default value |
|---|---|---|---|
| | [ ] | 0 ÷ 4294967295 | 1048576 |
| Description | The value of this parameter must be: = V361 for Rotary motor (1)<br>= V259 • 2000000 / V381 for Linear motor (1). | | |
| | | | |
| Note | (1) Vxxx are NUM DrivePro parameters. Please refer to NUM DrivePro Parameters manual M00066. | | |

#### 6.3.4.1 Example of NUM sensor configurations

| Encoder type | Parameter number / value |
|---|---|
| - Encoder type 3 Hiperface DSL SIL2<br>- Encoder type 4 Hiperface DSL SIL2<br>- Encoder type L Hiperface DSL<br>- Encoder type I Hiperface DSL | ***S5*** bit 7 = 0, bit 8 = 1, bit 9 = 0 (type 4, L)<br>***S5*** bit 7 = 0, bit 8 = 0, bit 9 = 1 (type 3, I)<br>***S6*** = 128<br>***S7*** = 1048576 |
| - Encoder type Z Hiperface DSL<br>- Encoder type Y Hiperface DSL | ***S5*** bit 7 = 0, bit 8 = 1, bit 9 = 0 (type Z)<br>***S5*** bit 7 = 0, bit 8 = 0, bit 9 = 1 (type Y)<br>***S6*** = 2048<br>***S7*** = 16777216 |
| - Encoder type P Hiperface SIN/COS<br>- Encoder type Q Hiperface SIN/COS | ***S5*** bit 7 = 1, bit 8 = 0, bit 9 = 0<br>**S6** = 1024<br>***S7*** = 32768 |
| - Encoder type J Hiperface SIN/COS<br>- Encoder type K Hiperface SIN/COS | ***S5*** bit 7 = 1, bit 8 = 0, bit 9 = 0<br>***S6*** = 128<br>***S7*** = 4096 |

### *S8* MULTI Coefficient (V306)

| General | Unit | Range of values | Default value |
|---|---|---|---|
| | [ ] | -2147483647 ÷ +2147483647 | 10000 |
| Description | Sensor MULTI coefficient. | | |
| | | | |
| Note | - | | |

### *S9* DIVI Coefficient (V307)

| General | Unit | Range of values | Default value |
|---|---|---|---|
| | [ ] | 0 ÷ 4294967295 | 512 |
| Description | Sensor DIVI coefficient | | |
| | | | |
| Note | - | | |

### 6.3.5 Motor poles pairs number

***S10*** **Motor pole pairs number (V257)**

| General | Unit | **Range of values** | **Default value** |
|---|---|---|---|
| | [ ] | 0 ÷ 4294967295 | 5 |
| Description | This parameter define the motor pair pole number. It must be eqiual to NUM DrivePro parameter V257.<br><br>This parameter is relevant only in case of sensorless motor (*S5.17* = 1) managing. | | |
| Note | - | | |

## 6.3.6 Speed Limit

The selection of the Safe Limited Speed values (“Speed Limit 1” ... “Speed Limit 4”) is done by means of the NUM-SAMX Logical Input **SpdLm1 ... SpdLm4 (Axn_SpdLm1 ... Axn_SpdLm4)** respectively.

The activation of the selected Safe Limited Speed (SLS) is done when NUM-SAMX Logical Input **GuardClsd** = 0 (**Axn_GuardClsd** = 0) and NUM-SAMX Logical Input **EnablingDevice** = 1 (**Axn_EnablingDevice** = 1)

When activation of the Safe Limited Speed is required

in case:

all NUM-SAMX Logical Input **SpdLm**n (**Axn_SpdLm**n) are = 0

or

more then one NUM-SAMX Logical Input **SpdLm**n (**Axn_SpdLm**n) is = 1

or

the value of the selected speed limit is = 0,

NUM-SAMX will release a Safety Alarm 62 Ext 1.

Once SLS monitoring function is activated the |motor speed| cannot exceed the limit defined in the parameter Speed Limit n selected, otherwise Alarm 61 Ext 2 (or 102) will release.

NUM-SAMX offers the possibility to monitor the speed also during Automatic Mode when *S15* <>0.

When *S15* = 0 no speed monitoring in Automatic Mode is performed.

When speed monitoring is active in Automatic Mode, the |motor speed| cannot exceed the limit defined in *S15*, otherwise Alarm 61 Ext 1 (or 101) will release.

The basic calculation formulas to define the speed limit in function of the kinematic chain is explained in chapter 6.3.6.1

### *S11* SLS1 Speed limit

| General | Unit | Range of values | Default value |
|---|---|---|---|
| | $\left[ 1/10\ rpm \right]$ or $\left[ 1/10\ \frac{2 \cdot Polepitch}{min} \right]$ | 0 ÷ 4294967295 | 1000 |
| Description | Safely Limited Speed #1 | | |
| | | | |
| Note | Must be *S11* > *S16*<br>In case of sensorless motor managing (*S5.17* = 1), must be *S11* ≥ 6000 / *S10*, otherwise Alarm 64 Ext 32 (or Ext 132) will be issued. | | |

### *S12* SLS2 Speed limit

| General | Unit | Range of values | Default value |
|---|---|---|---|
| | $\left[ 1/10\ rpm \right]$ or $\left[ 1/10\ \frac{2 \cdot Polepitch}{min} \right]$ | 0 ÷ 4294967295 | 2000 |
| Description | Safely Limited Speed #2 | | |
| | | | |
| Note | Must be *S12* > *S16*<br>In case of sensorless motor managing (*S5.17* = 1), must be *S12* ≥ 6000 / *S10*, otherwise Alarm 64 Ext 32 (or Ext 132) will be issued. | | |

## *S13* SLS3 Speed limit

| General | Unit | Range of values | Default value |
|---|---|---|---|
| | [ 1/10 rpm ] or [ 1/10 $\frac{2 \cdot Polepitch}{min}$ ] | 0 ÷ 4294967295 | 3000 |
| Description | Safely Limited Speed #3 | | |
| | | | |
| Note | Must be S13 > S16<br>In case of sensorless motor managing (S5.17 = 1), must be S13 ≥ 6000 / S10, otherwise Alarm 64 Ext 32 (or Ext 132) will be issued. | | |

## *S14* SLS4 Speed limit

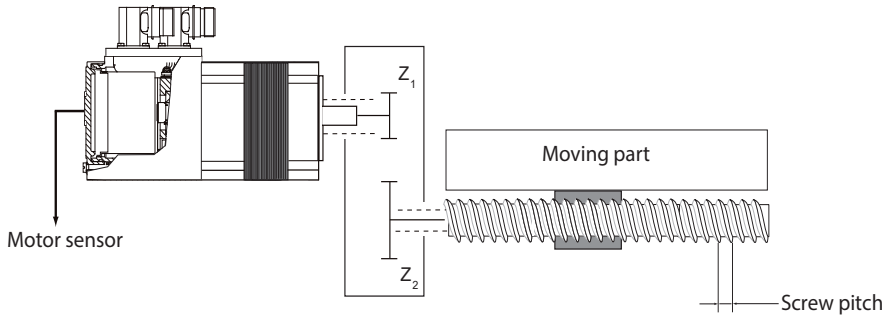
| General | Unit | Range of values | Default value |
|---|---|---|---|
| | [ 1/10 rpm ] or [ 1/10 $\frac{2 \cdot Polepitch}{min}$ ] | 0 ÷ 4294967295 | 4000 |
| Description | Safely Limited Speed #4. | | |
| | | | |
| Note | *Must be S14 > S16*<br>*In case of sensorless motor managing (S5.17 = 1), must be S14 ≥ 6000 / S10, otherwise Alarm 64 Ext 32 (or Ext 132) will be issued.* | | |

## *S15* Automatic mode speed limit

| General | Unit | Range of values | Default value |
|---|---|---|---|
| | [ 1/10 rpm ] or [ 1/10 $\frac{2 \cdot Polepitch}{min}$ ] | 0 ÷ 4294967295 | 32767 |
| Description | Safely Speed Monitor enabled in Automatic Mode if *S15* > 0 | | |
| | | | |
| Note | Must be S15 > S16<br>In case of sensorless motor managing (S5.17 = 1), must be S15 ≥ 6000 / S10, otherwise Alarm 64 Ext 32 (or Ext 132) will be issued.<br>S15=0 -> no speed monitor in Automatic Mode | | |

### 6.3.6.1 Calculation of Speed Limit in function of the kinematic chain

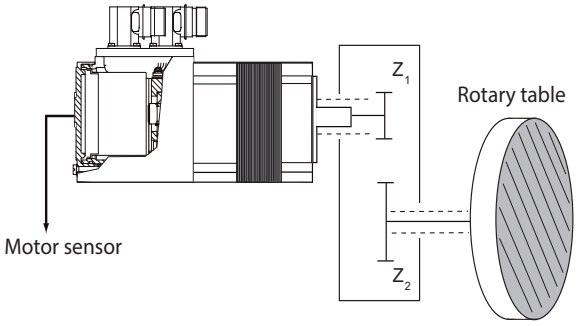
**Case 1) Linear axis with ball screw**




$$Z_{gear} = \frac{Z_2}{Z_1}$$

$$\textit{Speed Limit n [1/10 rpm] = LinearAxisSpeed} \left[\frac{m}{min}\right] \cdot \frac{Z_{gear}}{ScrewPitch \left[\frac{mm}{rev}\right]} \cdot 10000$$

**Case 2) Rotary axis**

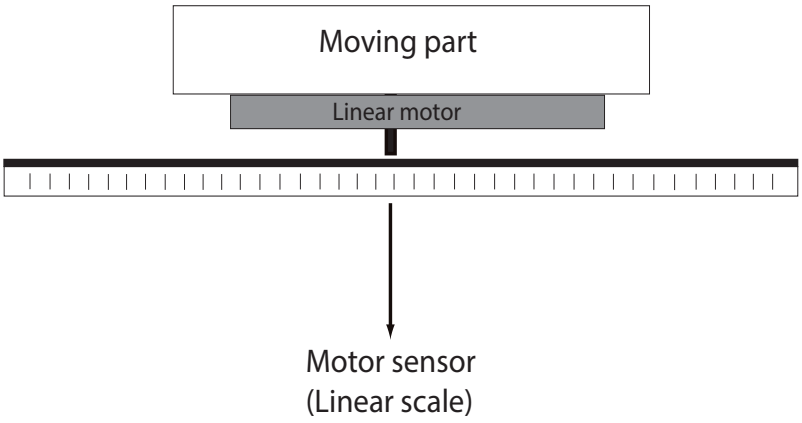



$$Z_{gear} = \frac{Z_2}{Z_1}$$

*Speed Limit n [1/10 rpm] = RotaryAxisSpeed [rpm] • $Z_{gear}$ • 10*

*Speed Limit n [1/10 rpm] = RotaryAxisSpeed [°/min] • $Z_{gear}$ • 10/360*

**Case 3) Linear axis with linear motor**




*Polepitch = linear motor pole pitch [mm] (= V259 NUM DrivePro parameter)*

$$\text{Speed Limit n}\left[1/10\,\frac{2 \bullet \text{Polepitch}}{\text{min}}\right] = \frac{\text{LinearAxisSpeed}\left[\frac{\text{m}}{\text{min}}\right]}{2 \bullet \text{Polepitch}} \bullet 10000$$

## 6.3.7 Motor zero speed threshold

### *S16* Motor standstill threshold

| General | Unit | Range of values | Default value |
|---|---|---|---|
| | $\left[1/10\ \text{rpm}\right]$ or $\left[1/10\ \frac{2 \bullet \text{Polepitch}}{\text{min}}\right]$ | 0 ÷ 4294967295 | 100 |
| Description | Motor standstill threshold.<br>When \|motor speed\| is lower than *S16* the NUM-SAMX **StandStill** Logical output bit becomes TRUE. | | |
| | In case of STO or sensorless motor managing (S5.16 = 1 or S5.17 = 1) the NUM-SAMX StandStill Logical output bit is alway FALSE. | | |
| Note | Such threshold is also used to trigger the SOS function following a safe deceleration process. The basic calculation formulas in function of the kinematic chain are identical to the ones defined in the chapter 6.3.6.<br><br>In case of STO or sensorless motor managing (S5.16 = 1 or S5.17 = 1), must be S16 = 0, otherwise Alarm 64 Ext 33 (or Ext 133) will be issued. | | |

## 6.3.8 Ramp parameters

### *S17* Ramp on E-Stop monitoring delay

| General | Unit | Range of values | Default value |
|---|---|---|---|
| | [ms] | 0 ÷ 65535 | 10 |
| Description | Delay time before ramp monitoring in case of E-Stop or S5.19 = 1 and SLS active and EnablingDevice released | | |
| | | | |
| Note | By means of the S17 it is defined the delay time between the triggering of the stopping process in case of E-Stop activation and the start of the deceleration's monitoring.<br>Used to take into account PLC/CNC response time and NUM-SAMX speed analysis. In case of sensorless motor managing (S5.17 = 1) the suggested value of S17 it should not be less then 140ms for Mono-Axis drive , 190ms for Bi-Axes drive and 250ms for Quad-Axes drive. See chapter 6.3.8.1<br>In case of STO mode managing (S5.16 = 1) it's the time that must elapse before applying the Safet Torque Off function. During the time the axis can actuate a braking procedure (not monitored). | | |

### *S18* Ramp on alarm monitoring delay

| General | Unit | Range of values | Default value |
|---|---|---|---|
| | [ms] | 0 ÷ 65535 | 150 |
| Description | Delay time for ramp monitoring in case of Safety Failure. | | |
| | | | |
| Note | By means of the *S18* it is defined the delay time between the triggering of the stopping process in case of NUM-SAMX alarm condition activation and the start of the deceleration's monitoring.<br>Used to take into account Drive response time or NUM-SAMX speed analysis. In case of sensorless motor managing (S5.17 = 1) the suggested value of S18 it should not be less then 140ms for Mono-Axis drive, 190ms for Bi-Axes drive and 250ms for Quad-Axes drive.<br>In case of STO mode managing (S5.16 = 1) it's the time that must elapse before applying the Safet Torque Off function. During the time the axis can actuate a braking procedure (not monitored). | | |

### *S19* CutOff Delay

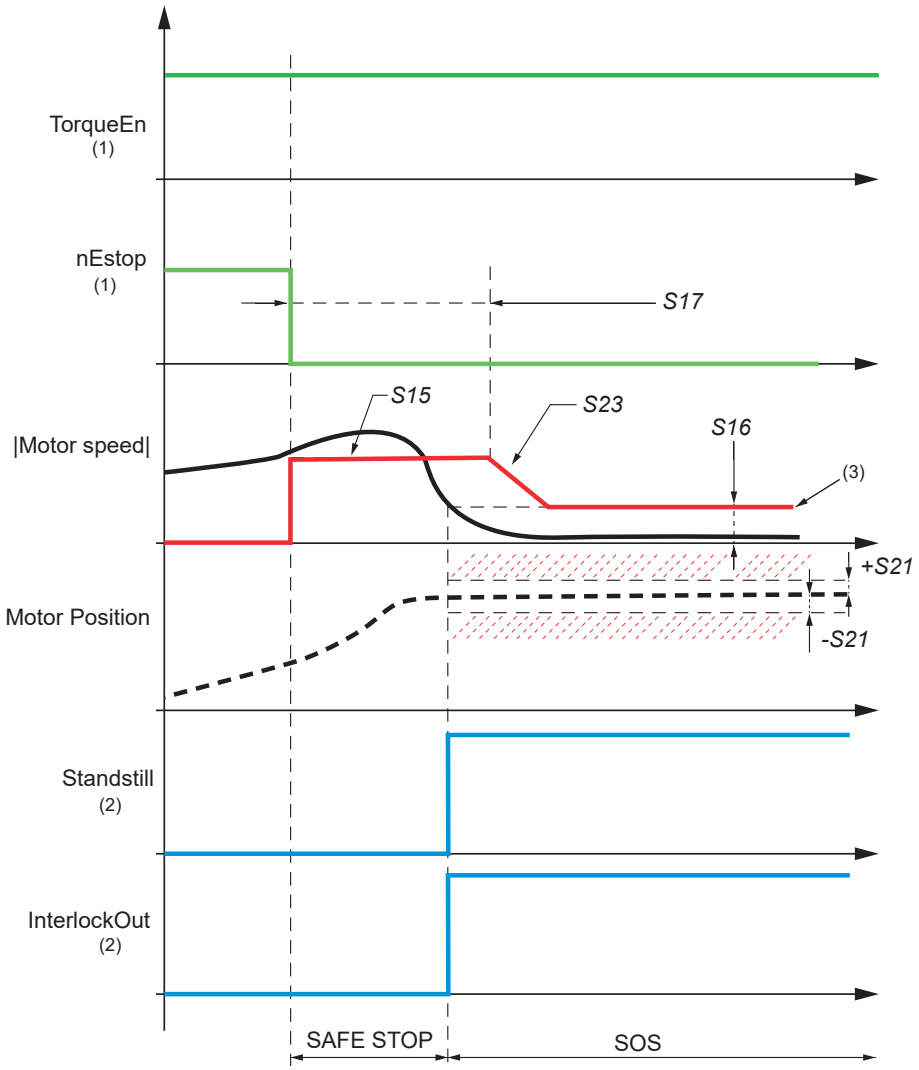
| General | Unit | Range of values | Default value |
|---|---|---|---|
| | [ms] | 0 ÷ 65535 | 150 |
| Description | Delay time for power stage/motor torque disabled. | | |
| | | | |
| Note | In case of motor brake managed by the drive this delay must be higher then V137 NUM DrivePro parameter to enable the brake locking with the motor with torque. | | |

The deceleration ramp starting point is calculated considering as starting point the real |motor speed| at the E-Stop or NUM-SAMX alarm condition event.

See drawing example of SS2 following an E-Stop command on 6.3.8.1.

The value assigned to *S17, S18* and *S19* must be checked by the customer during machine safe test certification.

### 6.3.8.1 SS2 following an E-Stop command diagram




(1) NUM-SAMX Logical Input (FSoE output)
(2) NUM-SAMX Logical Output (FSoE input)
(3) MPX1 profile

Following an E-Stop an automatic re-start cannot happen. The NUMSafe PLC has got a predefined function block (called FB_E-Stop) for the correct handling of the procedure.

The parameter *S23* has to be consistent (or in general lower than) with the FlexiumPro and/or NUM DrivePro deceleration ramps.

### 6.3.8.2 Calculation of the deceleration parameters in function of the kinematic chain

**Case 1) Linear axis with ball screw** (See figure chapter 6.3.6.1)

$$S23\ (Brake\ Ramp)\ \left[\frac{rpm}{s}\right] = P32^{(1)}\ \left[\frac{mm}{s^2}\right] \cdot \frac{Z_{gear}}{ScrewPitch\ \left[\frac{mm}{rev}\right]} \cdot 60$$

or

$$S23\ (Brake\ Ramp)\ \left[\frac{rpm}{s}\right] = V91^{(2)}\ \left[\frac{rpm}{s}\right]$$

**Case 2) Rotary axis** (See figure chapter 6.3.6.1)

$$S23\ (Brake\ Ramp)\ \left[\frac{rpm}{s}\right] = P32^{(1)}\ \left[\frac{deg}{s^2}\right] \cdot \frac{Z_{gear}}{360} \cdot 60$$

or

$$S23\ (Brake\ Ramp)\ \left[\frac{rpm}{s}\right] = V91^{(2)}\ \left[\frac{rpm}{s}\right]$$

**Case 3) Linear axis with linear motor** (See figure chapter 6.3.6.1)

$$S23\ (Brake\ Ramp)\ \left[\frac{2 \cdot Polepitch}{min \cdot s}\right] = P32^{(1)}\ \left[\frac{mm}{s^2}\right] \cdot \frac{30}{V259}$$

**or**

$$S23\ (Brake\ Ramp)\ \left[\frac{2 \cdot Polepitch}{min \cdot s}\right] = V93^{(2)}\ \left[\frac{mm}{s^2}\right] \cdot \frac{30}{V259}$$

(1) *S23* (Brake ramp) using CNC ramp.

(2) *S23* (Brake ramp) using NUM DrivePro ramp.

## 6.3.9 Position displacement threshold

### *S20* Encoder disalignment threshold

| General | Unit | Range of values | Default value |
|---|---|---|---|
| | [1 motor turn = 65536] for Synchronous or Linear.<br><br>[1 /10 rpm] for Asynchronous or Sensorless V/f. | 0 ÷ 4294967295 | 1000 |
| Description | Maximum allowed difference between:<br>- NUM DrivePro sensor counter and NUM-SAMX sensor counter for synchronous or linear motor<br>- NUM DrivePro motor speed and NUM-SAMX motor speed for asynchronous motor or Sensorless V/f. | | |
| | *S20* should be tuned during the setup using NUM-SAMX measure point MPX6.<br>Setting *S20* to 0 (the check of Alarm 63 Ext 1, Alarm 63 Ext 2, Alarm 63 Ext 101, Alarm 63 Ext 102, Alarm 64 Ext 22, Alarm 64 Ext 122 are disabled)<br>and setting *S15* to 0 (the check Alarm 61 Ext 1, Alarm 61 Ext 101 are disabled) to allow tuning.<br>Running the motor at maximum speed in MPX6 is latched the maximum value for *S20*.<br>The NUM-SAMX measure point value can be read by means of MP401 or MP402 of NUM DrivePro.<br>Transferring the highest value read from CPU1 or CPU2 +10% to *S20*, the system should run in all operating condition without alarm.<br>In case of Bi-Axes or Quad-Axes drive, the tuning of *S20* must be done after the configuration of all axes.<br>In case of Sensorless V/f application (*S5.17* = 1), we suggest to make test running the motor from +max to -max rpm will be used on the machine and viceversa.<br>The reset of the value stored into MPX6 is executed when the transition 0->1 of the signal FlexiumPro_NCK.RCNC.Axis[n].SAMX.TorqueEnabled is performed. | | |
| Note | Used to trigger Alarm 63 Ext 1, Alarm 63 Ext 2, Alarm 63 Ext 101, Alarm 63 Ext 102, Alarm 64 Ext 22, Alarm 64 Ext 122. | | |

### *S21* Position disalignment threshold for SOS and safe homing

| General | Unit | Range of values | Default value |
|---|---|---|---|
| | CNC IU | 0 ÷ 4294967295 | 100 |
| Description | When the SOS function is activated (for example following a safe deceleration, see chapter 6.3.8.1) the motor position is stored and after monitored.<br>In case difference, between the actual motor position and the motor position stored when SOS function has activated, exceeded the threshold define by the parameter *S21* an alarm 61 Ext 12 (Alarm 61 Ext 112) is issued and the STO function is activated. | | |
| Note | This parameter is not relevant in case of asynchronous motor management. | | |

## *S22* Safe homing positon

| General | Unit | Range of values | Default value |
|---|---|---|---|
| | CNC IU | -2147483647 ÷ +2147483647 | 0 |
| Description | This parameter is used to define the Safe Homing position. | | |
| | | | |
| Note | | | |

## *S23* Deceleration ramp

| General | Unit | Range of values | Default value |
|---|---|---|---|
| | $\left[\frac{rpm}{s}\right]$ or $\left[\frac{2 \cdot Polepitch}{min \cdot s}\right]$ | 0 ÷ 4294967295 | 5000 |
| Description | Definition of Safe Deceleration ramp. | | |
| | | | |
| Note | The parameter *S23* is used to monitor the motor deceleration (SS2). The violation of the deceleration ramp, by the motor, generates the activation of the STO function. | | |

## *S24* SSM Speed limit

| General | Unit | Range of values | Default value |
|---|---|---|---|
| | $\left[1/10\ rpm\right]$ or $\left[1/10\ \frac{2 \cdot Polepitch}{min}\right]$ | 0 ÷ 4294967295 | 0 |
| Description | Safe Speed Limit threshold used to manage NUM-SAMX Logical Output **Speed (Axn_Speed)** | | |
| | | | |
| Note | If \|Motor speed\| < S24 > 0, NUM-SAMX Logical Output Speed (**Axn_Speed**) = TRUE (See chapter 6.5.4)<br>Motor speed could be read using NUM-SAMX measure point MPX0 from CPU1 and MPX100 from CPU2 on NUM-SAMX by means of MP401 or MP402 on MDLUF drive. | | |

## 6.3.10 Position parameters

### *S32* to *S63* Safe position n lower / upper limit

| General | Unit | Range of values | Default value |
|---|---|---|---|
| | CNC IU | -2147483647 ÷ +2147483647 | 0 |
| Description | These parameters are used to define lower / upper position limits for Safe Limited Position n and Safe Cam n (n=0...15). | | |
| | | | |
| Note | | | |

Once SLP monitoring function is activated the axis position cannot exceed the limit defined in the related couple of Safe Limits Position:

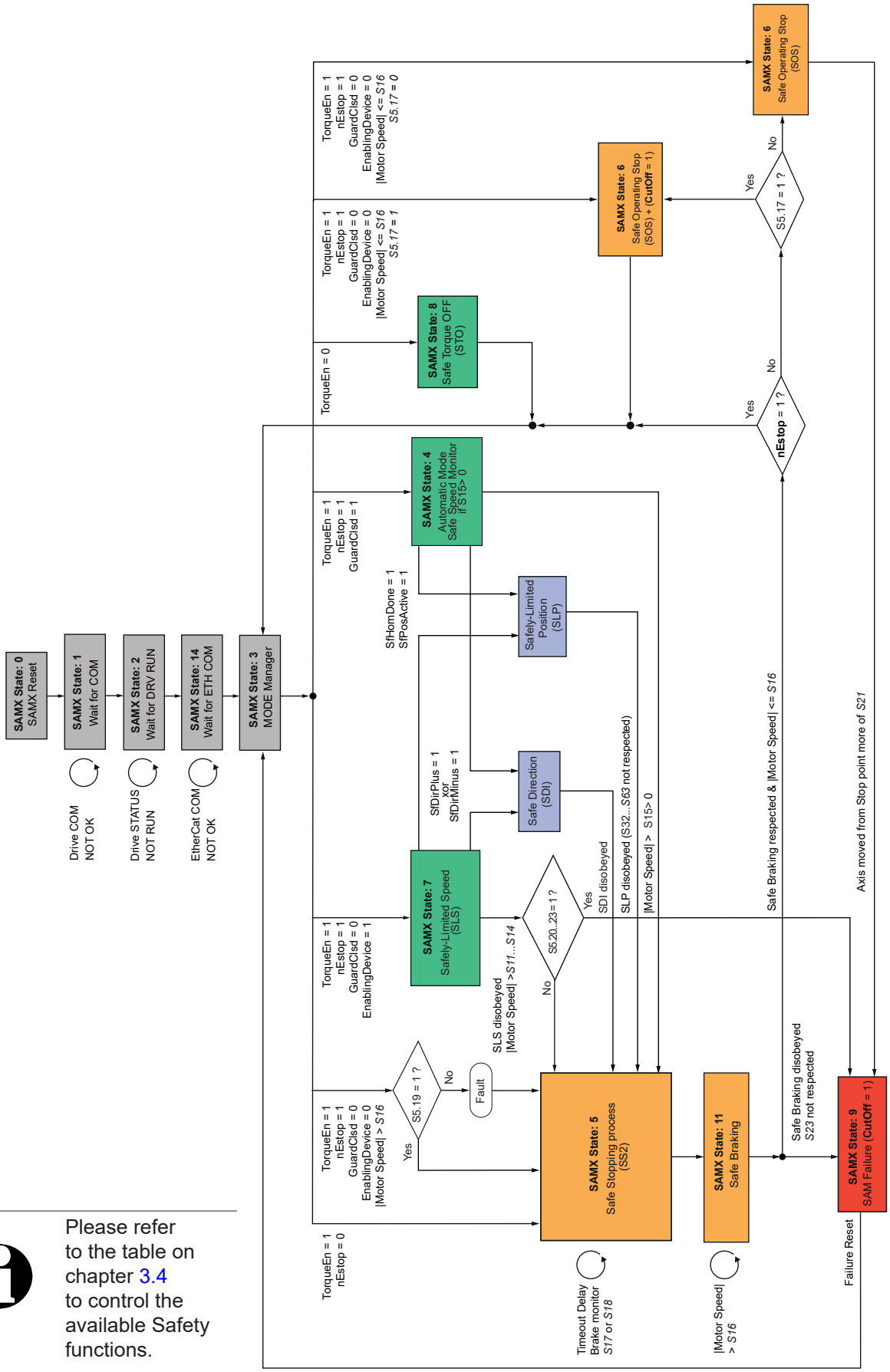
- Position n lower limit <= Safe axes position <= Position n upper limit.

Please refer chapter 6.4.7.

All Positions Limit and Homing Position are defined respect to the Machine Origin ‘OM’ (See FlexiumPro Programming manual M00073)

## 6.4 Operating mode

### 6.4.1 Operating mode and transitions diagram

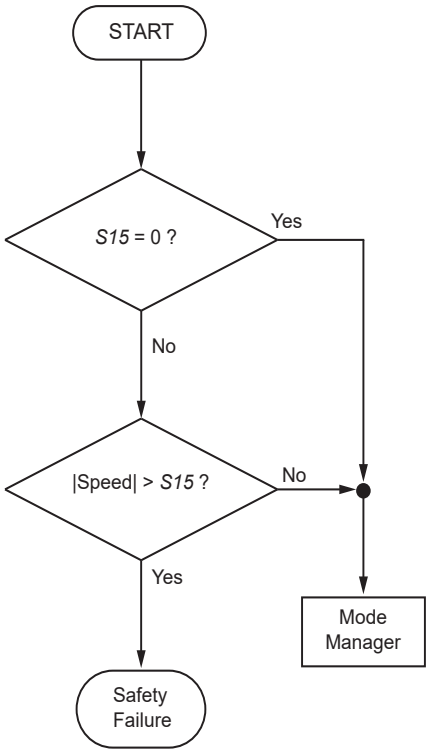



Please refer to the table on chapter 3.4 to control the available Safety functions.

### 6.4.2 Automatic Mode

The Automatic Mode is the mode where no safety functions are enabled.

In case *S15* is ≠ 0 NUM-SAMX implements a motor Safely Speed Limit monitor (see also 6.3.6).




Where: Speed = motor speed

### 6.4.3 Safely-Limited Speed (SLS) - Common rules

The FSoE output bits are set as follows (pre-conditions):

- **GuardClsd** = 0
- **EnablingDevice** = 1
- **nE-Stop** = 1
- **TorqueEn** = 1
- **SpdLm**1 = 1 or **SpdLm**2 = 1 or **SpdLm**3 = 1 or **SpdLm**4 = 1.

In setup mode with movement at least one safe limited speed must be defined at parameter level.

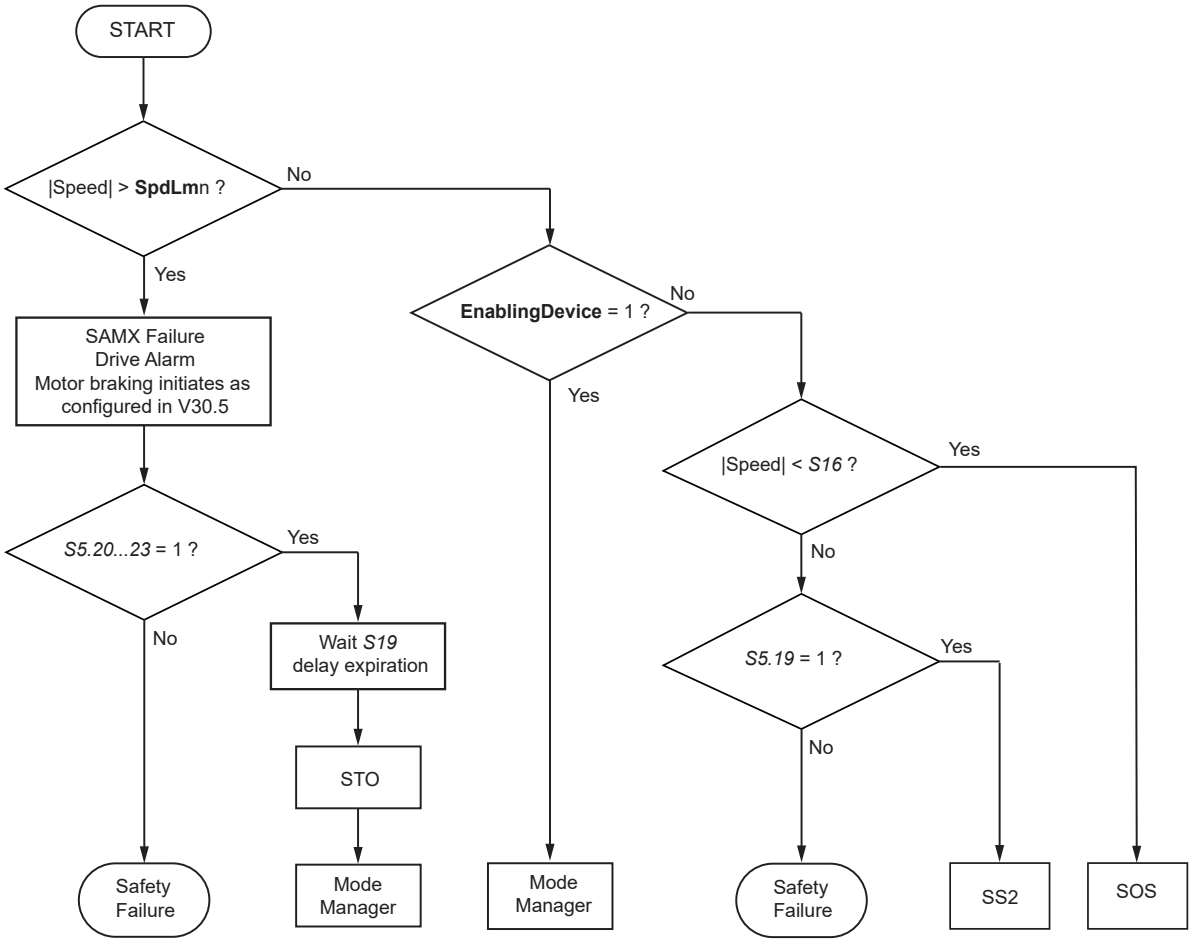
During activation of the **EnablingDevice** FSoE Output through the SafePLC, one of the 4 safe limited speed must be selected.

If

- more than one safe limited speed is selected or
- no safe limited speed is selected

a Safety Failure is triggered.

Below the behaviour flow chart when SLS function is active.




Where: Speed = motor speed

#### 6.4.3.1 Safely-Limited Speed (SLS) and *S5.20 ... 23* = 0

When a SLS is active and
**SpdLm1**= 1 and *S5.20* = 0 or
**SpdLm2**= 1 and *S5.21* = 0 or
**SpdLm3**= 1 and *S5.22* = 0 or
**SpdLm4**= 1 and *S5.23* = 0,

and the |motor speed| goes over the selected safe limited speed a Safety Failure is triggered.

#### 6.4.3.2 Safely-Limited Speed (SLS) and *S5.20 ... 23* = 1

When a SLS is active and
**SpdLm1**= 1 and *S5.20* = 1 or
**SpdLm2**= 1 and *S5.21* = 1 or
**SpdLm3**= 1 and *S5.22* = 1 or
**SpdLm4**= 1 and *S5.23* = 1,

and the |motor speed| goes over the selected safe limited speed the NUM-SAMX goes in alarm and activate immediately the STO function.

#### 6.4.3.3 Safely-Limited Speed (SLS) and *S5.19* = 0

When a SLS is active, if the axis is not in standstill condition (speed is higher than S16) and the **EnablingDevice** is released (bit set to zero) a Safety Failure is activated.

#### 6.4.3.4 Safely-Limited Speed (SLS) and *S5.19* = 1

When a SLS is active, when the **EnablingDevice** is released (bit set to zero), after the delay *S17*, the SS2 braking monitoring is activated. No Safety Failure is activated, if the braking monitoring is not violated.

### 6.4.4 Safe Direction (SDI)

This function is activated through the FSoE output bit **SfDirPlus** or **SfDirMinus**.

When the motor is not at standstill (|Motor speed| > *S16*) and the direction is opposite to the admitted the Safety Failure is activated.

### 6.4.5 Safe Homing

The safe homing requires 2 different and independent position sources.

One source is the Drive and it's homing switch or Absolute encoder (of the motor), the other is the NUM-SAMX sensor position together with a secondary homing switch connected to the Safe input of the Safe PLC (see also chapter 6.3.10).

The safe homing procedure task could be activated, after having recognized NCK homing done.

The safe homing acknowledgment bit (**SfHomDone**) is reset at each power off / on or in case of drive alarm whose require a new homing procedure.

The permitted accuracy and operating limit before homing is one motor turn x PLC cycle.

The below procedure assures the Safe Homing Position management:

- FlexiumPro is homed (by a homing procedure or automatically in case of absolute encoders).
- FlexiumPro and NUM DrivePro communicate the unsafe homed position to NUM-SAMX.
- Move the axis to the safe homing position.
- The operator must confirm, by means of a safe button, that the axis it's located in a certain pre-defined position of the axis travel. The information of the human interaction is passed through the safe PLC to NUM-SAMX using the FSoE bit **SfHoming**.
- Such pre-defined position must be consistent with the *S22* parameter +/- *S21*, if such condition is satisfied the **SfHomDone** bit is set, the **SfCam** are activated and the **SfPosition** could be activated.

### 6.4.6 Safe Cams (SCA)

The Safe Cams monitoring is a parallel operating mode and under stays the Safe Homing procedure defined in chapter 6.4.5.

The Safe Cams (SCA) are automatically enabled when the Safe Homing procedure has been performed with positive result defined by **SfHomDone** = TRUE.

In absence of this acknowledgement bit the Safe Cams are not active.

When SCA are enabled, all the cams are monitored.

The limits used to define the Cams path are the same used to define the SLP.

The SCA, when enabled, are active in any mode (Automatic, Safe Limited Speed,….).

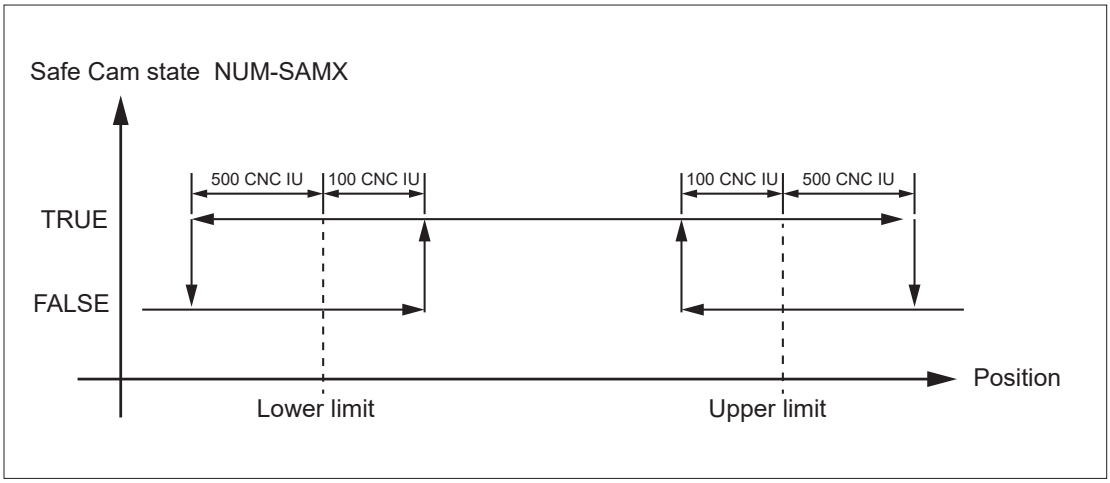
The SCA management doesn't foreseen any Safety Failure reaction by NUM-SAMX, they are signals that could be used into the Safe PLC program to create reaction defined by OEM.

The accuracy of the boundary limits of the Safe Cams compared to the NCK position depends from the accuracy of the Safe Homing procedure and the sensor resolution.

The Safe Cam's hysteresis is not linked to the parameter *S21*, but has fixed value (500 CNC IU while travelling OUT the Safe Cam zone, 100 CNC IU while travelling IN the Safe Cam zone).

### 6.4.6.1 Safe Cams (SCA) functional mode description

The Safe Cams functions are showed in the below diagram:




| | S32 | S34 | S33 | S35 | S36 | S37 | SfCam0 Output | SfCam1 Output | SfCam2 Output | Safe Homing Done |
|---|---|---|---|---|---|---|---|---|---|---|
| SfCam0 path | | | | | | | | | | |
| SfCam1 path | | | | | | | | | | |
| SfCam2 path | | | | | | | | | | |
| | X | | | | | | FALSE | FALSE | FALSE | FALSE |
| | X | | | | | | TRUE | FALSE | FALSE | TRUE |
| | | X | | | | | TRUE | TRUE | FALSE | TRUE |
| | | | | X | | | FALSE | TRUE | FALSE | TRUE |
| | | | | | | | FALSE | FALSE | FALSE | TRUE |
| | | | | | X | | FALSE | FALSE | TRUE | TRUE |
| X = Axis Position | | | | | | | | | | |


SCA function is foreseen for linear and rotary limited excursion axes applications, it is not foreseen for rotary endless applications (rotary axes modulo or spindle).
In case of use of absolute measure system, the axis travel must not pass through the 0 absolute position of the measure system.

### 6.4.7 Safely-Limited Position (SLP)

The Safely-Limited Position is a parallel function and under stays the Safe Homing procedure defined in chapter 6.4.5.

The Safely-Limited Position (SLP) is only accepted by the NUM-SAMX (acknowledgement via FSoE input: **SfPosActive**), if a Safe Homing procedure has been performed with positive result defined by **SfHomDone** = TRUE.

In absence of this acknowledgement bit the safe position function is not active and the Safe PLC program should provide an interlock to the function.

SLP is activated by means of the FSoE Output bits **SfPosition** n (n= 0..15)

More then one **SfPosition** n could be simultaneusly activated and their pathes could overlap.

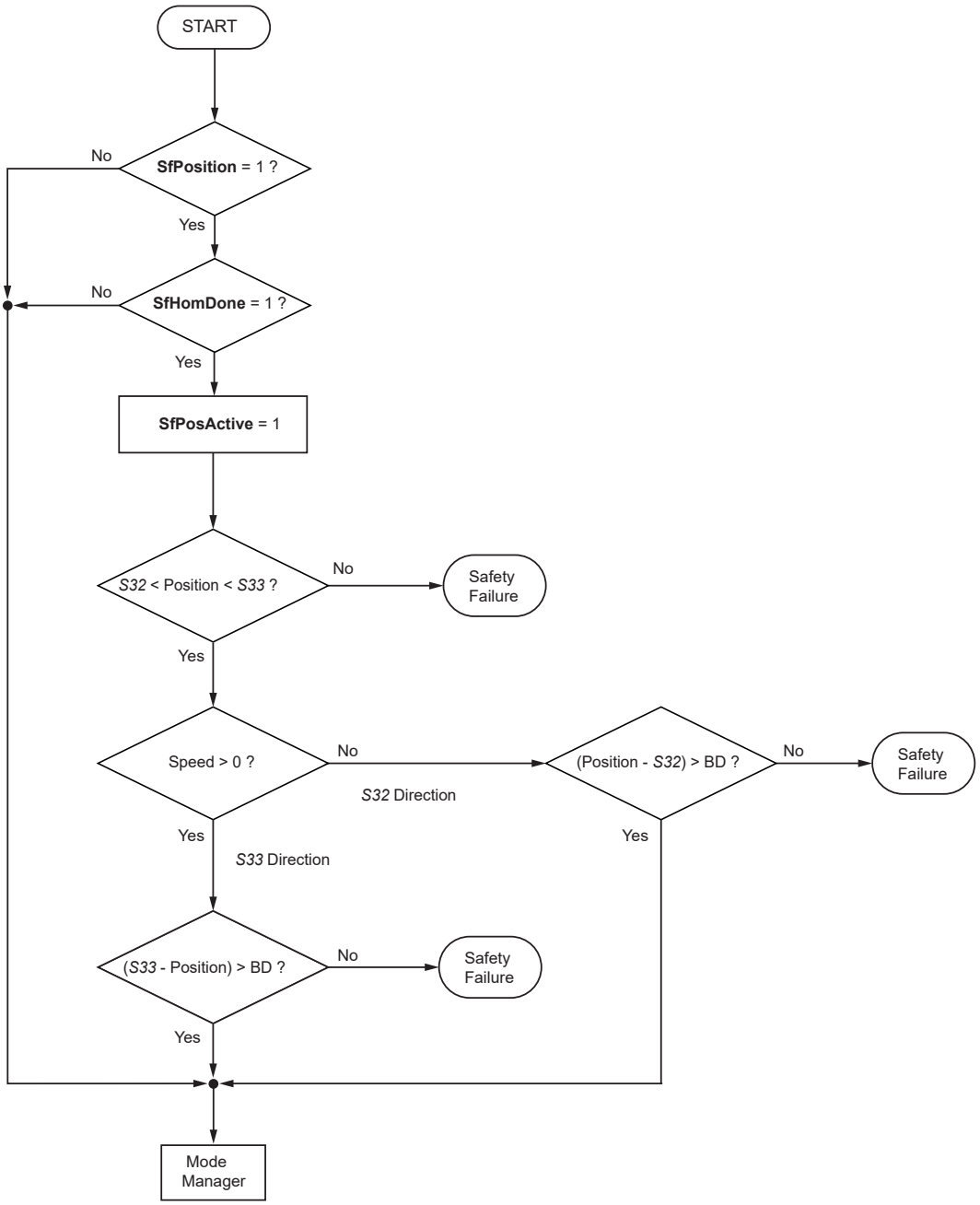
The SLP can be activated in any mode (Automatic, Safely-Limited Speed,….) NUM-SAMX dynamically monitors the direction of motion and issues an alarm if the position hits the defined thresholds (Position n lower limit <= Safe position n <= Position n higher limit), reduced by the brake distance.

In case of Position limit violation NUM-SAMX issue the Safety Failure reaction.

Since the violation of the software limits defined in the parameters can depend only on Software or programming errors of the PLC/CNC and not to H/W failures of Drive or NUM-SAMX, NUM-SAMX will not disable Power (CufOff = false) to permit NUM DrivePro to Stop the Motor.

See diagram on next page.


SLP function is foreseen for linear and rotary limited excursion axes applications, it is not foreseen for rotary endless applications (rotary axes modulo or spindle). In case of use of absolute measure system, the axis travel must not pass through the 0 absolute position of the measure system.




Where:

BD = Brake Distance

Position = Axis position

Speed = |motor speed|

*S32* = example of Lower Limit position

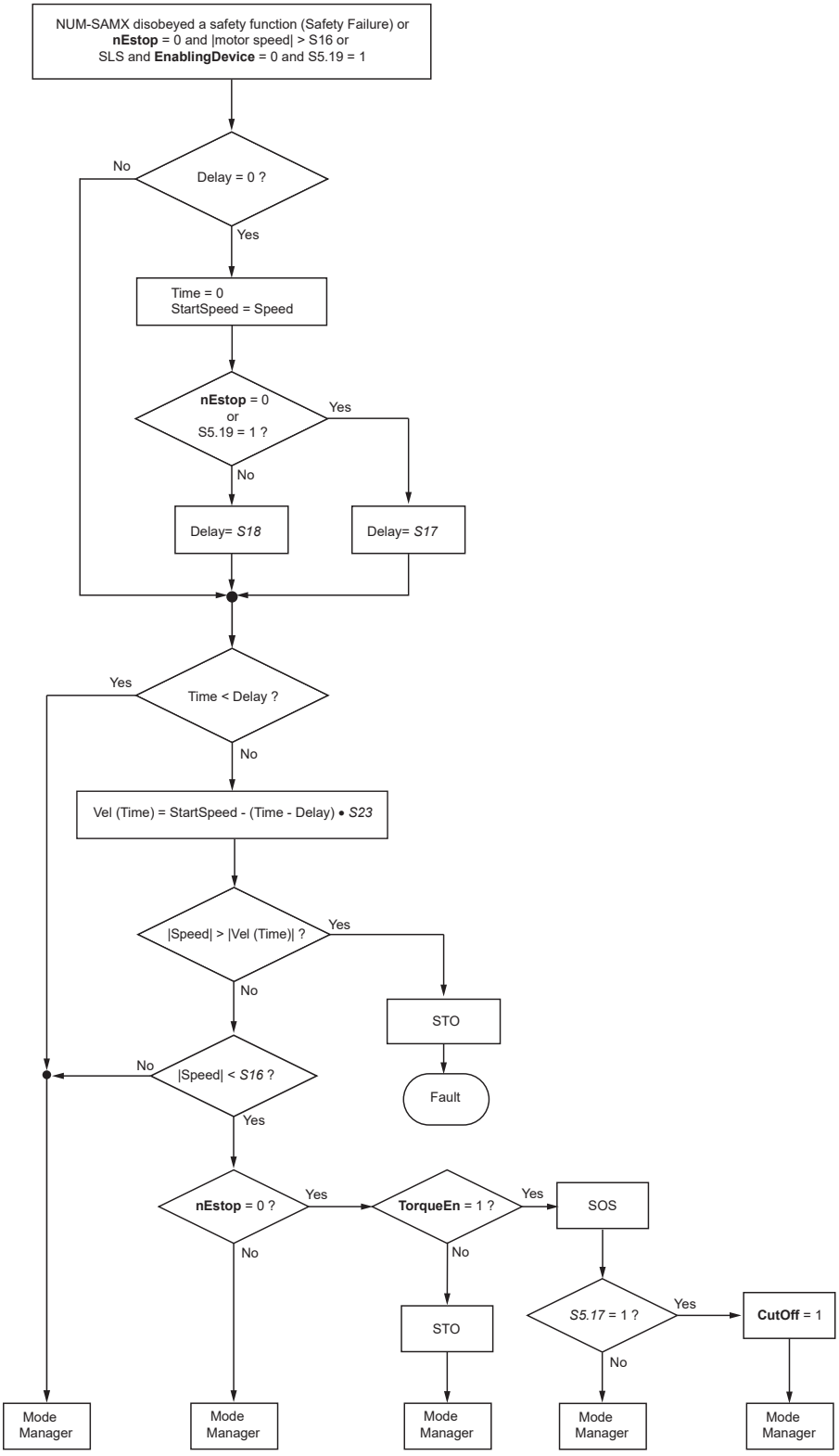
*S33* = example of Upper Limit position

More then one Safe Limited Position could be activate at the same time and switched on/off during the axis movement. If the safe path defined by the Safe Limited Position limits overlap, they are treated as only one Safe Limited Position path.

| SfPosition0 = TRUE | SfPosition1 = TRUE | SfPosition2 = TRUE | | S32 | S34 | S33 | S35 | S36 | S37 | SfCam0 Output | SfCam1 Output | SfCam2 Output | Safe Ho-ming Done | Safe Posi-tion Active | Alarm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SfCam0 path | | | | | | | | | | | | |
| | | | SfCam1 path | | | | | | | | | | | | |
| | | | SfCam2 path | | | | | | | | | | | | |
| · | · | · | | X | | | | | | FALSE | FALSE | FALSE | FALSE | FALSE | NO |
| · | · | · | | | | X | | | | FALSE | FALSE | FALSE | FALSE | FALSE | NO |
| · | · | · | | | | | | X | | FALSE | FALSE | FALSE | FALSE | FALSE | NO |
| · | | | | X | | | | | | TRUE | FALSE | FALSE | TRUE | TRUE | NO |
| · | | | | | X | | | | | TRUE | TRUE | FALSE | TRUE | TRUE | NO |
| · | · | | | | X | | | | | TRUE | TRUE | FALSE | TRUE | TRUE | NO |
| | · | | | | X | | | | | TRUE | TRUE | FALSE | TRUE | TRUE | NO |
| · | · | · | | | | | X | | | FALSE | TRUE | FALSE | TRUE | TRUE | NO |
| · | | · | | | | | X | | | FALSE | TRUE | FALSE | TRUE | TRUE | YES |
| · | · | · | | | | | | | | FALSE | FALSE | FALSE | TRUE | TRUE | YES |
| · | · | · | | | | | | X | | FALSE | FALSE | TRUE | TRUE | TRUE | NO |
| · | · | | | | | | | X | | FALSE | FALSE | TRUE | TRUE | TRUE | YES |
| X = Axis position | | | | | | | | | | | | | | | |

## 6.4.8 Safe Stop 2 (SS2)

The SS2 monitoring function is entered by:




Where: Speed = |motor speed|

Vel (Time) = Allowed |motor speed| during braking monitoring surveillance.

## 6.4.9 Braking ramp overview

In chapter 6.4.8 we see how NUM-SAMX monitors the motor braking phase, but how the braking phase is managed by the system CNC + NUM DrivePro it depends from the NUM DrivePro parameter configuration.

### 6.4.9.1 E-Stop managing

It is activated by NUM-SAMX Logical Input **nE-Stop** = 0.

NUM-SAMX informs directly NUM DrivePro that emergency stop as been requested.

The drive reacts based on V31.8 and V31.9 configuration.

In the same time NUM-SAMX jump into State 5, stores the actual |motor speed| and wait *S17* time expiration before to move in State 11 where the braking ramp is checked in agreement with *S23* value.

Case *S5.17* = 0 (motor with sensor feedback)

If the braking ramp is respected, the monitoring of the braking ramp stops when |motor speed| is below *S16* and NUM-SAMX moves in State 6 (SOS), memorize the actual motor (axis) position and starts the monitoring of the motor (axis) position deviation from the previous memorized value.

This deviation must be <= *S21*.

If this condition has disobeyed the NUM-SAMX moves in State 9 (Safety Failure) (see chapter 6.4.9.3)

**If no failure** condition happens, the emergency stop request does not create any alarm to the CNC.

Case S5.17 = 1 (motor V/f sensorless)

If the braking ramp is respected, the monitoring of the braking ramp stops when |motor speed| is below *S16* and NUM-SAMX moves in State 6 (SOS), and after the expiration of the S19 delay, NUM-SAMX will activate PWM **CutOff** (STO condition).

This delay is useful to allow the motor brake de-energizing if present, before cutting the motor torque.

Case S5.17 = 1 (STO mode)

If parameter S17 is set to a value greater than zero, NUM-SAMX will let the braking procedure be executed but not monitored, and after the time set in S17 is expired, it will execute the Safe Torque Off function.

The parameter *S17* it's dedicated to E-Stop procedure, because G75 CNC function could be needed by the machine application, in this case the requested delay could be longer respect a NUM-SAMX standard braking monitoring delay (*S18*) in case of failure.

- With drive parameter V31.9 = 0
  the drive reacts to E-Stop, depending on V31.8 configuration (V31.9 configuration has priority respect V31.8).
  - With drive parameter V31.8 = 0
    the drive brakes following the V30.5 configuration, so if V30.5 = 1 the drive will use braking ramp V91 (see M00066 manual for more detailed information)

    The drive status signal FlexiumPro_NCK.RCNC.Axis[x].SAMX.EmergencyQuickStop will be put on TRUE by E-Stop procedure activation.

    In this case we suggest to put FlexiumPro_NCK.WCNC.Channel[n].EmergencyReq:= FlexiumPro_NCK.RCNC.Axis[x].SAMX.EmergencyQuickStop to avoid following error alarm from CNC or end of movement with axis not position. (See manual M00044 for more detailed information about FlexiumPro_NCK.WCNC.Channel[n].EmergencyReq signal).
  - With drive parameter V31.8 = 1

the drive does not react to E-Stop and follows the reference coming from the CNC.

If the reaction foreseen by means of CNC will not match the configurated NUM-SAMX brake ramp definition, the NUM-SAMX will go in State 9 (Safety Failure) (see chapter 6.4.9.3).

The drive status signal FlexiumPro_NCK.RCNC.Axis[x].SAMX.EmergencyQuickStop will be put on TRUE by E-Stop procedure activation.

- With drive parameter V31.9 = 1
  the drive informs directly The CNC to activate the G75 function in the channel to which the axis belongs at that time.
  If G75 was not foreseen in the part program execution the CNC will react with own alarm.

  The external parameter E11022, in the channel to which the axis belongs at that time, is make = 2 to inform that the G75 function is request by NUM-SAMX, the drive follows the reference coming from the CNC.

  If the reaction foreseen by means of CNC will not match the configurated NUM-SAMX brake ramp definition, the NUM-SAMX will go in State 9 (Safety Failure) (see chapter 6.4.9.3)
  The drive status signal FlexiumPro_NCK.RCNC.Axis[x].SAMX.EmergencyStopStatus will be put on TRUE by E-Stop procedure activation.

**The drive command signals**

FlexiumPro_NCK.WCNC.Axis[x].SAMX.TorqueEnable

and

FlexiumPro_NCK.WCNC.Axis[x].SAMX.ReferenceEnable

have priority respect E-Stop procedure configuration.

### 6.4.9.2 E-Stop managing failure case

1. During the initial phase, when the function is waiting for *S17* delay expiration, if the motor exceeds the selected speed limit (*S15* <>0 or *S11...S14* if selected), as consequence NUM-SAMX goes in in State 9 (Safety Failure) and the Alarm 61 Ext 11 (or Alarm 61 Ext 111) is created.
   From Safety Failure trigger time, NUM-SAMX switches on waiting for *S18* delay expiration, then monitors the braking ramp defined by *S23*.
   The drive brakes the motor following the drive parameter V30.5 rule.

2. During the braking phase monitoring, then after the *S17* delay expired, if the |motor speed| is higher then value computed by the braking profile of NUM-SAMX, the NUM-SAMX goes in State 9 (Safety Failure) and the Alarm 61 Ext 11 (or Alarm 61 Ext 111) is created.
   After the expiration of the *S19* delay, NUM-SAMX will activate PWM **CutOff** (STO condition).
   This delay is useful to allow the motor brake de-energizing if present, before cutting the motor torque.

   The NUM-SAMX before cutting the PWM sends an information to the drive so it can de-energize the motor brake in case, it is managed by the drive itself. The drive de-energize immediately the motor brake and after the drive parameter V137 delay removes the torque to the motor. To agree to this management *S19* > V137.

### 6.4.9.3 Generic NUM-SAMX Safety Failure case

The NUM-SAMX goes in Safety Failure State 9 when any monitored parameter has exceeded: motor speed, moving with gate opened without enabling condition active, safe direction, safe limited position, etc. and the related alarm number and extension number is issued.

In this case the braking monitor delay *S18* is used.

The drive brakes the motor following the drive parameter V30.5 rule.

If the braking ramp profile is respected:

Case *S5.17* = 0 (motor with sensor feedback)

If the braking ramp is respected, the monitoring of the braking ramp stops when |motor speed| is below *S16* and NUM-SAMX moves in State 6 (SOS), memorize the actual motor (axis) position and starts the monitoring of the motor (axis) position deviation from the previous memorized value.

This deviation must be <= *S21*.

If this condition has disobeyed the Alarm 61 Ext 12 (or Alarm 61 Ext 112) is created.

After the expiration of the S19 delay, NUM-SAMX will activate PWM **CutOff** (STO condition).

This delay is useful to allow the motor brake de-energizing if present, before cutting the motor torque.

Case S5.17 = 1 (motor V/f sensorless)

If the braking ramp is respected, the monitoring of the braking ramp stops when |motor speed| is below *S16* and NUM-SAMX moves in State 6 (SOS), and after the expiration of the S19 delay, NUM-SAMX will activate PWM **CutOff** (STO condition).

This delay is useful to allow the motor brake de-energizing if present, before cutting the motor torque.

Case S5.17 = 1 (STO mode)

If parameter S18 is set to a value greater than zero, NUM-SAMX will let the braking procedure be executed but not monitored, and after the time set in S18 isexpired, it will execute the Safe Torque Off function.

If the braking ramp profile is disobeyed,
the Alarm 61 Ext 11 (or Alarm 61 Ext 111) is created. After the expiration of the *S19* delay, NUM-SAMX will activate PWM **CutOff** (STO condition).
This delay is useful to allow the motor brake de-energizing if present, before cutting the motor torque.

The NUM-SAMX before cutting the PWM sends an information to the drive so it can de-energize the motor brake in case, it is managed by the drive itself. The drive de-energize immediately the motor brake and after the drive parameter V137 delay removes the torque to the motor.

To agree to this management *S19* > V137.

### 6.4.9.4 CNC duplicated or synchronizated axes

In this case we have two or more axes managed by the CNC and for thouse axes we can configure drive and NUM-SAMX as described in chapters 6.4.9.1, 6.4.9.2, 6.4.9.3, but all the NUM-SAMX involved in such application must be parametrized with the same parameter values.

About the NUM-SAMX Logical Input management, because the axes involved into the application, moves under the same condition, this rule must be taken into account for managing the NUM-SAMX Logical input as showed in chapter 6.6.1.

### 6.4.9.5 DRIVE tandem application (AP03,AP04,AP05)

In this case we have one axis managed by the CNC and two or more drives and motors used to move the axis. Then we can speak of Drive **Master** and Drive/Drives **Slave**.

We can configure Drive **Master** and NUM-SAMX as described in chapters 6.4.9.1, 6.4.9.2, 6.4.9.3. The Drives **Slave** must be parametrized remembering that the Drives **Slave** are managed by the Drive **Master**.

Knowing if the braking has to be handled by CNC (via G75) or by the drive himself, we will have:

1) if **CNC handles the emergency braking via G75**

   then

   on Drive **Master**

   set V30 bit 4 "Acceleration-deceleration ramp (Master) [1=ON]" = 0
   set V30 bit 5 "Ramp on braking alarm/reference disable (Master) [1=ON]" = 0
   set V31 bit 8 "Braking on Emergency Stop [1=Disabled]" = 0
   set V31 bit 9 "Emergency Stop G75 request [1=Enabled]" = 1
   set V32 bit 2 "A8: Local link" = 1
   set V32 bit 11 "A52: Anti-backlash function" = 1
   set V32 bit 13 "A61: Safety Module class 1" = 1
   set V32 bit 14 "A62: Safety Module class 2" = 1

   on Drive **Slave**

   set V31 bit 1 "Braking when torque disabled [1=Brake]" = 0
   set V30 bit 4 "Acceleration-deceleration ramp (Master) [1=ON]" = 0
   set V30 bit 5 "Ramp on braking alarm/reference disable (Master) [1=ON]" = 0
   set V31 bit 8 "Braking on Emergency Stop [1=Disabled]" = 1
   set V31 bit 9 "Emergency Stop G75 request [1=Enabled]" = 0
   set V32 bit 2 "A8: Local link" = 0
   set V32 bit 11 "A52: Anti-backlash function" = 0
   set V32 bit 13 "A61: Safety Module class 1" = 0
   set V32 bit 14 "A62: Safety Module class 2" = 0

   NUM-SAMX on Drive **Master** and Drives **Slave** must have the same parameter value

2) if **DRIVE handles the emergency braking**

then

on Drive **Master**

| | |
|---|---|
| set V30 bit 4 | "Acceleration-deceleration ramp (Master) [1=ON]" = 0 |
| set V30 bit 5 | "Ramp on braking alarm/reference disable (Master) [1=ON]" = 1 |
| set V31 bit 8 | "Braking on Emergency Stop [1=Disabled]" = 0 |
| set V31 bit 9 | "Emergency Stop G75 request [1=Enabled]" = 0 |
| set V32 bit 2 | "A8: Local link" = 1 |
| set V32 bit 11 | "A52: Anti-backlash function" = 1 |
| set V32 bit 13 | "A61: Safety Module class 1" = 1 |
| set V32 bit 14 | "A62: Safety Module class 2" = 1 |
| set V91 | "Acceleration/deceleration ramp" = proper value... |
| | ...you have to know it... |
| | it should be faster than *S23* declared in NUM-SAMX |

on Drive **Slave**

| | |
|---|---|
| set V31 bit 1 | "Braking when torque disabled [1=Brake]" = 0 |
| set V30 bit 4 | "Acceleration-deceleration ramp (Master) [1=ON]" = 0 |
| set V30 bit 5 | "Ramp on braking alarm/reference disable (Master) [1=ON]" = 0 |
| set V31 bit 8 | "Braking on Emergency Stop [1=Disabled]" = 1 |
| set V31 bit 9 | "Emergency Stop G75 request [1=Enabled]" = 0 |
| set V32 bit 2 | "A8: Local link" = 0 |
| set V32 bit 11 | "A52: Anti-backlash function" = 0 |
| set V32 bit 13 | "A61: Safety Module class 1" = 0 |
| set V32 bit 14 | "A62: Safety Module class 2" = 0 |

NUM-SAMX on Drive **Master** and Drives **Slave** must have the same parameter value

Remember:

the Drives **Slave** do NEVER handles the braking !!!
it's always the Drive **Master** that handles the braking

or committed by CNC

or managed by drive itself.

About the NUM-SAMX Logical Input management, because the axes involved into the application, moves under the same condition, this rule must be taken into account for managing the NUM-SAMX Logical input as showed in chapter 6.6.2 or 6.6.3

### 6.4.9.6 Check of the braking ramp profile (MPX1)

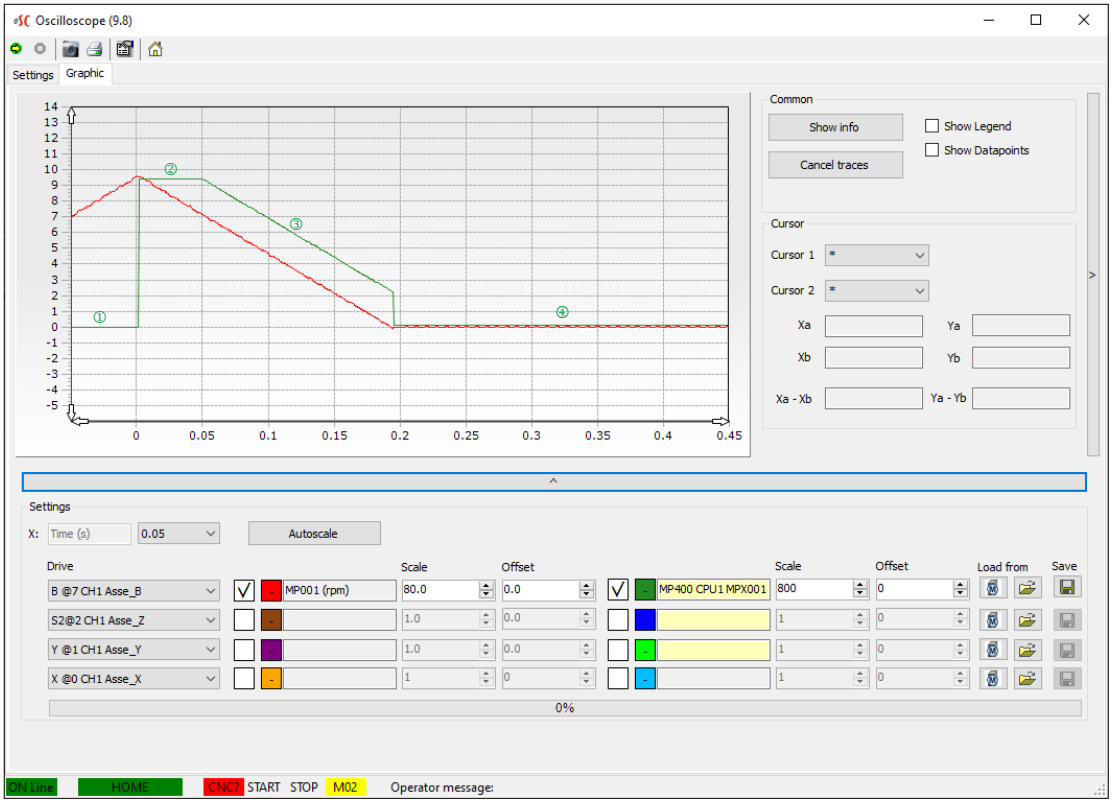



*Fig.1*

On Fig.1 we can see an example of motor speed profile (red line) and NUM-SAMX braking ramp profile (green line), we can obtain in case of NUM-SAMX safety condition disobeyed, for example the motor speed is moving over the *S15* limit (Automatic Mode Speed Limit).

The braking ramp profile is made by 4 main sections:

① The value 0, that is the initial condition

② The speed value detected by NUM-SAMX when the NUM-SAMX braking ramp profile is activated and *S18* delay

③ The NUM-SAMX braking ramp profile used to control the motor braking

④ The NUM-SAMX braking ramp profile end

The NUM-SAMX braking ramp profile is activate by two conditions:

case a) A NUM-SAMX safety condition disobeyed

case b) Emergency condition: NUM-SAMX Logical Input **nE-Stop** = 0

The trace showed in Fig. 1 could be obtaind configuring the drive oscilloscope trigger:
as indicated in Fig. 2 in case of NUM-SAMX safety condition disobeyed
or
as indicated in Fig. 3 Emergency condition: NUM-SAMX Logical Input **nE-Stop** = 0

The transition ① → ② is the NUM-SAMX braking ramp profile activation

The duration of the section ② depends from the activation condition:

case a) the duration time of section ② is = *S18*

case b) the duration time of section ② is = *S17*

The slope of section ③ is = *S23*

The transition ③ → ④ is visible when the NUM-SAMX braking ramp profile is NOT disobeyed and it is the moment where the NUM-SAMX detects that the motor speed is below *S16*.

The value of section ④ is = *S16*

**V34 | Configuration DF1/DF2 relay [1=Open]**

| Bit | Value | Description | Default |
|---|---|---|---|
| 0 | ☐ | Alarm 2: BUS overvoltage | ☐ |
| 1 | ☐ | Alarm 3: Motor overtemperature | ☐ |
| 2 | ☐ | Alarm 4: Drive overtemperature | ☐ |
| 3 | ☐ | Alarm 5: Braking resistor or PWS overtemperature | ☐ |
| 4 | ☐ | Alarm 6: Short-circuit to earth | ☐ |
| 5 | ☐ | Alarm 7: Auxiliary power supply | ☐ |
| 6 | ☐ | Alarm 8: Local link | ☐ |
| 7 | ☐ | Alarm 9: S1 sensor | ☐ |
| 8 | ☐ | Alarm 10: Timeout | ☐ |
| 9 | ☐ | Alarm 11: Overspeed | ☐ |
| 10 | ☐ | Alarm 12: Drive overcurrent | ☐ |
| 11 | ☐ | Alarm 15: Data memory checksum error | ☐ |
| 12 | ☐ | Alarm 16: Incompatible parameters | ☐ |
| 13 | ☐ | Alarm 18: Self-calibration | ☐ |
| 14 | ☐ | Alarm 37: Following error | ☐ |
| 15 | ☐ | Alarm 38: S2 sensor | ☐ |
| 16 | ☐ | Alarm 49: I^2t | ☐ |
| 17 | ☐ | Alarm 51: Congruence position S1-S2 | ☐ |
| 18 | ☐ | Alarm 52: Anti-backlash function | ☐ |
| 19 | ☐ | Alarm 70: Torque duplication function | ☐ |

*Fig.2*

**V328 | S1 Sensor alarms handling**

| Bit | Value | Description | Default |
|---|---|---|---|
| 0 | ☐ | Alarms 9 Ext 248/260 exclusion [1=Excluded] | ☐ |
| 1 | ☐ | Not used | ☐ |
| 2 | ☐ | EnDat 2.2. sensor CRC error [0=Alarm 9 Ext 259] [1=Warning] | ☐ |
| 3 | ☐ | Alarms 9 Ext 230/248/254/260/261 exclusion [1=Excluded] | ☐ |
| 4 | ☐ | UGA misalignment handling [0=Alarm 9 Ext 230] [1=Warning] | ☐ |
| 5 | ☐ | Alarm 9 Ext 231 exclusion [1=Excluded] | ☐ |
| 6 | ☐ | Alarm 9 Ext 245 fault-detection signal enabling (pin 21) [1=Enabled] | ☐ |
| 7 | ☐ | Alarms 9 Ext 60 to 9 Ext 67 Endat2.2 Safety bit [1=Excluded] | ☐ |

*Fig.3*

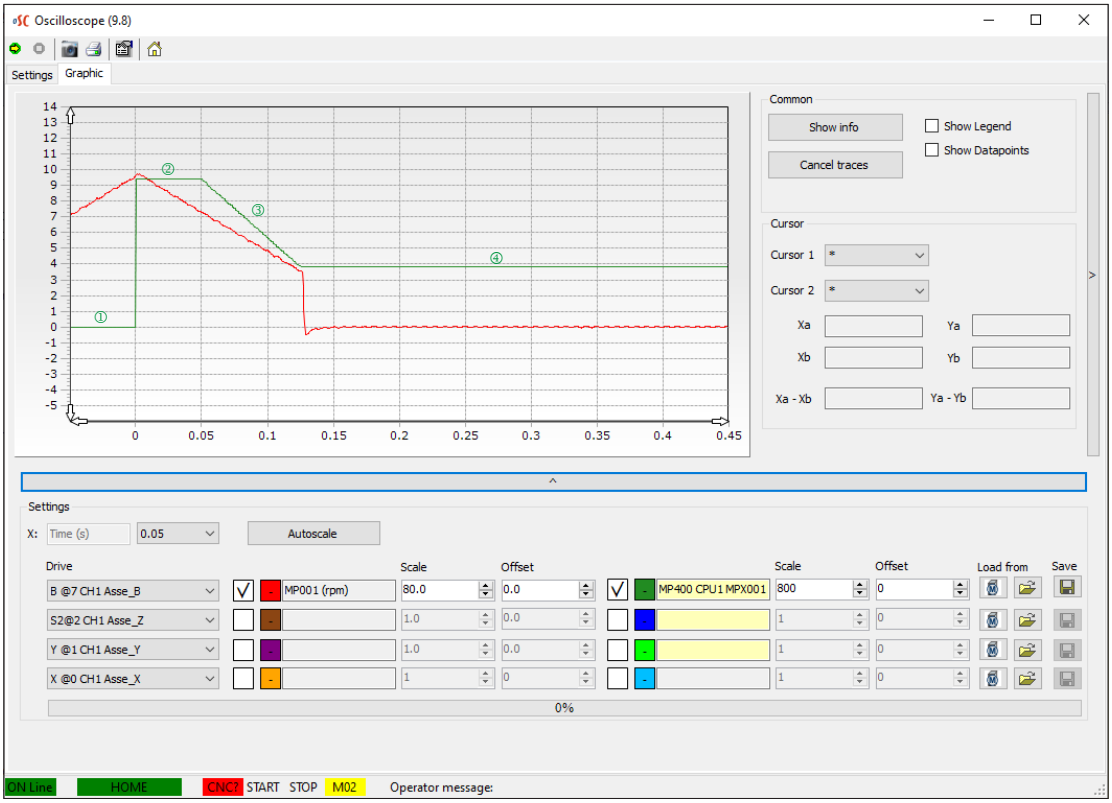



*Fig.4*

On Fig. 4 we can see the case, where the motor braking ramp, doesn't match the NUM-SAMX braking ramp profile. In this case we will receive also the drive Alarm 61 Ext 11 (or Ext 111) created by NUM-SAMX.

In this case we must verify the congruence of *S23* with drive parameter V91 or other drive or NCK parameter depending on the motor braking method choosen.

To have a good view of the two slopes, rermember to check the scales of the two traces, the scale of the "green line" must be 10 times the "red line", because the motor speed is showed in rpm and the NUM-SAMX braking ramp profile is showed in 0.1 rpm.

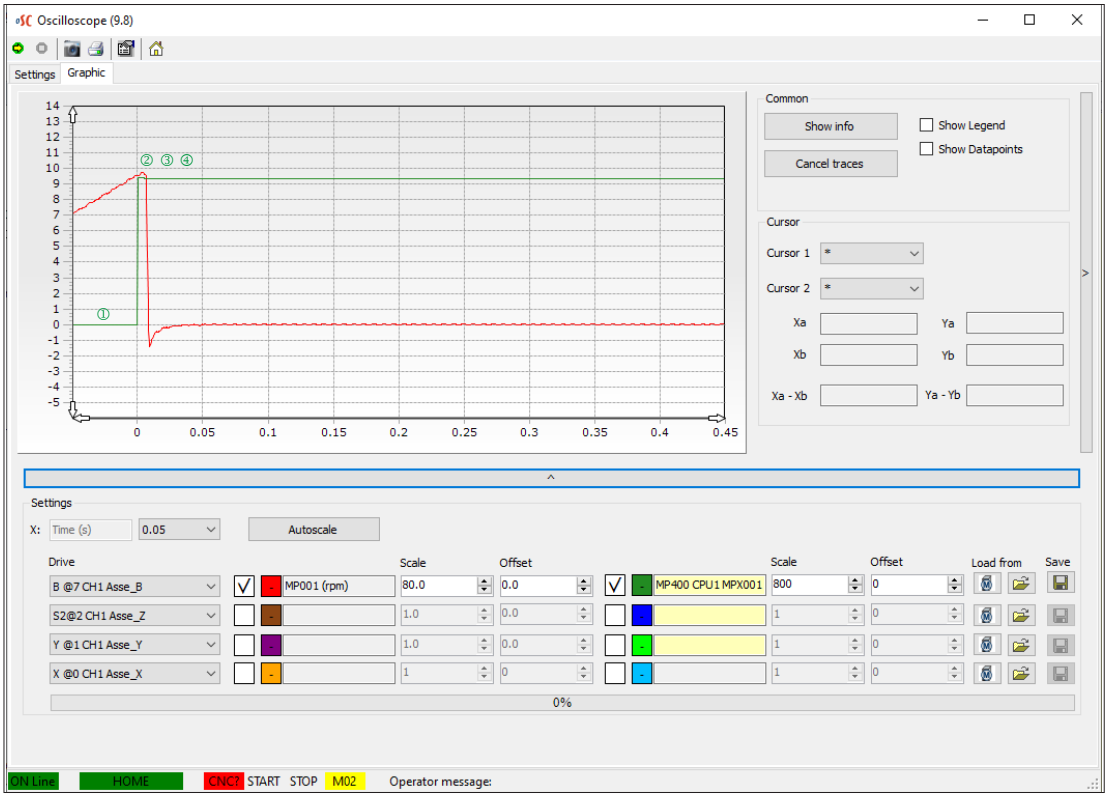


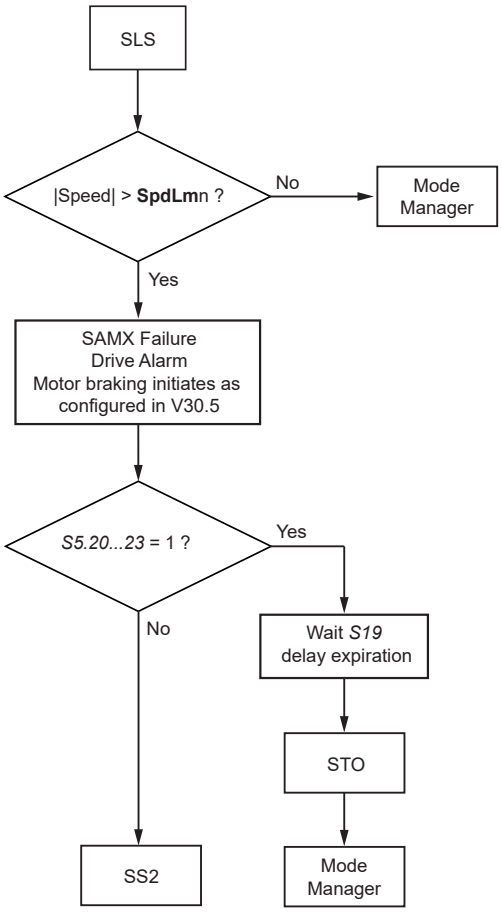

*Fig.5*

On Fig. 5 we can see the case, where the motor braking ramp, doesn't match the NUM-SAMX braking ramp profile. In this case we will receive also the drive Alarm 61 Ext 11 (or Ext 111) created by NUM-SAMX.

In this case we could have *S18* or *S17* too short.

### 6.4.10 Safe Stop 1 (SS1)

The SS1 function is obtained by enabling STO (by means of **TorqueEn** = 0) once the SS2 function is terminated (see chapter 6.4.8), or initiates the motor deceleration (if configured into drive parameter with V30.5 = 1) and make STO function after an application specific time delay.

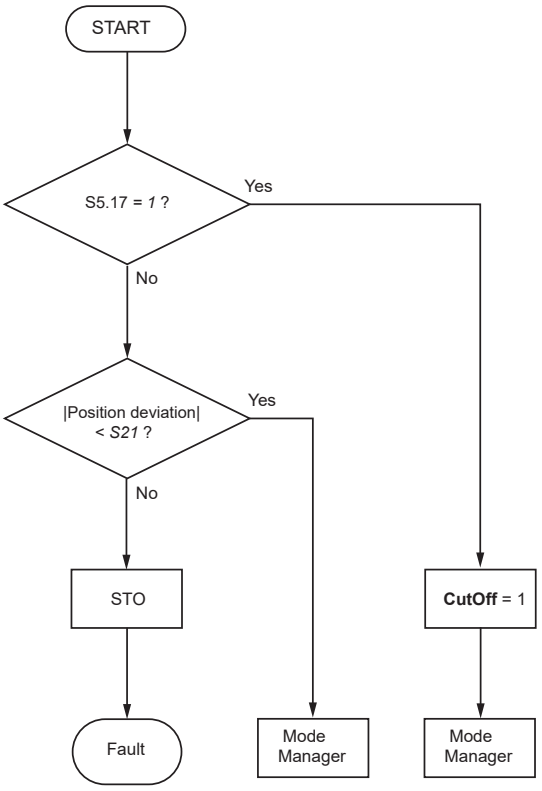



Where: Speed = motor speed

### 6.4.11 Safe Operating Stop (SOS)

The SOS monitoring function is entered by:

- As conclusion of the SS2 monitoring function in case of **GuardClsd**= 0 and **EnablingDevice** = 0
- **GuardClsd**= 0 in standstill conditions (Speed <= *S16*) and **EnablingDevice** = 0.




### 6.4.12 Safe Torque Off (STO)

The STO function is activated by:

- **TorqueEn**=0
- Internal diagnostic failure (fail safe)
- SS2 or SOS disobeyed (Safety Failure).
- SLSn disobeyed and related *S5.20* ... 23 = 1
- SOS and *S5.17* =1

### 6.4.13 InterlockOut management

The NUM-SAMX Logical Output **InterlockOut** is set to one only in case the standstill conditions is confirmed, it means Speed < *S16* (in this case also the Standstill output is set to one).

Then after opening the safety guard (NUM-SAMX Logical Input **GuardClsd** = 0) the SOS function is activated.

If the motor stays stopped the NUM-SAMX Logical Output **InterlockOut** remains set to one.

After that the Safe Limited Speed function could be activated (**GuardClsd**= 0, **EnablingDevice**= 1, **nE-Stop**= 1, **TorqueEn**= 1, **SpdLm**n= 1) and NUM-SAMX Logical Output **InterlockOut** remains set to one.

## 6.5 NUM-SAMX Logical Output behaviour

### 6.5.1 Standard mode *S5.16* = 0 and *S5.17* = 0

**StandStill** = 1 in case of:

- |motor speed| ≤ *S16*

**StandStill** = 0 in case of:

- Alarm 63 any extension
- Alarm 64 any extension
- |motor speed| > *S16*

**CutOff** = 1 in case of:

- Alarm 63 any extension
- Alarm 64 any extension
- NUM-SAMX Logical Input **TorqueEn** = 0
- As consequence of Alarm 61 Ext 11 (or Ext 111) “Safe deceleration process: not enough brake ramp”
- As consequence of Alarm 61 Ext 12 (or Ext 112) “Safe Operating Stop disobeyed”

**CutOff** = 0 if no case of **CutOff** = 1

**InterlockOut** = 1 in case of:

- NUM-SAMX Logical Input **TorqueEn** = 0
- NUM-SAMX Logical Output **Standstill** = 1

**InterlockOut** = 0 in case of:

- Alarm 63 any extension
- Alarm 64 any extension
- NUM-SAMX Logical Output **Standstill** = 0

**Speed** = 1 in case of:

- |motor speed| < S24 and S24 > 0

**Speed** = 0 in case of:

- |motor speed| ≥ S24
- S24 = 0

### 6.5.2 STO mode *S5.16* = 1

**StandStill** = 0 always

**CutOff** = 1 in case of:

- Alarm 63 any extension
- Alarm 64 any extension
- NUM-SAMX Logical Input **TorqueEn** = 0

**CutOff** = 0 if no case of **CutOff** = 1

**InterlockOut** = 1 in case of:

- NUM-SAMX Logical Input **TorqueEn** = 0

**InterlockOut** = 0 in case of:

- Alarm 63 any extension
- Alarm 64 any extension
- NUM-SAMX Logical Input **TorqueEn** = 1

**Speed** = 0 always

### 6.5.3 V/f mode *S5.17* = 1

**StandStill** = 0 always

**CutOff** = 1 in case of:

- Alarm 63 any extension
- Alarm 64 any extension
- NUM-SAMX Logical Input **TorqueEn** = 0
- As consequence of Alarm 61 Ext 11 (or Ext 111) “Safe deceleration process: not enough brake ramp”

**CutOff** = 0, in the other cases different from cases of **CutOff** = 1

**InterlockOut** = 1 in case of:

- NUM-SAMX Logical Input **TorqueEn** = 0

**InterlockOut** = 0 in case of:

- Alarm 63 any extension
- Alarm 64 any extension
- NUM-SAMX Logical Input **TorqueEn** = 1

**Speed** = 0 always

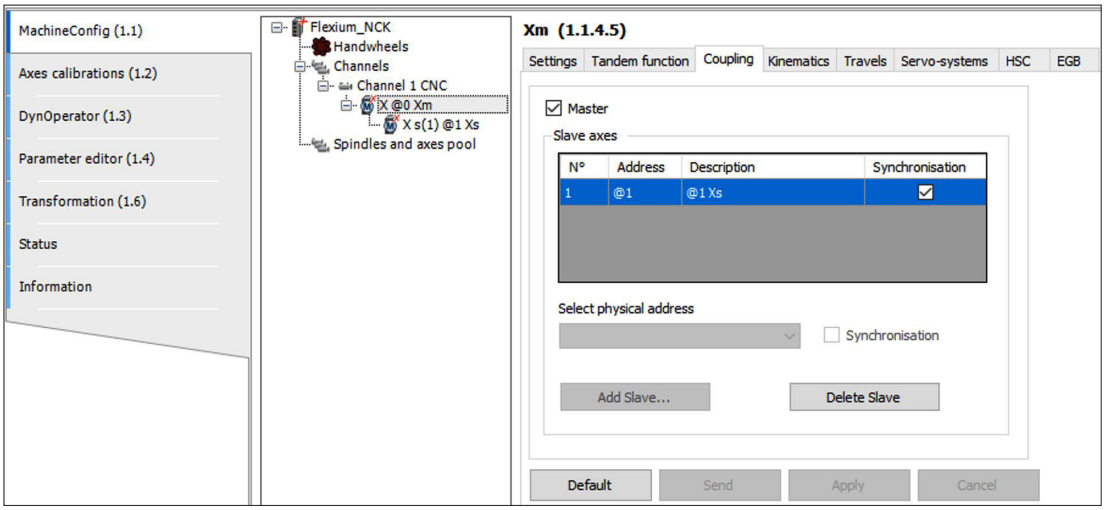
### 6.5.4 Not admitted mode *S5.16* = 1 *and S5.17* = 1

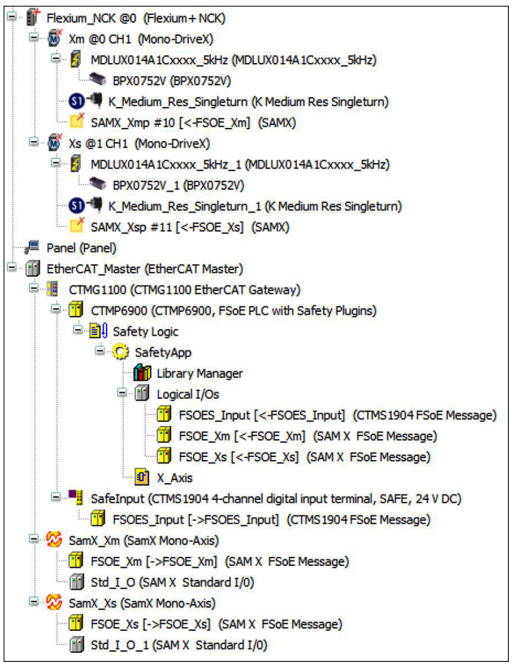
- Alarm 64 ext 31 (or 131) will be issue
- Alarm 64 with other extensions could be issue depending on the other bits selected on *S5* parameter

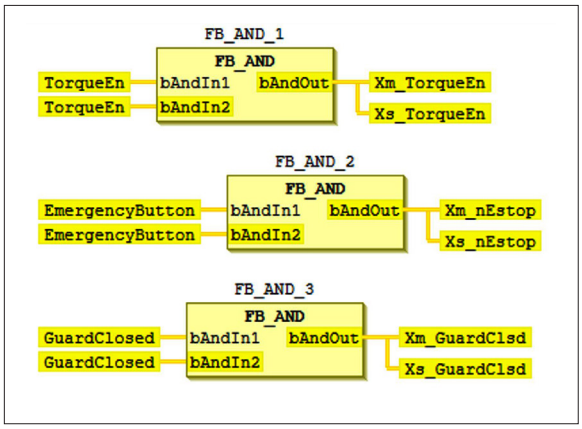
## 6.6 Application example

### 6.6.1 NUM-SAMX Logical Input management with CNC duplicated or synchronizated axes

???



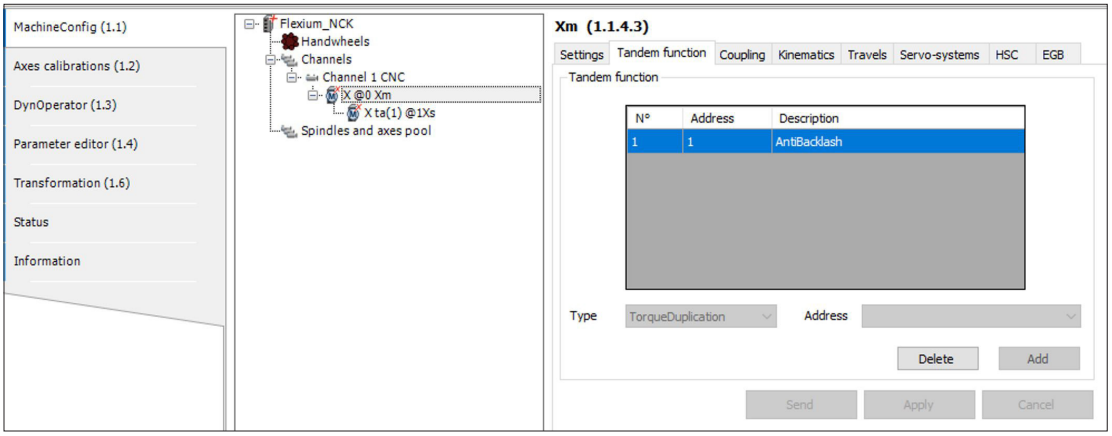

Because the axes involved into the application, moves under the same condition, this rule must be taken into account for managing the NUM-SAMX Logical Input as showed.

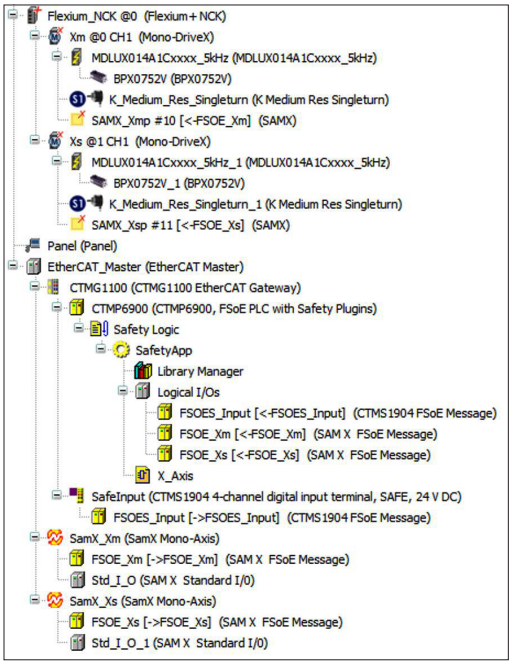
This example is limited to the main NUM-SAMX Logical Input, but could be extended to all the others NUM-SAMX Logical Input required in the customer application.

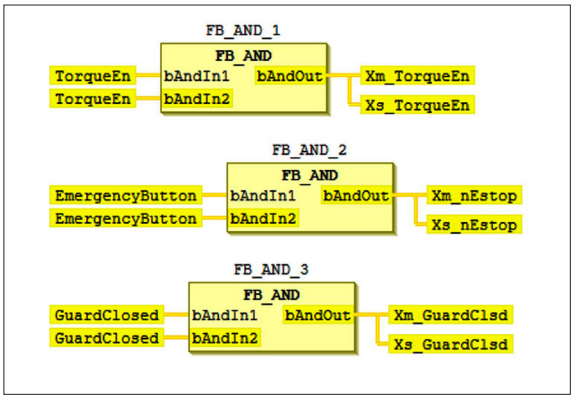
The condition showed to managed the NUM-SAMX Logical Input must be adapted to the customer application, for example in case the axes duplication function is not always active, in such case the NUM-SAMX Logical Input must be managed in independent mode for each axis.

## 6.6.2 NUM-SAMX Logical Input management with DRIVE tandem application

???



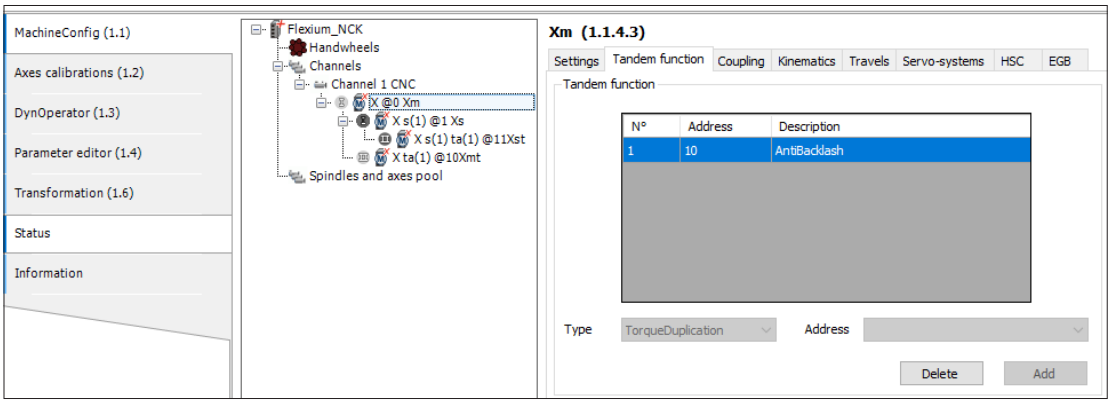



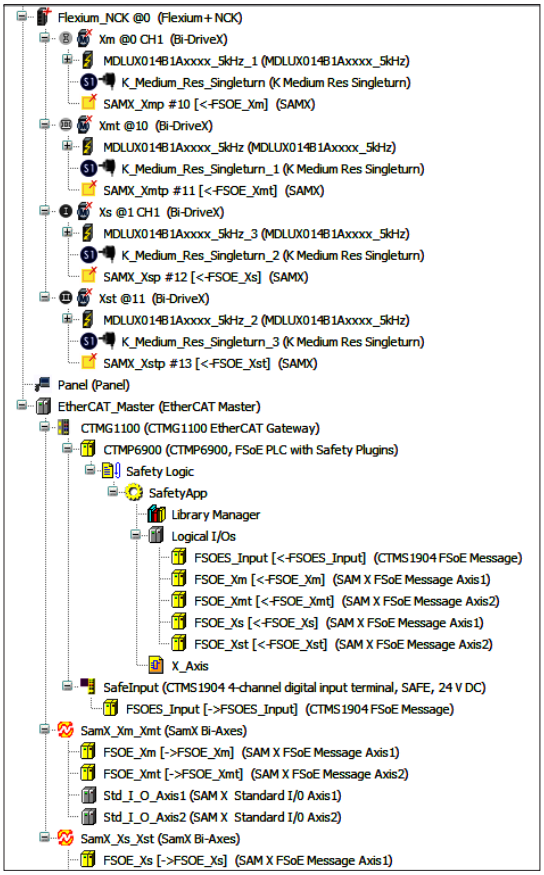

Because the axes involved into the application, moves under the same condition, this rule must be taken into account for managing the NUM-SAMX Logical Input as showed.

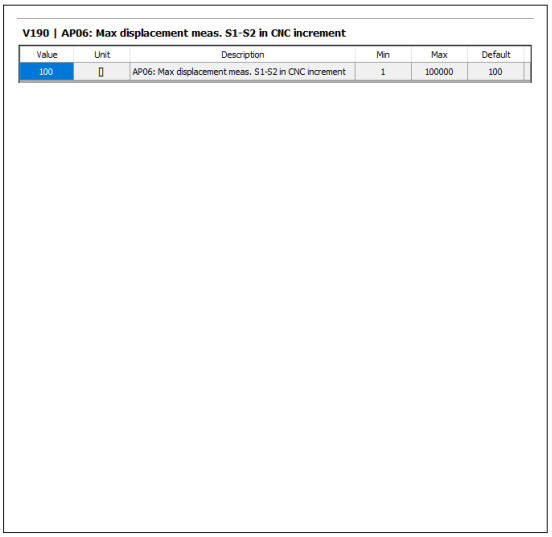
This example is limited to the main NUM-SAMX Logical Input, but could be extended to all the others NUM-SAMX Logical Input required in the customer application.

The condition showed to managed the NUM-SAMX Logical Input must be adapted to the customer application.

## 6.6.3 NUM-SAMX Logical Input management with CNC synchronizated axes and DRIVE tandem application




Because the axes involved into the application, moves under the same condition, this rule must be taken into account for managing the NUM-SAMX Logical Input as showed.

This example is limited to the main NUM-SAMX Logical Input, but could be extended to all the others NUM-SAMX Logical Input required in the customer application.

The condition showed to managed the NUM-SAMX Logical Input must be adapted to the customer application.

### 6.6.4 NUM-SAMX Logical Input management with DRIVE in parking

When the Drive is set in parking status (V30 bit 30 = 1) the NUM-SAMX Logical Input **TorqueEn** must be set = 0.

The "Drive in parking" status information is disposable on PLC in the bit:

FlexiumPro_NCK.RCNC.Axis[n].SAMX.DriveInParking.

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# Summary


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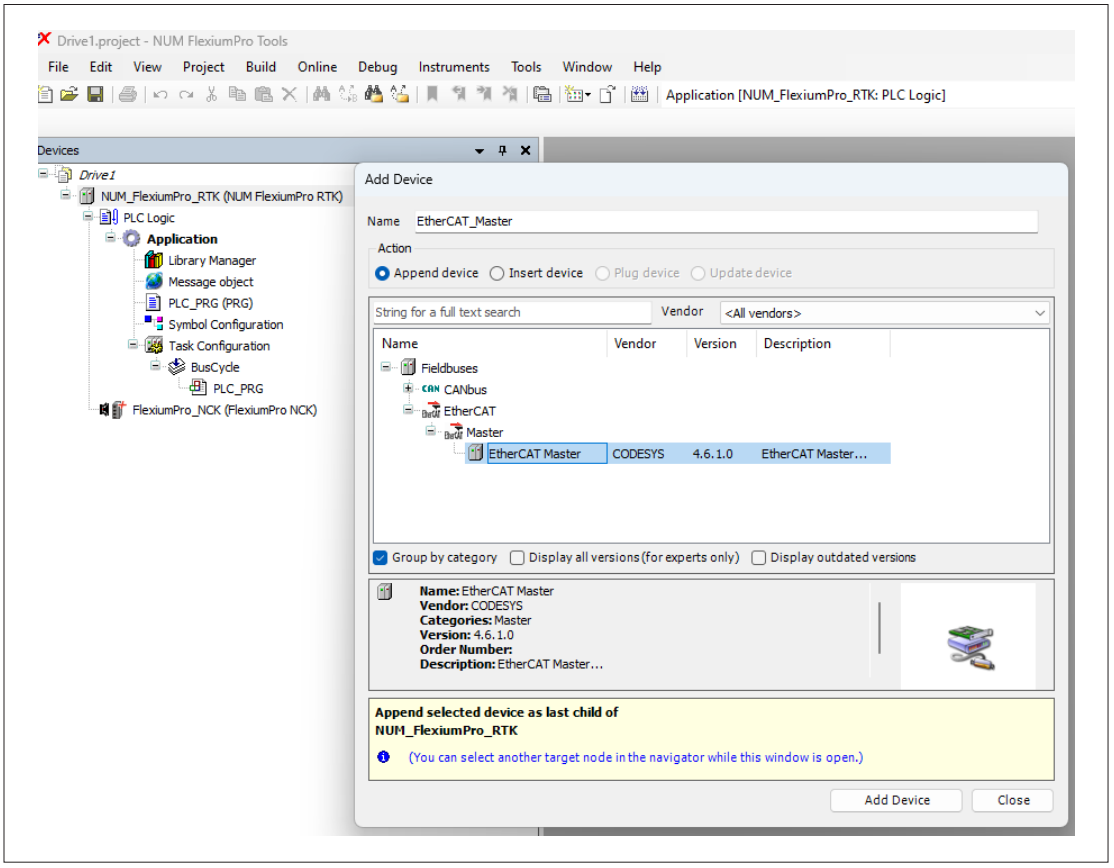
# 7 Integration in a FlexiumPro project

## 7.1 Adding and addressing devices in a FlexiumPro project

### 7.1.1 Adding an EtherCAT Master to the device tree

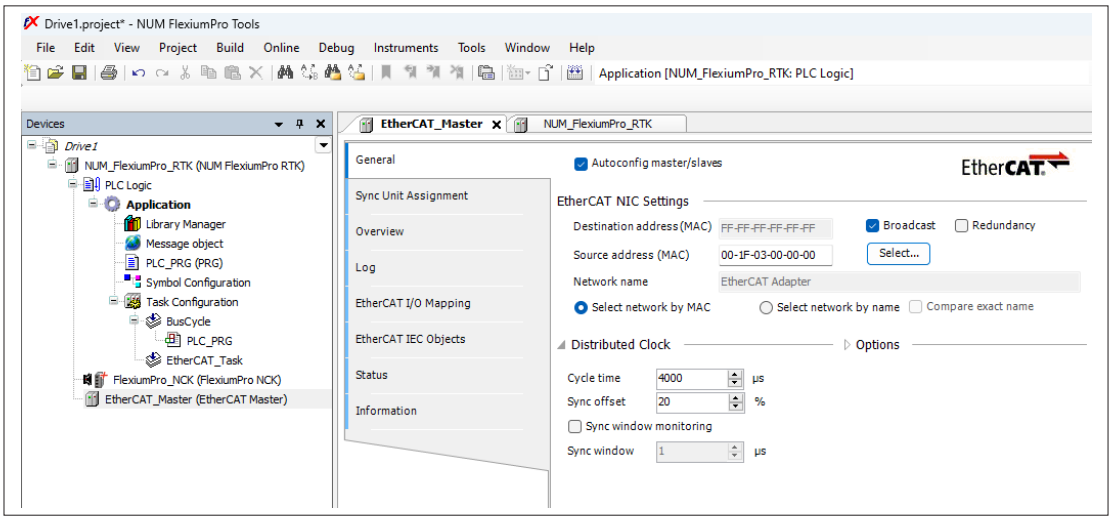
A right-click on the controller opens the context menu, from which the *“Add device...”* command is selected. The *“EtherCAT Master”* device is then selected in the following dialogue.




*Inserting a EtherCAT Master*

### 7.1.2 Adapting the EtherCAT Master settings

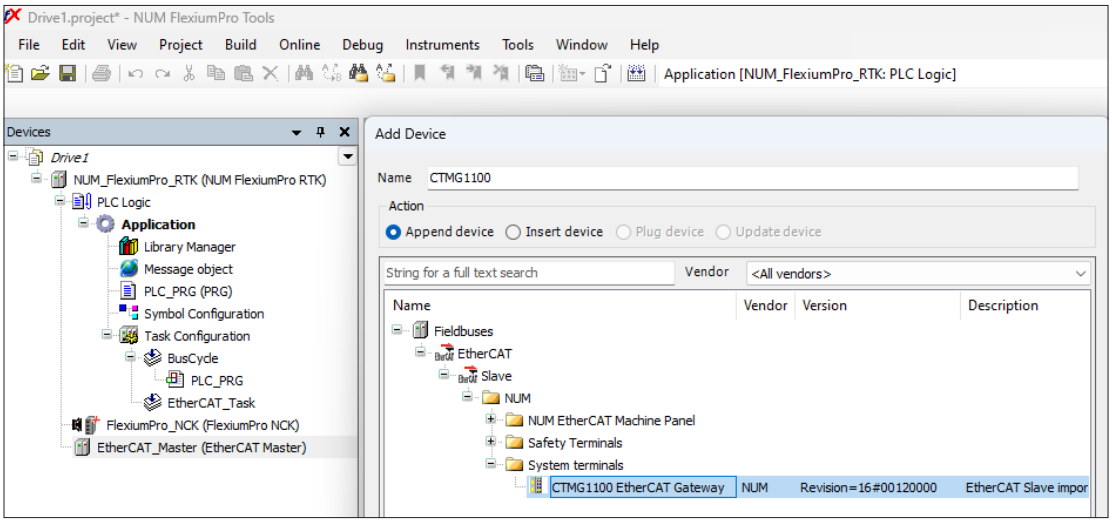
A double-click on the *“EtherCAT Master”* device in the device tree opens the associated editor for setting the parameters. In this example the desired network adaptor is selected and the dialogue is quit with *“OK”* .




*Adapting EtherCAT Master settings*

### 7.1.3 Adding an EtherCAT gateway (CTMG1100)

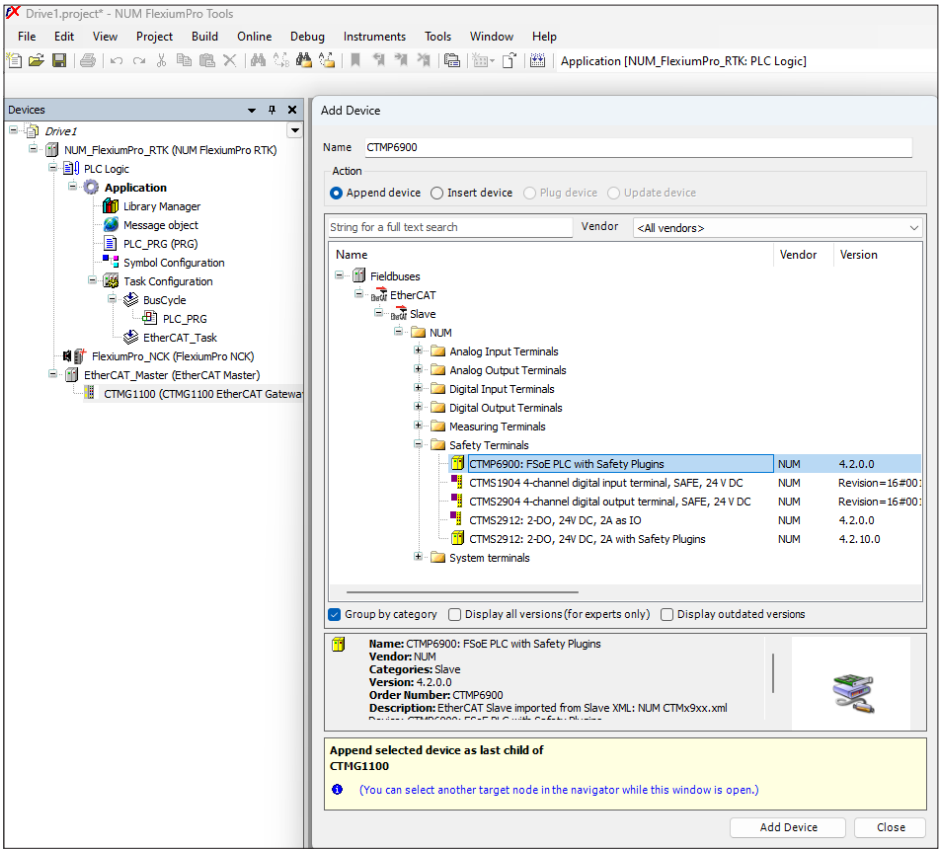
A right-click on the EtherCAT master opens the context menu, from which the *“Add device...”* command is selected. The *“CTMG1100”* device is then selected in the following dialogue.



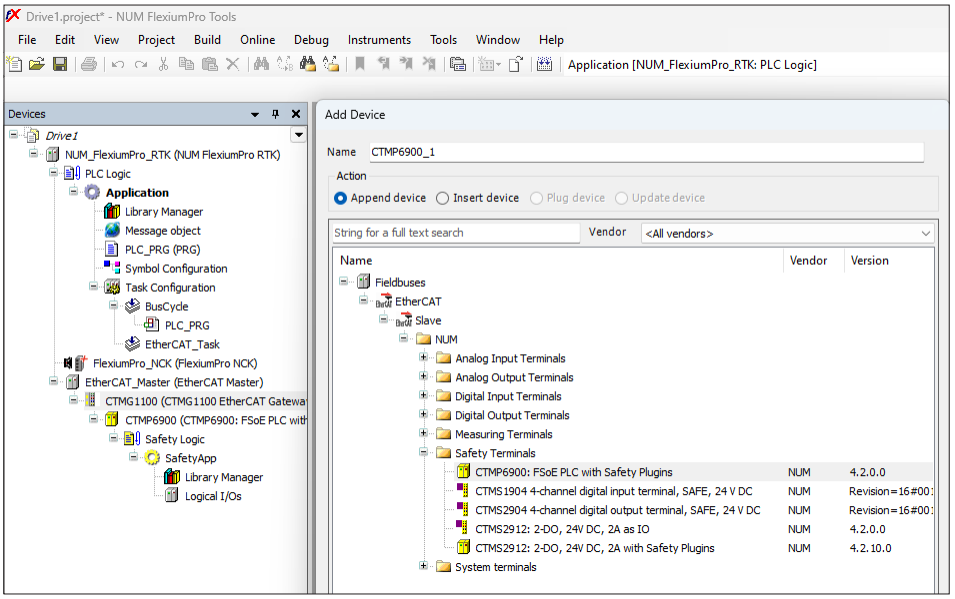

*Adding EtherCAT gateway CTMG1100*

## 7.1.4 Adding a CTMP6900 (or CTMS1904 or CTMS2904)

A right-click on the NUMEtherCAT gateway (CTMG1100) opens the context menu, from which the *“Add device...”* command is selected. The *“CTMP6900”* device is then selected in the following dialogue



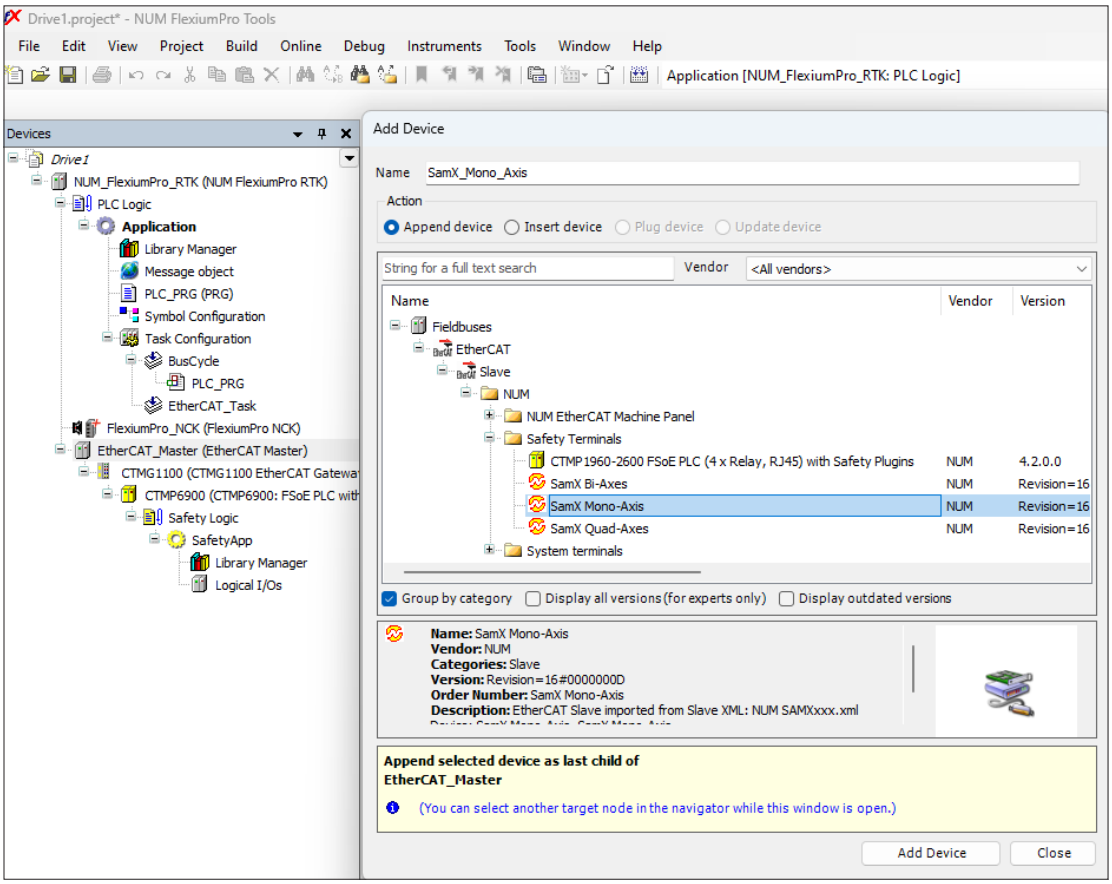

*and added pushing “Add Device”*



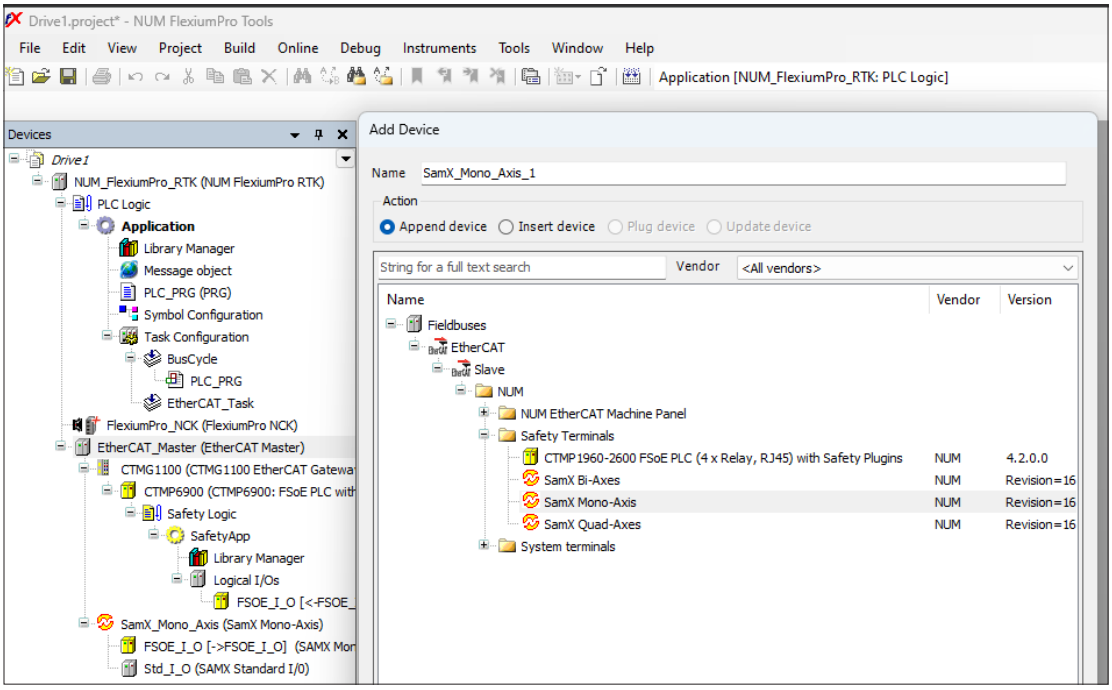

See manual M00033, M00034, M00035 and M00037 for more informations regarding Safe PLC and Safe I/Os installation and programming.

## 7.1.5 Adding a NUM-SAMX

A right-click on the EtherCAT master opens the context menu, from which the *“Add device...”* command is selected. The *“SAMX”* device (Mono-Axis or Bi-Axes or Quad-Axes) is then selected in the following dialogue

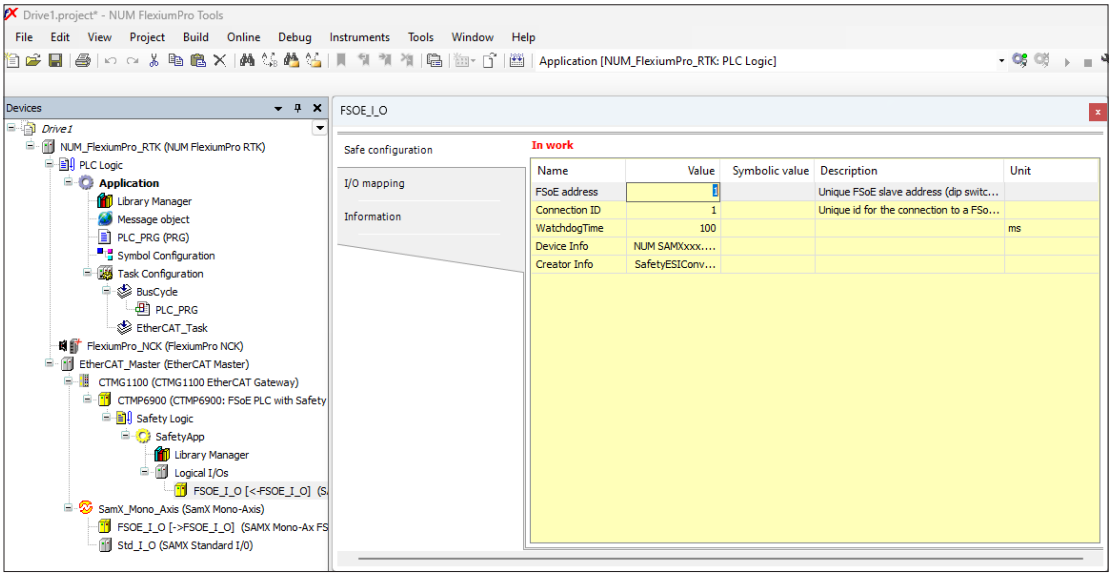


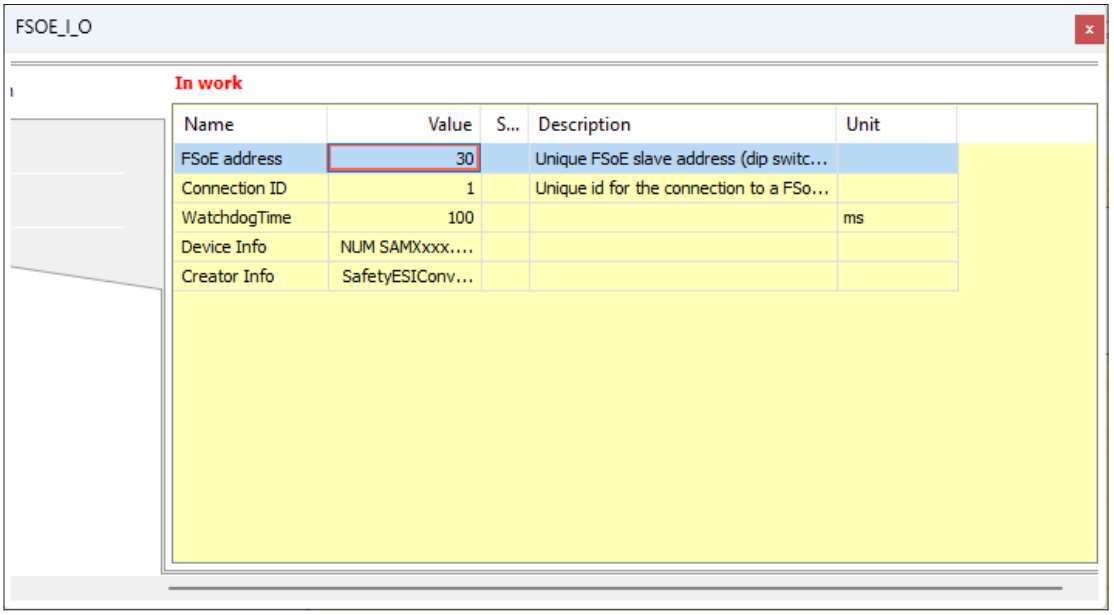

*and added pushing “Add Device”*



### 7.1.6 Address settings of the NUM-SAMX

The FSoE address must be then confirmed in the safe Logical I/Os in the following dialogue.

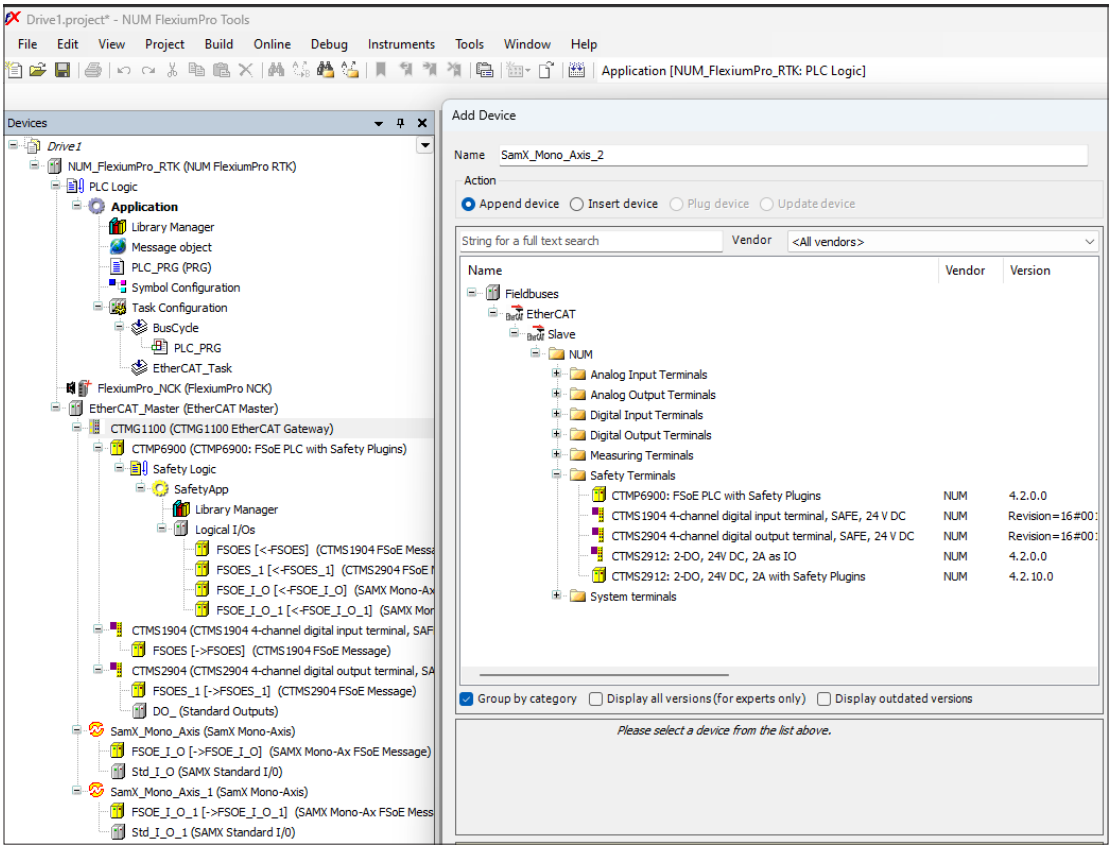


### 7.1.7 Adding other NUMSafe terminals and NUM DrivePro devices.

Using the same method applied for the CTMP6900, other NUMSafe terminals (CTMS1904 and CTMS2904) can be added as well and the FSoE address is also set in the same manner.

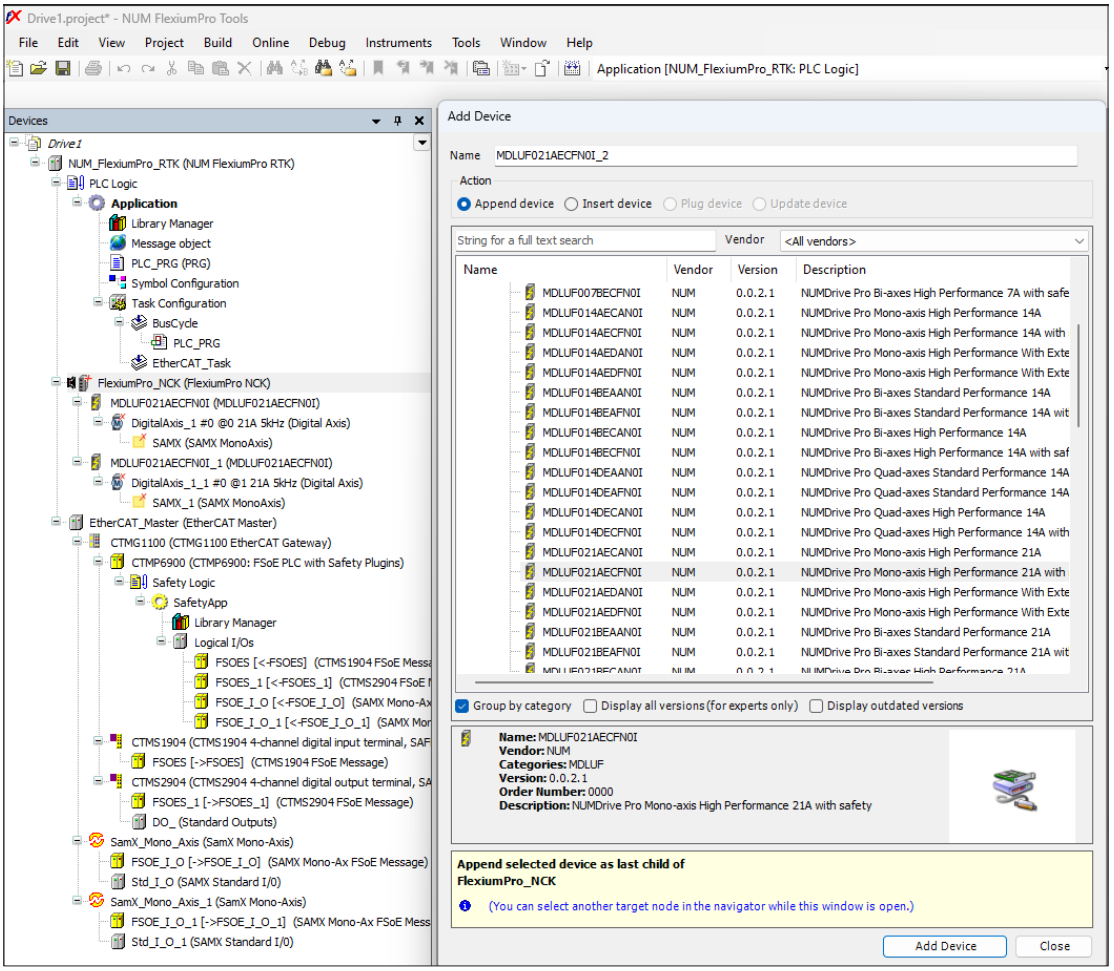
For more details about programming CTMP6900 programming see NUMSafe CTMP6900 Programming manual M00037.




*Adding other terminals*

## 7.2 Adding a NUM-SAMX Parameters folder

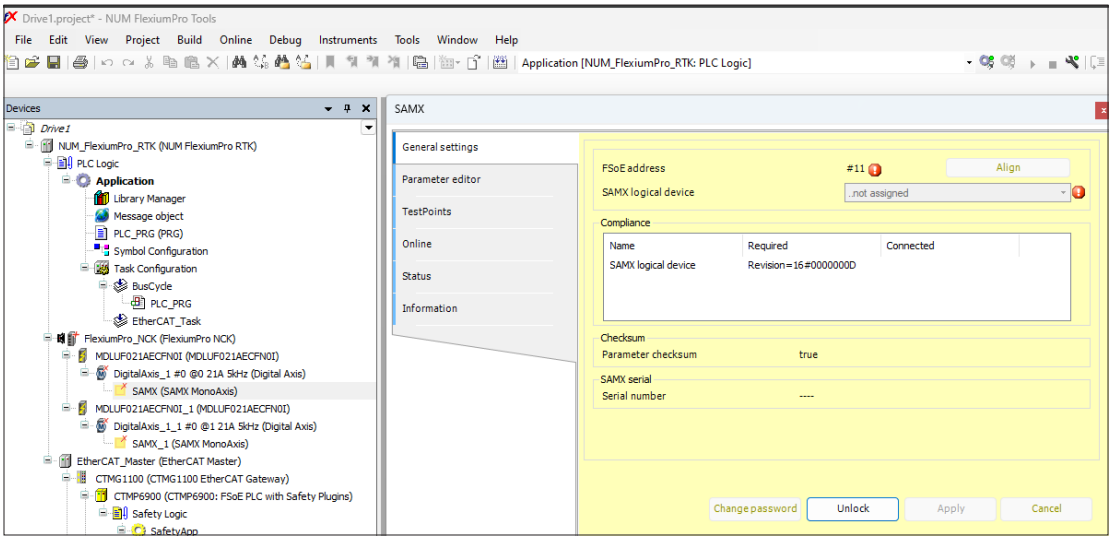
A right-click on the FlexiumPro_NCK opens the context menu, from which the “Add device...” command is selected. The drive equipped with NUM-SAMX (Mono-Axis or Bi-Axes or Quad-Axes) is then selected in the following dialogue.



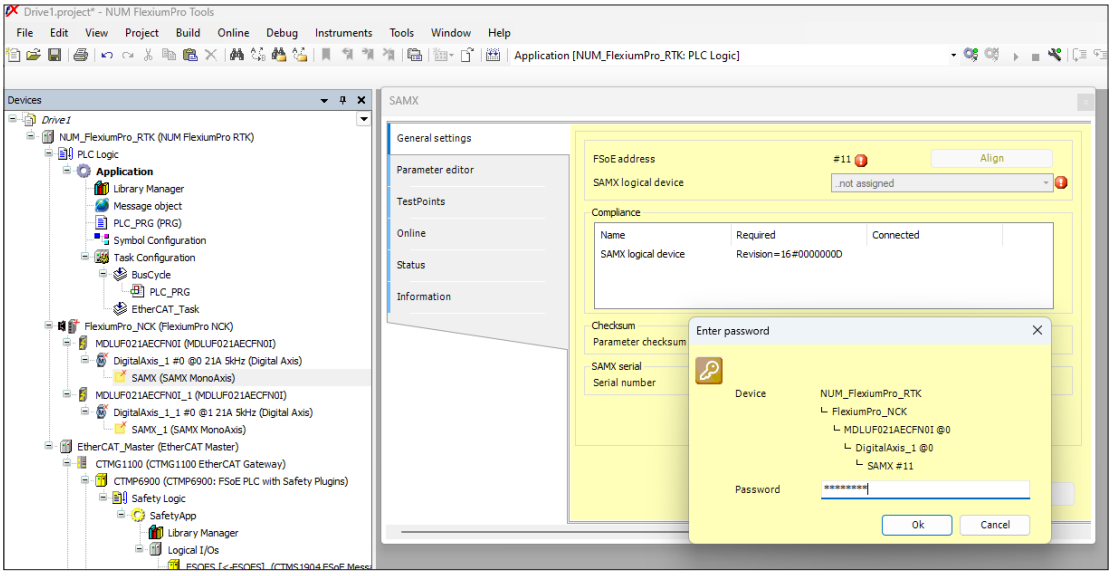

*Parameters folder selection*

### 7.2.1 General setting page

A double-click on the SAMX parameter folder opens the “General settings” context menu.

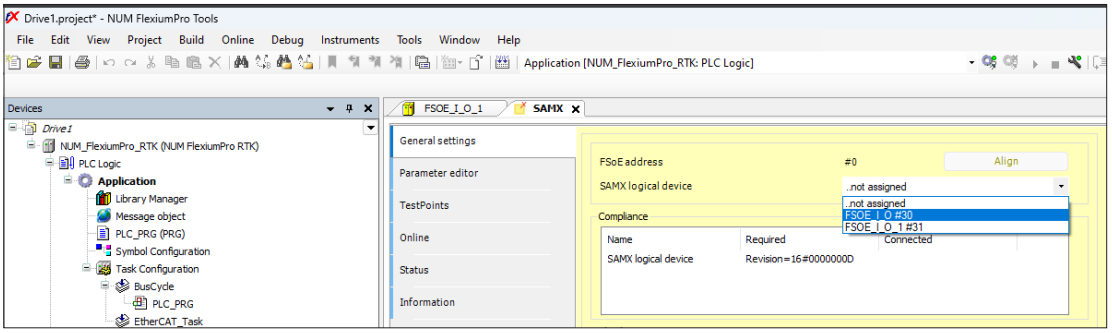



NUM-SAMX device association (press Unlock), insert the default password **SAMXSAFE** and press OK.

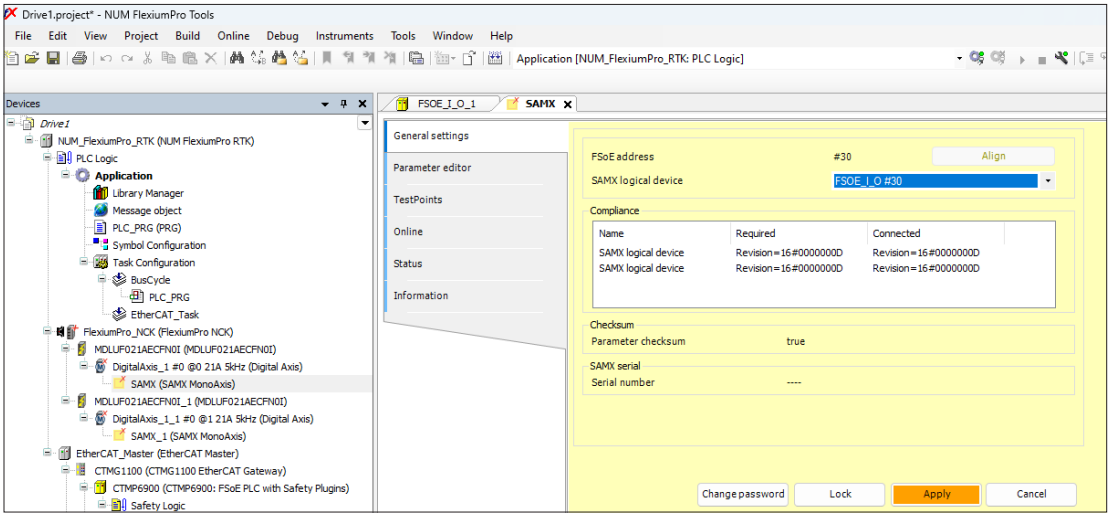


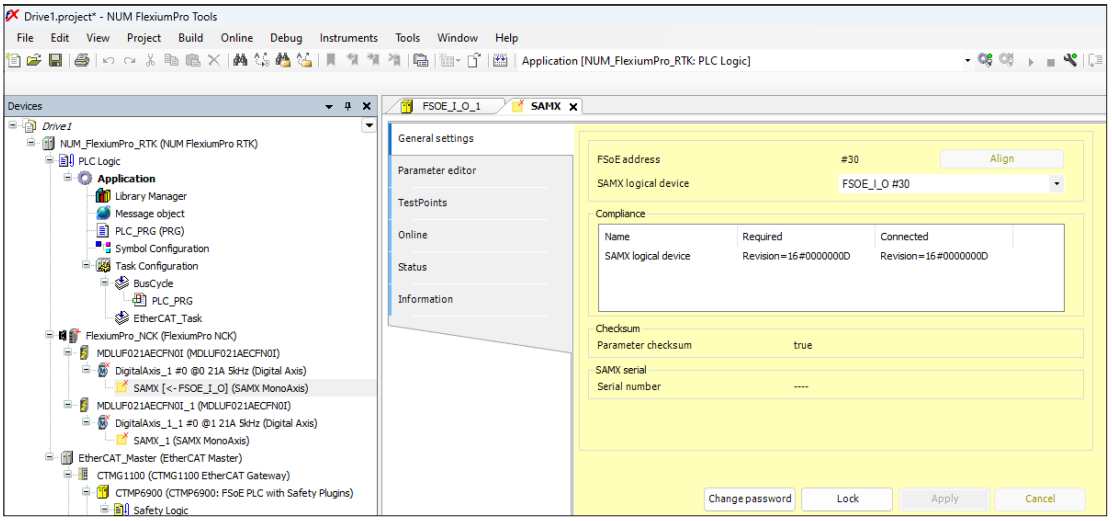
## 7.2.2 NUM-SAMX Device association

Select NUM-SAMX logical device respecting the field location of the NUM-SAMX on the drive respect NUM-SAMX device on EtherCAT field.

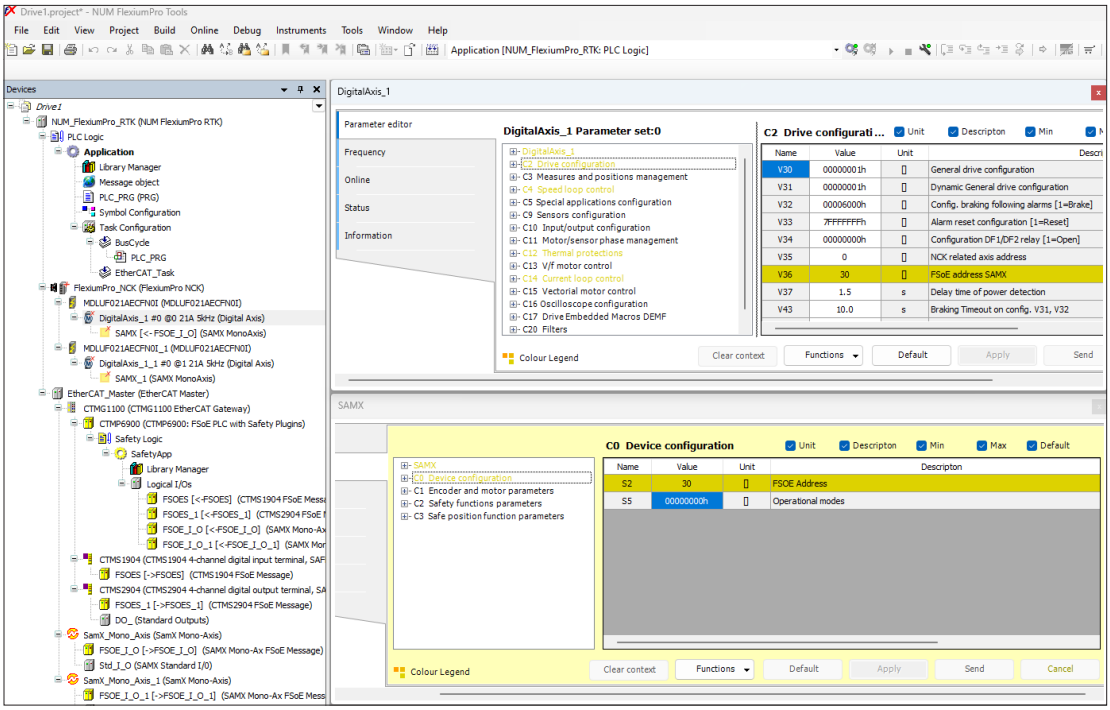



and press “Apply“



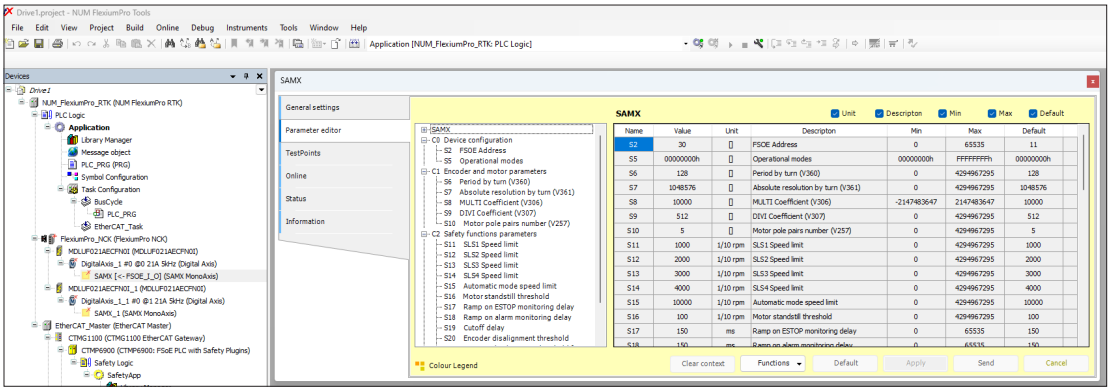



Making “Apply” command the drive parameter V36 and NUM-SAMX parameter *S2* will be automatically loaded with NUM-SAMX FSoE address.

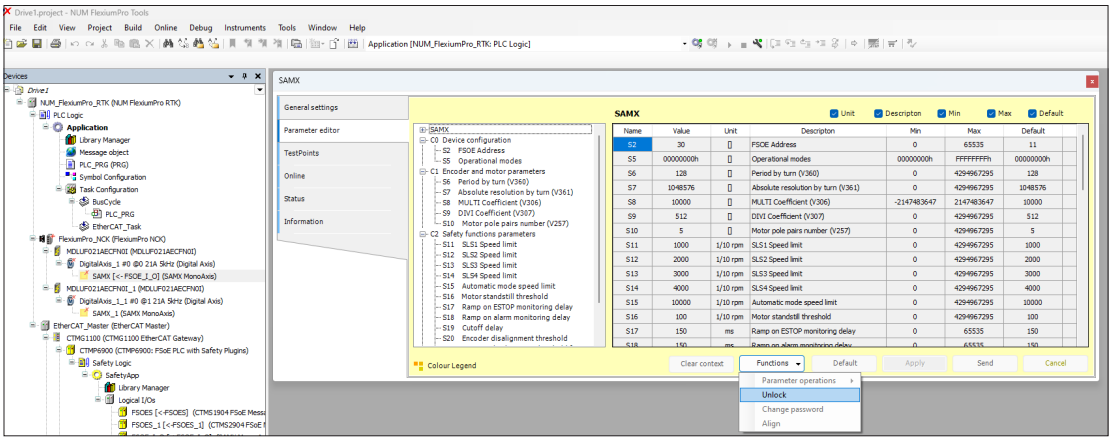


### 7.2.3 NUM-SAMX Parameters editor in OFFLINE mode

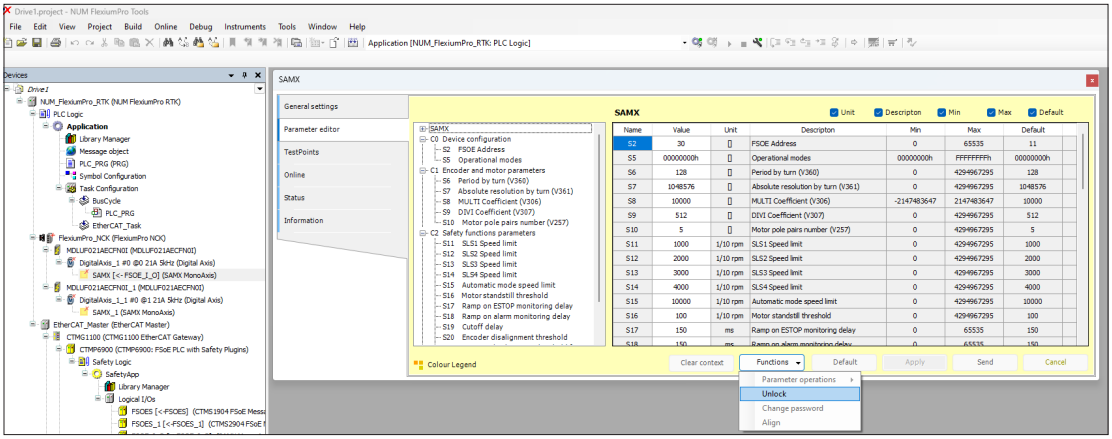
Click on “Parameter editor” to show the parameters page:



Click “Unlock” command to enable the parameters editing.

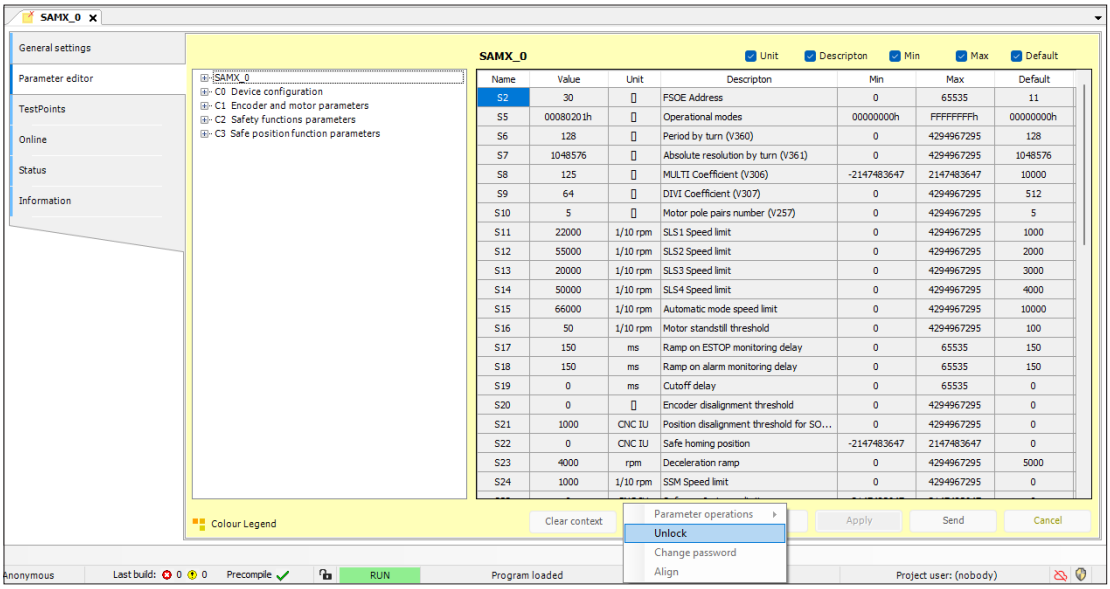



Insert the password (default value **SAMXSAFE**) and press OK.



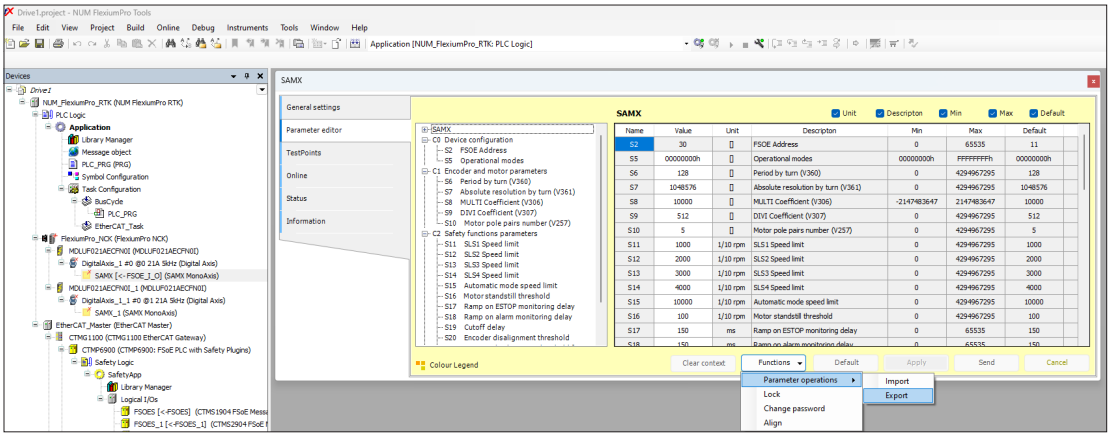
## 7.2.4 NUM-SAMX Parameters editor in ONLINE mode

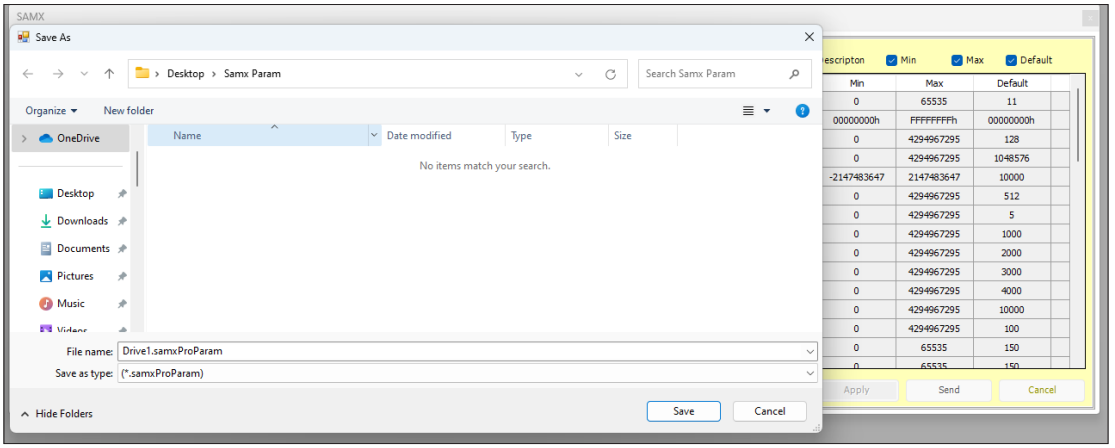
Click on “Parameter editor” to show the parameters page:



## 7.2.5 Export NUM-SAMX Parameter to a *.samxProParam file

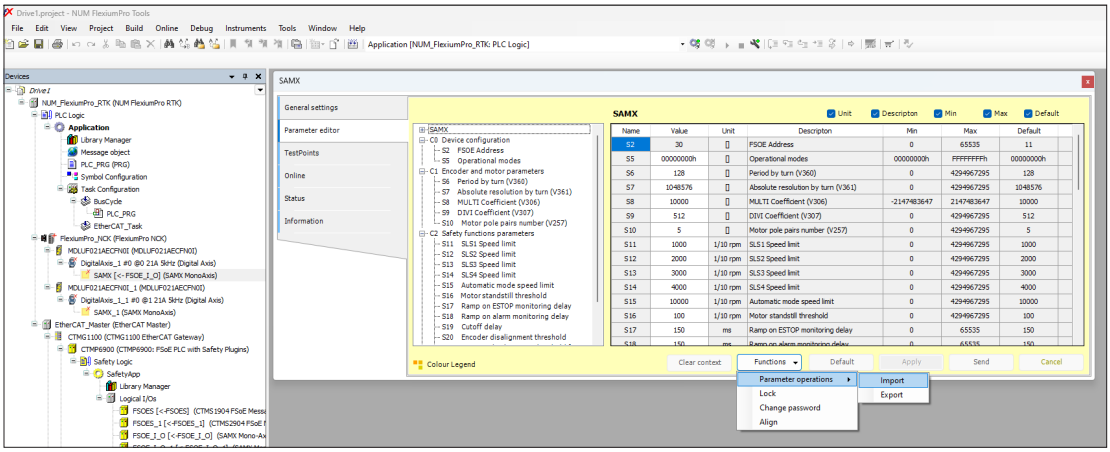
Click on “Export”:

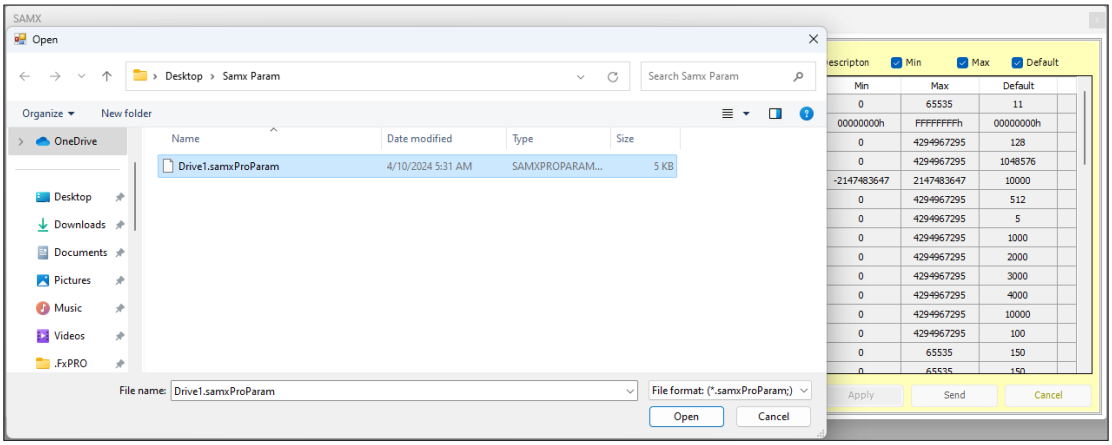


## 7.2.6 Import NUM-SAMX parameter from a *.samxProParam file

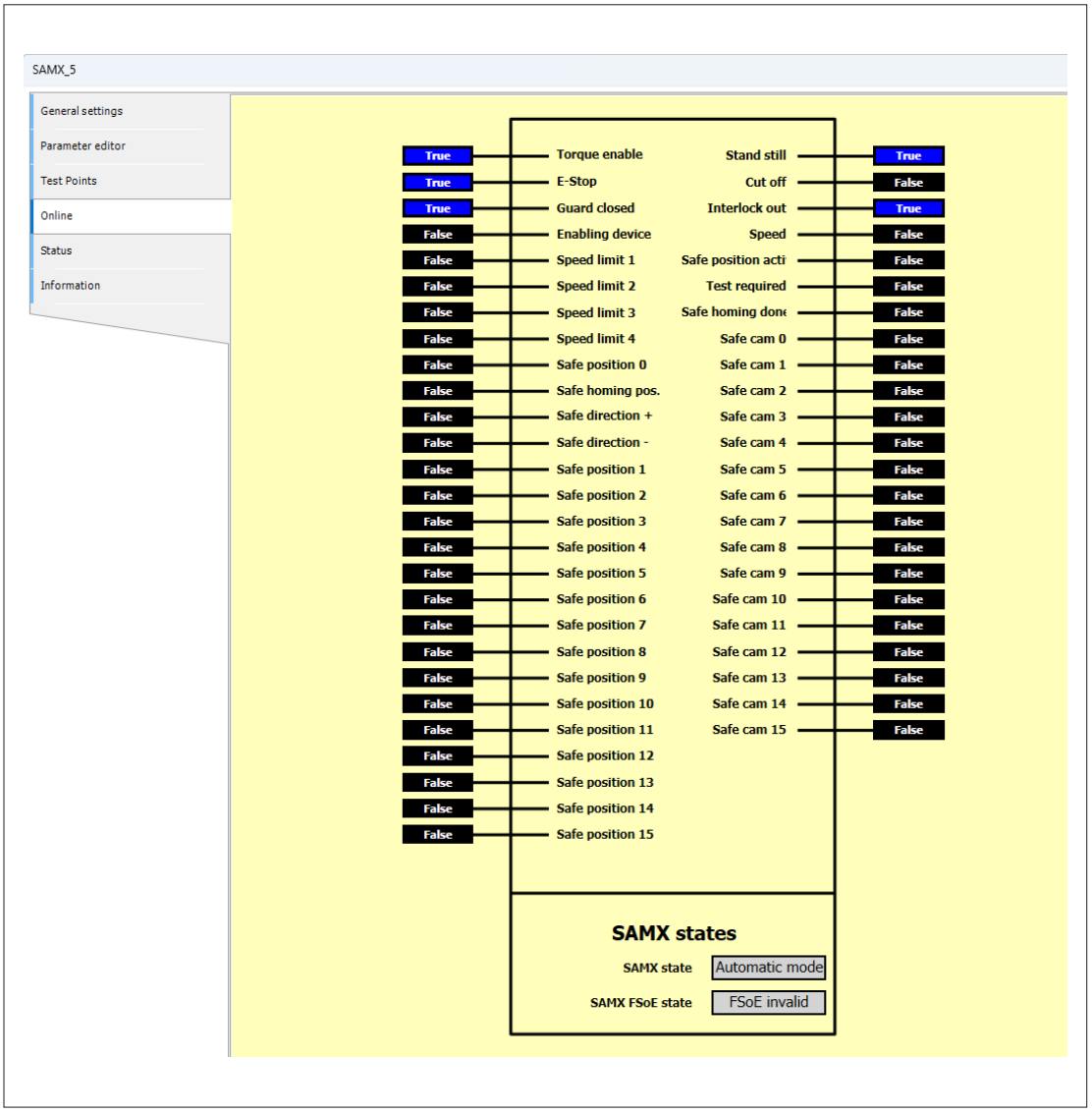
Click on “Import”:



### 7.2.7 NUM-SAMX Diagnostic in ONLINE mode

Click on “Diagnostic” to show the status of the NUM-SAMX FSoE I/Os and NUM-SAMX states.
The map size of the FSoE I/Os depend from the NUM-SAMX revision chosen into the project:

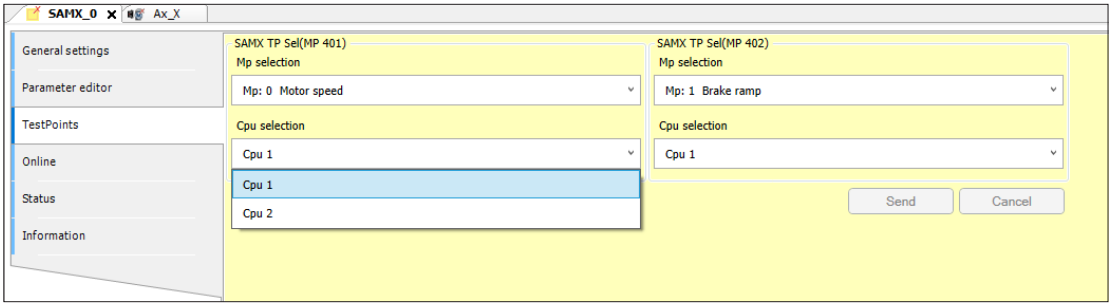


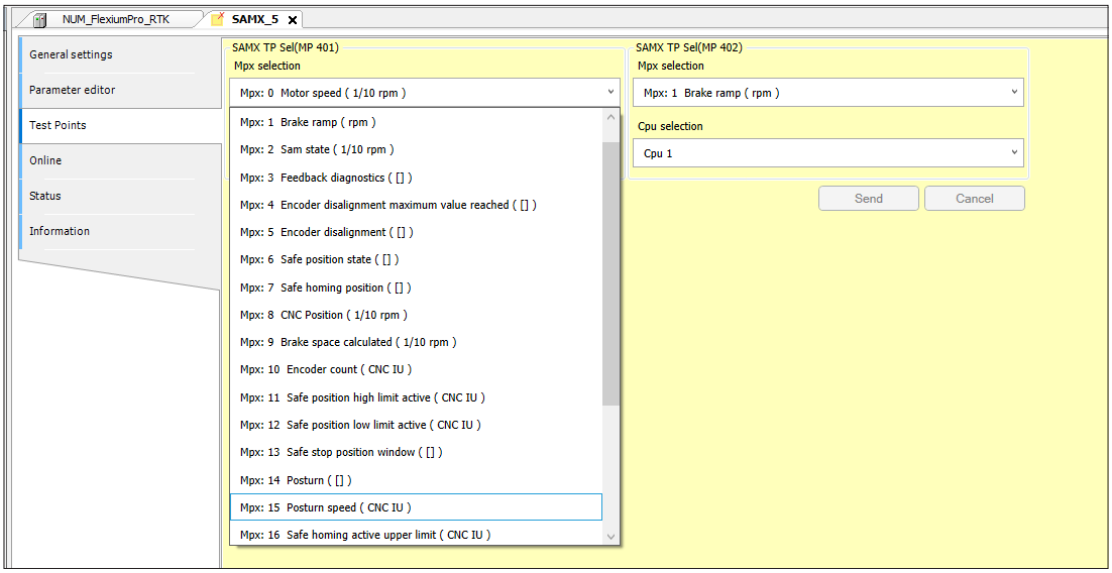
### 7.2.7.1 NUM-SAMX Test points in ONLINE mode

Click on “Test points” to show the Test points page. The test point could be chosen only in ONLINE mode, but the selection remain stored into the NUM-SAMX configuration.

The value took from the NUM-SAMX test point is visible via NUM DrivePro **MP401 and MP402**.

NUM-SAMX has two CPUs so we have to choose the CPU and then the MPX:



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# Summary

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# 8 NUM-SAMX Measure point MPX list

| MPX | Description | Unit | Utilisation |
|---|---|---|---|
| **MPX0** | Motor speed | [ 1/10 rpm ] or [ $1/10 \frac{2 \cdot Polepitch}{min}$ ] | Motor speed calculated by NUM-SAMX based on encoder data. |
| **MPX1** | Brake ramp | [ 1/10 rpm ] or [ $1/10 \frac{2 \cdot Polepitch}{min}$ ] | Braking ramp profile generated by NUM-SAMX, starting from the configuration parameters (*S23* and (*S18* or *S17*)). |
| **MPX2** | Brake ramp starting speed | [ 1/10 rpm ] or [ $1/10 \frac{2 \cdot Polepitch}{min}$ ] | |
| **MPX3** | Feedback diagnostic | [] | Feedback diagnostic on cutoff lines. |
| **MPX4** | Samx state | [] | NUM-SAMX state related to its internal state machine. |
| **MPX5** | Drive state | [] | |
| **MPX6** | Encoder disalignment max | [] | |
| **MPX7** | Encoder disalignment | [] | |
| **MPX8** | Position | CNC IU | Position in CNC increments calculated by NUM-SAMX based on encoder data. |
| **MPX9** | SOS position window | CNC IU | |
| **MPX10** | Brake space | CNC IU | Brake space calculated dynamically by the NUM-SAMX when the axis is moving with the Safe Homing procedure done to check if the movement can cause the axis to exceed Safe Position's limits with not enough space to brake. |
| **MPX11** | Encoder count | [] | |
| **MPX12** | Safe position state | [] | |
| **MPX13** | Safe homing registered position | CNC IU | |
| **MPX14** | Safe homing active upper limit | CNC IU | |
| **MPX15** | Safe homing active lower limit | CNC IU | |
| **MPX16** | Posturn | [] | |
| **MPX17** | Drive's posturn speed | [] | |
| **MPX18** | Drive's safe posturn received | [] | |
| **MPX19** | Posturn difference | [] | |
| **MPX20** | Device die temperature | Celsius | |
| **MPX21** | Failure reason | [] | See chapter 8.1 |

## 8.1 MPX21 meanings

MPX21 is used to store a value that could be used to better understand the root cause of an occurred Safety Alarm. It contents and related unit measure depends from the triggered alarm. The contents is cleared when a drive alarm reset is requested, via NCK reset (FlexiumPro_NCK.WCNC.General.Reset ).

The description stay valid also for the alarms with Extension higher then 100.

This depend from which NUM-SAMX CPU detects the alarm.

Example:

Alarm 61 Ext 1 is detected by CPU1 and Alarm 61 Ext 101 is the same but detected by CPU2.

The value can be read from the CPU 1 or 2 to which the Alarm belong.

| Alarm | Units | Description |
|---|---|---|
| 61 Ext 1 | $\left[ 1/10\ rpm \right]$ or $\left[ 1/10\ \frac{2 \cdot Polepitch}{min} \right]$ | First speed value that exceeded the threshold *S15* (Automatic mode) |
| 61 Ext 2 | $\left[ 1/10\ rpm \right]$ or $\left[ 1/10\ \frac{2 \cdot Polepitch}{min} \right]$ | First speed value that exceeded the threshold *S11... S14* (SLS 1/2/3/4) |
| 61 Ext 3 | CNC IU | Safe limited position - lower limit exceeded |
| 61 Ext 4 | CNC IU | Safe limited position - upper limit exceeded |
| 61 Ext 5 | CNC IU | Position value that is found outside the Safe Position limits |
| 61 Ext 11 | $\left[ \frac{rpm}{s} \right]$ or $\left[ \frac{2 \cdot Polepitch}{min \cdot s} \right]$ | Safe deceleration - not enough brake ramp |
| 61 Ext 12 | CNC IU | Safe operational stop disobeyed - axis exceeded parameter. (*S21*) |
| 62 Ext 1 | [] | CPU1: safe limited speed - invalid SLS selection<br>The showed value is the status of the SLS selection bits |
| 62 Ext 3 | °C | System temperature - too high |
| 62 Ext 4 | °C | System temperature - too low |
| 63 Ext 1 | 1/65536 turn | Value greater than *S20,* that iussues the alarm<br>(for synchronous motor *S5.1* = 0). |
| 63 Ext 2 | $\left[ 1/10\ rpm \right]$ or $\left[ 1/10\ \frac{2 \cdot Polepitch}{min} \right]$ | Value greater than *S20,* that iussues the alarm<br>(for asynchronous motor *S5.1* = 1 and / or for Sensorless V/f motors *S5.17*=1). |
| 64 Ext 1 | V | Hardware error - 3.3V undervoltage/overvoltage |
| 64 Ext 2 | V | Hardware error - 5V undervoltage/overvoltage |
| 64 Ext 3 | V | Hardware error - 7.5V undervoltage/overvoltage |
| 64 Ext 4 | V | CPU1: hardware error - +15V undervoltage/overvoltage |
| 64 Ext 5 | V | Hardware error - VDD undervoltage/overvoltage |
| 64 Ext 6 | V | Hardware error - VDD_flash undervoltage/overvoltage |
| 64 Ext 8 | V | Cutoff feedbacks error - invalid analog value |
| 64 Ext 9 | V | Cutoff feedbacks error - invalid logical state |
| 64 Ext 20 | [] | CPU1: system error - outputs mismatch CPU1-CPU2 ( - 500ms)<br>The showed value is the XOR of the SAMX output bits |

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# 9 Diagnostics and Maintenance

## 9.1 Status of EtherCAT connector S8, S9 LEDs

**LEDs EtherCAT status “Yellow LEDs” on both EtherCAT connectors (S8/S9)**

| LEDs Status | SAMX status | Description |
|---|---|---|
| **OFF** | INITIALIZATION | The SAMX module is in state INIT |
| **Blinking** | PRE-OPERATIONAL | The SAMX module is in PRE-OPERATIONAL state |
| **Single Flash** | SAFE-OPERATIONAL | The SAMX module is in SAFE-OPERATIONAL state |
| **ON** | OPERATIONAL | The SAMX module is in OPERATIONAL state |

**LEDs Link Ethernet active “Green LEDs” on both EtherCAT connectors (S8/S9)**

| LEDs Status | Ethernet activitystatus | Description |
|---|---|---|
| **ON** | No link | Ethernet cable unconnected |
| **Single Flash** | Link without activity | Ethernet cable connected but without any activity |
| **Blinking** | Link and activity | Ethernet cable connected with activity |

## 9.2 NUM-SAMX alarms and alarms extension and trouble shooting

- Safety Class 60 alarms are originated by the NUM DrivePro.
- Safety Class 61, 62, 63, 64 alarms are originated by the NUM-SAMX.

**Alarm 60** Safety Module class 0

These alarms are issued by the NUM DrivePro and they are related to the NUM-SAMX Safety board.

This class of alarms are mainly related to setup (Parameterization of NUM DrivePro and NUM-SAMX) and operating conditions.

The Fault reaction is generally STO.

| Alarm 60 extension | | Trouble shooting |
|---|---|---|
| **255** | NUM-SAMX communication - Togglebit FrameRF does not toggle | NUM-SAMX-SW Error, reboot NUM DrivePro. |
| **256** | NUM-SAMX communication - Wrong communication checksum | |
| **259** | NUM-SAMX requested by control board but not detected | HW Failure:<br>exchange the NUM DrivePro. |
| **260** | NUM-SAMX detected but not requested by control board | Invalid NUM DrivePro Configuration (exchange the NUM DrivePro). |
| **261** | NUM-SAMX doesn't communicate | Reboot NUM DrivePro (remove and apply Aux Power) and if the error is still present: SW of NUM-SAMX not working. (Exchange of NUM DrivePro necessary) |
| **262** | FSoE address NUM-SAMX doesn't match with the parameter V36 | Align the parameters V36 of NUM DrivePro to S2 of NUM-SAMX. |
| **263** | NUM-SAMX alarm code not defined | Wrong Alarm Class.<br>(SW error of NUM-SAMX) |
| **300** | PWM disabled while axis in Operational state | |
| **301** | NUM-SAMX communication - locked: missing msgId increment | |
| **302** | NUM-SAMX communication - failure: SAMX receives wrong CRC | |
| **324** | NUM-SAMX Safe Homing - timeout writing Safe Homing position | |
| **325** | NUM-SAMX Safe Homing - abort writing  Safe Homing position | |
| **326** | NUM-SAMX Safe Homing - unable to write Safe Homing position | |

**Alarm 61** Safety Module class 1

These alarms are issued by the NUM DrivePro and they are related to the NUM-SAMX Safety board.

This class of alarms are mainly related to wrong parameterization of NUM DrivePro and/or NUM-SAMX and invalid operating conditions.

The Fault reaction is generally SS2.

| Alarm 61 extension | | Trouble shooting |
|---|---|---|
| **0** | CPU1: class 1 error forced | Undetected fault condition. |
| **1** | CPU1: automatic mode speed exceeded (*S15*) See chapter 8.1 | |
| **2** | CPU1: SLS mode speed exceeded (*S11...S14*) See chapter 8.1 | |
| **3** | CPU1: safe limited position - lower limit exceeded. See chapter 8.1 This alarm is issued if the NUM-SAMX detects a movement (direction and speed related) that will take the position outside the lower limit. | |
| **4** | CPU1: safe limited position - upper limit exceeded. See Chapter 8.1 This alarm is issued if the NUM-SAMX detects a movement (direction and speed related) that will take the position outside the upper limit. | |
| **5** | CPU1: safe limited position - activated while out of bounds. See chapter 8.1 This alarm is issued if the NUM-SAMX detects a position (axis stopped) outside the position limits. | |
| **6** | CPU1: safe direction plus disobeyed | |
| **7** | CPU1: safe direction minus disobeyed | |
| **8** | CPU1: safe direction invalid - double selection | |
| **9** | CPU1: safe homing invalid - position doesn't match parameter (*S22*) | |
| **10** | CPU1: guard closed disobeyed in automatic mode. | |
| **11** | CPU1: safe deceleration - not enough brake ramp. See chapter 8.1 | |
| **12** | CPU1: safe operational stop disobeyed - axis exceeded parameter. (*S21*). See chapter 8.1 | |
| **14** | CPU1: STO MODE - SLS speed limit selected while STO mode is active | |
| **15** | CPU1: STO or sensorless mode - safe homing requested while STO mode or sensorless mode are active | |
| **16** | CPU1: STO MODE - guards closed disobeyed while STO mode is active | |
| **17** | CPU1: STO or sensorless mode - safe direction selected while STO mode or sensorless mode are active | |
| **18** | CPU1: STO MODE - E-Stop pressed while STO mode is active | |
| **20** | CPU1: safe position 0 - limits invalid (S32 - S33) | |
| **21** | CPU1: safe position 1 - limits invalid (S34 - S35) | |
| **22** | CPU1: safe position 2 - limits invalid (S36 - S37) | |
| **23** | CPU1: safe position 3 - limits invalid (S38 - S39) | |
| **24** | CPU1: safe position 4 - limits invalid (S40 - S41) | |
| **25** | CPU1: safe position 5 - limits invalid (S42 - S43) | |
| **26** | CPU1: safe position 6 - limits invalid (S44 - S45) | |
| **27** | CPU1: safe position 7 - limits invalid (S46 - S47) | |
| **28** | CPU1: safe position 8 - limits invalid (S48 - S49) | |
| **29** | CPU1: safe position 9 - limits invalid (S50 - S51) | |
| **30** | CPU1: safe position 10 - limits invalid (S52 - S53) | |
| **31** | CPU1: safe position 11 - limits invalid (S54 - S55) | |
| **32** | CPU1: safe position 12 - limits invalid (S56 - S57) | |
| **33** | CPU1: safe position 13 - limits invalid (S58 - S59) | |
| **34** | CPU1: safe position 14 - limits invalid (S60 - S61) | |
| **35** | CPU1: safe position 15 - limits invalid (S62 - S63) | |
| **100** | CPU2: class 1 error forced | Undetected fault condition. |
| **101** | CPU2: automatic mode speed exceeded (*S15*). See chapter 8.1 | All the following Alarms are referred to invalid operating conditions or wrong parameterization. |
| **102** | CPU2: SLS mode speed exceeded (*S11...S14*) See chapter 8.1 | |

| Alarm 61 extension | | Trouble shooting |
|---|---|---|
| **103** | CPU2: safe limited position - lower limit exceeded. This alarm is issued if the NUM-SAMX detects a movement (direction and speed related) that will take the position outside the lower limit. See chapter 8.1 | |
| **104** | CPU2: safe limited position - upper limit exceeded. This alarm is issued if the NUM-SAMX detects a movement (direction and speed related) that will take the position outside the upper limit. See chapter 8.1 | |
| **105** | CPU2: safe limited position - activated while out of bounds See chapter 8.1 This alarm is issued if the NUM-SAMX detects a position (axis stopped) outside the position limits. | |
| **106** | CPU2: safe direction plus disobeyed | |
| **107** | CPU2: safe direction minus disobeyed | |
| **108** | CPU2: safe direction invalid - double selection | |
| **109** | CPU2: safe homing invalid - position doesn't match parameter (*S22*) | |
| **110** | CPU2: guard closed disobeyed in automatic mode. | |
| **111** | CPU2: safe deceleration - not enough brake ramp. See chapter 8.1 | |
| **112** | CPU2: safe operational stop disobeyed - axis exceeded parameter (*S21*). See chapter 8.1 | |
| **114** | CPU2: STO MODE - SLS speed limit selected while STO mode is active See chapter 8.1 | |
| **115** | CPU2: STO or sensorless mode - safe homing requested while STO mode or sensorless mode are active | |
| **116** | CPU2: STO MODE - guards closed disobeyed while STO mode is active | |
| **117** | CPU2: STO or sensorless mode - safe direction selected while STO mode or sensorless mode are active | |
| **118** | CPU2: STO MODE - E-Stop pressed while STO mode is active See chapter 8.1 | |
| **120** | CPU2: safe position 0 - limits invalid *(S32 - S33)* | |
| **121** | CPU2: safe position 1 - limits invalid *(S34 - S35)* | |
| **122** | CPU2: safe position 2 - limits invalid *(S36 - S37)* | |
| **123** | CPU2: safe position 3 - limits invalid *(S38 - S39)* | |
| **124** | CPU2: Safe position 4 - limits invalid *(S40 - S41)* | |
| **125** | CPU2: safe position 5 - limits invalid *(S42 - S43)* | |
| **126** | CPU2: safe position 6 - limits invalid *(S44 - S45)* | |
| **127** | CPU2: Safe position 7 - limits invalid *(S46 - S47)* | |
| **128** | CPU2: safe position 8 - limits invalid *(S48 - S49)* | |
| **129** | CPU2: safe position 9 - limits invalid *(S50 - S51)* | |
| **130** | CPU2: safe position 10 - limits invalid *(S52 - S53)* | |
| **131** | CPU2: safe position 11 - limits invalid *(S54 - S55)* | |
| **132** | CPU2: safe position 12 - limits invalid *(S56 - S57)* | |
| **133** | CPU2: safe position 13 - limits invalid *(S58 - S59)* | |
| **134** | CPU2: safe position 14 - limits invalid *(S60 - S61)* | |
| **135** | CPU2: safe position 15 - limits invalid *(S62 - S63)* | |

**Alarm 62** Safety Module class 2

These alarms are issued by the NUM DrivePro and they are related to the NUM-SAMX Safety board.

This class of alarms are mainly related to setup (Parameterization of NUM DrivePro and NUM-SAMX) and operating conditions.

The Fault reaction is generally SS2.

| Alarm 62 extension | | Trouble shooting |
|---|---|---|
| **0** | CPU1: class 2 error forced | Undetected fault condition. |
| **1** | CPU1: safe limited speed - invalid SLS selection See chapter 8.1 | The Safe PLC Input Speed selector have an invalid combination. |
| **2** | CPU1: system temperature - sensor failure | NUM-SAMX HW Error. (Exchange the NUM DrivePro) |
| **3** | CPU1: system temperature - too high. See chapter 8.1 | Invalid operating condition. (Control air conditioner of cabinet) |
| **4** | CPU1: system temperature - too low. See chapter 8.1 | Invalid operating conditions. (Pullover for NUM-SAMX needed) |
| **100** | CPU2: class 2 error forced | Undetected fault condition. |
| **101** | CPU2: safe limited speed - invalid SLS selection See chapter 8.1 | The Safe PLC Input Speed selector have an invalid combination. |
| **102** | CPU2: system temperature - sensor failure | NUM-SAMX HW Error. (Exchange the NUM DrivePro) |
| **103** | CPU2: system temperature - too high. See chapter 8.1 | Invalid operating condition. (Control air conditioner of cabinet) |
| **104** | CPU2: system temperature - too low. See chapter 8.1 | Invalid operating conditions. (Pullover for NUM-SAMX needed) |

**Alarm 63** Safety Module class 3

These alarms are issued by the NUM DrivePro and they are related to the NUM-SAMX Safety board.

This class of alarms are mainly related to either invalid Setup conditions (Parameters) or dynamic errors. Generally the motor is moving during the occurrence.

The Fault reaction is STO.

All the NUM-SAMX Logical Output are put = 0 except **CutOff** = 1.

| Alarm 63 extension | | Trouble shooting |
|---|---|---|
| **0** | CPU1: class 3 error forced | Undetected fault condition. |
| **1** | CPU1: system error - encoder disalignment with drive *(S20)* See chapter 8.1 | Encoder Counter mismatch between NUM DrivePro and NUM-SAMX: Align *S6*/*S7* to V360/V361 parameters.<br><br>Control *S20*:<br>if the Error appears at high speed increase *S20*. |
| **2** | CPU1: system error - speed disalignment with drive *(S20)* See chapter 8.1 | Chek *S6* and *S7* values.<br>If the error happens with high accelleration ramp, increase *S20* value. |
| **100** | CPU2: class 3 error forced | Undetected fault condition. |
| **101** | CPU2: system error - encoder disalignment with drive *(S20)* See chapter 8.1 | Encoder Counter mismatch between NUM DrivePro and NUM-SAMX: Align *S6*/*S7* to V360/V361 parameters.<br><br>Control *S20*:<br>if the Error appears at high speed increase *S20*. |
| **102** | CPU2: system error - speed disalignment with drive *(S20)* See chapter 8.1 | Chek *S6* and *S7* values.<br>If the error happens with high accelleration ramp, increase *S20* value. |

**Alarm 64** Safety Module class 4

These alarms are issued by the NUM DrivePro and they are related to the NUM-SAMX Safety board.

This class of alarms are related to the result of HW and SW diagnostic tests.

The Fault reaction is STO.

All the NUM-SAMX Logical Output are put = 0 except **CutOff** = 1.

| Alarm 64 extension | | Trouble shooting |
|---|---|---|
| **0** | CPU1: class 4 error forced | Undetected fault condition. |
| **1** | CPU1: hardware error - 3.3V undervoltage/overvoltage See chapter 8.1 | HW Error.(Exchange the NUM DrivePro) |
| **2** | CPU1: hardware error - 5V undervoltage/overvoltage See chapter 8.1 | |
| **3** | CPU1: hardware error - 7.5V undervoltage/overvoltage See chapter 8.1 | |
| **4** | CPU1: hardware error - +15V undervoltage/overvoltage See chapter 8.1 | |
| **5** | CPU1: hardware error - VDD undervoltage/overvoltage See chapter 8.1 | |
| **6** | CPU1: hardware error - VDD_flash undervoltage/overvoltage See chapter 8.1 | |
| **7** | CPU1: communication error - CPU1-CPU2 | |
| **8** | CPU1: cutoff feedbacks error - invalid analog value See chapter 8.1 | |
| **9** | CPU1: cutoff feedbacks error - invalid logical state See chapter 8.1 | |
| **10** | CPU1: system error - serial number mismatch with drive, default parameters reloaded | Change the Parameter File or at least one parameter and reset the alarm. |
| **11** | CPU1: system error - parameters' CRC mismatch CPU1-CPU2 | The Checksum of the User Parameter file is different.<br><br>Since it is not possible to know what parameters does not match:<br>1. Save parameter file to HD.<br>2. Reload the Parameter file.<br>3. Reset the Error. |
| **12** | CPU1: system critical error - stack overflow | SW Error: Control SW Release and known bug list (if any). |
| **13** | CPU1: system critical error - instruction memory corruption | HW Error. (Exchange the NUM DrivePro) |
| **14** | CPU1: system critical error - flash data memory corruption | Reload Application SW and FW. |
| **15** | CPU1: system error - parameters' CRC invalid | Reload Parameter file. |
| **16** | CPU1: system critical error - L1 cache corruption | HW Error. (Exchange the NUM DrivePro) |
| **17** | CPU1: communication error - drive's CRC invalid | Electrical noise if the error occurs sometimes) or HW error if the error is present even with drive disabled. |
| **18** | CPU1: system critical error - SAMX model not coherent with drive | Invalid NUM-SAMX SW (Mono-Axis<br>instead of Bi-Axis or viceversa) or invalid Ethercat EEPROM content.<br>Control SW Version:<br>- 3.xx.yyyy Mono-Axis<br>- 4.xx.yyyy Bi-Axes<br>If Sw version is ok download XML through Ethercat into EEPROM of Ethercat-IP. |
| **19** | CPU1: system critical error - Arithmetic Logic Unit failure | Mismatch in pulse counting: noise or HW Error if persistent. |
| **20** | CPU1: system error - outputs mismatch CPU1-CPU2 ( - 500ms) See chapter 8.1 | Invalid operating condition or SW error or dynamic incongruency. |

| Alarm 64 extension | | Trouble shooting |
|---|---|---|
| **21** | CPU1: system critical error - oscillator frequency mismatch CPU1-CPU2 | HW Error: Replace the NUM DrivePro. |
| **22** | CPU1: system error - encoder count mismatch CPU1-CPU2 | |
| **23** | CPU1: cutoff feedbacks error - cutoff dynamic test not passed | Download compatible FW release. (076XYY000001.xlv) |
| **25** | CPU1: hiperface DSL protocol error - communication KO | NUM-SAMX HW Failure. (Exchange the NUM DrivePro) |
| **26** | CPU1: hiperface DSL protocol error - communication CRC invalid | Check *S5* bit 8 set to 1 for DSL Encoder with Hiperface protocol. If the used encoder is coherent to the safe parameter, an HW failure is detected. (Exchange the NUM DrivePro module or Encoder) |
| **27** | CPU1: hiperface DSL protocol error - communication FIX2 pattern invalid | |
| **30** | CPU1: system config error - sensorless can be activated only on motor M1 | |
| **32** | CPU1: system config error - sensorless monitoring speed active too low | |
| **33** | CPU1: system config error - STO mode and sensorless mode do not allow standstill function, S16 must be set to zero | |
| **40** | CPU1: system config error - STO mode does not allow speed monitoring, *S15* must be set to zero | |
| **70** | CPU1: system config error - invalid motor type selection | See note (1) chapter 6.3.3 |
| **71** | CPU1: system config error - invalid encoder type selection | See note (2) chapter 6.3.3 |
| **72** | CPU1: system config error - invalid operational mode selection | See note (3) chapter 6.3.3 |
| **100** | CPU2: class 4 error forced | Undetected fault condition. |
| **101** | CPU2: hardware error - 3.3V undervoltage/overvoltage See chapter 8.1 | HW Error. (Exchange the NUM DrivePro) |
| **102** | CPU2: hardware error - 5V undervoltage/overvoltage See chapter 8.1 | |
| **103** | CPU2: hardware error - 7.5V undervoltage/overvoltage See chapter 8.1 | |
| **104** | CPU2: hardware error - +15V undervoltage/overvoltage See chapter 8.1 | |
| **105** | CPU2: hardware error - VDD undervoltage/overvoltage See chapter 8.1 | |
| **106** | CPU2: hardware error - VDD_flash undervoltage/overvoltage See chapter 8.1 | |
| **107** | CPU2: communication error - CPU1-CPU2 | |
| **108** | CPU2: cutoff feedbacks error - invalid analog value See chapter 8.1 | |
| **109** | CPU2: cutoff feedbacks error - invalid logical state See chapter 8.1 | |
| **110** | CPU2: system error - serial number mismatch with drive, default parameters reloaded | Change the Parameter File or at least one parameter and reset the alarm. |
| **111** | CPU2: system error - parameters' CRC mismatch CPU1-CPU2 | The Checksum of the User Parameter file is different.<br><br>Since it is not possible to know what parameters does not match:<br>1. Save parameter file to HD.<br>2. Reload the Parameter file.<br>3. Reset the Error. |
| **112** | CPU2: system critical error - stack overflow | SW Error: Control SW Release and known bug list (if any). |
| **113** | CPU2: system critical error - instruction memory corruption | HW Error. (Exchange the NUM DrivePro) |
| **114** | CPU2: system critical error - flash data memory corruption | Reload Application SW and FW. |
| **115** | CPU2: system error - parameters' CRC invalid | Reload Parameter file. |
| **116** | CPU2: system critical error - L1 cache corruption | HW Error.(Exchange the NUM DrivePro) |

| Alarm 64 extension | | Trouble shooting |
|---|---|---|
| **117** | CPU2: communication error - drive's CRC invalid | Electrical noise if the error occurs sometimes) or HW error if the error is present even with drive disabled. |
| **118** | CPU2: system critical error - SAMX model not coherent with drive | Invalid NUM-SAMX SW (Mono-Axis instead of Bi-Axis or viceversa) or invalid Ethercat EEPROM content.<br>Control SW Version:<br>- 3.xx.yyyy Mono-Axis<br>- 4.xx.yyyy Bi-Axes<br><br>If Sw version is OK download XML through Ethercat into EEPROM of Ethercat-IP. |
| **119** | CPU2: system critical error - Arithmetic Logic Unit failure | Mismatch in Pulse Counting: noise or HW Error if persistent. |
| **120** | CPU2: system error - outputs mismatch CPU1-CPU2 ( - 500ms)<br>See chapter 8.1 | Invalid Operating Condition or SW Error or dynamic incongruously. |
| **121** | CPU2: system critical error - oscillator frequency mismatch CPU1-CPU2 | HW Error: Replace the NUM DrivePro. |
| **122** | CPU2: system error - encoder count mismatch CPU1-CPU2 | |
| **123** | CPU2: cutoff feedbacks error - cutoff dynamic test not passed | Download compatible FW release. (076XYY000001.xlv) |
| **125** | CPU2: hiperface DSL protocol error - communication KO | NUM-SAMX HW Failure. (Exchange the NUM DrivePro) |
| **126** | CPU2: hiperface DSL protocol error - communication CRC invalid | Check *S5* bit 8 set to 1 for DSL Encoder with Hiperface protocol. If the used encoder is coherent to the safe parameter, an HW failure is detected. (Exchange the NUM DrivePro module or Encoder). |
| **127** | CPU2: hiperface DSL protocol error - communication FIX2 pattern invalid | |
| **130** | CPU2: system config error - sensorless can be activated only on motor M1 | |
| **132** | CPU2: system config error - sensorless monitoring speed active too low | |
| **133** | CPU2: system config error - STO mode and sensorless mode do not allow standstill function, S16 must be set to zero | |
| **140** | CPU2: system config error - STO mode does not allow speed monitoring, S15 must be set to zero | |
| **170** | CPU2: system config error - invalid motor type selection | See note (1) chapter 6.3.3 |
| **171** | CPU2: system config error - invalid encoder type selection | See note (2) chapter 6.3.3 |
| **172** | CPU2: system config error - invalid operational mode selection | See note (3) chapter 6.3.3 |

Diagnostic tests and fault reaction functions are realized inside of the NUM-SAMX board.

Therefore no external feedbacks should be used by external device.

## 9.3 Fault reaction and Response time

### 9.3.1 PDS fault reaction

NUM-SAMX triggers four Safety Failure classes (61, 62, 63, 64), see chapter 8.1 for details, the PDS reaction depends on the fault family and depends on drive setting.

**Safety Failure classes 61 and 62**:

- NUM-SAMX generate an alarm and start the SS2 monitoring function.
- NUM DrivePro reacts to such alarm in functions of the drive parameter V32, V30 and V31.
- The Safety Failure classes 61 and 62 are triggered in case the safety thresholds are disobeyed (when corresponding safety mode is active).

The NUM DrivePro reaction is as follows:

- *Safety Failure class 61*: with the drive parameter V32 bit 13 it's possible to define whether to remove the power to the motor or start braking.
  (See NUM DrivePro parameter manual M00066)
- *Safety Failure class 62*: with the drive parameter V32 bit 14 it's possible to define whether to remove the power to the motor or start braking.
  (See NUM DrivePro parameter manual M00066)
- In case the drive parameter V32 is set to start braking the V30 bit 5 defines how to brake: with drive ramps or with maximum current. The deceleration ramps are defined in the drive parameter V91 (see NUM DrivePro parameter manual M00066)
- In case the drive parameter V31 bi 9 is set, the E-Stop request is sent to the FlexiumPro in order to activate the G75 retraction function (see FlexiumPro Programming manual M00073 for G75 definition / managing).

**Safety Failure classes 63 and 64:**

- NUM-SAMX generate an alarm and activate the STO function (power removal).
- The Safety Failure classes 63 and 64 are triggered in case of internal diagnostic failure.
  (NUM SAMX faults that can be due to hardware, software, noise etc.)

**Fault reaction and Response time**

| CNC alarm display | Fault reaction | Response time |
|---|---|---|
| **60 Safety Module class 0** | STO | < 50µs |
| **61 Safety Module class 1** | SS2 | < 10ms |
| **62 Safety Module class 2** | SS2 | < 10ms |
| **63 Safety Module class 3** | STO | < 50µs |
| **64 Safety Module class 4** | STO | < Diagnostic Interval/Procedure Duration + 50µs |

## 9.4 State of being maintained

### 9.4.1 Maintenance

The NUM-SAMX safety module are maintenance-free!

**Observe the specified environmental conditions!**
Please ensure that the NUM-SAMX safety module are only stored and operated under the specified conditions (see technical data).

If the terminal is operated outside the permitted temperature range it will switch to Global Fault state, see the chapter Diagnosis.

Cleaning

Protect the NUM-SAMX safety module from unacceptable soling during operation and storage!

If the NUMSafe Bus Terminal were subjected to unacceptable soiling they may no longer be operated!

**Have soiled terminals checked!**
Cleaning of the NUM-SAMX safety module by the user is not permitted!
Please send soiled terminals to the manufacturer for inspection and cleaning.

## 9.5 Service life

The NUM-SAMX safety module are designed for a service life of 20 years.

Due to the high diagnostic coverage within the life cycle no special proof tests are required.

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