Bonfiglioli

Vectron

AXIA VERT
Functional Safety Module Manual
SMA-MOT-11

Frequency inverter 230 V / 400 V
0,25 kW ... 15 kW

Bonfiglioli

TABLE OF CONTENTS

1 General Information about the Documentation

1.1 Instruction Manuals

For better clarity, the documentation is structured according to the customer-specific requirements made on the frequency inverter.

Quick Start Guide

The "Quick Start Guide" describes the basic steps required for mechanical and electrical installation of the frequency inverter. The guided commissioning supports you in the selection of necessary parameters and the configuration of the frequency inverter by the software.

Operating Instructions

The Operating Instructions document the complete functionality of the frequency inverter. The parameters required for special purposes, for adjustment to the application and the numerous additional functions are described in detail.

Application manual

The application manual supplements the documentation for purposeful installation and commissioning of the frequency inverter. Information on various topics in connection with the use of the frequency inverter is described in context with the specific application.

> If you need a copy of the documentation or additional information, contact your local representative of BONFIGLIOLI.

The following instructions are available for the *AXIA* series:

AXIA Operating Instructions	Function of frequency inverter.
Quick Start Guide *AXIA*	Installation and commissioning Supplied with the device.
Manuals Communication interfaces	
Manuals Extension modules	
Functional Safety manual	Safety functions
Application manuals	Application-specific settings, best practices and preconditions
Graphical User Interface Manual	Description of intended use of the GUI

Safety over EtherCAT®

> The products for EtherCAT® communication comply with the specifications of the user organization ETG (EtherCAT Technology Group).

> EtherCAT® and Safety over EtherCAT® are registered trademarks and patented technologies, licensed by Beckhoff Automation GmbH, Germany.

The present documentation was prepared with great care and it was subjected to extensive and repeated reviews. For reasons of clarity, it was not possible to include all details of all types of the product in the documentation. Neither was it possible to consider all conceivable installation, operation or maintenance situations. If you require further information or if you meet with specific problems which are not dealt with in sufficient detail in the documentation, contact your local BONFIGLIOLI agent.

The original operating instructions was written in English. Other language versions are translations of the original operating instructions.

1.2   This Document

This document pertains to the Functional Safety of frequency inverters of the *AXIA* series in combination with SMA-MOT-11 Safety Module.

The Functional Safety manual contains important information on the installation and the use of the product in its specified application range. Compliance with user documentation contributes to avoiding risks, minimizing repair cost and downtimes and increasing the reliability and service live of the frequency inverter.

For this reason, make sure you read the Functional Safety manual carefully.

IMPORTANT:

Compliance with the documentation is required to ensure safe operation of the frequency inverter. Bonfiglioli Deutschland GmbH shall not be held liable for any damage caused by any non-compliance with the documentation.

ℹ	In case any problems occur which are not covered by the documentation sufficiently, please contact the manufacturer.

ℹ	For safe commissioning and operation of the AXV (AXIA) series, the following documentation must be complied with:

–   The Operating Instructions Document
–   This Functional Safety manual "Safety Manual"

Validity / Applicability

This document applies to the following frequency inverter series:

–   AXIA

1.3   Target Audience

This manual is aimed at individuals with the qualification level "Qualified Electricians" and higher. See Chapter "Terminology" below for definition of qualification levels.

1.4   Warranty and Liability

BONFIGLIOLI Deutschland GmbH (hereinafter referred to as "manufacturer") notes that the contents of this document do not form part of any previous or existing agreement, assurance or legal relationship between the manufacturer and the user of this document (hereinafter referred to as the "User"). Neither are they intended to supplement or replace such agreements, assurances or legal relationships. Any obligations of the manufacturer shall solely be based on the relevant purchase agreement which also includes the complete and solely valid warranty stipulations. These contractual warranty provisions are neither extended nor limited by the specifications contained in this documentation.

The manufacturer reserves the right to correct or amend the specifications, product information and omissions in this document without prior notice. The manufacturer assumes no responsibility to update this document. The manufacturer shall not be liable for any damage, injuries or costs which may be caused by the aforementioned reasons.

In addition, the manufacturer excludes any warranty and disclaims all liability, including without limitation direct, indirect, special, punitive, incidental, exemplary or consequential damages arising out of or in connection with one or more of the following causes:

–   inappropriate use of the frequency inverter,
–   non-compliance with the instructions, warnings and prohibitions contained in the documentation,
–   unauthorized modifications of the frequency inverter,
–   insufficient monitoring of parts of the machine/plant which are subject to wear,
–   repair work at the machine/plant not carried out properly or in time,
–   catastrophes by external impact and Force Majeure.

1.5   Obligation

The Functional Safety manual must be read before commissioning and complied with. Anybody entrusted with tasks in connection with the

−   transport,
−   assembly,
−   installation of the frequency inverter and
−   operation of the frequency inverter

must have read and understood the Functional Safety manual and, in particular, the safety instructions in order to prevent personal and material losses.

1.6   Copyright

In accordance with applicable law any copyrights relating to this document shall remain with

> BONFIGLIOLI Deutschland GmbH
> Europark Fichtenhain B6
> 47807 Krefeld
> Germany

This document is intended for the operator of the frequency inverter. Any disclosure or copying of this document, exploitation and communication of its contents (as hardcopy or electronically) shall be forbidden, unless permitted expressly.

Any non-compliance will constitute an offense against the copyright law, the law against unfair competition and the German Civil Code and may result in claims for damages. All rights relating to patent, utility model or design registration reserved.

1.7   Storage of Documents

The documentation forms an integral part of the frequency inverter. It must be stored such that it is accessible to operating staff at all times. If the frequency inverter is sold on to other users, then the documentation must also be handed over.

2 General Safety Instructions and Information On Use

This chapter contains general safety instructions for the Operator and the Operating Staff. At the beginning of certain main chapters, some safety instructions are included which apply to all work described in the relevant chapter. Special work-specific safety instructions are provided before each safety-relevant work step.

2.1 Terminology

According to the documentation, different activities must be performed by certain persons with certain qualifications.

The groups of persons with the required qualification are defined as follows:

Operator

This is the entrepreneur/company who/which operates the frequency inverter and uses it as per the specifications or has it operated by qualified and instructed staff.

Operating staff

The term Operating Staff covers persons instructed by the Operator of the frequency inverter and assigned the task of operating the frequency inverter.

Skilled Personnel

The term Skilled Personnel covers staff that are assigned special tasks by the Operator of the frequency inverter, e.g. installation, maintenance and service/repair and troubleshooting. Based on their qualification and/or know-how, Skilled Personnel must be capable of identifying defects and assessing functions.

Qualified electrician

The term Qualified Electrician covers qualified and trained staff who has special technical know-how and experience with electrical installations. In addition, Qualified Electricians must be familiar with the applicable standards and regulations, they must be able to assess the assigned tasks properly and identify and eliminate potential hazards. Qualified electricians must have well-founded knowledge in functional safety and applicable norms, e.g. ISO 13849.

Instructed person

The term Instructed Person covers staff who was instructed and trained about/in the assigned tasks and the potential hazards that might result from inappropriate behavior. In addition, instructed persons must have been instructed in the required protection provisions, protective measures, the applicable directives, accident prevention regulations as well as the operating conditions and verified their qualification. Instructed persons must have well-founded knowledge in functional safety and applicable norms, e.g. ISO 13849.

Expert

The term Expert covers qualified and trained staff who has special technical know-how and experience relating to frequency inverter. Experts must be familiar with the applicable government work safety directives, accident prevention regulations, guidelines and generally accepted rules of technology in order to assess the operationally safe condition of the frequency inverter. Experts must have well-founded knowledge in functional safety and applicable norms, e.g. ISO 13849.

2.2 Designated Use

The frequency inverter is designed according to the state of the art and recognized safety regulations. The frequency inverters are electrical drive components intended for installation in industrial plants or machines. Commissioning and starting of operation is not allowed until it has been verified that the machine meets the requirements of the EC Machinery Directive 2006/42/EC and DIN EN 60204-1.

The frequency inverters meet the requirements of the low voltage directive 2014/35/EU and DIN EN 61800-5-1. CE-labelling is based on these standards. Responsibility for compliance with the EMC Directive 2014/30/EU lies with the operator. Frequency inverters are only available at specialized dealers and are exclusively intended for commercial use as per EN 61000-3-2.

No capacitive loads may be connected to the frequency inverter.

The technical data, connection specifications and information on ambient conditions are indicated on the rating plate and in the documentation and must be complied with in any case.

NOTICE

Operation Restrictions

Operation within the boundaries of designated use refers to operational range parameters defined in the applicable technical data as published by the manufacturer in corresponding documents and on the rating plate.

Operation outside the operational range parameters as defined by the manufacturer shall be considered misuse.

- Adhere to the permitted operational temperature range (0…40 [°C]).
- ☞ 📖 AXv GettingStarted VEC20B
- ☞ 📖 AXIA Technical Data VEC309

2.3 Misuse

Any use other than that described in "Designated use" shall not be permissible and shall be considered as misuse.

For, example, the machine/plant must not be operated

- by uninstructed staff,
- while it is not in perfect condition,
- without protection enclosure (e.g. covers),
- without safety equipment or with safety equipment deactivated,
- when general requirements, such as operating conditions and technical data, are not met.

The manufacturer shall not be held liable for any damage resulting from such misuse. The sole risk shall be borne by the operator.

Explosion protection

The frequency inverter is an IP 20 ingress protection rating device. For this reason, use of the device in explosive atmospheres is not permitted.

2.4 Residual Risks

Residual risks are special hazards involved in handling of the frequency inverter which cannot be eliminated despite the safety-compliant design of the device. Residual risks are not obviously identifiable and can be a potential source of injury or a health hazard.

Typical residual hazards include:

- Electrical hazard
- Danger of contact with energized components due to a defect, opened covers or enclosures or improper working on electrical equipment.
- Danger of contact with energized components in frequency inverter if no external disconnection device was installed by the operator.

During operation, all covers must be installed correctly, and all electrical cabinet doors must be closed to minimize electrical hazards.

When LEDs and other indicating elements on the frequency inverter go out, this does not necessarily mean that the device is deenergized. Before carrying out any Work at the device where contact with energized parts might be possible, it must be checked in any case, i.e. irrespective of the status of any indicating elements that may be installed, if the device is deenergized.

Charged capacitors in DC link

The DC-link may have dangerous voltage levels even up to 3 minutes after shutdown.

Electrostatic discharge

Touching electronic components entails the risk of electrostatic discharges.

Thermal hazards

Risk of accidents by hot machine/plant surfaces, e.g. heat sink, transformer, fuse or sine filter.

2.5   Safety and Warning Signs at Frequency Inverter

- Comply with all safety instructions and danger information provided on the frequency inverter.
- Safety information and warnings on the frequency inverter must not be removed.

2.6   Warning Information and Symbols

2.6.1   Hazard Classes

The following hazard identifications and symbols are used to mark particularly important information:

	DANGER
⚠	Identification of immediate threat holding a **high** risk of death or serious injury if not avoided.

	WARNING
⚠	Identification of immediate threat holding a **medium** risk of death or serious injury if not avoided.

	CAUTION
⚠	Identification of immediate threat holding a **low** risk of minor or moderate physical injury if not avoided.

NOTICE
Identification of a threat holding a risk of material damage if not avoided.

2.6.2   Hazard Symbols

Symbol	Meaning	Symbol	Meaning
⚠	General hazard	⚠	Suspended load
⚠	Electrical voltage	⚠	Hot surfaces
⚠	Danger of crushing		

2.6.3   Prohibition Signs

Symbol	Meaning
🚫	No switching; it is forbidden to switch the machine/plant, assembly on

2.6.4   Personal Safety Equipment

Symbol	Meaning
🔵	Wear body protection
🔵	Wear ear protectors

2.6.5 Recycling

Symbol	Meaning
	Recycling, to avoid waste, collect all materials for reuse

2.6.6 Grounding Symbol

Symbol	Meaning
	Ground connection

2.6.7 ESD Symbol

Symbol	Meaning
	ESD: Electrostatic Sensitive Devices, i.e. components and assemblies sensitive to electrostatic energy

2.6.8 Information Signs

Symbol	Meaning
	Tips and information making using the frequency inverter easier.

2.6.9 Font Style in Documents

Example	Font style	Use
1234 / 0x123456789	bold	Representation of parameter numbers / object numbers
Parameter / Object	inclined, font: Times New Roman	Representation of parameter names / object designations
P.1234	bold	Representation of parameter numbers without name, e.g. in formulas
Q.1234	bold	Representation of source numbers
`01234`	Courier new	Representation of parameter values / object settings

2.7 Directives and Guidelines for Operators

The operator must follow the following directives and regulations:

- Ensure that the applicable workplace-related accident prevention regulations as well as other applicable national regulation are accessible to the staff.
- An authorized person must ensure, before using the frequency inverter, that the device is used in compliance with its designated use and that all safety requirements are met.
- Additionally, comply with the applicable laws, regulations and directives of the country in which the frequency inverter is used.
- For liquid cooled frequency inverters, comply with the cooling water guideline VGB-R 455 P.
- Any additional guidelines and directives that may be required additionally shall be defined by the operator of the machine/plant considering the operating environment.

2.8 Operator's General Plant Documentation

- In addition to the Operating Instructions and other related documents, the operator should issue separate internal user manuals for the frequency inverter. The documentation of the frequency inverter must be included in the documentation of the whole plant.

2.9 Operator's/Operating Staff's Responsibilities

2.9.1 Selection and Qualification Of Staff

- Any work on the frequency inverter may only be carried out by skilled personnel. The staff must not be under the influence of any substance likely to interfere with mental or body functions.

Observe the minimum age required by law. Define the staff's responsibility pertaining to all work on the frequency inverter clearly.

- Work on the electrical components may only be performed by a qualified electrician according to the applicable rules of electrical engineering.
- The operating staff must be trained for the relevant work to be performed.

2.9.2 General Work Safety

- In addition to the Operating Instructions of the machine/plant, any applicable legal or other regulations relating to accident prevention and environmental protection must be complied with. The staff must be instructed accordingly.
  Such regulations and/or requirements may include, for example, handling of hazardous media and materials or provision/use of personal protective equipment.
- In addition to this Functional Safety manual, issue any additional directives that may be required to meet specific operating requirements, including supervision and reporting requirements, e.g. directives relating to work organization, workflow and employed staff.
- Unless approved of expressly by the manufacturer, do not modify the frequency inverter in any way, including addition of attachments or retrofits.
- Only use the frequency inverter if the rated connection and setup values specified by the manufacturer are met.
- Provide appropriate tools as may be required for performing all work on the frequency inverter properly.

2.9.3 Ear Protectors

- The frequency inverter produces noise. Due to noise development, frequency inverters should only be installed in normally unstaffed areas.

2.10 Organizational Measures

2.10.1 General

- Train your staff in the handling and use of the frequency inverter and the machine/plant as well as the risks involved.
- Use of any individual parts or components of the frequency inverter in other parts of the operator's machine/plant is prohibited.
- Optional components for the frequency inverter must be used in accordance with their designated use and in compliance with the relevant documentation.

2.10.2 Use with Third-Party Products

- The manufacturer will not accept any responsibility for compatibility with third-party products (e.g. motors, cables or filters)..
- In order to enable optimum system compatibility the manufacturer offers components facilitating commissioning and providing optimum synchronization of the machine/plant parts in operation.
- If you use the frequency inverter in combination with third-party products, you do so at your own risk.

2.10.3 Handling and Installation

- Do not commission any damaged or destroyed components.
- Prevent any mechanical overloading of the frequency inverter. Do not bend any components and never change the isolation distances.
- Do not touch any electronic construction elements and contacts. The frequency inverter is equipped with components which are sensitive to electrostatic energy and can be damaged if handled improperly. Any use of damaged or destroyed components will endanger the machine/plant safety and shall be considered as non-compliance with the applicable standards.
- Only install the frequency inverter in a suitable operating environment. The frequency inverter is exclusively designed for installation in industrial environments.
- If seals are removed from the case, this can result in the warranty becoming null and void.

2.10.4 Electrical Connections

- The five safety rules must be complied with.
- Never touch live terminals. In sizes 1 through 7, the DC-link may have dangerous voltage levels up to 3 minutes after shutdown.

- When performing any work on/with the frequency inverter, always comply with the applicable national and international regulations/laws on work on electrical equipment/plants of the country in which the frequency inverter is used.
- The cables connected to the frequency inverters may not be subjected to high-voltage insulation tests unless appropriate circuitry measures are taken before.
- Only connect the frequency inverter to suitable supply mains. The frequency inverter may be operated in TN, TT and IT grid types. Precautions must be taken for operation in IT grids, see Chapter 7 "Electrical installation". Operation in a corner-grounded TN grid shall not be permissible.

The Five Safety Rules

When working on/in electrical plants, always follow the five safety rules:

1 Disconnect
2 Secure to prevent restarting
3 check for absence of voltage,
4 carry out earthing and short-circuiting
5 cover or shield neighboring live parts

2.10.5 Safe Operation

- During operation of the frequency inverter, always comply with the applicable national and international regulations/laws on work on electrical equipment/plants.
- Before commissioning and the start of the operation, make sure to fix all covers and check the terminals. Check the additional monitoring and protective devices according to the applicable national and international safety directives.
- During operation, all covers must be installed correctly, and all electrical cabinet doors must be closed. During operation, never open the machine/plant.
- No connection work shall be carried out while power supply is on.
- The machine/plant holds high voltage levels during operation, is equipped with rotating parts (fan) and has hot surfaces. Any unauthorized removal of covers, improper use, wrong installation or operation may result in serious injuries or material damage.
- Some components, e.g. the heat sink or braking resistor, may be hot even some time after the machine/plant was shut down. Don't touch any surfaces directly after shutdown. Wear safety gloves where necessary.
- The frequency inverter may hold dangerous voltage levels until the capacitor in the DC link is discharged. After shutdown, wait for at least 3 minutes before starting any electrical or mechanical work on the frequency inverter. Even after this waiting time, make sure that the equipment is deenergized in accordance with the safety rules before starting the work.
- In order to avoid accidents or damage, only skilled personnel and electricians may carry out the work such as installation, commissioning or setup.
- In the case of a defect of terminals and/or cables, immediately disconnect the frequency inverter from mains supply.
- Persons not familiar with the operation of the frequency inverter and children must not have access to the device.
- Do not bypass nor decommission any protective devices.
- The frequency inverter may be connected to power supply every 60 s. This must be considered when operating a mains contactor in jog operation mode. For commissioning or after an emergency stop, a non-recurrent, direct restart is permissible.
- After a failure and restoration of the power supply, the motor may start unexpectedly if the AutoStart function is activated.
  If staff are endangered, a restart of the motor must be prevented by means of external circuitry.
- Before commissioning and the start of the operation, make sure to fix all covers and check the terminals. Check the additional monitoring and protective devices according to EN 60204 and applicable the safety directives (e.g. Working Machines Act or Accident Prevention Directives).

2.10.6 Maintenance and Service/Troubleshooting

- Visually inspect the frequency inverter when carrying out the required maintenance work and inspections at the machine/plant.
- Perform the maintenance work and inspections prescribed for the machine carefully, including the specifications on parts/equipment replacement.
- Work on the electrical components may only be performed by a qualified electrician according to the applicable rules of electrical engineering. Only use original spare parts.

- Unauthorized opening and improper interventions in the machine/plant can lead to personal injury or material damage. Any repair work may only be carried out by the manufacturer or persons approved/licensed by the manufacturer. Any repair work must be carried out by qualified electricians. Check protective equipment regularly.
- Before performing any maintenance work, the machine/plant must be disconnected from mains supply and secured against restarting. The five safety rules must be complied with.

2.10.7 Final Decommissioning

Unless separate return or disposal agreements were made, recycle the disassembled frequency inverter components:

- Scrap metal materials
- Recycle plastic elements
- Sort and dispose of other component materials

> **i** Electric scrap, electronic components, lubricants and other utility materials must be treated as special waste and may only be disposed of by specialized companies.

> In any case, comply with any applicable national disposal regulations as regards environmentally compatible disposal of the frequency inverter. For more details, contact the competent local authorities.

Final decommissioning of the product

After the end of product service life, the user/operator must take the device out of operation.

> **i** For more information about the decommissioning of the device refer to the applicable operating instructions document.

Disposal requirements under European Union WEEE regulations

The product is marked with the WEEE symbol shown below.

This product cannot be disposed as general household waste. Users responsible for the final disposal must make sure that it is carried out in accordance with the European Directive 2012/19/EU, where required, as well as the relative national transposition rules. Fulfil disposal also in according with any other legislation in force in the country.

2.11 Safety Instructions on Function "Safe Torque Off" (STO)

The function „Safe Torque Off" (STO) is a functional safety feature, i.e. it protects staff from damage, provided that projecting, installation and operation are performed properly. This function does not disconnect the device from power supply.

In order to disconnect the device from power supply (e.g. for maintenance work), an "Emergency Stop" provision as per EN 60204 must be installed.

	WARNING
⚠️	**Uncontrolled Starting** Improper installation of the safety circuitry may result in uncontrolled starting of the drive. This may cause death, serious injuries and significant material damage. • Safety functions may only be installed and commissioned by skilled personnel. The STO function is not suitable for emergency stop as per EN 60204. An emergency stop can be implemented by installing a mains contactor. An emergency stop according to EN 60204 must be functioning in all operation modes of the frequency inverter. Resetting of an emergency stop must not result in uncontrolled starting of the drive. The drive is started again according to parameterized settings when the function STO is no longer requested and if additional restart conditions are met (e.g. if restart acknowledge input is activated). In order to comply with EN 60204, ensure by taking external measures that the drive does not start without prior confirmation. Without a mechanical brake, the drive will not stop immediately but coast to a standstill. If this may result in personal or material damage. • Take additional safety measures. • If persons may be endangered after disconnection of the motor power supply by STO, access to the hazard areas must be prevented until the drive has stopped. • Check the safety function at regular intervals according to the results of your risk analysis. The manufacturer **strongly** recommends that the check be performed after one year, at the latest. The STO function is fail-safe for one fault. However, on rare occasions, the occurrence of component defects may cause jerking of the motor shaft (max. 180°/pole pair, e. g. jerk by 90° with 4-pole motor, 180°/2). • Check if this causes a dangerous movement of the machine. • If the STO function is used, the special safety instructions, installation instructions and instructions on use shall be complied with.

	WARNING
⚠️	**Dangerous voltage!** The safety function "Safe Torque Off" may only be used if mechanical work is to be performed on the driven machines, not for work on live components. After disconnection of an external DC 24 V power supply, the DC link of the frequency inverter is still connected to mains supply. Even if power supply to the motor is disconnected, and the motor is coasting to a standstill or has already stopped, high voltages may still be present on the motor terminals. Before working (e. g. maintenance) on live parts, the plant must always be disconnected from mains supply (main switch). This must be documented on the plant. When the function "Safe Torque Off" is triggered, the motor is not isolated from the DC link of the frequency inverter. High voltage levels may be present at the motor. • Do not touch live terminals.

ℹ️	The safety manual must be complied with, particularly if the safety function described there is used.

3 Device Overview

The scope of delivery described can be supplemented by optional components and adapted to the customer-specific requirements.
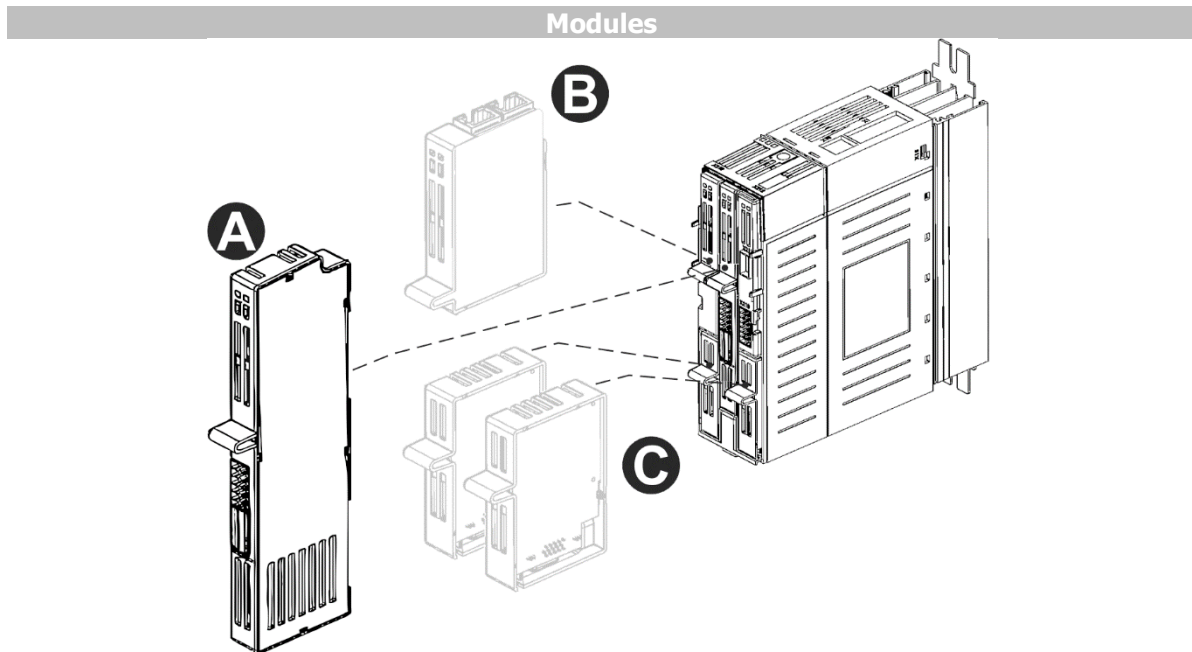
A	Safety module	**B**	Communication module	
C	Encoder modules			

3.1 Disassembly

WARNING
Risk of short circuit and fire!
During assembly, make sure that no foreign particles (e.g. chips, dust, wires, screws, tools) can get inside the frequency inverter. Otherwise, there is the risk of short circuits and fire.
• The frequency inverter complies with IP20 ingress protection rating only if the covers, components and terminals are mounted properly. • Overhead installation or installation in horizontal position is not permissible.

CAUTION!
Destroying inverter and/or module
Connecting / disconnecting the module while the inverter is connected to live voltage can destroy the module and/or the inverter.
• Disconnect the frequency inverter from the power supply before disassembly of the module. Working under live voltage is not permissible. • Handle the module with care to prevent mechanical damage • Do not touch the PCB visible on the back of the module, otherwise components may be damaged.

NOTICE

By default, the safety module comes pre-assembled with the frequency inverter. If replacing the module becomes necessary during the lifetime of the frequency inverter, make sure that **only an instructed person** or an **expert** performs the steps necessary for replacement. This ensures the safety of the overall application.

For further details ☞ 📖 the operating instructions document VEC2en1-.

- Disconnect the frequency inverter from voltage and protect it against being energized unintentionally.
- Observe capacitor discharge times of the inverter.
- Remove covers of the frequency inverter, if necessary.
- Take measures against electrostatic discharge.
  - ○ Avoid touching the PCB of the module.
  - ○ Use ESD protection equipment.
- Disconnect/unplug any connected lines.
- Unplug the module from its slot by
  - ○ Depressing the latch at the side of the module housing (use a thin screwdriver)
  - ○ pulling at the handle at the front of the module housing. Proceed carefully to not damage the module.

3.2 Mechanical Installation

By default, the frequency inverters of IP20 degree of protection are designed for installation in electrical cabinets.

- During installation, comply with the installation and the safety instructions and note the device specifications.

WARNING
Risk of short circuit and fire!
During assembly, make sure that no foreign particles (e.g. chips, dust, wires, screws, tools) can get inside the frequency inverter. Otherwise, there is the risk of short circuits and fire.
• The frequency inverter complies with IP20 ingress protection rating only if the covers, components and terminals are mounted properly.
• Conductive contamination not permissible.
• Mount the device in electrical cabinets with protection class IP54 according to IEC529.
• Overhead installation or installation in horizontal position is not permissible.

CAUTION!
Destroying inverter and/or module
Connecting / disconnecting the module while the inverter is connected to live voltage can destroy the module and/or the inverter.
• Disconnect the frequency inverter from the power supply before installation of the module. Working under live voltage is not permissible.
• Handle the module with care to prevent mechanical damage
• Do not touch the PCB visible on the back of the module, otherwise components may be damaged.

> **NOTICE**
>
> By default, the safety module comes pre-assembled with the frequency inverter. If replacing the module becomes necessary during the lifetime of the frequency inverter, make sure that **only an instructed person** or an **expert** performs the steps necessary for replacement. This ensures the safety of the overall application.
>
> For further details ☞ 📖 the operating instructions document VEC2en1-.

> **NOTICE**
>
> **Validating the safety function**
>
> Whenever the module is replaced during the product life of the inverter, the user must ensure that the safety module is free from any defects. This requires the safety functions to be validated within the application.
>
> - The user validates the safety function within the application. ☞ 🗋 8 for more information.

ℹ️ ☞ 🗋 7.1.1 for setting the FSoE address.

Work steps:
- Disconnect the frequency inverter from voltage and protect it against being energized unintentionally.
- Remove covers of the frequency inverter. The slot for the safety module is now accessible.
- Insert the safety module into the slot until it engages audibly.

4 Electrical Installation

⚠️	**CAUTION!**
	Destroying inverter and/or module
	Using multi-core wires for connectors may shorten the air gap and/or creepage distance which can lead to short-circuits. These can destroy the module and/or the inverter.
	• Use wire-end-ferrules and/or other suitable mitigation measures.

NOTICE

To ensure proper functioning of the SMA-MOT-11, the external 24 V interface of the main device (X12) **must** be connected to an external 24 V supply.

The external 24 V power supply must meet the requirements of SELV/PELV 24 V voltage.

For further details ☞ 📖 the operating instructions document VEC2en1-.

NOTICE

To ensure proper functioning of the safety module, the encoders must respond to the following requirements:

- Encoders connected to the motor **housing** must be safely connected as defined in EN 61800-5-1
- Encoders connected to the motor **shaft** must be safely connected as defined in EN 61800-5-2

4.1 Dimensioning of Conductor Cross-Section

The connecting cables must be protected externally, considering the maximum voltage and maximum current values of the fuses. The line fuses and cable cross-sections must be dimensioned according to EN 602041 and DIN VDE 0298 Part 4 for the nominal operating point of the frequency inverter.

ℹ️	The fuses must be chosen depending on the individual application. The values recommended in the technical data apply for the continuous rated operation without overload.

The cable dimensions should be selected according to the current load and voltage drop to be expected. Select the cable cross-section of the cables such that the voltage drop is as small as possible. If the voltage drop is too great, the motor will not reach its full torque. Also comply with any additional national and application-specific regulations and the separate UL instructions.

4.2 Control Terminals

⚡	**CAUTION**
	Live voltage
	The control terminals may be energized.
	• The unit may only be wired with the power supply switched off.
	• Verify safe isolation from power supply.
	• Switch off power supply before connecting or disconnecting the control inputs and outputs. Otherwise, components may be damaged.

ℹ️	There are three application modes for the control terminals:
	a) Using external safety switching devices with OSSD outputs
	b) Using passive encoders/sensors with external PELV supply
	c) Using passive encoders/sensors with 24V OSSD outputs of the safety module
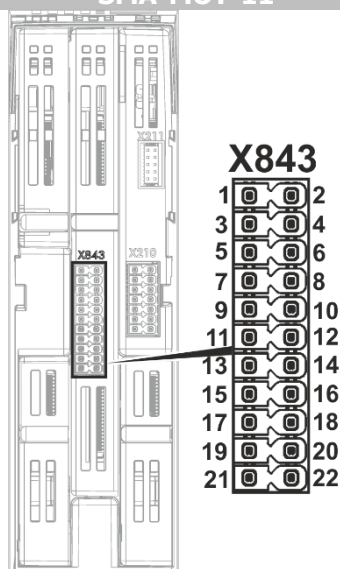
1	DI1-A	**2**	DI1-B
3	DI2-A	**4**	DI2-B
5	DI3-A	**6**	DI3-B
7	DI4-A	**8**	DI4-B
9	Error Acknowledge	**10**	Restart Acknowledge
11	GND	**12**	GND
13	DO1-A	**14**	DO1-B
15	DO2-A	**16**	DO2-B
17	GND	**18**	GND
19	Status SBC	**20**	n.c.
21	DC 24 V (U_{OSSD})	**22**	DC 24 V (U_{OSSD})

Technical data of control terminals

Digital inputs: Low Signal: DC -3 V…5 V, High signal: DC 11 V…30 V,
response time: max. 20 ms (depending on debouncing filter), EN 61131-2 type 3 compatible, OSSD compatible (pulse length <1 ms, repetition rate > 500 ms)

Digital output: Low Signal: DC -3 V…5 V, High Signal: DC 11 V…30 V, OSSD (pulse length > 500 µs),
Maximum output current: 100 mA

Conductor cross-section:
The signal terminals are suitable for the following cable sizes:
with ferrule: 0.25 … 0.75 mm²
without ferrule: 0.25 … 1.5 mm²

DC 24 V (U_{OSSD}) outputs
short-circuit-proof
combined current load: max. 250 mA

NOTICE

Component damage

The safe digital outputs may be subjected to switch-off testing and to short-circuit detection.

- The capacitive load on the safe digital outputs may not exceed `1 µF`.

OSSD – test pulse detection

All the digital inputs of the safety module (X843.1..8) are compatible to OSSD test pulses (<1 ms). In the application modes a) and c), the corresponding external sensor output can be applied to the terminals.

The 24 V (OSSD) digital output terminals (X843.13 and X843.14 or X843.15 and X843.16) can be optionally used to provide the pulsed voltage for external sensors in the application mode c) in order to detect external short-circuits between two inputs (when configured to "always on" for this purpose).

⚠️	**WARNING**
	Safety function failure
	Passive encoders/sensors with external PELV supply do not feature an OSSD pulse signal. The line integrity cannot be ensured without the OSSD pulse signal.
	• In the application mode b), the user is required to implement safety measures according to IEC 61800-5-2 and EN ISO 13849 to prevent short-circuits on signal lines.

4.3 External 24 V power supply input

The control interface X12 can be used as a voltage input. By connecting an external power supply of DC 24 V ±10% to X12, the function of inputs and outputs as well as the communication can be parameterized and maintained, even when mains voltage is off.

X12 External 24 V supply interface 4 pole
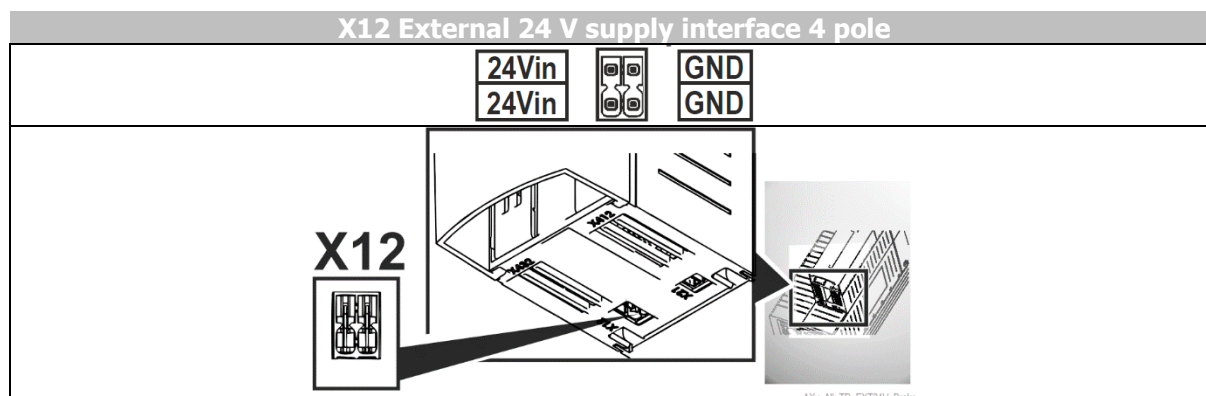
Requirements to be met by external power supply	
Input voltage range	DC 24 V ±10%
Rated input current	Max. 1.1 A
Peak inrush current	Typically: < 25 A
External fuse	Via standard fuse elements for rated current, characteristic: slow
Safety	Safety extra low voltage (SELV) according to EN 61800-5-1

The SMA-MOT modules require an external 24 V supply to operate the brake connected to the SBC brake output.

4.4 Brake output (SBC)

NOTICE
Configuration specifics
In AXv devices **with functional safety** (i.e. including the safety module), the **X21** interface terminal is coded **yellow**. In devices **without functional safety,** it is coded **black**.
• Observe the correct device/terminal combination.

Brake malfunctioning

The electrical wires connected to the safe digital outputs may be affected by unintended external influence which may lead to brake malfunctioning.

- Protect the wires connected to safe digital outputs to prevent damage to the wires and avoid brake malfunctioning.

The 2-pole brake output X21 supplies an external brake with the necessary operating voltage.

X21 Brake power supply interface

Output voltage	DC 24 V
Output current	3 A
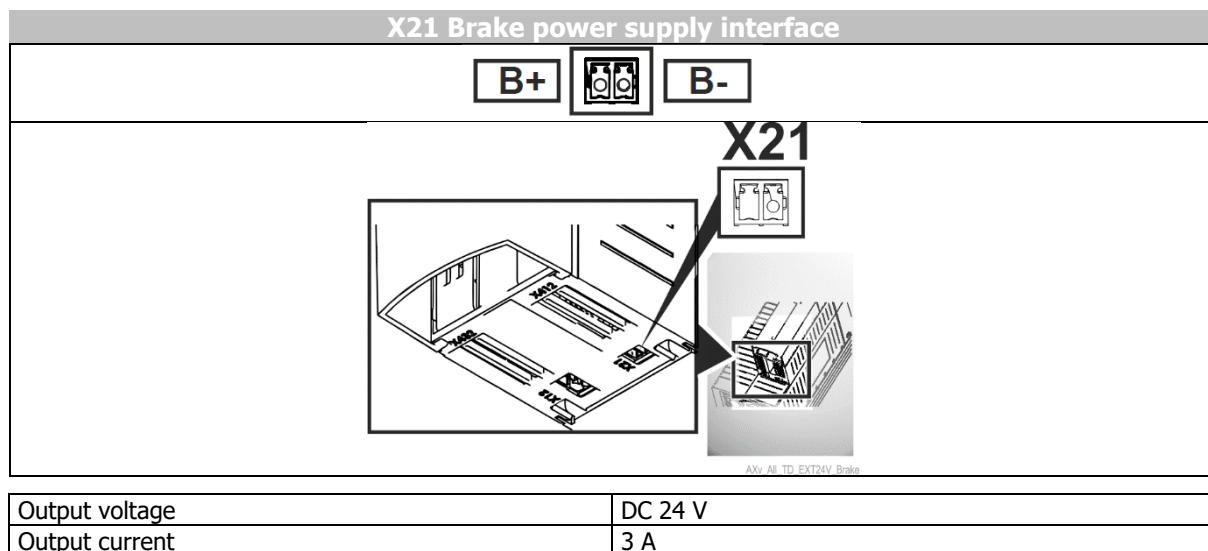
4.5 External switching components

Restart acknowledge is necessary if the restart is blocked by SS1+STO/SBC functions (⟳ 7.2 ⟳ 8).

- Plan the application as shown below to meet safety requirements:
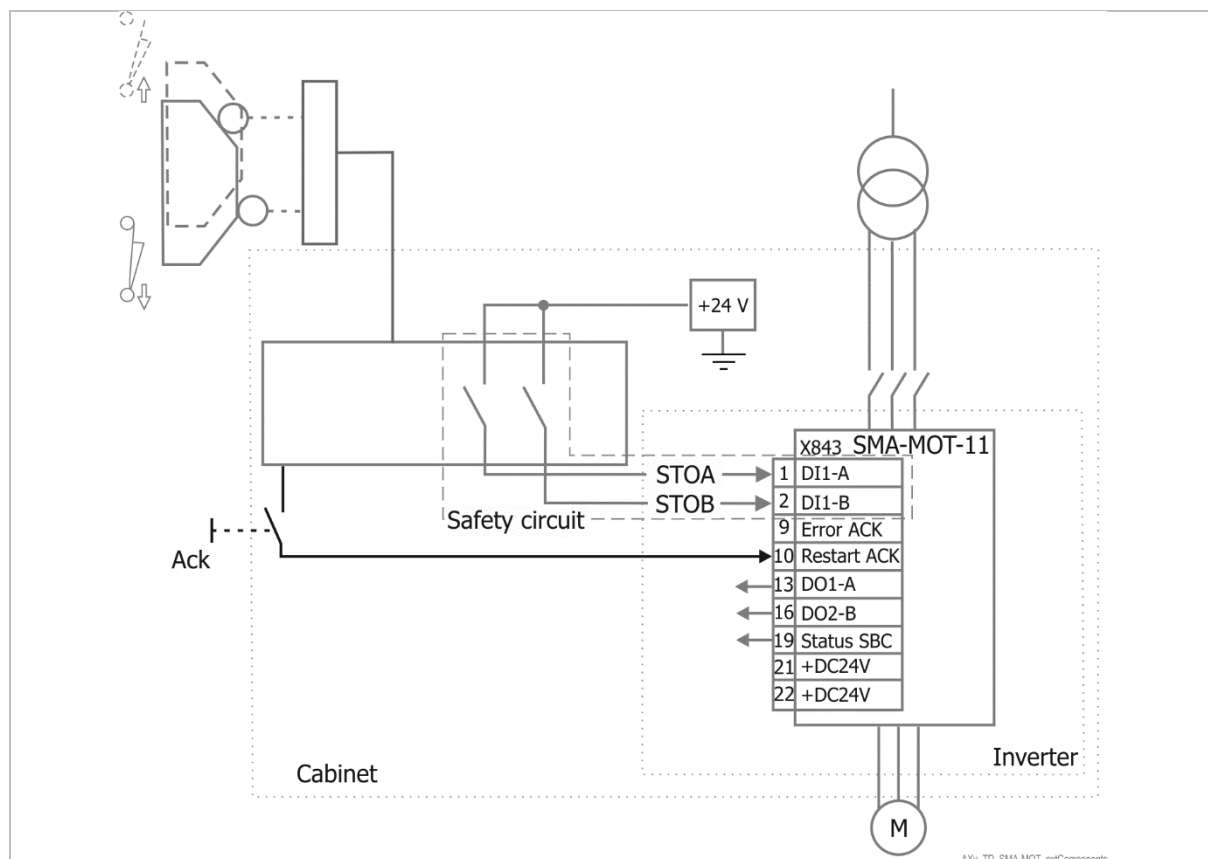
5 Control Inputs and Outputs

By default, the safety module connects to the user PLC or HMI via the implemented bus system. Note that a communication module is required in order to implement this functionality. Alternatively, there is a customer interface implemented in the safety module. This interface allows external customer signals to be connected directly to the safety module.

Depending on the type of the safety module employed there are different signals usable with the customer interface.

> ☞🗎 4 for an overview of the customer signal interface.

5.1 Digital Outputs

DO1 – double pole programmable digital output – see Object **0x3E0C** in the object list
DO2 – double pole programmable digital output – see Object **0x3E0D** in the object list
Status SBC – non-programmable digital dynamized output for fault-free SBC status signaling (24VDC, up to 100mA)

⚠️	**WARNING**
	Signaling delay
	In case the digital output is used to signalize the STO status, a "high" signal means that the safety module has processed the STO request. Note that an additional delay time of 10 ms must be accounted for until the STO state is reached. The same applies to the SBC status, where the additional delay time depends on the brake's response time.
	• Observe signaling delays when configuring safety applications.

NOTICE
Status SBC
As long as the brake circuit is fault-free, the Status SBC output provides a clocked square wave output signal. Signal frequency is 250 Hz at a sampling rate of 50 %.

5.2 Digital Inputs

DI1..4-A/B – Programmable double pole Digital inputs for various safety functions
Restart acknowledgement – fixed input for STO, SS1, SS2 restart function
Error acknowledgement - fixed input for acknowledgement of safety module related faults

The double-pole inputs must always be actuated simultaneously. The maximum tolerated discrepancy time can be adjusted via object **0x3E61**. The single-pole restart acknowledgement inputs and error acknowledgement inputs must be actuated with a pulsed signal (low->high->low), where the pulse length must be between 100 ms and 5000 ms.

NOTICE
Discrepancy time
Consider a tolerance of +/- 10 ms for the value set in the maximum *Discrepancy Time* **0x3E61** (also dependent on the set debouncing time).

6 Parameterization Options

6.1 Configuration Software

For the general parameterization of AXIA inverters, the manufacturer provides free-of-charge software. The software (AxiaManager Suite) can be downloaded via the Bonfiglioli homepage (www.bonfiglioli.com). The AxiaManager Suite includes a Graphical User Interface (GUI), that supports the user with the parameterization.

> AxiaManager GUI software ☞ 📖 VEC1en51.
>
> AxiaManager SAFETY software ☞ 📖 VEC1en52.

Specific safety settings are parameterized using the software "AxiaManager SAFETY", that is part of the AxiaManager installation package (☞ 7.2).

6.2 Access to Objects

To change settings of the parameters listed in the chapter "Object list", the operator can access the module via the bus connection provided in the current device configuration, by default, via the communication module of the inverter. Specifically, safe parameterization is provided via EtherCAT/FSoE in conjunction with the corresponding communication module.

In terms of the HMI, the parameterization in the safety module is done via the software "AxiaManager SAFETY".

To change the values of safety objects, three paths are given:

− via direct connection (peer-to-peer) between the configuring PC workstation and the AXIA inverter (this option requires an additional communication module to be installed in the AXIA inverter)
− via indirect (e.g. network switch or PLC) connection between the configuring PC workstation and the AXIA inverter
− via download of a safe file containing pre-parameterized objects

> The safety object values are stored in the safety module. Setting default values in the main device does not affect the settings of the safety module.

6.3 Password

By default, a generic password (`00000000`) is set in the safety module at the production site. When the user establishes the connection with the inverter for the first time, they will be required to set a new safe password.

If the user does not set a new safe password, the error message `F12C1 Default password` will be displayed until the new safe password is set.

6.4 Safety Configuration File

In order to upload the new configuration file to the safety module, the user must verify the new objects in the software "AxiaManager SAFETY". To do this, the user must validate the objects by setting the "validated" flag next to the altered objects.

6.5   Resetting to Defaults

To reset the safety module to default values without using additional software or computers, you can proceed as follows:

- Remove the safety module (☞📄 3.1) from the inverter.
- On the DIP switch array, set all switches to "on" (☞📄 7.1.1).
- Insert the safety module back into its slot in the inverter.
- Apply 24 V to the inverter and wait, until the red LED on the front of the safety module is continuously on.
- Interrupt the power supply to the inverter and remove the safety module (☞📄 3.1) from the inverter again.
- Set the FSoE address for the safety module as needed (☞📄 7.1.1).
- This concludes the reset procedure.

    Any settings made previously are set to default.
    The password is set to "00000000".

- The user must set a safe password again.
- Safety functions must be parameterized again (☞📄 7).

7 Commissioning

WARNING
Moving components
Any alterations to the safety object values may lead to the risk of injury by moving parts or even to failure of safety systems.
• Any required alterations to default values may be made only when the drive train is standing still and secured against unintentional operation.
• Install additional safety measures (such as a mechanical brake), if necessary.

NOTICE
Device verification
• After replacement of the safety module, the parameterization must be verified using the AXIA Manager SAFETY software. The entire safety chain must be validated.
• The user must validate all safety functions after commissioning.
☞🖹 6 for parameterization options.

NOTICE
Error
The external 24 V supply for the SBC-connected brake must be energized before or simultaneously with the mains voltage. Otherwise, the error `F12A4 External 24V Supply Exceeds Limits` will be triggered.
• Apply the external 24 V voltage for SBC before the mains voltage is applied.
• To acknowledge the error message, reboot the main device while the external 24 V voltage for SBC is applied.

The safety module comes preconfigured with default safety object values set in the firmware. At least the password has to be changed to a user-defined password, to be able to leave the safe state. However, applications typically will require the default safety object values to be altered and validated to suit the particular application requirements.

- The user must check if the default safety object values in the firmware are correct for their chosen application.
- The user must ensure that any changes made to default object settings do not compromise the safe operation of the inverter.

NOTICE
Fault display when writing objects to the module
When a new set of objects is written to the safety module, the error messages `F0D0C` and `F12C4` may be triggered. This is not a fault but occurs due to communication between the safety module and the main device being briefly interrupted. The error messages can be acknowledged by the user.

7.1 Commissioning with FSoE

CAUTION
IT security
A threat analysis of the FSoE network must be carried out. If this determined that a malicious or unauthorized action posing a threat to IT security is reasonably foreseeable, an IT security threat analysis should be carried out. For guidance, see IEC 62443.
• The user must ensure the IT security of the FSoE network. Consider this when planning the safety measures in the application.

> **NOTICE**
>
> **Parameterization via EtherCAT/CoE**
>
> To be able to use FSoE, the CMA-EC-01 or CMA-IE-01 EtherCat module must be installed.

> **NOTICE**
>
> **Watchdog time**
>
> The minimum configurable watchdog time for the FSoE connection is 10 ms. After watchdog time elapses, time to safe state must be considered 20 ms for worst case scenario.

> **NOTICE**
>
> **Parameterization via EtherCAT/CoE**
>
> When using parameterization of the safety objects via EtherCAT/CoE, the user must ensure, that the system transmits all required parameters via CoE after every power cycle.

7.1.1 Setting the FSoE Address via DIP Switches

The DIP switch array is located at the side of the SMA-MOT module. To set the DIP switches you will have to remove the module from its mounting slot. The first six switches set the address (1 to 62) as binary code.

AXv_All_TD_ModulesOverview
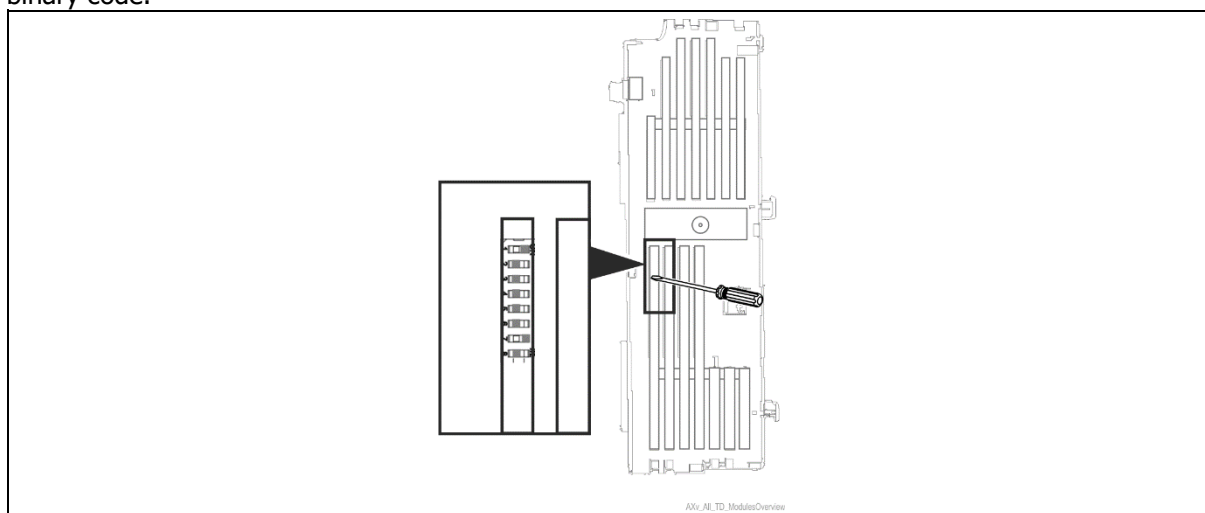
If the inverter has already been commissioned:
- Stop the inverter and secure its drive train from moving unintentionally.
- Shut down the inverter.
- Disconnect the inverter from power and wait at least 3 minutes to allow the DC circuit to discharge.
- Secure the power supply of the inverter from being energized unintentionally.
- Disconnect the mains line from the inverter and switch off any connected 24 V power.

Continue or start with the following steps if the inverter has not been commissioned yet:
- Follow the instructions of 🔗 3.1 to remove the SMA module from its mounting slot.
- Use a thin screwdriver to reach inside the housing of the SMA module and to set the FSoE address of the SMA module.
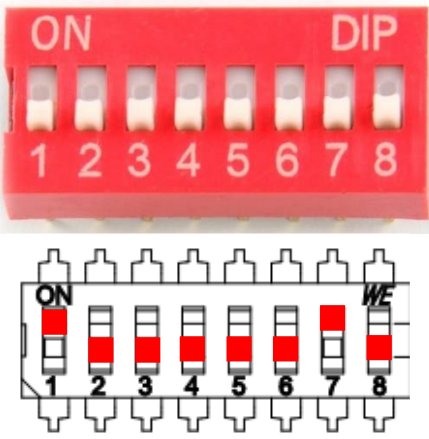
Setting up the FSoE-Address:

- Set the FSoE-Address of the SMA-MOT module by configuring the DIP switches at the side of the SMA-MOT module.
- The number of the activated DIP switches must be even. To ensure this, set the parity switch to "on" if necessary. The parity switch is the second-to-last switch in the row.
- You may not set the address to "0"; this setting is invalid if you want to use FSoE.
- Also, you may not use the address "63".

> The Least Significant Bit (LSB) on the DIP-switch-array is the switch numbered "1" and the Most Significant Bit (MSB) is the switch numbered "6". In the address table next to the image this order is reversed to correspond to the binary code conventions.

DIP setting	Address
01000001	1
01000010	2
00000011	3
01000100	4
00000101	5
...	...
01011010	26
00011011	27
01011100	28
...	...
01111110	62

- In the AxiaManager, check the object **0xE901/2** *Safe Address* to make sure that the value defined by the DIP switch array is correct.

Proceed with the following steps to re-insert the SMA module into its mounting slot:

- Follow the instructions of ☞🖥 3.2 to insert the SMA module into its mounting slot.
- Connect the wires to the control terminals of the SMA module if necessary.

NOTICE
To ensure proper functioning of the SMA-MOT-11, the external 24 V interface of the main device (X12) **must** be connected to an external 24 V supply.

The external 24 V power supply must meet the requirements of SELV/PELV 24 V voltage.

For further details ☞ 📖 the operating instructions document VEC2en1-.

- Check the status of the drive train to prevent the drive train from starting unintentionally.
- Connect the external 24 V supply to the inverter.
- Apply the mains voltage to the inverter.

7.1.2 Setting the Safety Address

- In the AxiaManager, set the object **0x3902** *Safety Address* to the value defined by the DIP switch array.

7.1.3 Enabling Safety

- In the AxiaManager, set the object **0x3904/15** *Safety Enabled* to "`true`".

7.1.4 Activating Fieldbus

- In the AxiaManager SAFETY, set the safe object **0x3E28** (Fieldbus Type) to "`1`".

7.1.5 Preparing the Safe Connection

- Switch the power supply to the Axia inverter off and back on.

The device is now ready to establish a safe connection. The FSoE master must have the corresponding CRC to be able to establish an FSoE connection.

7.2 Configuring the Safety Functions

You can configure the functions to be controlled via FSoE in the AxiaManager SAFETY.

- Start the AxiaManager SAFETY software.
- Access the object tree branch "Function Assignment".
- Configure the safety functions as needed.

For more details ⌒⊡ 11.

For process data assignment of FSoE communication, see the ESI file corresponding to the device and firmware version.

7.3   Functional Assignment for Digital Inputs

Using the "Function Assignment" subsection in the AxiaManager SAFETY, you can assign Digital Inputs as command sources for the Safety Functions. Also, you can always assign the FSoE fieldbus as command source.

- Start the AxiaManager SAFETY software.
- Access the object tree branch "Function Assignment".
- Configure the safety functions as needed.

Relevant objects:

Index/Sub	Designation	Index/Sub	Designation
0x2600/0	STO command source	0x2608/3	SLS command source
0x2601/0	SS1 command source	0x2608/4	SLS command source
0x2603/0	SBC command source	0x2609/0	SLP command source
0x2606/0	SS2 command source	0x2614/0	SLS-SL command source
0x2608/1	SLS command source	0x2644/0	Source start homing
0x2608/2	SLS command source	0x2645/0	Source reference switch signal

For the above objects the following selection list applies:

Sorting	Designation
0xEF80	Deactivated
0x0011	Safe DI 1
0x0022	Safe DI 2
0x0033	Safe DI 3
0x0044	Safe DI 4
0x1000	Controlled by Fieldbus

Relevant objects:

Index/Sub	Designation
0x260A/0	SDI positive direction command source
0x260B/0	SDI neg. direction command source
0x2611/0	Restart acknowledge source
0x2612/0	Error acknowledge source

For the Object **0x260A/0** the following selection list applies

Sorting	Designation
0x0000	Positive Direction Disabled
0x0011	Safe DI 1
0x0022	Safe DI 2
0x0033	Safe DI 3
0x0044	Safe DI 4
0x1000	Controlled by Fieldbus
0xEF80	Positive Direction Enabled

For the Object **0x260B/0** the following list applies

Sorting	Designation
0x0000	Negative Direction Disabled
0x0011	Safe DI 1
0x0022	Safe DI 2
0x0033	Safe DI 3
0x0044	Safe DI 4
0x1000	Controlled by Fieldbus
0xEF80	Negative Direction Enabled

For the objects **0x2611/0**; **0x2612/0** the following list applies:

Sorting	Designation
0x0005	Digital Input
0x1000	Fieldbus
0x1005	Digital Input or Fieldbus

7.4 Velocity and Position Acquisition

The Velocity and Position Acquisition subsection in the AxiaManager SAFETY, you can configure objects pertaining to encoder settings and objects pertaining to positioning.

Relevant objects:

Index/Sub	Designation	Index/Sub	Designation
0x264A	Encoder Type	0x264D	PWM Switching Frequency
0x263F	HDSL Safe channel 1 nr. of bits	0x264E	No. of Motor Pole Pairs
0x2640	HDSL Safe channel 2 nr. of bits	0x2642	Homing Required
0x2641	HDSL Version	0x2646	Drive Direction to Ref. Switch
0x264F	HDSL Max. Dev. CH1 / CH2	0x2647	Time Window for Homing
0x264B	Min. Encoder Voltage	0x2643	Absolute reference position
0x264C	Max. Encoder Voltage		

0x264A Encoder Type	
Sorting	**Designation**
0x0000	Off
0x0001	Sensorless
0x0002	Hiperface DSL

7.5 Commissioning with Hiperface DSL Encoder

> **NOTICE**
>
> **Safe encoders**
>
> The encoders used with the safety module must fulfil certain requirements regarding their safety.
>
> - Only use encoders certified for usage in safety applications.
> - The manufacturer recommends employing encoders of the company SICK AG™.

> **NOTICE**
>
> **Safe encoders**
>
> The encoders used with the safety module must fulfil certain requirements regarding their safety.
>
> - The encoders must provide a safe shaft connection between the motor shaft and the encoder shaft as defined in EN 61800-5-2.
> - The encoders must provide a safe housing connection between the motor chassis and the encoder housing as defined in EN 61800-5-1.

> **NOTICE**
>
> **HIPERFACE DSL implementation**
>
> The Hiperface DSL encoders used with the safety module are restricted regarding their implementation.
>
> - A safety function based on HIPERFACE DSL® shall only be used in servo motor applications.

- Carry out the commissioning of the Hiperface DSL encoder as described in the corresponding manual(s).
- In order to activate the safe evaluation by the SMA-MOT module, carry out the following settings:
- Set the safe object **0x264A** *Encoder Type* to value `2 – Hiperface DSL`.
- Set the safe objects **0x263F**, **0x2640**, **0x264B**, **0x264C** and **0264F** according to the technical data of the encoder.
- For Object **0x263F** and **0x2640**, use the safety-related resolution as mentioned in the encoder data sheet. E.g., for Sick EEM37 **0x263F** = 15 or 17 bits, **0x2640** = 15 or 17 bits
- Switch the power supply to the Axia inverter off and back on.

The HDSL encoder is now ready for safe evaluation.

The actual values for the safe position and speed can be monitored via the objects **0x6611** *Safe Position Actual Value* and **0x6613** *Safe Velocity Actual Value*. The position has the format of 16 bit per revolution, independent of the particular encoder resolution.

NOTICE
Operation Restrictions

    – The position value is available either

        o if the encoder delivers a safe absolute position.

    In this case, in the AxiaManager SAFETY, set **0x2642** *Homing Required* to `false`.

        o Or a homing has been already carried out.

    Then, in the AxiaManager SAFETY, set **0x2642** *Homing Required* to `true`, parameterize homing and carry it out.

    – The encoder must be qualified for safety applications. See data sheet.

    – The encoders of the family EFx50 by Sick-Stegmann may not be used since SMA-MOT module does not support the test function "cyclic request of incorrect check-sum".

    – In case of fault "Interruption of mechanical coupling" between the encoder and the drive, the fault must be eliminated. The SMA-MOT module cannot detect such faults.

    • Consider information by encoder manufacturer for safe mechanical coupling.

    – In absolute value encoders with safe absolute position (operation without homing), position overrun must be prevented. The encoder must deliver a definite position over the entire motion range.

7.6   Commissioning without Safety Encoder

This procedure can be used in open-loop applications or using a standard (non-safety) encoder with a speed-related safety function.

• Carry out the commissioning of the inverter as described in the corresponding manual(s).
• In order to activate the safe evaluation by the SMA-MOT module, carry out the following settings:
• With the AxiaManager SAFETY, set the safe objects
    o **0x264A** *Encoder Type* to value `1 – Sensorless`
    o **0x264D** *PWM Switching Frequency*
    o **0x264E** *Number Of Motor Pole Pairs*
• Switch the power supply to the Axia inverter off and back on.

The actual values for the safe speed can be monitored in the AxiaManager via the object **0x6613** *Safe Velocity Actual Value*.

NOTICE

Operation Restrictions

– The minimum speed is 250 rpm. For lower speeds the output shall still be 250 rpm. The maximum measurable speed is 120000 rpm.

– The sensorless speed capturing can only be used, as long as the power stages of the inverter are active.

– The time for capturing the current speed amounts to half the period of the current stator frequency. For example, after stator frequency jumping from 0 to 50 Hz, the speed would not be captured until after 10 ms at the earliest (worst case 20 ms). Additionally, a PT1 filter with time constant of 3 ms is applied on the speed signal.

– In asynchronous motors there is a load-dependent slip between the motor rotation speed and stator frequency (which is the basis for sensorless rpm calculation in the SMA module). In motor operation the calculated rpm is therefore always higher than the actual rpm of the shaft. Consider this in parameterization of safety functions when using sensorless operation.

– The sensorless speed capturing can only be used, if the generator operation of the drive is prevented by the application.

– The ratio of the switching frequency to the stator frequency must be at least 4 and the over-modulation range must be avoided. Otherwise, false-positive fault triggering due to fluctuations in the speed capturing may occur.

– The calculation of the velocity is based on stator frequency and parameterized number of motor pole pairs (safe object **0x264E**). Make sure, the value is valid.

8 Function Overview

The AXIA safety functions are implemented in the safety module.

Further normative reference

The safety functions listed in this document are suited for applications corresponding to EN ISO 13849-1 and IEC 61508.

The SMA-MOT-11 features the following functions:
- STO – Safe Torque Off
- SBC – Safe Brake Control
- SS1 Safe Stop 1
- SS2 Safe Stop 2
- SOS Safe Operating Stop
- SLS Safely Limited Speed
- SLS-SL Safely Limited Speed, Sliding Limit
- SDI Safe Direction
- SSM Safe Speed Monitor
- SLP Safely Limited Position

The following prerequisites apply for the various safety functions:

Function	Module	Risk mitigation w/ Encoder */**	Risk mitigation w/o Encoder	Restart-block / -release
STO	SMA-MOT-11	SIL 3/PLe Cat4	SIL 3/PLe Cat4	Configurable (internal/external)
SS1	SMA-MOT-11	SIL 3/PLe Cat4	SIL 2/PLd Cat3	Configurable (internal/external)
SOS	SMA-MOT-11	SIL 3/PLe Cat4	-	Configurable (internal/external)
SLS	SMA-MOT-11	SIL 3/PLe Cat4	SIL 2/PLd Cat3	No
SLS-SL	SMA-MOT-11	SIL 3/PLe Cat4	SIL 2/PLd Cat3	No
SS2	SMA-MOT-11	SIL 3/PLe Cat4	-	Configurable (internal/external)
SBC	SMA-MOT-11	SIL 3/PLe Cat4	SIL 3/PLe Cat4	No
SLP	SMA-MOT-11	SIL 3/PLe Cat4	-	No
SDI	SMA-MOT-11	SIL 3/PLe Cat4	-	No
SSM	SMA-MOT-11	SIL 3/PLe Cat4	SIL 2/PLd Cat3	No

*The Risk mitigation with encoder depends also on the encoder. The values from the table are the maximum achievable risk reductions.

**SIL 3/PL e Cat4 is the maximum achievable risk mitigation. However, for Hiperface DSL encoders, the maximum is SIL 3/PL e Cat.3.

	STO	SBC	All other
MTTFD	392 years	266 years	392 years
Dcavg	97,7%	98,1%	97,7%
PFD 61508	3,113E-04	3,172E-04	3,113E-04
PFH 61508	3,778E-09	3,845E-09	3,778E-09
PFH 62061	4,153E-08	4,185E-08	4,153E-08

NOTICE

Safety definition / Time behavior

The overall reaction time for the application is the sum of:

- Reaction time of the SMA module = max. 20 ms
- Data transfer time: application-dependent
- Processing time of safety PLC: application dependent

• Consider this calculation while planning.

NOTICE

Safety definition / Safe State

A safe state of the frequency inverter is defined as follows:

- Power output stage deactivated
- Control outputs deactivated
- In SBC and related functions: SBC braking function activated

• Consider this information while planning.

NOTICE

Safety definition / Safe Brake

A safe state of the mechanical brake is defined as follows:

- The brake engages as soon as the power supply deactivates (Fail-Safe-State)
- The brake disengages only when power supply is restored AND
- When the dedicated signal output is activated

• Only use brakes that fulfill these requirements.

NOTICE

Validating the safety function

Whenever the module is replaced during the product life of the inverter, the user must ensure that the safety module is free from any defects. This requires the safety functions to be validated within the application. The user must also validate the safety function after any changes to the safety-relevant parameterization.

• The user validates the safety function within the application.

8.1   STO - Safe Torque Off

WARNING
Moving components
Whenever external momentums apply to the drive train, the STO function **alone** may not suffice to halt any moving components. This may lead to the risk of injury by moving parts.
• Install additional safety measures (such as a mechanical brake), if necessary. For that, the STO Function can be combined with the SBC function.

WARNING
Moving components
The safety module transmits STO state = TRUE as soon as the safety module has carried out the function. Additional system-related delays of up to 10 ms must be expected, before STO is actually active.
• Install additional safety measures (such as a mechanical brake), if necessary. • Consider the system-wide delays when planning the safety measures in the application.

NOTICE
Electric shock
The STO state **does not** provide safe disconnect from the power supply as required according to electrical safety provisions.
• Establish additional protection from electric shock in the drive train, if necessary.

The safety function STO deactivates the drive using a safe impulse blockage.

The STO state is triggered by various causes.

- By deactivating the dedicated or a configured two-channel input of the safe drive module (e. g. via actuating an emergency-stop actuator/device)
- By receiving a safe field bus telegram requesting the execution of the safety function
- By triggering the safety function SS1 (see below)
- By detecting a safety-relevant deviation of the nominal values from the rated values in the active safety functions listed below or due to internal faults

Relevant objects

Index	Designation	Min	Max	Default
0x3E60	Debouncing time	4 [ms]	12 [ms]	4 [ms]
0x6641	Restart acknowledge for STO	FALSE	TRUE	TRUE
0x6643/1	STO activates SBC	Selection		

For the Object **0x6643/1** the following selection list applies:

Sorting	Designation
0x00000000	SBC NOT activated by STO
0x66600001	STO Activates SBC

STO function behavior

The STO state is achieved by interrupting the impulse pattern to the power output stages and by inhibiting the build-up of a rotational field in the motor. The STO state does not provide protection against electric shock. In the case of external loads the STO state may result in hazards if no other measures are taken.
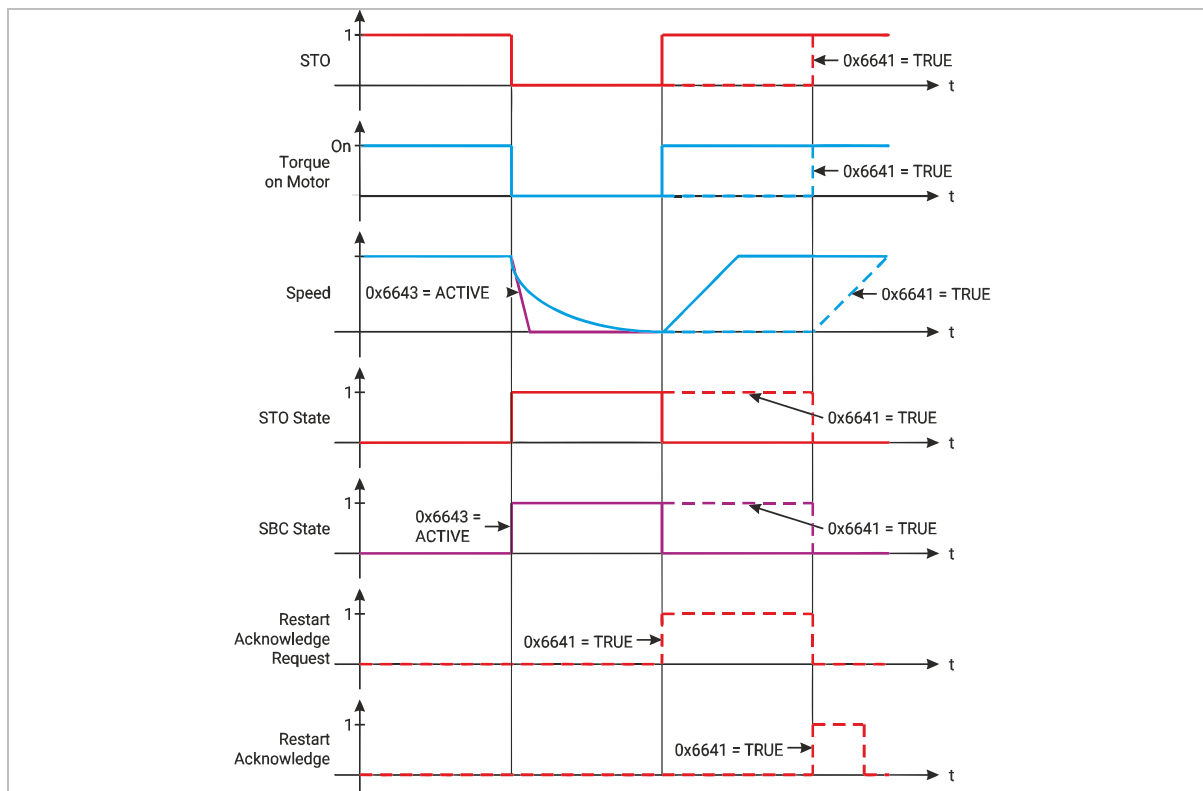
Figure 1: safety function STO

8.2   SBC – Safe Brake Control

The SBC function provides a safe two-channel output which can be used to connect a safe brake (24V).

WARNING
Risk of injury
By default, the AXIA inverters are not suited for implementation in personal lift systems. Implementing AXIA inverters in lifts for transporting people may lead to injuries in operation.
• Do not integrate AXIA inverters in lift systems.

NOTICE
Malfunction
For correct function of the module, you have to connect an external 24 V DC voltage to the terminal X12 of the main inverter. The external 24 V DC voltage must be applied before the mains voltage is applied to the inverter. Failure to do so will result in an error message.
• Apply a 24 V DC voltage from an external source at the terminal X12 of the main inverter before applying the mains voltage to the inverter.

In SMA-MOT-11, the SBC function can be combined with the STO function in three different ways.
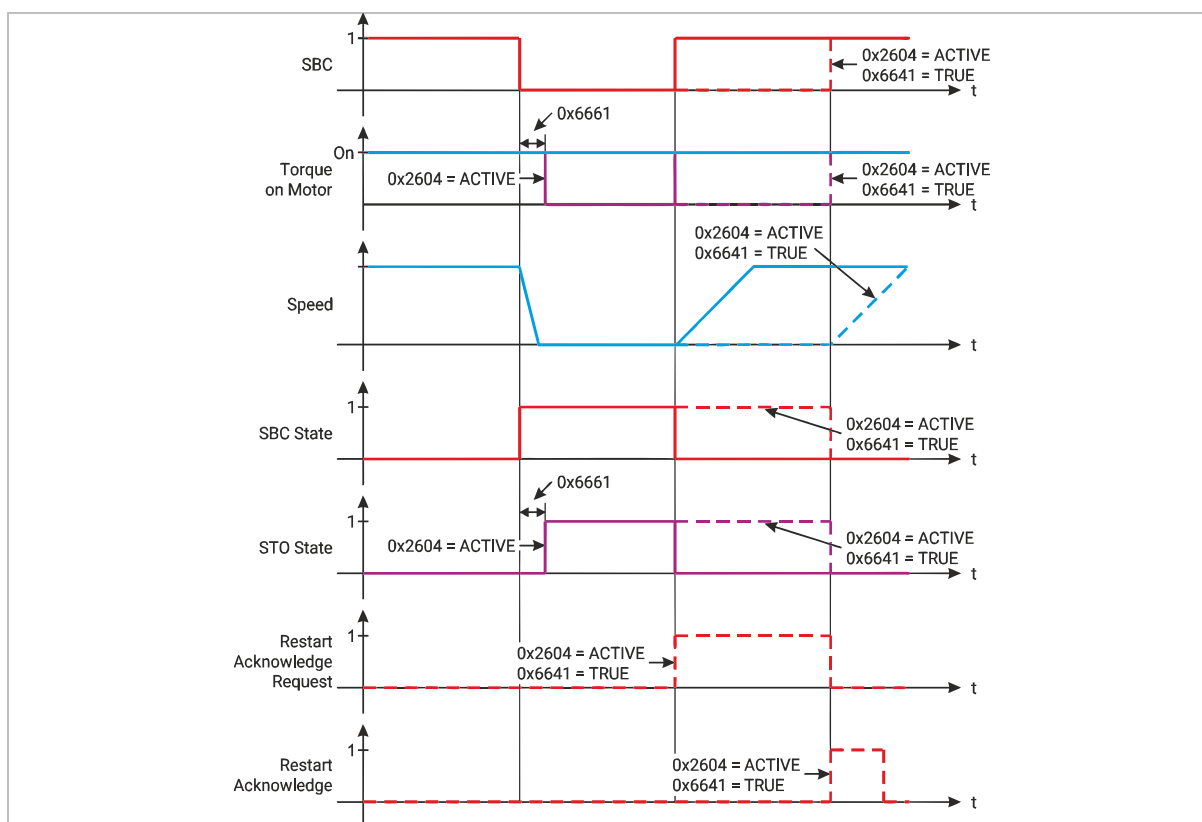
Figure 2: safety function SBC

Depending on the application, the SBC and STO functions can be activated simultaneously, with a delay (SBC + ΔT -> STO) or independently.

Relevant objects

Index	Designation	Min	Max	Default
0x3E60	Debouncing time	4 [ms]	12 [ms]	4 [ms]
0x6661	SBC Brake Time Delay	0 [ms]	65535 [ms]	0 [ms]
0x2604	SBC activates STO	Selection		

For the Object **0x2604** the following selection list applies:

Sorting	Designation
0x00000000	STO NOT activated by SBC
0x66400001	STO Activated by SBC

8.3 SS1 - Safe Stop 1

WARNING
Moving components
In the SS1-t function, the STO state starts after a parameterizable delay.
After a failure and restoration of the power supply, the motor may start unexpectedly if the Restart Acknowledge feature is not activated. This may lead to the risk of injury by moving parts.
• Install additional braking measures, if necessary.
• If staff are endangered, prevent the motor from restarting by using the Restart Acknowledge feature of SMA-MOT.
• When SBC is chosen to be activated first as subsequent function instead of STO, be sure that SBC will activate STO. Otherwise STO will not be activated!

NOTICE
Electric shock
The STO state <u>does not</u> provide safe disconnect from the power supply as required according to electrical safety provisions.
• Establish additional protection from electric shock in the drive train, if necessary.

After SS1 is triggered, the drive controller decelerates the drive. When the parameterizable rotation speed limit is reached (SS1-d and SS1-r) or when the parameterizable SS1 time (SS1-t, and also SS1-d, SS1-r) expires, the drive enters the STO state.

Relevant objects

Index	Designation	Min	Max	Default
0x2602	SS1 type select		Selection	
0x3E60	Debouncing time	4 [ms]	12 [ms]	4 [ms]
0x6650/1	SS1 Status	FALSE	TRUE	FALSE
0x6651	SS1 time to STO	0 [ms]	65535 [ms]	0 [ms]
0x6653	SS1 velocity zero window	0 [rpm]	200000 [rpm]	0 [rpm]
0x6656	SS1 deceleration limit	1 [rpm/s]	1000000[rpm/s]	3000 [rpm/s]
0x6657	SS1 time delay deceleration monitoring	0 [ms]	65535 [ms]	0 [ms]
0x6658	SS1 activate SBC		Selection	

For the Object **0x2602** the following selection list applies:

Sorting	Designation
0x0000	SS1-t Time Controlled (default)
0x0001	SS1-r Ramp Monitored
0x0002	SS1-d Deceleration Controlled

For the Object **0x6658** the following selection list applies:

Sorting	Designation
0x66400001	Activate STO
0x66600001	Activate SBC
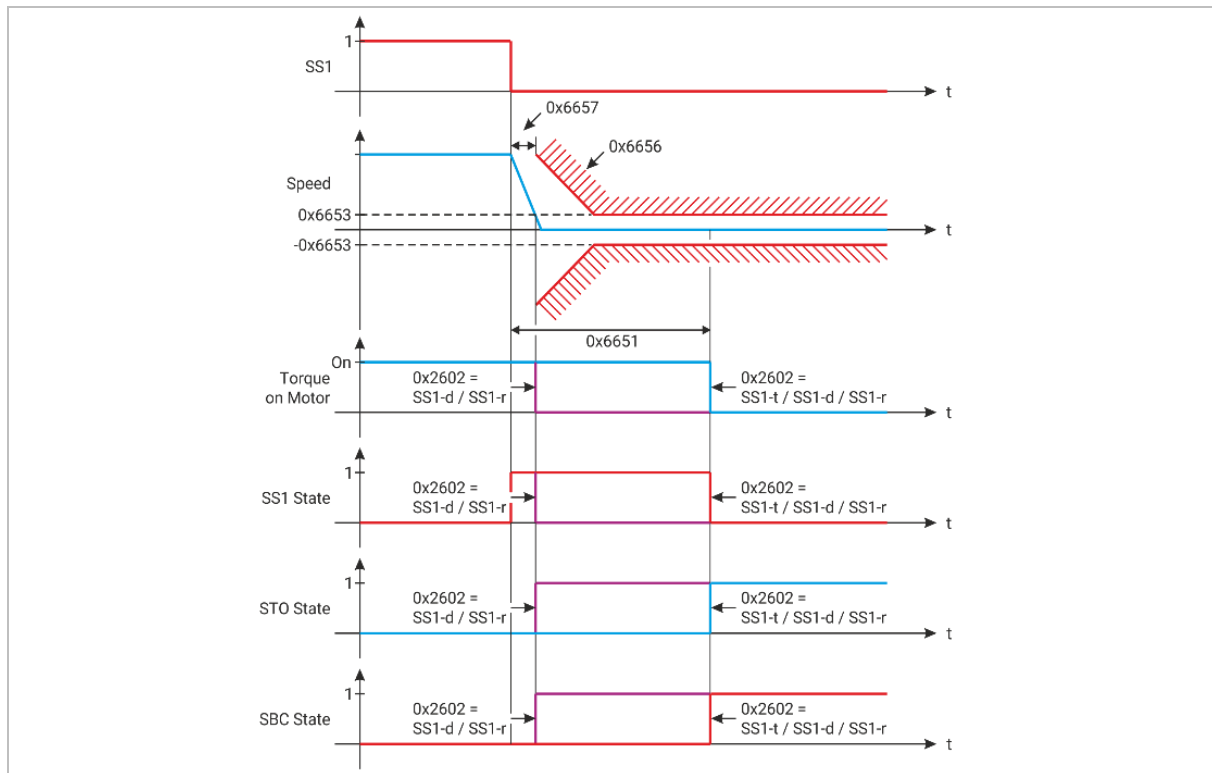
Figure 3: safety function SS1

SS1-t

In the SS1-t function, the SMA-MOT-11/ SMA-SS1-11 does not monitor the braking ramp. When the parameterizable deceleration time $[t_1-(t_0+\Delta t)]$ elapses, the drive enters the STO or SBC state, depending on the setting in **0x6658**.

SS1-r

In the SS1-r function, the SMA-MOT-11 **does** monitor the braking ramp. When the parameterizable rotation speed limit (**0x6653** *SS1 velocity zero window u32*) is reached, the drive enters the STO or SBC state, depending on the setting in **0x6658**.

Additionally, the drive enters the STO state when the ramp is not in accordance with the ramp set in **0x6656** *SS1 deceleration limit u32* in rpm/s, or the time **0x6651** *SS1 time to STO* elapses and the drive shows the error message `F1220 – Error Monitoring SS1`.

SS1-d

In the SS1-d function, the SMA-MOT-11 does not monitor the braking ramp. When the parameterizable rotation speed limit (**0x6653** *SS1 velocity zero window u32*) is reached, the drive enters the STO state.

If the velocity zero window limit is not reached before `t1` **0x6651** *SS1 time to STO*, the drive also enters the STO state and the error message `F1220 – Error Monitoring SS1` is triggered in addition to STO or SBC if set via **0x6658**. The time **0x6651** *SS1 time to STO* starts counting at SS1 request.

In sensorless operation mode or with a standard encoder, the value in **0x6653** must be set to `>250 rpm`, otherwise the drive does not start. This is the sensitivity threshold for safe detection of zero speed.

The SS1 status is monitored in **0x6650/1**. The value remains `TRUE` as long as SS1 is requested.

8.4   SS2 - Safe Stop 2

After SS2 is triggered, the drive controller decelerates the drive. When the parameterizable rotation speed limit is reached (SS2-d and SS2-r) or when the parameterizable SS2 time (SS2-t) expires, the drive enters the SOS state.
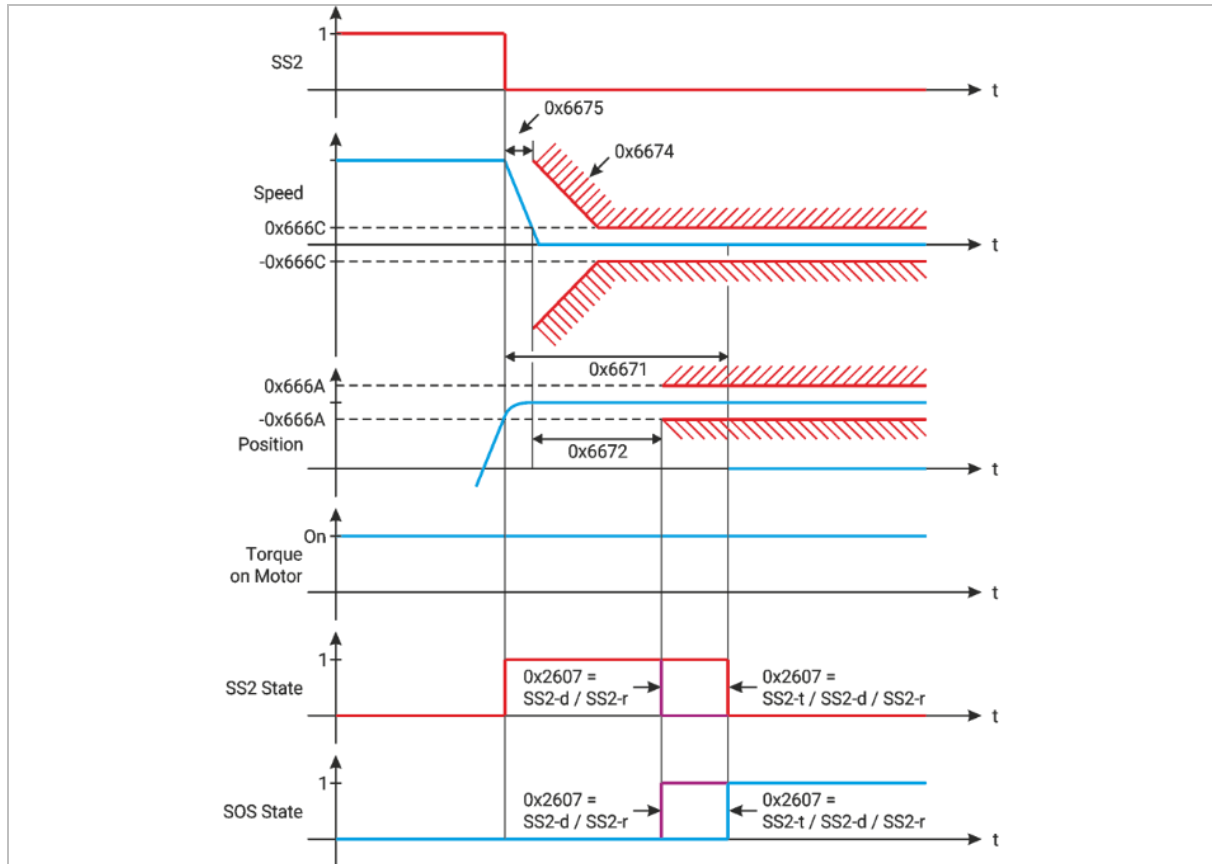
Figure 4: safety function SS2-SOS

> To implement these functions, the EMA-SABS module and a safety encoder must be installed. If the installed hardware is not sufficient, the error message `F12D6 Unsupported Safety Function Activated` is triggered.

If the tolerance limit is reached during the braking ramp, the STO function is immediately activated.

SS2-d

In the SS2-d function, the SMA-MOT-11 <u>does not monitor</u> the braking ramp. When the parameterizable rotation speed limit is reached, the drive enters the SOS state.

SS2-r

In the SS2-r function, the SMA-MOT-11 **does** monitor the braking ramp. When the parameterizable rotation speed limit is reached, the drive enters the SOS state.

SS2-t

In the SS2-t function, the SMA-MOT-11 <u>does not monitor</u> the braking ramp. When the parameterizable deceleration time $[t_1-(t_0+\Delta t)]$ expires, the drive enters the SOS state.

SOS Safe Operating Stop

The SOS safety function can be implemented only in conjunction with the SS2 safety function.

The SOS function monitors whether the drive remains in its halt position and withstands external momentums. Capturing the position requires analog signals or high-resolution increments to be processed. Also, even at absolute standstill the encoder signals are not static. Therefore, a tolerance range must be parameterized.

The object **0x6670/1** displays the *SS2 status*. As long as SS2 is requested the SS2 status is TRUE.

Relevant objects

Index	Designation	Min	Max	Default
0x2605	SOS error reaction		Selection	
0x2607	SS2 type select		Selection	
0x3E60	Debouncing time	4 [ms]	12 [ms]	4 [ms]
0x666C	SS2/SOS velocity zero window	0 [rpm]	200000 [rpm]	0 [rpm]
0x6670/1	SS2 status	FALSE	TRUE	FALSE
0x6671	SS2 time to SOS	0 [ms]	65535 [ms]	0 [ms]
0x6672	SS2 time for Velocity zero	0 [ms]	65535 [ms]	0 [ms]
0x6674	SS2 deceleration limit	1 [rpm/s]	1000000[rpm/s]	3000 [rpm/s]
0x6675	SS2 time delay deceleration monitoring	0 [ms]	65535 [ms]	0 [ms]
0x6676	SS2 restart ack. behavior	FALSE	TRUE	TRUE

For the Object **0x2605** the following selection list applies:

Sorting	Designation
0x66400001	Activate STO
0x66600001	Activate SBC

For the Object **0x2607** the following selection list applies:

Sorting	Designation
0x0000	SS2-t Time Controlled (default)
0x0001	SS2-r Ramp Monitored
0x0002	SS2-d Deceleration Controlled

8.5 SLS - Safely Limited Speed

At triggering the function, after a parameterizable timespan of Δt, the inverter monitors whether the drive operates at a set limited speed.

The following settings are made on the unsafe side via the AxiaManager software:

Via **0x6693**, you can parameterize 4 different safe limited speed target values. These values are requested via 4 different digital signals or via FSoE. If an SLS target value is > the actual speed target value, there will be no acceleration towards the SLS target value.

Via **0x6691** you can set the timespan during which the target values must be reached or after which the function checks if the requested SLS target value has been reached. The ramps are defined on the unsafe side, so the time must be set such that the drive is able to reach the target value.

If the requested velocity cannot be reached in the timespan set in **0x6691**, the fault reaction set in the object **0x6698** is triggered and the error message `F1231-4 SLS1-4 Speed Limit Exceeded` is triggered.

The object **0x6690** shows the SLS Status, which is `TRUE` as long as SLS request is active.

☞ 📖 the operating instructions document VEC2en1- for more information on the above objects.
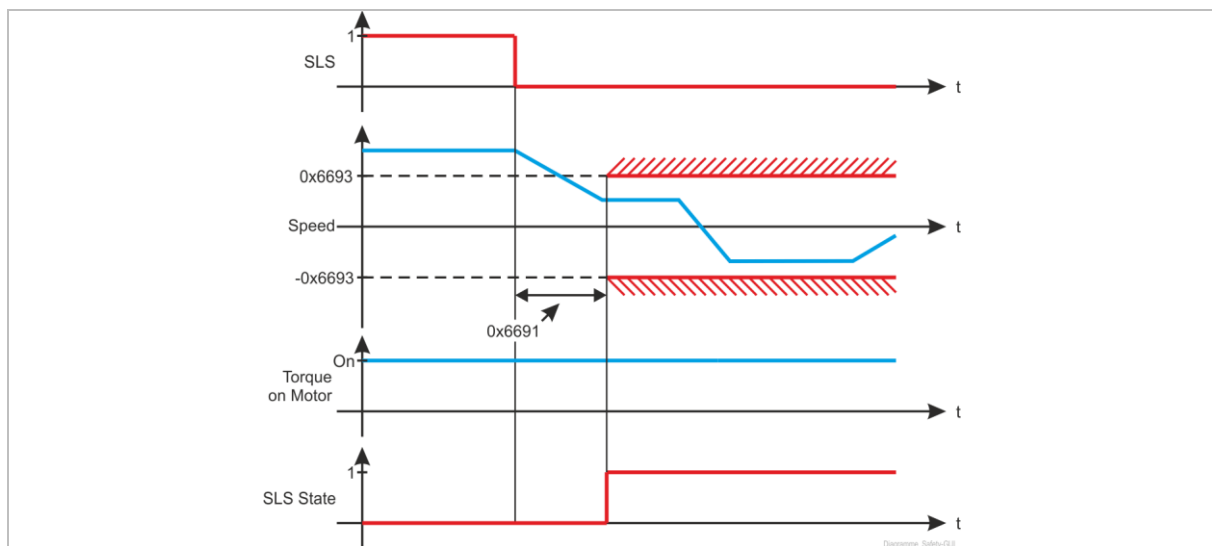
Figure 5: safety function SLS

Relevant objects

Index	Subindex	Designation	Min	Max	Default
0x3E60	-	Debouncing time	4 [ms]	12 [ms]	4 [ms]
0x6691	1	SLS time to velocity monitoring	0 [ms]	65535 [ms]	0 [ms]
0x6691	2	SLS time to velocity monitoring	0 [ms]	65535 [ms]	0 [ms]
0x6691	3	SLS time to velocity monitoring	0 [ms]	65535 [ms]	0 [ms]
0x6691	4	SLS time to velocity monitoring	0 [ms]	65535 [ms]	0 [ms]
0x6693	1	SLS velocity limit	0 [rpm]	200000 [rpm]	0 [rpm]
0x6693	2	SLS velocity limit	0 [rpm]	200000 [rpm]	0 [rpm]
0x6693	3	SLS velocity limit	0 [rpm]	200000 [rpm]	0 [rpm]
0x6693	4	SLS velocity limit	0 [rpm]	200000 [rpm]	0 [rpm]
0x6698	1	SLS Error reaction	STO (default) / SS1 / SS2		
0x6698	2	SLS Error reaction	STO (default) / SS1 / SS2		
0x6698	3	SLS Error reaction	STO (default) / SS1 / SS2s		
0x6698	4	SLS Error reaction	STO (default) / SS1 / SS2		

8.6 SLS-SL Safely Limited Speed, Sliding Limits

At triggering the function, after a parameterizable timespan of Δt (**0x2618**), the inverter monitors whether the drive operates at a set limited speed. The limit is transmitted via the process data channel of a safe field bus (**0x261B**), which allows continuous adaptation of the limit value. The limit value set via the safe field bus can be scaled by the SMA-MOT-11 using a parameterizable value (**0x2617** - e.g. 110%. Actual speed may be 10% higher than SLS-SL Velocity Setpoint). Further parameters define a maximum (**0x2615)** and minimum (**0x2616)** speed limit. The safety function is only available, if a communication via safe field bus is available. Otherwise, an error message is shown when the function is requested.

Via **0x6691** you can set the timespan during which the target values must be reached or after which the function checks if the requested SLS target value has been reached. The ramps are defined on the unsafe side, so the time must be set such that the drive is able to reach the target value.
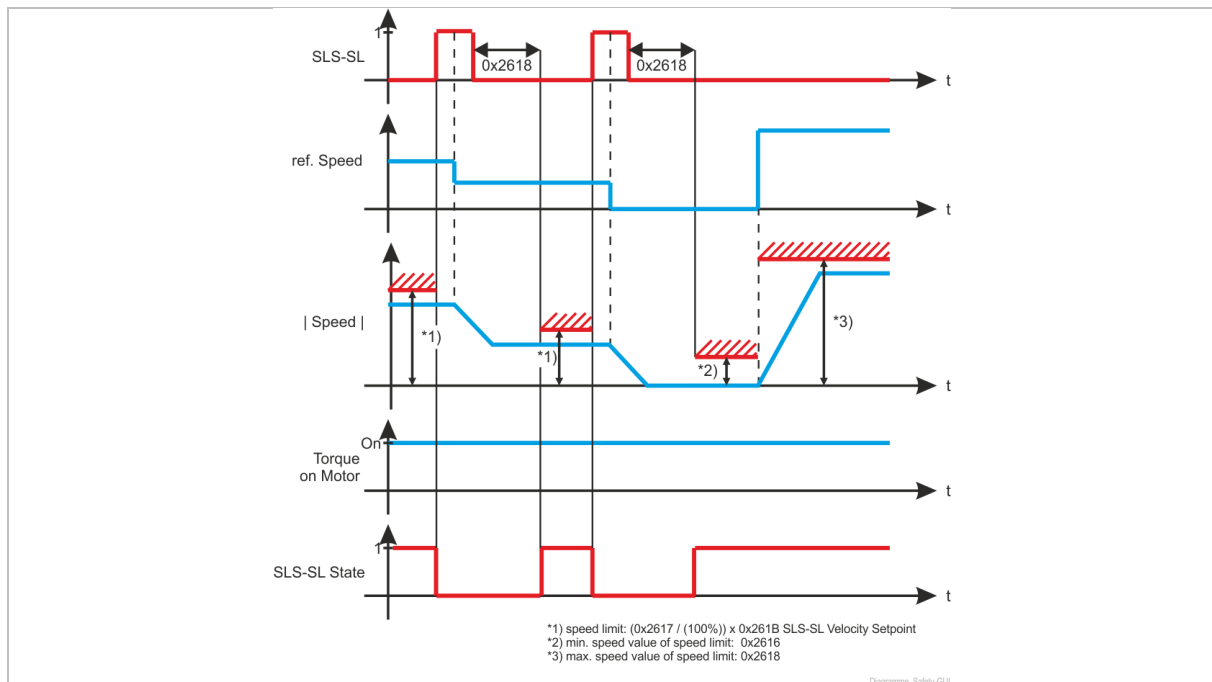
Figure 6: safety function SLS-SL

Relevant objects

Index	Designation	Min	Max	Default
0x3E60	Debouncing time	4 [ms]	12 [ms]	4 [ms]
0x2614	SLS-SL command source	Selection List (see below)		
0x2615	SLS-SL velocity max. limit	0 [rpm]	200000 [rpm]	200000 [rpm]
0x2616	SLS-SL velocity min. limit	0 [rpm]	200000 [rpm]	0 [rpm]
0x2617	SLS-SL velocity scale value	0 [%/100]	10000 [%/100]	10000 [%/100]
0x2618	SLS-SL time to velocity monitoring	0 [ms]	65535 [ms]	0 [ms]
0x2619	SLS-SL Error reaction	STO (default) / SS1 / SS2		
0x261B	SLS-SL Velocity Setpoint	Value [rpm] transferred via FSoE		

For the Object **0x2614** the following selection list applies:

Sorting	Designation
0x0000	Activated
0x0011	Safe DI 1
0x0022	Safe DI 2
0x0033	Safe DI 3
0x0044	Safe DI 4
0x1000	Controlled by Fieldbus
0xEF80	Deactivated

8.7 SDI - Safe Direction

The Safe Direction (SDI) safety function ensures that the drive shaft keeps a parameterized sense of rotation (see figure below).
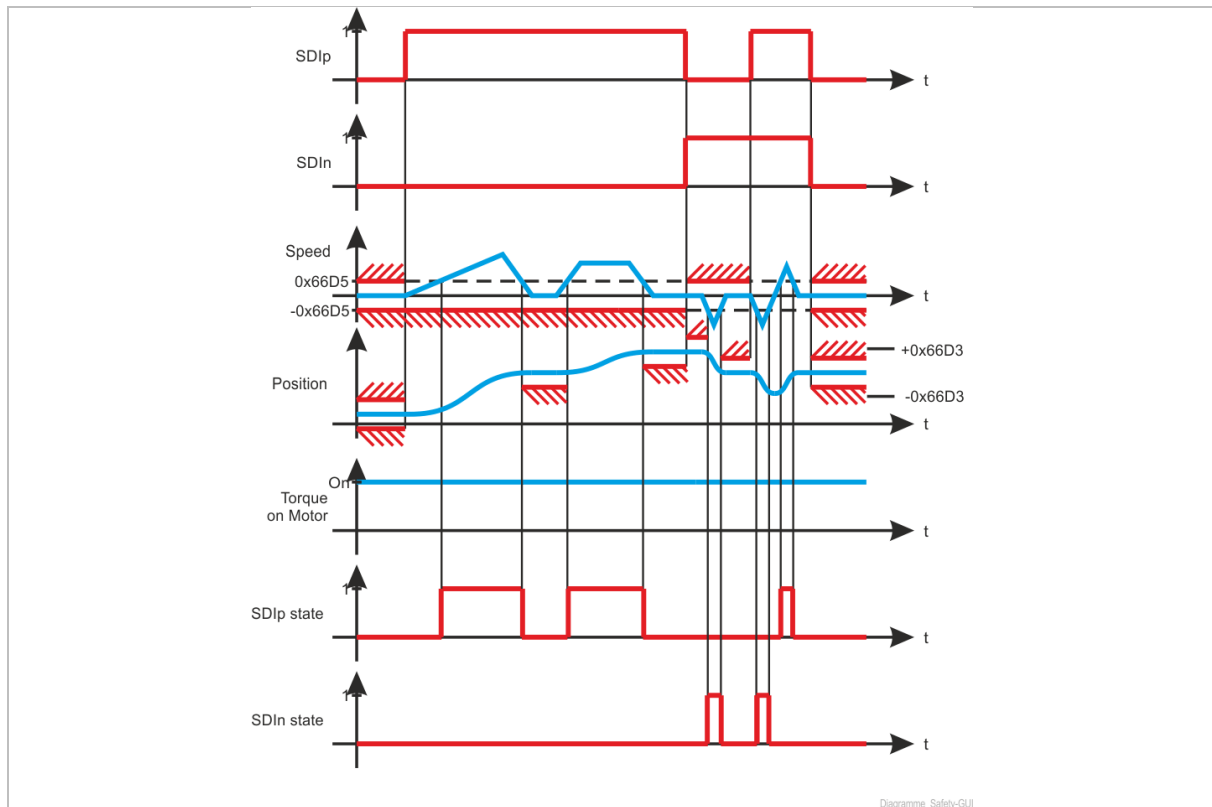
Figure 7: safety function SDI

If the drive shaft reverses the defined sense of rotation, the SDI function is triggered. Upon triggering the function, the inverter immediately initiates the transition to the STO state, and a safety error is generated. The specific error code depends on the direction of rotation: `F1225` for positive direction detected, or `F1224` for negative direction detected.

The SDI status operates as a sensor to monitor the movement of the drive: if the drive moves in the positive direction while the negative direction is disabled (SDIn command input low) the status bit SDIp is active as soon as the velocity zero window or position zero window is exceeded. If the drive moves in the negative direction while the positive direction is disabled (SDIp command input low), the status bit SDIn is active as soon as the velocity zero window or position zero window is exceeded.

Zero window position is defined by object **0x66D3** and zero window velocity is defined by object **0x66D5**.

> Status-bits SDIp and SDIn are only available, if the Safe Direction (SDI) safety function is activated. ☞🖹 7.3

Relevant objects

Index	Designation	Min	Max	Default
0x3E60	Debouncing time	4 [ms]	12 [ms]	4 [ms]
0x66D3	SDI position zero window	0 [Incr]	4194304 [Incr]	0 [Incr]
0x66D5	SDI velocity zero window	0 [rpm]	200000 [rpm]	200000 [rpm]

8.8   SSM - Safe Speed Monitor

The SSM safety function produces a safe output signal as long as the rotational speed is within a given range (see figure below).

This monitoring function does not influence the operation of the drive. It provides a safe output signal for controlling safety-relevant actors or safe protocol data information to be forwarded to a safety control device.
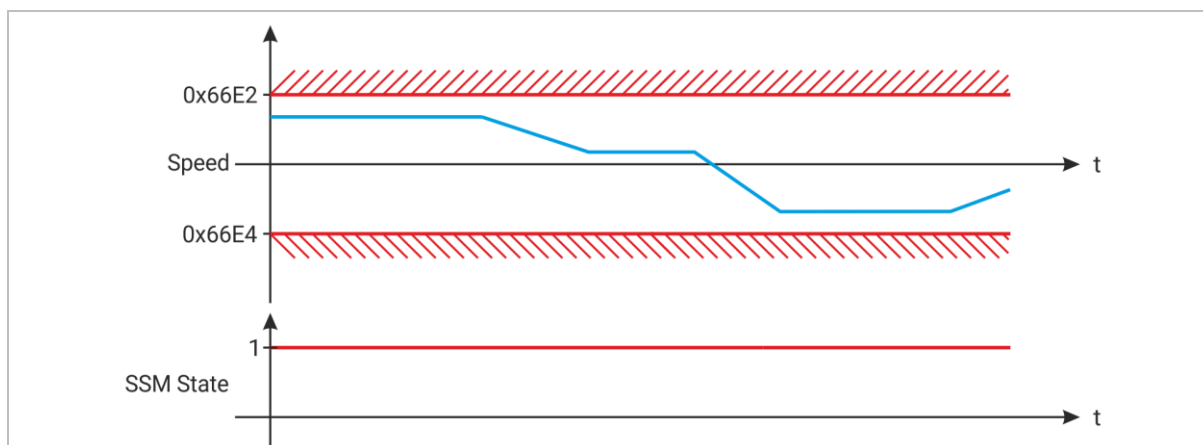
Figure 8: safety function SSM

This function activates when the object **0x264A** *Encoder type* is set to a value other than `0 - Off`. For the function to execute correctly, velocity and position acquisition parameters must be configured correctly (☞📄 7.4). The SSM function is not activated externally, but it is continuously monitoring the actual velocity. If the actual velocity exceeds limits set in **0x66E2** *SSM velocity upper limit* and **0x66E4** *SSM velocity lower limit*, the **0x66E0** *SSM Status* changes to `FALSE`. The SSM Status can be set as operation mode of the safety outputs.

NOTICE

Restrictions in Sensorless Operation
−   The minimum speed in sensorless operation is 250 rpm. Speeds lower than
     250 rpm will NOT be monitored by the SSM function.
−   The SSM function should not be used for standstill monitoring.
−   The sensorless speed capturing can only be used, as long as the power stages of
     the inverter are active. If the power stages are deactivated (e.g. due to a fault), the
     SSM function may report "within defined speed range" although the drive actually
     exceeds the speed limit.

Relevant objects

Index	Designation	Min	Max	Default
0x66E2	SSM velocity upper limit	-200000 [rpm]	200000 [rpm]	0 [rpm]
0x66E4	SSM velocity lower limit	-200000 [rpm]	200000 [rpm]	0 [rpm]

8.9   SLP - Safely Limited Position

> **NOTICE**
>
> **Optimal functioning**
>
> At request of the SLP safety function the drive shaft must be within the parameterized limits.
>
> - Ensure that the drive shaft is within the parameterized limits.

> **NOTICE**
>
> **Optimal functioning**
> - When capturing all safe positions for the drive train, consider system parameters such as the mechanical hysteresis of the position switch and any mechanical slip.

> **NOTICE**
>
> **Optimal functioning**
>
> After Power-ON a per default a homing has to be performed before the SLP function can be activated. Otherwise an error message will occur. The SLP function can be used without homing when parametrized.
>
> - For a deactivated homing ensure, the encoder delivers a safe absolute position (see encoder manual).

The SLP safety function ensures that the drive shaft does not exceed the absolute position limits as parameterized (see figure below).

Using the parameters "Position limit 1" and "Position limit 2" the limited maximum motion range of the drive is defined.

In order to be able to execute the SLP safety function, the safety module must have the safe absolute position. Prior to the first request of the SLP safety function a reference run must be executed.
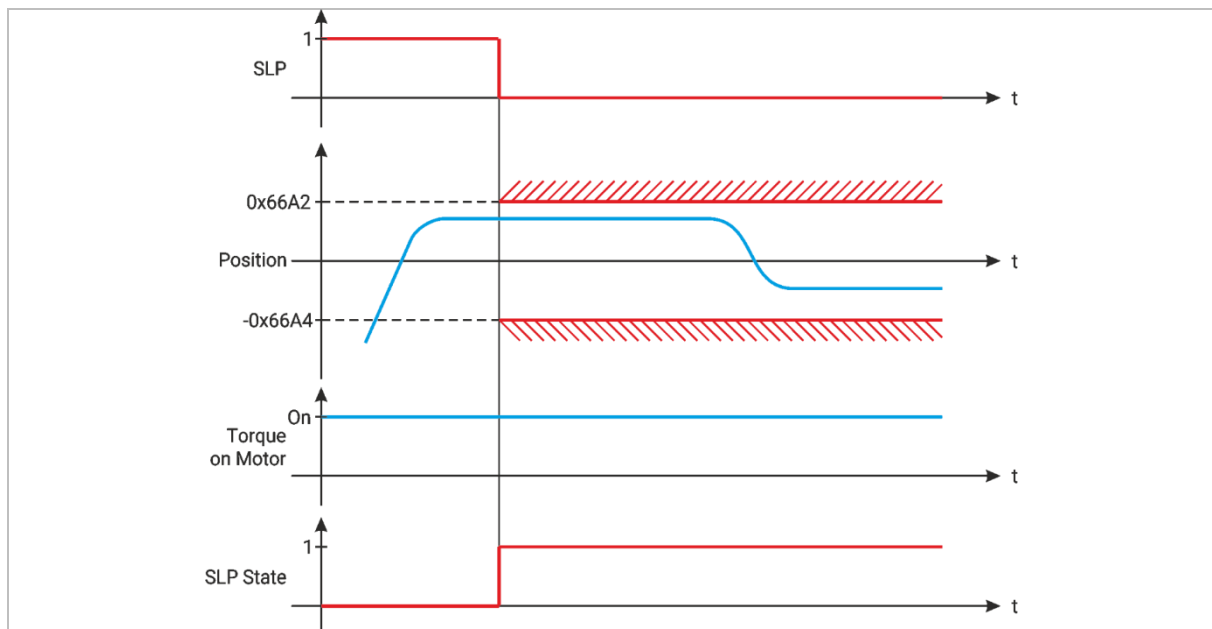
Figure 9: safety function SLP

Relevant objects

Index	Designation	Min	Max	Default
0x3E60	Debouncing time	4 [ms]	12 [ms]	4 [ms]
0x66A2	SLP position upper limit	-200000 [rpm]	200000 [rpm]	0 [rpm]
0x66A4	SLP position lower limit	-200000 [rpm]	200000 [rpm]	0 [rpm]
0x66A5	SLP error reaction		Selection	

8.10   Restart Acknowledge

> **WARNING**
>
> **Moving components**
>
> If only the SBC function is activated, restarting is not blocked by SMA-MOT. This may lead to the risk of injury by moving parts.
>
> * Install additional braking measures, if necessary.
> * When SBC is chosen to be activated first as subsequent function of SS1, be sure that object *SBC activates STO* **0x2604** is set to `STO activated by SBC`.

> **WARNING**
>
> **Moving components**
>
> If the acknowledge signal is in an undefined state when the inverter is activated, this may lead to the risk of injury by moving parts.
>
> * Make sure that the input chosen for the acknowledge signal is set to its "low" level at the moment the inverter is switched on.

Restart acknowledge is necessary, if the restart is blocked by SS1/SS2+STO/SOS functions (☞📄 8.1 8.3 8.4). The object *Restart Acknowledge Source* **0x2611** controls the input for the acknowledge signal. If the terminal X843.10 (☞📄 4.2) is chosen as source, the acknowledgement is realized via falling signal flank at the terminal. The "high" signal must apply for a duration of 100 ms - 5000 ms.

> ℹ️ Restart acknowledge is set to active/inactive via *Restart Acknowledge for STO* **0x6641**.
> If `Digital Input` is set as source in **0x2611**, the restart acknowledging is done without safe field bus.

8.11   Position Homing

In encoders where the absolute position is unsafe, position homing is required (*Homing Required* **0x2642**). This necessitates toggling a reference switch connected through two channels to one of the safe interfaces of the module. Alternatively, this can be accomplished through FSOE. (*Source start homing* **0x2644**: `0x00001000 Controlled by Fieldbus` or e.g. `0x00000011 SAFE DI 1`)

During the homing process, the SMA-MOT module monitors the reference run for a limited time period (*Time Window for Homing* **0x2647**). It is essential to ensure appropriate parameterization of safety functions SDI, SLS3 (for the negative direction), and SLS4 (for the positive direction) before initiating homing. This setting is crucial because it ensures that the speed and running direction of the system remain within the defined limits during homing. If the system violates the defined limits during homing, an appropriate error message such as "`F1233 SLS3 Speed Limit exceeded`" is generated.

Additionally, **0x2646** *Drive direction to the ref. switch* must be set to either `0xAAAA` (positive direction) or `0x5555` (negative direction) based on the selected homing method or run direction on the inverter.

Position homing can be performed independently from the homing of the inverter or simultaneously, using the same reference/limit switch on both the inverter and safety module sides. In the latter scenario, it is necessary to set the homing/limit switch source in the inverter to the safety module inputs. During simultaneous inverter and safety module homing, the *Safe Position Actual value* **0x6611** is equal to the *Position Actual value* **0x6064** (at the falling flank of the reference switch) plus the absolute position (*Absolute reference* **0x2643**) value.

To ensure accurate positioning, the reference position switch must be toggled on by moving in one direction and off by moving in the opposite direction.

9 Operational Diagnosis and Error Diagnosis

Fault ID	Name
F1200	General Safety Fault
F1201	SS1 Error Reaction Triggered
F1205	Discrepancy Monitoring STO Inputs
F1209	SS1-t Supervison
F1210	Discrepancy Monitoring SBC Inputs
F1211	Discrepancy Monitoring Safe Digital Input 1
F1212	Discrepancy Monitoring Safe Digital Input 2
F1213	Discrepancy Monitoring Safe Digital Input 3
F1214	Discrepancy Monitoring Safe Digital Input 4
F1220	Error Monitoring SS1
F1221	Error Monitoring SS2
F1222	SOS Tolerance Limit Exceeded
F1223	SLP: No Homing
F1224	SDI: Negative Direction Detected
F1225	SDI: Positive Direction Detected
F1226	Homing Timed Out
F1227	SLP: Min. Position
F1228	SLP: Max. Position
F1230	Error Acknowledge without Error
F1231	SLS1 Speed Limit Exceeded
F1232	SLS2 Speed Limit Exceeded
F1233	SLS3 Speed Limit Exceeded
F1234	SLS4 Speed Limit Exceeded
F123F	SLS-SL Speed Limit Exceeded
F1241	Encoder Voltage Limit Exceeded
F1250	HDSL Encoder Sync Error
F1251	HDSL Encoder Status Monitoring
F1252	HDSL Encoder Position Monitoring Error
F1253	HDSL Cycle Time Error
F1254	HDSL CRC Error
F1255	HDSL Startup-Error
F1256	HDSL Position Error
F1257	HDSL Connection Lost
F1258	HDSL Velocity Crosscheck failed
F1269	Maximum Velocity Exceeded
F1270	Diagnostic Error Safe Digital Output 1
F1271	Diagnostic Error Safe Digital Output 2
F1272	Diagnostic Error Safe Digital Input 1
F1273	Diagnostic Error Safe Digital Input 2
F1274	Diagnostic Error Safe Digital Input 3
F1275	Diagnostic Error Safe Digital Input 4
F1280	FSoE Watchdog Error
F1281	FSoE Control Flow Monitoring
F1282	FSoE Input Image Discrepance
F1283	FSoE CRC Error Safety Related Application Parameters
F1284	FSoE Output Image Discrepance
F1285	FSoE Non Critical Error
F1286	FSoE Softerror Detection
F1287	FSoE Invalid F-Address
F1288	FSoE Error Initialising
F1289	Output Image Deviation
F128A	Diagnostic Error F-Address Switch
F128B	Parity Error F-Address Switch
F128C	FSoE Data State Broken
F128D	FSoE Critical Error
F12A0	Undertemprature Safety Module
F12A1	Overtemprature Safety Module
F12A3	3V3 Supply Exceeds Limits
F12A4	External 24V Supply Exceeds Limits
F12A5	5V Supply Outside Permissible Range
F12A6	24V Supply Outside Permissible Range
F12A7	Internal Cross-Communication Error

F12A8	Unknown Hardware-Id
F12A9	Error Testing FailSafe Circuit
F12AA	Unsupported Safety Board Version
F12AF	3V Supply Exceeds Limits
F12B0	Diagnostic Error 24V Supply
F12B1	Diagnostic Error 5V Supply
F12B2	Diagnostic Error Encoder Voltage
F12B3	Diagnostic Error Temprature Monitoring
F12B4	Control Flow Error
F12B5	Cycle Time Monitoring Error
F12C0	Invalid Parameter-Set
F12C1	Default Password
F12C2	Softerror Detection Parameter-Set
F12C4	Safe State during Write Access
F12C5	Safe File Deviation
F12C6	Invalid Serial Number
F12C7	Firmware Deviation Channel A/B
F12C8	CRC Error Safe Application
F12C9	Safety Application Out of Date
F12D0	STO Diagnostic Error
F12D1	SBC Diagnostic Error
F12D2	24V Sensor Supply Diagnostic Error
F12D3	Sensorless Speed Diagnostic Error
F12D4	Wrong Switching Frequency Detected
F12D5	Sensorless Speed Plausibility Check Failed
F12D6	Unsupported Safety Function Activated
F12D7	Regenerative Operation
F12D8	Overcurrent Detection 24V
F12E0	CPU-Error: Lockstep
F12E1	CPU-Error: Peripherals
F12E2	CPU-Error: ECC/EDC Flash Memory
F12E3	CPU-Error: ECC/EDC RAM Memory
F12E4	CPU-Error: ECC Logic
F12E5	CPU-Error: Clock
F12E6	CPU-Error: Voltage Monitor
F12E7	CPU-Error: Watchdog
F12E8	CPU-Error: Undertemperature
F12E9	CPU-Error: Overtemperature
F12EA	CPU-Error: Register Protection
F12EB	CPU-Error: Register Redundancy
F12EC	CPU-Error: Failsafe Switchoff
F12ED	CPU-Error: ADC
F12EE	CPU-Error: RAM-Test
F12EF	CPU-Error: Unexpected Reset
F12F0	Stack Overflow / Stack Underflow
F12F1	Register Protection
F12FD	Unexpeced Initializing Request
F12FE	Asynchronous Channels
F12FF	Unknown Safety Fault

10 Error Behavior and Warning Behavior

⚠	**CAUTION**
	Moving components
	Due to faults in the power output stage of the inverter, the drive train may be caused to move unintentionally. The movement range depends on the number of pole pairs of the particular motor and on the gear ratio of any gear boxes in the drive train.
	• Consider this when planning the safety measures in the application.

NOTICE

Fault accumulation

Fault accumulation in external components of the safety chain must be excluded at commissioning as well as at re-activation after power off (OFF→ON). This must be done by check or diagnosis.

• The user must perform and confirm the necessary steps.

NOTICE

Missing feedback

In case of the device being in safe state (e.g. after an internal error) all outputs are low. The expected feedback (e.g. for SSM status, STO status, etc.) might be missing.

• The user must take this into consideration.

NOTICE

Error acknowledgement
• After a discrepancy error for the double pole inputs has occurred, both channels A and B have to be set to low, before the error can be acknowledged!

NOTICE

Reaction time

Reaction time of the double pole inputs depends also on the setting of the debouncing time (see Object **0x3E60** in the object list).

NOTICE

The status output via the LEDs is NOT safe!

Status output via Safety module LEDs (green and red LED):

LED	ON	OFF	FLASHING QUICKY	FLASHING SLOWLY	Short FLASH
ON	Start-Up	STO not activated	STO not (yet) activated. Safety function as fault reaction shall be executed.		
OFF	Non-acknowledgeable error (safe state)	Reset or no voltage	STO activated. Safety function as fault reaction shall be (or has been) executed. Error acknowledgement expected.	Waiting for error acknowledgement (safe state)	
FLASHING QUICKLY		STO active. Waiting for restart acknowledgement			
FLASHING SLOWLY		STO active			Wait for Init (Encoder/ FSoE)

11 Object List

The objects listed can be accessed as read-only, write-only or read/write. In the following table the read-only objects are designated by (1), write-only by (2) and read/write by (3).

Index	Name	Value Range	Default Value	Data Type	Description
0x2600 (3)	STO command source		0x0011	uint16_t	Source selection for STO activation or deactivation.
0x2601 (3)	SS1 command source		0xEF80	uint16_t	Source selection for SS1 activation or deactivation.
0x2602 (3)	SS1 type select	0x0000 – SS1-t 0x0001 – SS1-r 0x0002 – SS1-d	0x0000	uint16_t	0x0000 – SS1-t (SS1 **t**ime controlled) 0x0001 – SS1-r (SS1 **r**amp monitored) 0x0002 – SS1-d (SS1 **d**eceleration control-led)
0x2603 (3)	SBC command source		0x0011	uint16_t	Source selection for SBC activation or deactivation.
0x2604 (3)	SBC activates STO	0x00000000 – no action 0x66400001 – STO (AX1)	0x00000000	uint32_t	Selection, whether SBC shall activate STO (possibl. after a delay).
0x2605 (3)	SOS error reaction	0x66400001 - STO 0x66600001 - SBC	0x66400001	uint32_t	Fault reaction if SOS criteria not met.
0x2606 (3)	SS2 command source		0xEF80	uint16_t	Source selection for SS2 activation or deactivation.
0x2607 (3)	SS2 type select	0x0000 – SS2-t 0x0001 – SS2-r 0x0002 – SS2-d	0x0000	uint16_t	0000h – SS2-t (SS2 **t**ime controlled) 0001h – SS2-r (SS2 **r**amp monitored) 0002h – SS2-d (SS2 **d**eceleration controlled)
0x2608 (3) 0..3	SLS command source		0xEF80	uint16_t	Source selection for SLS activation or deactivation [0..3].
0x2609 (3)	SLP command source		0xEF80	uint16_t	Source selection for SLP activation or deactivation.
0x260A (3)	SDI positive direction command source		0xEF80	uint16_t	Source selection for SDI-POS activation or deactivation.
0x260B (3)	SDI negative direction command source		0xEF80	uint16_t	Source selection for SDI-NEG activation or deactivation.
0x2611 (3)	Restart acknowledge source	0x0005 – digital input 0x1000 – fieldbus 0x1005 – fieldbus or digital in-put	0x1005	uint16_t	Source selection for the confirmation signal of the restart release after STO/SOS.
0x2612 (3)	Error acknowledge source	0x0050 – digital input 0x1000 – fieldbus 0x1050 – fieldbus or digital in-put	0x1050	uint16_t	Source selection for the confirmation signal of the restart release after a non-permanent fault/error.
0x2614 (3)	SLS-SL command source		0xEF80	uint16_t	Source selection for SLS-SL activation or deactivation.
0x2615 (3)	SLS-SL velocity max. limit	0…200000	200000	uint32_t	SLS-SL velocity max. limit
0x2616 (3)	SLS-SL velocity min. limit	0…200000	0	uint32_t	SLS-SL velocity min. limit

Index	Name	Value Range	Default Value	Data Type	Description
0x2617 [3]	SLS-SL velocity scale	0…100000	10000	uint32_t	Scaling variable limit.
0x2618 [3]	SLS-SL time to velocity monitoring	full value range of the data type	0x0000	uint16_t	Delay until start of limit monitoring. Unit: Millisecond
0x2619 [3]	SLS-SL error reaction	0x66400001 - STO 0x66500001 - SS1 0x66700001 - SS2	0x66400001	uint32_t	Fault reaction if parameterized SLS-SL speed limit is exceeded.
0x263F [3]	HDSL safe Channel 1 nr. of bits	1-48	20	uint16_t	HDSL resolution Safe Channel 1
0x2640 [3]	HDSL Channel 2 nr. of bits	1-48	9	uint16_t	HDSL resolution Safe Channel 2
0x264F	HDSL Max. Dev. CH1/CH2	0-16	3	Uint16_t	HDSL maximum allowed deviation between Channel 1 / Channel 2 (see datasheet of encoder).
0x2641 [3]	HDSL Version	0x00 – 0xFF	0x17	uint16_t	permissible HDSL Version (Format like Register 0Bh of the IP-Core)
0x2642 [3]	Homing required	0x00 0x01	0x01	bool_t	Selection, whether a Homing must be performed in order to use SLP. 0x00=no Homing 0x01=perform Homing
0x2643 [3]	Absolute homing position	full value range of the data type	0x00000000	int32_t	Reference position to capture at the reference switch.
0x2644 [3]	Source start homing	0x0000 - deactivated 0x0011 – DI1 0x0022 – DI2 0x0033 – DI3 0x0044 – DI4 0x1000 – fieldbus	0x0044	uint16_t	Selection of digital input to start the Homing
0x2645 [3]	Source homing switch signal	0x0000 - deactivated 0x0011 – DI1 0x0022 – DI2 0x0033 – DI3 0x0044 – DI4 0x1000 – fieldbus	0x0033	uint16_t	Selection of digital input to connect the reference switch to
0x2646 [3]	Drive direction to ref. switch	0x5555 - positive 0xAAAA - negative	0xAAAA	uint16_t	Selecting the rotation direction for moving towards the reference switch 0x5555=negative rotation direction (counter-clockwise) 0xAAAA=positive rotation direction (clockwise)
0x2647 [3]	Time window of homing	0--600000	10000	uint32_t	Timeframe for completion of the homing
0x264A [3]	Encoder type	0x0000 – Off 0x0001 – Sensorless Speed evaluation 0x0002 – Hiperface DSL	0x0000	uint16_t	Selection of the encoder employed or activation of open-loop capturing
0x264B [3]	Minimum encoder volt-age	450-1300	700	uint16_t	Minimum encoder voltage in V/100
0x264C [3]	Maximum encoder volt-age	450-1300	1200	uint16_t	Maximum encoder voltage in V/100

Index	Name	Value Range	Default Value	Data Type	Description
0x264D [3]	PWM Switching Frequency	2-16	4	uint16_t	PWM Switching Frequency expected value in kHz (for open-loop speed capturing)
0x264E [3]	Number of pole pairs	1-128	2	uint16_t	Number of pole pairs of the motor (for open-loop speed capturing)
0x2625 [1]	Current fault / error code	full value range of the data type		uint16_t	Current fault. NOT SAFE DATA
0x2626 [1]	Last fault / error code	full value range of the data type		uint16_t	Last fault. NOT SAFE DATA
0x3E0C [3]	DO1 output select	0x0000 – Output off 0x0001 – STO 0x0002 – SSM 0x0004 – SOS 0x0006 – SdiPos 0x0007 – SdiNeg 0x0008 – No Error 0x0009 – Restart ack pending 0x000A – Sls1 0x000B – Sls2 0x000C – Sls3 0x000D – Sls4 0x000E – Slp 0x000F – SlsSl 0x0010 – Sbc 0x0016 – Ss1 0x0017 – Ss2 0x0018 – safe Abs.-Position 0x0100 – Output on (Test-pulse) 0x1000 –Field bus control	0x0000	uint16_t	Selection of information to put out at DO.
0x3E0D [3]	DO2 output select	see Object 0x3E0C	0x0000	uint16_t	Selection of information to put out at DO.
0x3E21 [1]	Serial number	full value range of the data type		uint32_t	Serial number of SMA-MOT-11 assembly. NOT SAFE DATA Format: YYMMTTXXX (Year/month/day/consecutive number 3-digit) Example: 181217001 -> first module produced on 12/17/2018.
0x3E28 [3]	Field bus	0x0000 – no Fieldbus 0x0001 - FSoE	0x0000	uint16_t	Field bus protocol slave selection
0x3E60 [3]	Debouncing time	4,6,8,10,12	4	uint16_t	Filtering time for de-bouncing of the safe digital inputs in milliseconds
0x3E61 [3]	Discrepancy Time	100..5000	500	uint16_t	Tolerance time for a deviation among two digital inputs of a safe two-channel input (DI1 - DI4) in milliseconds. This time is safety tolerated. Time for error reaction depends also on settings for debouncing time and further signal delays.
0x6611 [1]	safe position actual value			int32_t	Safe position actual value. NOT SAFE DATA
0x6613 [1]	safe velocity actual value			int32_t	Safe velocity actual value. NOT SAFE DATA

Index	Name	Value Range	Default Value	Data Type	Description
0x6620 (1) 1..6	safety controlword		0	ARRAY OF BYTE	Control word. NOT SAFE DATA
0x6621 (1) 1..4	safety statusword		0	ARRAY OF BYTE	Status word. NOT SAFE DATA
0x6640 (2)	STO command	0/1	0	bool_t	Write access: 0 = safety function activated 1 = safety function deactivated Read access: sSTO status NOT SAFE DATA
0x6641 (3)	STO restart acknowledge behavior	0x00 (false) – automatic restart 0x01 (true) – manual restart	0x01 (true)	bool_t	Selection of restart behavior: 0x00 – Restart after STO w/o manual restart release 0x01 – Restart after STO requires manual restart release
0x6643/1 (3)	STO activates SBC	0x00000000 – no SBC 0x66600001 – SBC (AX1)	0x00000000	uint32_t	Selection, whether STO shall activate SBC.
0x6650/1 (2)	SS1 Status	0/1	0	bool_t	Write access: 0 = safety function activated 1 = safety function deactivated Read access: SS1 status
0x6651 (3)	SS1 time to STO	full value range of the data type	0x0000	uint16_t	Delay for the triggering of STO by SS1. Unit: Millisecond
0x6653 (3)	SS1 velocity zero window	full value range of the data type	0x00000000	uint32_t	Velocity window for rpm = 0 detection. Unit: rpm
0x6656 (3)	SS1 deceleration limit	1..1000000	3000	uint32_t	Deceleration limit for SS1-r Unit: rpm/s
0x6657 (3)	SS1 time delay deceleration monitoring	full value range of the data type	0x0000	uint16_t	Delay until the start of monitoring of the braking ramp. This parameter shall be used for SS1-r only. It must be set to lower values than "0x6651 SS1 time to STO". Unit: Millisecond
0x6658 (3)	SS1 activate SBC	0x66400001 – STO (AX1) 0x66600001 – SBC (AX1)	0x66400001	uint32_t	This parameter shall set, whether SS1 activates SBC. SBC then in turn shall activate (possibl. after a delay) STO. This is not a fault reaction function! In case of fault STO shall be activated immediately at all times.
0x6660/1 (2)	SBC Status	0/1	0	bool_t	Write access: 0 = safety function activated 1 = safety function deactivated Read access: SBC status
0x6661 (3)	SBC brake time delay	full value range of the data type	0x0000	uint16_t	Delay between activation of SBC and STO. Unit: Millisecond
0x6668/1	SOS Status				
0x666A (3)	SOS position zero window	0..4194304	0x00000000	uint32_t	Position window for the stop function Unit: Increments

Index	Name	Value Range	Default Value	Data Type	Description
0x666C [3]	SS2/SOS velocity zero window u32	full value range of the data type	0x00000000	uint32_t	Window for detection of velocity = 0. Unit: rp
0x6670/1 [2]	SS2 Status	0/1	0	bool_t	Write access: 0 = safety function activated 1 = safety function deactivated Read access: SS2 status
0x6671 [3]	SS2 time to SOS	full value range of the data type	0x0000	uint16_t	Delay to activation of SOS by SS2 Unit: Millisecond
0x6672 [3]	SS2 time for Velocity zero	full value range of the data type	0x0000	uint16_t	Minimum time velocity must be below object 0x666C until velocity zero condition is recognized.
0x6674 [3]	SS2 deceleration limit	1..1000000	3000	uint32_t	Deceleration limit for SS2-r Unit: rpm/s
0x6675 [3]	SS2 time delay deceleration monitoring	full value range of the data type	0x0000	uint16_t	Time delay to activate deceleration limit
0x6676 [3]	SS2 (SOS) restart acknowledge behavior	0x00 (false) – automatic restart 0x01 (true) – manual restart	0x01 (true)	bool_t	Selection of restart behavior: 0x00 – Restart after SOS w/o manual restart release 0x01 – Restart after SOS requires manual restart release
0x6690 [2] 0..3	SLS Status	0/1	0	ARRAY OF bool_t	Write access: 0 = safety function activated 1 = safety function deactivated Read access: SLS status
0x6691 [3] 1..4	SLS time to velocity monitoring	full value range of the data type	0x0000	ARRAY OF uint16_t	Delay until start of limit monitoring. Unit: Millisecond
0x6693 [3] 1..4	SLS velocity limit	full value range of the data type	0x00000000	ARRAY OF uint32_t	Velocity limit Unit: rpm
0x6698 [3] 1..4	SLS error reaction	0x66400001 - STO 0x66500001 - SS1 0x66700001 - SS2	0x66400001	uint32_t	Fault reaction if parameterized SLS speed limit is exceeded.
0x66A0/1 [2]	SLP Status	0/1	0	bool_t	Write access: 0 = safety function activated 1 = safety function deactivated Read access: SLP status
0x66A2 [3]	SLP position upper limit	-2147000000..2147000000	0x00000000	int32_t	Upper Position limit Unit: Increments
0x66A4 [3]	SLP position lower limit	-2147000000..2147000000	0x00000000	int32_t	Lower Position limit Unit: Increments
0x66A5 [3]	SLP error reaction	0x66400001 - STO 0x66500001 - SS1 0x66700001 - SS2	0x66400001	uint32_t	Fault reaction if SLP criteria not met.

Index	Name	Value Range	Default Value	Data Type	Description
0x66D0 (2)	SDI Pos. status	0/1	0	bool_t	Write access: 0 = safety function activated 1 = safety function deactivated (clockwise rotation released) Read access: SDI status
0x66D1	SDI neg. Status	0/1	0	bool_t	Write access: 0 = safety function activated 1 = safety function deactivated (counter-clockwise rotation released) Read access: SDI status
0x66D3 (3)	SDI position zero window	0..4194304	0x00000000	uint32_t	Position frame for Stop Position.
0x66D5 (3)	SDI velocity zero window	full value range of the data type	0x00000000	uint32_t	Window for detection speed = 0.
0x66E0/1 (2)	SSM Status	0/1	0	bool_t	Read access 0 = speed beyond limits 1 = speed within limits
0x66E2 (3)	SSM velocity upper limit	-200000..200000	0x00000000	int32_t	velocity upper limit
0x66E4 (3)	SSM velocity lower limit	-200000..200000	0x00000000	int32_t	velocity lower limit

Functional Safety manual AXIA
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Bonfiglioli

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We have a relentless commitment to excellence, innovation & sustainability. Our team creates, distributes and services world-class power transmission & drive solutions to keep the world in motion.

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