Servo Controller
SE-Power FS

- **STO-Manual**

Complementary document to the Operating Instruction

Translation: English

afag

Table of Contents

List of figures:

List of tables:

This manual is a complementary document to the operating instructions and applies to:

Type	Order No.
SE-Power FS Safety Module FSM 2.0 STO	50393463

Version of this documentation: SE-Power FS STO-manual vers. 1.6 en.12.08.2015

Assembly and initial start-up may be carried out by qualified personnel only and according to these operating instructions.

Caution!

As this manual is a complementary document to the operating instructions it alone is not sufficient to carry out installation and commissioning of the device.

Please pay attention to the notes in:

1.1 Documentation

The information's in this manual refers to the following hardware variants and Firmware versions of the servo positioning controller SE-Power and the version of the Parameterization program Afag SE-Commander

Firmware:	**from version 4.0 KM-Release 1.1**
Parameterization program:	**from version 4.0**
Hardware:	**SE-Power FS with Safety Module FSM 2.0 STO from revision 1.5**

1 General

1.1 Documentation

For the Servo Controllers of the SE-Power series are considerably documentations available. There are main documents and complementary documents.

The documents contain safety instructions that must be followed.

Main document:

present	documentation / description
☐	▪ **SE-Power FS Operating manual** Description of the technical data and the functions of the device as well as notes on the plug assignment, installation and operation of the SE-Power FS servo controller series. It is meant for persons who want to get familiar with the SE-Power FS servo controller

Caution!

The operating manual is the main document and must be read by all means before installation and start-up of all devices of the SE-Power FS series.

Complementary documents to the operating manual:

present	documentation / description
☐	▪ **SE-Power FS mounting instructions** This manual is included during delivery of the SE-Power FS devices and provides an extract from the manual represents the installation instructions contained therein make sure that they can easily operate the servo drive.
☒	▪ **SE-Power FS STO-manual** Description of the technical data and the device functionality, installation, and operation of the safety module STO.
☐	▪ **SE-Power FS MOV-manual** Description of the technical data and the device functionality, installation, and operation of the safety module MOV.
☐	▪ **SE-Power Software-manual** Description of the software SE-Commander with the individual functions.
☐	▪ **SE-Power CANopen-manual** Description of the implemented CANopen protocol according to CiA DSP402 and DS301.

☐	▪ **SE-Power FS PROFIBUS/PROFINET-manual** Description of the implemented PROFIBUS-DP and PROFINET protocols, the technical data and the device functionality, installation, and operation of the fieldbus-modules „SE-Power Profibus Interface“ and „SE-Power Profinet Interface“.
☐	▪ **SE-Power EtherCAT-manual** Description of the fieldbus control by using the CoE (CANopen over EtherCAT) protocol, the technical data and the device functionality, installation, and operation of the fieldbus-module „SE-Power EtherCAT Interface“.
☐	▪ **SE-Power FS programming example Siemens S7 V5.5** Description of the configuration and program from the programming example for Siemens S7 V5.5.
☐	▪ **SE-Power FS programming example Siemens S7 TIA V12** Description of the configuration and program from the programming example for Siemens S7 TIA V12.
☐	▪ **SE-Power FS Programming example Profinet Siemens S7 TIA V13/V14** Description of the configuration and program to the programming example for Profinet for Siemens S7 TIA V13.1 and V14.0.

These documents are available for download on our homepage:

www.afag.com

2 Used symbols

Information

Important information and notes.

Caution!

No observance may result in severe property damages.

DANGER!

No observance may result in property damages and in personal injuries.

Caution! Life-threatening voltages.
The safety instruction contains a pointer to the occurrence of a possibly life-threatening voltage.

3 Safety and requirements for product use

3.1 Safety

3.1.1 General safety information

Caution!

The operating manual is the main document and must be read by all means before installation and start-up of all devices of the SE-Power FS series

Note

Danger of loss of the safety function.

Non-compliance with environmental and connection conditions can lead to loss of the safety function.

- ❖ Observe the specified environmental and connection conditions, in particular the input voltage tolerances *Technical data, Appendix 9.1.*

Note

Incorrect handling can damage the safety module or the servo drive.

- ❖ Before mounting and installation work, switch off the supply voltage. Switch on the supply voltage only when the mounting and installation work is complete.

- ❖ Never unplug a module from, or plug a module into the servo drive when it is energised!
- ❖ Observe the handling specifications for electrostatically-sensitive devices.

3.1.2 Intended use

The safety module SE-Power FS Safety Module STO serves as an expansion of the servo drive SE-Power FS to achieve the safety function:

- Safely switched-off torque – “Safe Torque Off” (STO) with SIL3 according to EN 61800-5-2 / EN 62061 / IEC 61508 or category 4 / PL e according to EN ISO 13849-1.

The servo drive SE-Power FS with safety module SE-Power FS Safety Module STO is a product with safety-relevant functions and is intended for installation in machines or automation systems and for use as follows:

- in a faultless technical condition
- in its original condition, without any modifications by the user
- within the product’s limits as defined by the technical data *(➔ Appendix 9.1)*
- in an industrial environment.

The Functional Safety Modules SE-Power FS Safety Module can be operated in all servo drives of the product family SE-Power FS. Those are equipped with the slot for safety modules (“FSM slot”). The safety modules cannot be inserted into one of the extension slots for technology modules (TECH1 or TECH2).

➔ **Note**

Bei Schäden, die aus unbefugten Eingriffen oder nicht bestimmungsgemäßer Verwendung entstehen, erlischt der Gewährleistungs- und Haftungsanspruch gegenüber dem Hersteller.

3.1.3 Possible incorrect application

Improper use includes the following possible cases of incorrect application:

- use in a device other than the servo drive SE-Power FS
- use outdoors
- use in a non-industrial area (residential area)
- use in applications where switching off can result in hazardous movements or conditions.

➔ **Note**

- The STO function is insufficient as the sole safety function for drives subject to permanent torque (e.g. suspended loads).
- Bypassing of safety equipment is impermissible.
- Repairs on the module are impermissible!

The STO (Safe Torque Off) function does not provide protection against electric shock, only against hazardous movements!

➔ SE-Power FS Operating manual

3.1.4 Achievable safety level, Safety function according to EN ISO 13849-1 / EN 61800-5-2

The safety module fulfils the basic test requirements:

- Category 4 / PL e according to EN ISO 13849-1,
- SIL CL 3 according to EN 61800-5-2 / EN 62061 / IEC 61508,

and can be used in applications up to cat. 4 / PL e according to EN ISO 13849-1 and SIL 3 according to EN 62061 / IEC 61508.

The achievable safety level depends on the other components used to achieve a safety function.

3.2 Requirements for product use

- Make this documentation available to the design engineer and installer or person responsible for commissioning the machine or system in which this product will be used.
- Ensure compliance with specifications in the documentation at all times. Also take into account the documentation for the other components and modules (e.g. servo drive, lines, etc.).
- Take into account the legal regulations applicable to the destination, as well as:
  - regulations and standards
  - regulations of the testing organisations and insurers
  - national specifications.
- For emergency stop applications, protection against automatic restart must be provided according to the required safety category. This can be achieved through an external safety switching device, for example.

3.2.1 Technical requirements

General conditions for the correct and safe use of the product, which must be observed at all times:

- Comply with the connection and environmental conditions of the safety module *(➔ Appendix 9.1),* the servo drive and all connected components.
  The product can be operated in accordance with the relevant safety guidelines only if the limit values or load limits are observed.
- Observe the warnings and instructions in this documentation.

3.2.2 Qualification of the specialist personnel (requirements for personnel)

The device may only be placed in operation by a qualified electrical engineer who is familiar with:

- installation and operation of electrical control systems,
- the applicable regulations for operating safety-engineered systems,
- the applicable regulations for accident protection and occupational safety, and
- product documentation.

3.2.3 Diagnostic coverage (DC)

Diagnostic coverage depends on the connection between the servo drive with safety module and the control loop system as well as the implemented diagnostic measures.

If a potentially hazardous disturbance is recognised during diagnosis, appropriate measures for maintaining the safety level must be implemented.

➔ **Note**

Check whether cross-circuit detection of the input circuit and the connection wiring is required in your application.

If needed, use a safety switching device with horizontal cross-circuit detection to activate the safety module.

3.2.4 Range of applications and certification

The servo drive with built-in safety module is a safety component in accordance with the machinery directive; the servo drive bears the CE mark.

Standards and test values which the product must comply with and fulfils can be found in the *section „Technical data“ (➔ Appendix 9.1).* The product-relevant EU directives can be found in the declaration of conformity.

4 Product description SE-Power Safety Module STO

4.1 Product overview

4.1.1 Purpose

As processes become increasingly automated, protecting people from potentially hazardous movements is gaining in importance. Functional safety describes the measures offered by electrical or electronic devices that are required to reduce or eliminate malfunction-induced hazards. In normal operation, safety devices prevent human intervention in hazardous areas. In certain operating modes, during set-up for example, people also need to be in hazardous areas. In such situations, the machine operator must be protected by drive and internal control measures.

Integrated functional safety technology provides the conditions required by controller and drive for the optimised realisation of safety functions. Planning and installation complexity is reduced. The use of integrated functional safety technology increases machine functionality and availability over the levels achieved by conventional safety technology.

Type	Description
Safety Module STO (FSM 2.0 – STO)	Safety module with STO function and DIP switches.
Safety Module MOV (FSM 2.0 – MOV)	Safety module with the safety functions STO, SS1, SS2, SOS, SBC, SLS, SSR, SSM and DIP switches.

Table 1: Overview safety-activation-modules for the SE-Power FS

4.1.2 Supported devices

The SE-Power FS Safety Module STO can only be used in servo drives in conformity with *Section 3.1.2*.

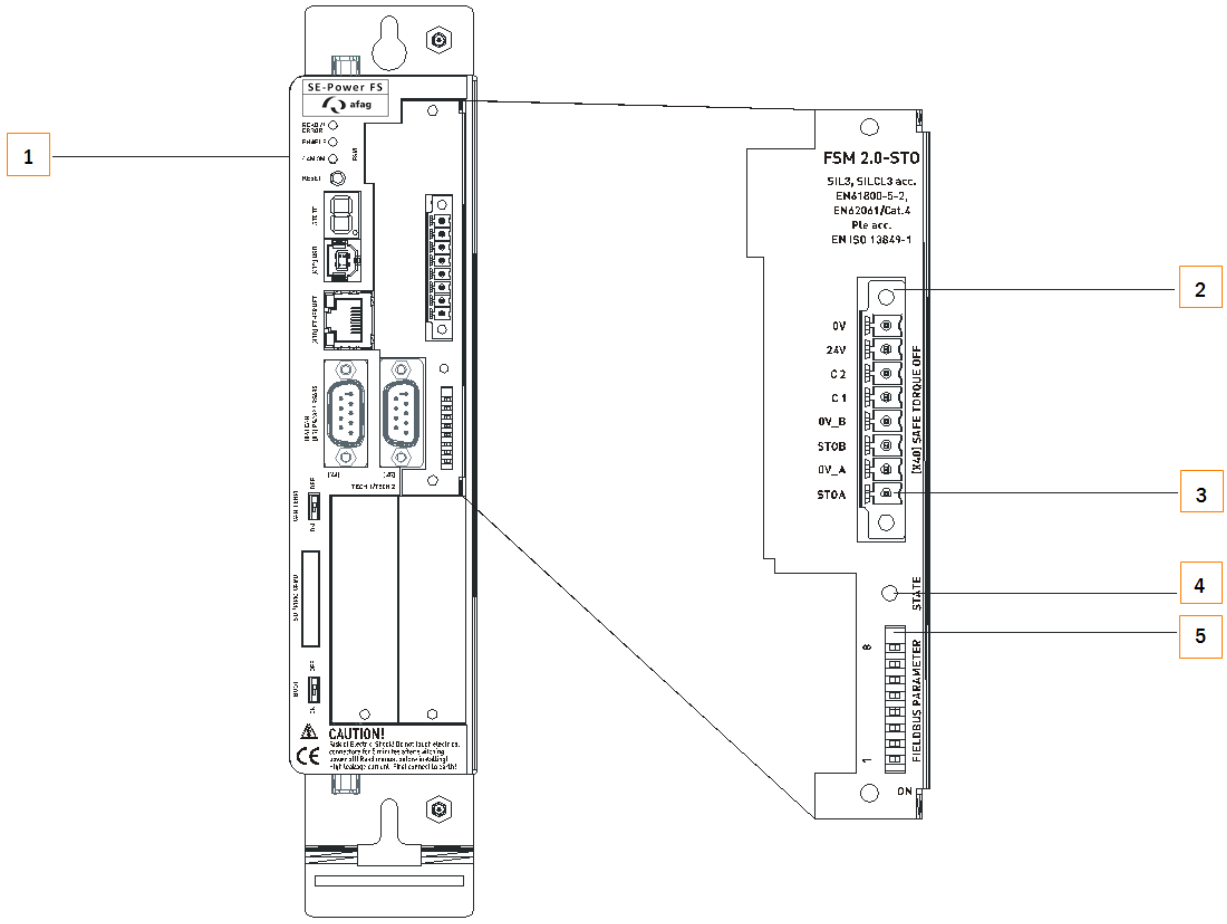
As a standard, the SE-Power FS series servo drives come supplied with the ordered safety module (STO or MOV) for integrated functional safety.

The use of the SE-Power FS Safety Module STO enables the safety functions, described in this product manual for the integrated functional safety of safety stops, to be expanded.

For the use of the SE-Power FS Safety Module MOV it requires the manual: „SE-Power FS MOV-Manual“.

4.1.3 Control sections and connections

The SE-Power FS Safety Module STO has the following control sections, connections and display components.



1 Servo drive SE-Power FS with slot for a Functional Safety Module

2 Digital I/O-interface [X40] for control of the STO function

3 Pin 1 of the interface [X40]

4 LED for status display (functional safety status)

5 DIP-switch (activation/configuration of the fieldbus communication in the servo drive)

Figure 1: Operator panel and connections SE-Power FS Safety Module STO

4.2 Function and application

The safety module SE-Power FS Safety Module STO has the following performance characteristics:

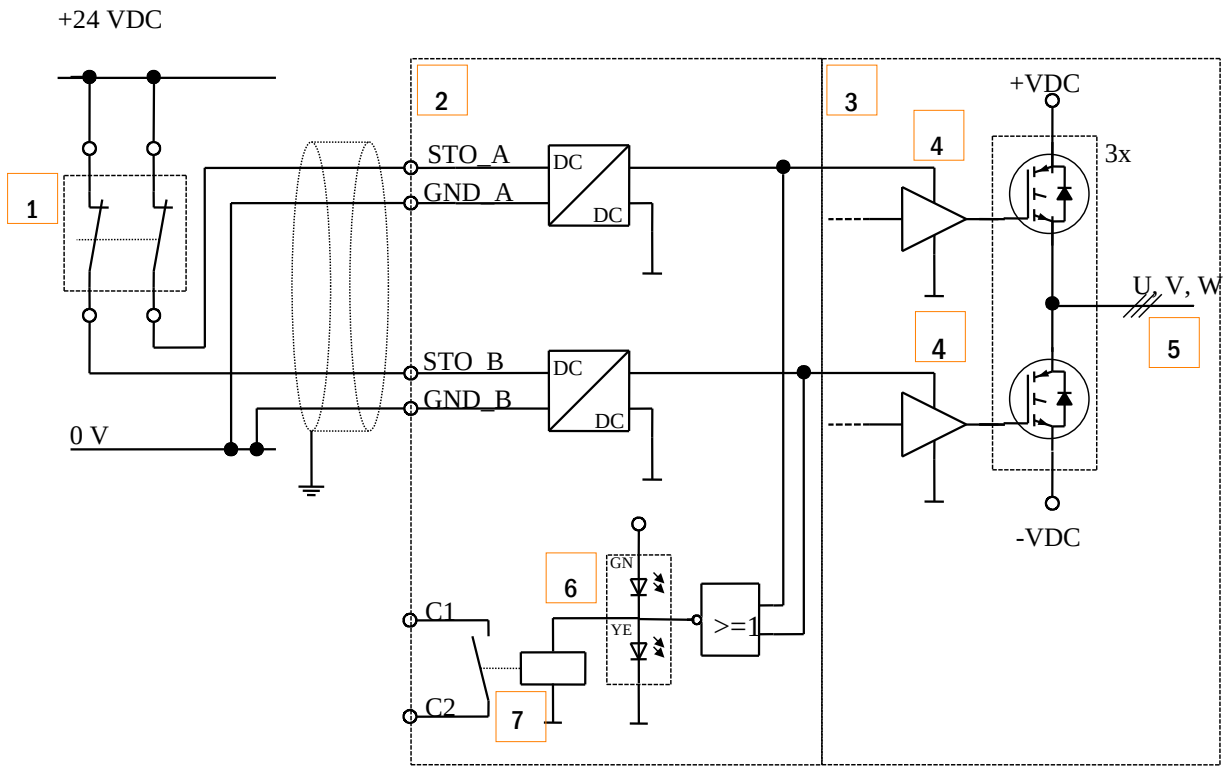
- “Safe Torque Off” (STO) function,
- Potential-free feedback contact for the operating status,
- Designed as a plug-in module that can be plugged in from the outside thus enabling retrofits,
- Suitable solely for SE-Power FS servo drives series.

The “Safe Stop 1” (SS1) function can be realised by employing a suitable external safety switching device and appropriate servo drive SE-Power FS circuitry.

4.2.1 Description of the safety function STO

Use the function “Safe Torque Off” (STO) whenever you have to reliably disconnect the energy supply to the motor in your particular application.

The function “Safely Torque Off” switches off the driver supply for the power semiconductor, thus preventing the power end stage supplying the voltage required by the motor see *Figure 2.*



1 Safety circuit (switch, relay, safety switching device)

2 SE-Power FS Safety Module STO

3 Power end stage in the SE-Power FS (only one phase illustrated)

4 Driver supply

5 Motor connection

6 LED (green / yellow), status display

7 Feedback contact

Figure 2: “Safe Torque Off” – Operating principle for the SE-Power FS

The power supply to the drive is reliably disconnected via the active safety function STO “Safe Torque Off”. The drive cannot generate torque and so cannot perform any hazardous movements. With suspended loads or other external forces, additional measures must be taken to reliably prevent sagging (e.g. mechanical holding brake). In the STO “Safe Torque Off” state, the standstill position is not monitored.

The machine must be stopped in a safe manner, e.g. via a safety switching device. This applies specifically to vertical axes without self-locking mechanism, clamping unit or counterbalance.

Note

There is a risk that the drive will advance in case of multiple errors in the SE-Power FS.

If the output stage of the servo drive fails while in the STO status (simultaneous short circuit of 2 power semiconductors in different phases), a limited dwell movement of the rotor may result. The rotation angle / path correspond to a pole pitch. Examples:

- Rotary axis, synchronous machine, 8-pin ➔ movement < 45° at the motor shaft.
- Linear motor, poles pitch 20 mm ➔ movement < 20 mm at the moving part.

4.2.2 Overview of interface [X40]

On its front, the safety module provides an 8-pin connection [X40] for control ports, feedback contact and a 24 V auxiliary supply for external sensors ➔ *Section 5.2*.

The safety function STO is requested solely via the two digital control ports STO-A and STO-B. A safety circuit for additional interfaces at the SE-Power servo drive is neither required nor intended

Cross-circuit detection in the input circuit is not carried out by the safety module.

The status of the servo drive is reported back to an external safety switching device through a potential-free acknowledgment contact (normally open). This enables downwards-compatible activation in a mixed configuration, comprising an SE-Power (previous series with the “Safe Stop” function to be realised via the connection [X3]) and the SE-Power FS ➔ *Section 8.3*.

The interface [X40] permits the direct connection of active and passive sensors, since a 24 V supply voltage (auxiliary supply) with corresponding reference potential is lead out.

Connections	Description
STO-A (Pin 1) 0V-A (Pin 2)	Control port A for the STO function with corresponding reference potential. [1)] – Request for “Safe Torque Off” (STO) at Low (0 signal), together with STO-B
STO-B (Pin 3) 0V-B (Pin 4)	Control port B for the STO function with corresponding reference potential. [1)] – Request for “Safe Torque Off” (STO) at Low (0 signal), together with STO-B.
C1 (Pin 5) C2 (Pin 6)	Feedback contact for the “Safe Torque Off” (STO) status, e.g. to an external controller. – Feedback contact opened: „Safe Torque Off“ (STO) not active – Feedback contact closed: „Safe Torque Off“ (STO) active
24 V (Pin 7) 0 V (Pin 8)	Auxiliary supply, e.g. for safety peripherals (24 V DC logic supply of the servo drive).
1) Control inputs 24 V, high active, based on EN 61131-2, deviating signal level, see *Section 9, Table 21*.	

Table 2: Function of the module connections

The connections are electrically isolated from each other in groups and from the 24 V-supplies to the servo drive ➔ *Section 9, Table 24*.

4.2.3 Control ports STO-A, 0V-A / STO-B, 0V-B [X40]

The safety function STO (Safe Torque Off) is requested via the two control ports STO-A and STO-B. They permit the direct connection of safe semiconductor outputs (electronic safety switching devices, active safety sensors, e.g. light curtains with OSSD signals) and of switch contacts (safety switching device with relay outputs, passive safety sensors, e.g. forcibly-guided position switches) ➔ *e.g. Section 5.2.3, Figure 7*.

To request the safety function STO (Safe Torque Off), the 24 V control voltage at both control ports STO-A and STO-B is switched off (0 V).
If the two control ports are switched off simultaneously or within a defined discrepancy time, the STO function is active.

For control ports STO-A and STO-B, an under voltage monitoring mechanism is integrated to eliminate the possibility of invalid voltage ranges for the downstream electronics, as well as an overvoltage monitoring mechanism to protect against overvoltage.

Table 21 in Section 9.1.4 describes the technical data for the control ports within the specified operating range of the logic voltages.

Tolerance ranges are defined for the input voltage range of control ports STO-A and STO-B. The amount of energy stored in the safety module components (e.g. capacitors) depends on the input voltage level. During switching operations, these energies must be charged or discharged. Consequently, switch-off time values for the transition to the safe state (STO) and the tolerance time vis-a-vis OSSD signals (buffer time) depend on the input level

The time response requirements are contained in the technical specifications in *Section 9.1.4*. The time Response itself is described in *section 4.4.*

4.2.3.1 Discrepancy time

The transition between the safe and the unsafe state is initiated via level changes at the control ports STO-A and STO-B of the safety module FSM 2.0 – STO. According to the safety function specification, the two levels must be identical otherwise an error message will be generated. The finite state machine in the servo drive internally monitors the driver supply voltage after the control ports have been activated. Due to component tolerances or bouncing safety controller ports, for example, these level changes do not normally occur precisely at the same time. The firmware tolerates this for as long as the second input occurs within a defined time, the so-called discrepancy time. If this time is exceeded, the servo drive generates an error message.

The default discrepancy time is 100ms.
Recommendation: Always switch STO-A and STO-B simultaneously.

4.2.3.2 Test pulse

Temporary test pulses from safety controllers are tolerated and thus do not trigger the STO function.

The tolerance to test pulses from sensors with OSSD signals is rated for the operating range specified in accordance with *Appendix 9.1.4*, *Table 22*. The permissible test pulse length is dependent upon the control voltage level at inputs STO-A and STO-B.

Example: Input voltage for STO-A and STO-B = 24 V
➔ OSSD signals with a test pulse length of 3.5ms are tolerated.

4.2.4 Feedback contact C1, C2 [X40]

If the STO function is inactive, the feedback contact opens. This is the case, for example, when only one of the two control voltages STO-A or STO-B is present, if the 24 V logic power supply is switched off or if the supply voltage fails.
When the STO function is active, the relay contact is closed.

The feedback contact has a single channel and may be used for diagnostic purposes, but not in the safety circuit.

Table 23 in Section 9.1.4 describes the electrical data, *Table 22* the time response of the feedback contact. When the 24 V supply to the basic device is turned on and off, the switching status of the relay may – due to the internal supply voltages powering up at a different speed – deviate briefly (approx. 100ms) from the state of the control ports STO-A and STO-B.

4.2.5 Auxiliary supply 24V, 0V [X40]

The servo drive SE-Power FS with safety module SE-Power FS Safety Module STO provides a 24 V auxiliary supply to [X40]. This can be employed when using the feedback contact C1/C2 or to supply external, active sensors.

Table 24 in Section 9.1.4 describes the electrical data for the auxiliary supply.

4.2.6 Status display

To display the status of the safety function, the safety module has an LED on its front, see *Section 7.4.1.*

The status LED displays the module's operating state (green = STO inactive, yellow = STO active). The display corresponds to the state of the feedback contact C1/C2.

4.2.7 DIP switch

Located on the front of the safety module are DIP switches. These switches have no safety function. The meaning of the individual switches depends on the technology module used for the fieldbus communication.

The fieldbus communication can be activated/deactivated or a station address can be set, for example, via the DIP switches.

4.3 Functionalities in the basic SE-Power FS

The following functions in the basic unit SE-Power FS are not certified according to EN 61800-5-2. They are functional supplements and offer additional diagnostics options.

Error messages generated by the safety module, such as exceeding the discrepancy time, are detected and analysed by the non-safety finite state machine of the servo drive. If conditions for an error status are detected, an error message is generated. In this case, it cannot always be guaranteed that power end stage has been safely switched off.

The safety module SE-Power FS Safety Module STO controls only the provisioning of the driver supply for the servo drive SE-Power FS. Although input voltage levels are monitored area by area, the safety module does not have its own error analysis function and is unable to display errors.

Note

When error messages are acknowledged, all acknowledgeable errors regarding functional safety are also always acknowledged ➔ *Section 7.4.2*.

The servo drive SE-Power FS monitors the status of the control ports STO-A and STO-B.

Consequently, the servo drive firmware detects the request for the safety function STO (Safe Torque Off) and various non-safety functions are then performed:

- Detection of deactivated driver supply for the power semiconductor via the safety module
- Deactivation of the drive controller and activation of the power semiconductor (PWM)
- The holding brake controller is deactivated (if configured)
- Finite state machine on the servo drive with activation analysis (discrepancy time)
- Detection of application-related error messages
- Hardware diagnostics
- Status and error display via display, digital outputs, fieldbuses etc.

Note

The brake is activated by the servo drive's non-safety firmware.

Note

If one of the control ports STO-A or STO-B is deactivated with an active output, the drive coasts unbraked if no holding brake is connected.

This can cause damage to the machine. It is therefore recommended that a holding brake is connected to the servo drive.

Please check whether the motors with holding brake you use is designed to decelerate and bring the motor to a standstill via the holding brake, should malfunction occur.

The safe state can be requested when the power semiconductor (PWM) is activated. The two driver supply voltage states are detected and analysed in 10ms cycles. If they are unequal over a prolonged period, an error message is generated ➔ *Section 7.4.2*. The safety function presupposes that the two signals have the same status. Unequal signals are tolerated only during a transition period, the so-called "discrepancy time ➔ *Section 4.2.3*

The finite state machine in the servo drive SE-Power FS has its own status in parallel to the safety module SE-Power FS Safety Module STO. Due to the discrepancy time analysis, this finite state machine may reach the “Safe status” only with a considerable delay. Accordingly, this state can also be signalled via digital outputs or a fieldbus only with a considerable delay. The power end stage itself is then, however, “safely switched off”. This finite state machine is processed within the 10ms cycle.

This generally results in a graded response speed as per *Table 3*:

Function	Response time	Reaction
Switching time from high to low	T_STO-A/B_OFF	➔ *Section 9.1.4, Table 21*
Switching time from low to high	T_STO-A/B_ON	➔ *Section 9.1.4, Table 21*
Detection of driver supply failure	$t_{Reaction} \leq 125\mu s$	Activation of the power semiconductor (PWM) is switched off
Activation of holding brake	$t_{Reaction} \leq 10ms$	Activation of the holding brake after detection of the driver supply failure
Signal analysis and status display	$t_{Reaction} \leq 10ms$	Status transitions in the internal finite state machine, triggering an error message and showing the status on the display if necessary

Table 3: Detection and response times of the driver supply voltage

4.4 Time behaviour

Functionally, the STO-A and STO-B inputs are identical. The switch sequence of STO-A/STO-B is interchangeable across all diagrams.

4.4.1 Basic time behaviour STO

Figure 3 displays the basic time behaviour of the safety module. The time specifications can be found in *Table 4*. :

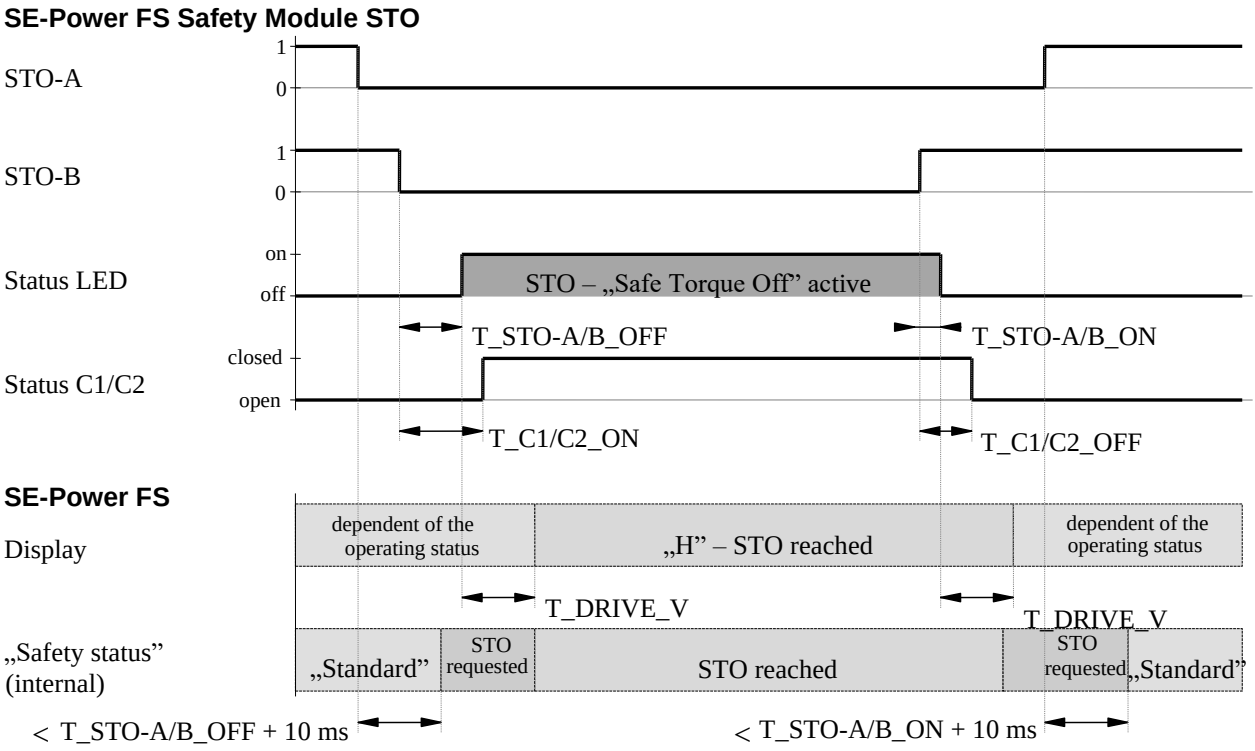


Figure 3: Basic time behaviour when activating and deactivating the safety function STO

Time	Description	Value
T_STO-A/B_OFF	STO-A/B – Switching time from High to Low	➔ *Section 9.1.4, Table 21*
T_STO-A/B_ON	STO-A/B – Switching time from Low to High	➔ *Section 9.1.4, Table 21*
T_C1/C2_ON	C1/2 – Switching time closing	➔ *Section 9.1.4, Table 23*
T_C1/C2_OFF	C1/2 – Switching time opening	➔ *Section 9.1.4, Table 23*
T_DRIVE_V	Delay of the SE-Power FS	0 … 10ms

Table 4: Time data concerning *Figure 3*

4.4.2 Time behaviour for activating STO during operation with restart

Figure 4 displays the time behaviour starting from interruption of the control voltage to STO-A/B, as well as the sequence required to allow the device to restart. The time specifications can be found in *Table 5.* Notes:

- The holding brake is activated via the servo drive, not a safety function.
- The coasting of the motor, irrespective of brake activation/deactivation, is displayed.
- The set point value is only activated when the holding brake delay T_BRAKE_V has expired.
- An error is triggered because the STO inputs are deactivated while the output stage is active.

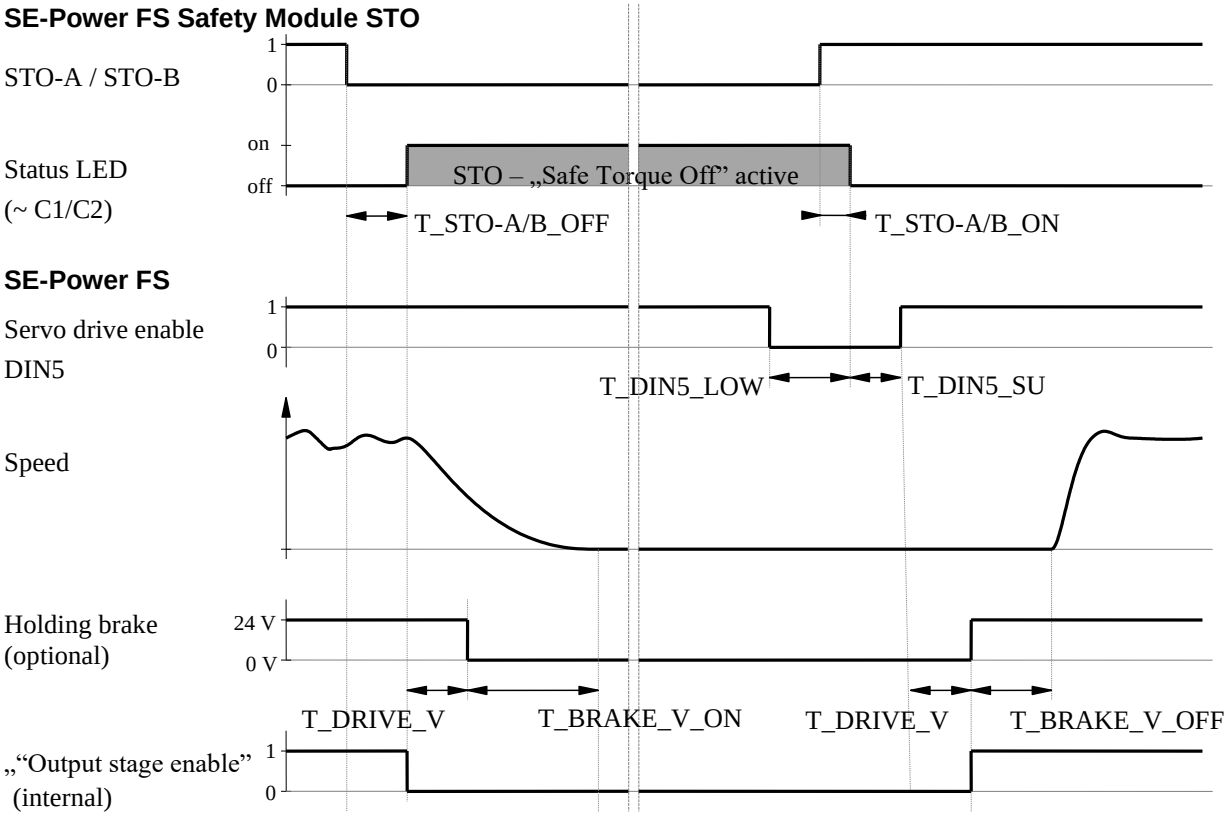


Figure 4: Time behaviour when activating the safety function STO with restart

Time	Description	Value
T_STO-A/B_OFF	STO-A/B – Switching time from High to Low	➔ *Section 9.1.4, Table 21*
T_STO-A/B_ON	STO-A/B – Switching time from Low to High	➔ *Section 9.1.4, Table 21*
T_DIN5_LOW	Time for which the DIN5 must be Low before STO-A/B is switched on again	0ms
T_DIN5_SU	Time for which the DIN5 must be Low after switching on STO-A/B again and status change of the STO module	> 20ms
T_DRIVE_V	Delay of the SE-Power FS	0 … 10ms
T_BRAKE_V_ON	Switch off delay of the holding brake	Dependent on the brake [1)]
T_BRAKE_V_OFF	Switch on delay of the holding brake	Dependent on the brake [2)]

1) Physical delay until the brake closes.

2) Minimum time: Physical delay until the brake opens. This time can be parameterised in the servo drive via a large value.

Table 5: Time data concerning *Figure 4*

4.4.3 Time behaviour for activating SS1 during operation with restart

The time behaviour in *Figure 5* is based on the typical circuit for SS1 in *Section 5.3.2*, starting from control signal S1 for K1. The time specifications can be found in *Table 6*.

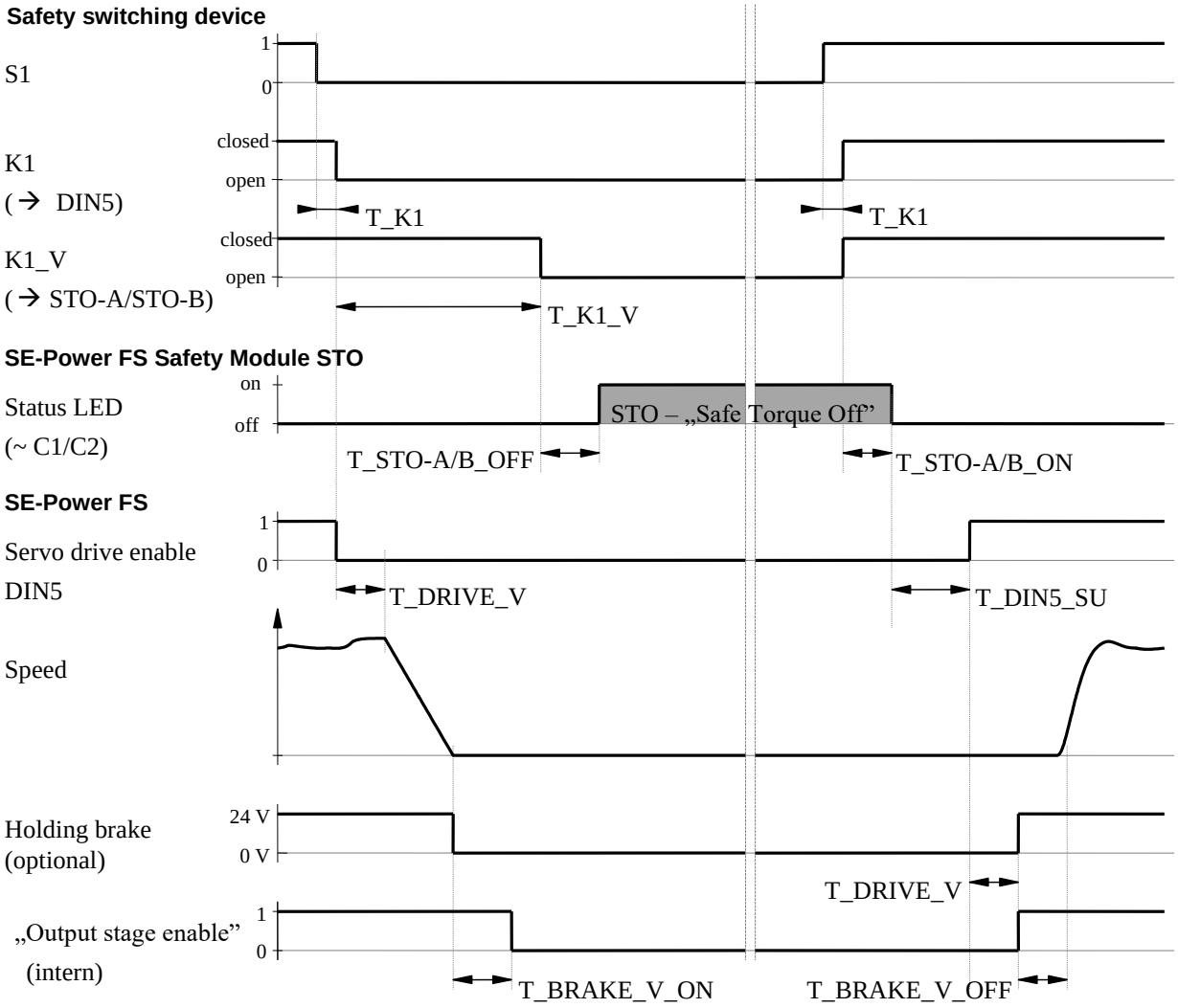


Figure 5: **Time behaviour when activating the safety function SS1 (external switching) with restart**

Time	Description	Value
T_K1	Delay between the switching of S1 and the closing of the undelayed contact K1	➔ Data sheet for the safety switching device
T_K1_V	Delay between S1 and the opening of the relapse delayed contact K1	Can be set on the safety switching device
T_STO-A/B_OFF	STO-A/B – Switching time from High to Low	➔ *Section 9.1.4, Table 21*
T_STO-A/B_ON	STO-A/B – Switching time from Low to High	➔ *Section 9.1.4, Table 21*
T_DRIVE_V	Delay of the SE-Power FS	0 … 10ms
T_DIN5_SU	Time for which the DIN5 must be Low after switching on STO-A/B again and status change of the STO module	> 20ms
T_BRAKE_V_ON	Switch off delay of the holding brake	Dependent of the brake [1)]
T_BRAKE_V_OFF	Switch on delay of the holding brake	Dependent of the brake [2)]

1) Physical delay until the brake closes.

2) Minimum time: Physical delay until the brake opens. This time can be parameterised in the servo drive via a large value.

Table 6: Time data concerning *Figure 5*

5 Assembly and Installation

5.1 Mounting / Dismounting

The safety module SE-Power FS Safety Module STO is suitable only for integration into the servo drive SE-Power FS. It cannot be operated outside the servo drive.

Warning

Danger of electric shock if the safety module is not mounted.

Contact with conducting parts will cause severe injuries and may result in death.

Before touching conducting parts during maintenance, repair and cleaning work and during long service interruptions:

1. Switch off the power to the electrical equipment and secure it to prevent a restart.
2. After switching it off, wait at least 5 minutes of discharge time and check that it is voltage-free before accessing the servo drive.

Note

Incorrect handling can damage the safety module or servo drive.

- Before mounting and installation work, switch off the supply voltage. Switch on the supply voltage only when the mounting and installation work have been completely finished.

- Never unplug a module from, or plug a module into the servo drive when it is energised!
- Observe the handling specifications for electrostatically-sensitive devices. Do not touch the printed circuit board or the pins of the manifold rail in the servo drive. Hold the safety module only by the front plate or the edge of the board.

5.1.1 Mounting the safety module

1. Insert the safety module SE-Power FS Safety Module STO into the extension slot for safety modules so that the board runs in the lateral guides of the slot.
2. Insert safety module; when the back of the contact strip within the servo drive is reached, carefully press it into the contact strip until it stops.
3. Then screw the safety module with the two screws onto the front of the servo drive housing.

Tighten the screws with approx. 0.35 Nm.

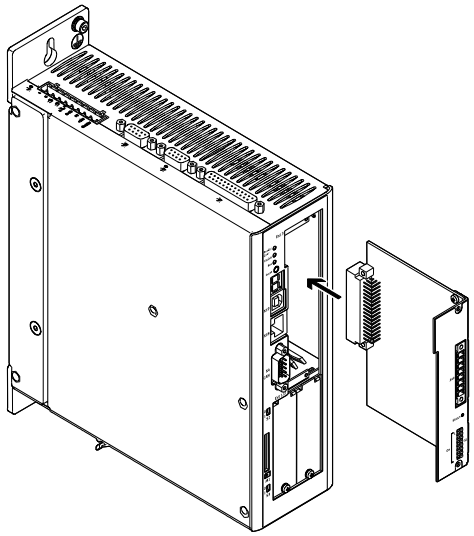


Figure 6: Mounting / Dismounting

5.1.2 Dismounting the safety module

1. Unscrew screws on the safety module.
2. Loosen the safety module by gently levering the front cover or by pulling on the counter plug by just a few millimetres.
3. Pull the safety module out of the slot.

5.2 Electrical installation

5.2.1 Safety instructions

During installation, the requirements of EN 60204-1 must be fulfilled.

Warning

Danger of electric shock in case of voltage sources without safety measures.

- Use only PELV (protective extra-low voltage) circuits according to EN 60204-1 for the electric logic supply.
  Also observe the general requirements for PELV power circuits according to EN 60204-1.
- Only use power sources which guarantee reliable electrical isolation of the operating voltage according to EN 60204-1.

Protection against electric shock (protection against direct and indirect contact) is guaranteed in accordance with EN 60204-1 by using PELV circuits (electrical equipment of machines, general requirements). The 24 V power supply unit used in the system must satisfy the requirements of EN 60204-1 for DC power supply (behaviour during power interruptions, etc.).

The cable is connected via a plug, making it easier to replace the safety module.

Make sure that no jumpers or the like can be inserted parallel to the safety wiring, e.g. through the use of the maximum wire cross section of 1.5 mm² or suitable wire end sleeves with insulating collars.

Use twin wire end sleeves for looping through lines between neighbouring devices.

5.2.2 ESD protection

With non-assigned plug connectors, there is a danger of the device that other parts of the system may be damaged as a result of ESD (electrostatic discharge). Earth the system parts prior to installation and use suitable ESD equipment (e.g. shoes, earthing straps, etc.).

5.2.3 Connection [X40]

The SE-Power FS Safety Module STO has a combined interface for control and acknowledgment via the plug connector [X40].

- Type on device: PHOENIX MINICOMBICON MC 1,5/8-GF-3,81 BK
- Plug (supplied as standard): PHOENIX MINICOMBICON MC 1,5/8-STF-3,81 BK, connection corresponds to *Section 9.1.4, Table 26*.

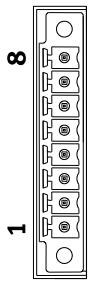
Plug	Pin	Designation	Value	Description
	8	0V	0 V	Reference potential for auxiliary power supply.
	7	24V	+24 V DC	Auxiliary power supply (24 V DC logic supply of the servo drive carried out).
	6	C2	–	Feedback contact for the status “STO” on an external controller.
	5	C1		
	4	0V-B	0 V	Reference potential for STO-B.
	3	STO-B	0 V / 24 V	Control port B for the function STO.
	2	0V-A	0 V	Reference potential for STO-A.
	1	STO-A	0 V / 24 V	Control port A for the function STO.

Table 7: Pin assignment [X40]

In order to ensure the STO “Safe Torque Off” functions correctly, the control ports STO-A and STO-B are to be connected in two channels with parallel wiring see *Section 5.3.1, Figure 7*. This interface can be part of an emergency stop circuit or a protective door arrangement, for example.

5.2.4 Minimum wiring for commissioning [X40]

If at the moment of the commissioning of the servo positioning controller, there’s not (yet) a safety orientated connection, the servo positioning controller SE-Power FS with the SE-Power FS Safety Module STO can be commissioned with a minimal wiring according *Figure 7* with one emergency stop switch (2).

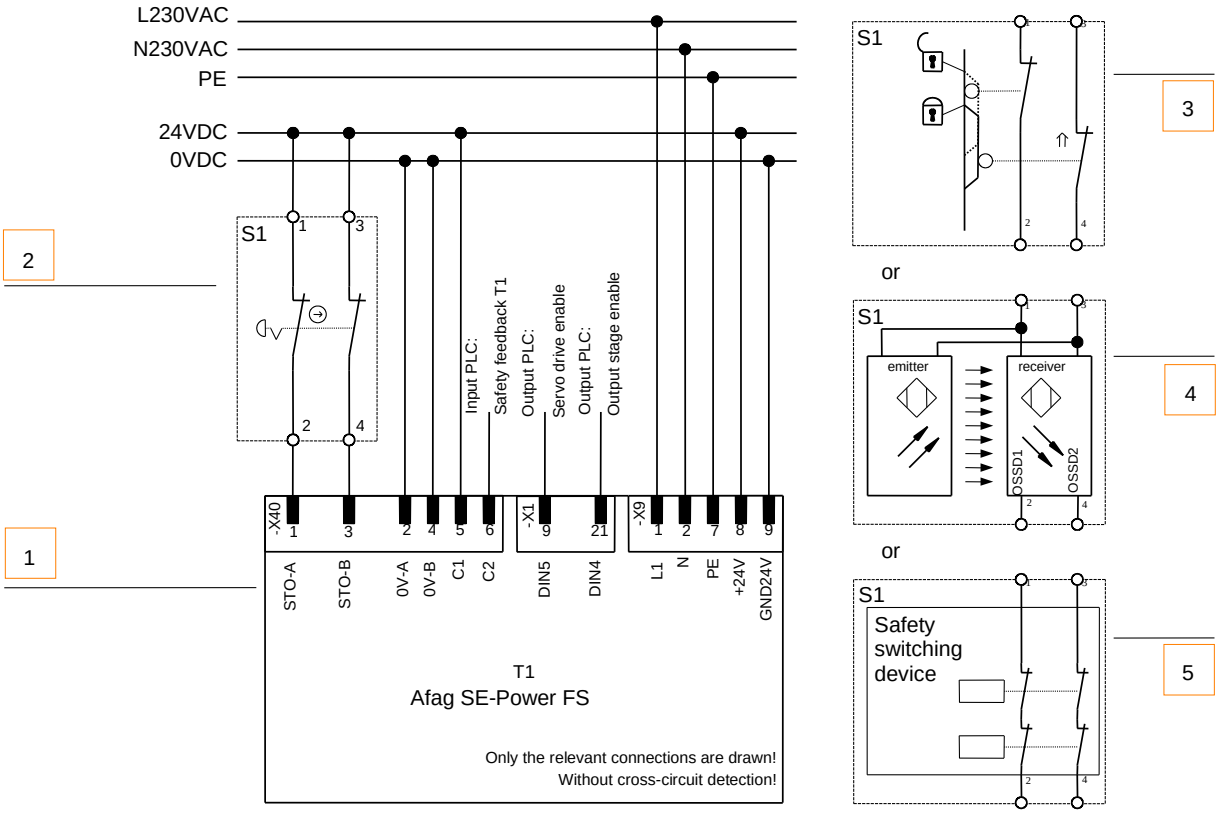
Note

Safety functions should never be bridged.

Do the minimal wiring of the inputs STO-A/STO-B and 0V-A/0V-B for commissioning such a way that they must be forcibly removed if the final safety circuit will be done.

5.3 Typical circuits

5.3.1 Safe Torque Off (STO)



1 Servo drive with safety module
(only relevant connections illustrated)

2 Emergency stop switch

3 Protective door

4 Light curtain

5 Safety switching device

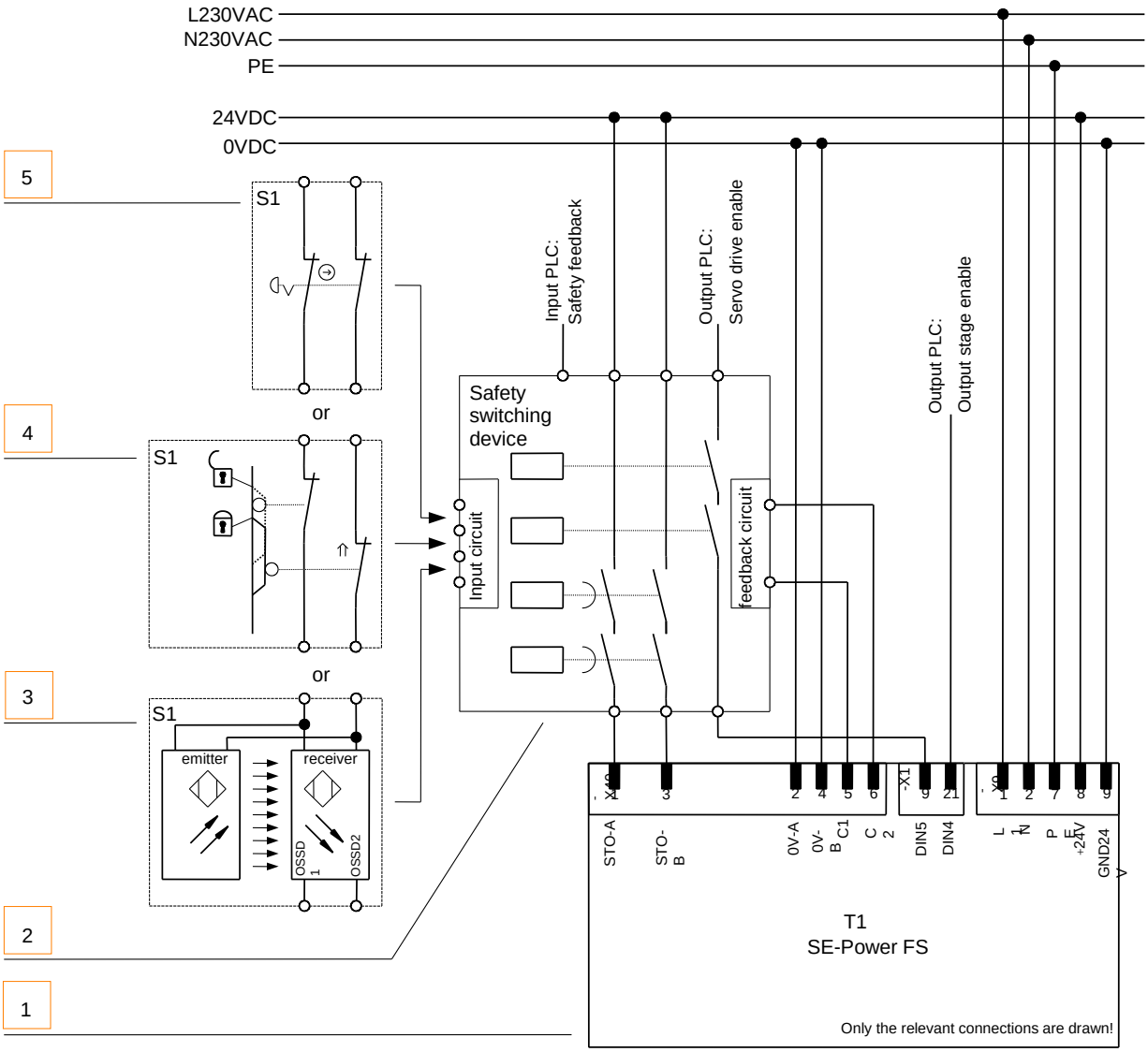
Figure 7: Connection of the SE-Power FS Safety Module STO, example of single-phase servo drive SE-Power FS

The safety function “Safe Torque Off” (STO) can be requested via various devices. The switch S1 can be, for example, an emergency stop switch, a safety door switch, a light barrier or a safety switching device. The safety request is made in 2 channels via switch S1 and routes to the 2-channel switch-off of the output stage. Once the output stage has been switched off, it is output by the floating contact C1/C2.

Notes with regard to a typical circuit:

- The servo drive with safety module does not have integrated cross-circuit detection. With direct light barrier wiring, the light barrier detects cross-circuits if designed to do so.
- When using safety switching devices, the contacts C1, C2 can be integrated in the feedback circuit of the safety switching device.
- The typical circuit shows a 2-channel structure, which is suitable for categories 3 and 4 with additional measures.
- Which additional measures are required depends on the range of applications and the safety concept of the machine.

5.3.2 Delays and safe torque off (SS1, „Safe Stop 1“)



1 Servo drive with safety module
(only relevant connections illustrated)

2 Safety switching device

3 Light curtain

4 Protective door

5 Emergency stop switch

Figure 8: Typical circuit “Decelerate and safe torque off” (SS1, “Safe Stop 1”), example single-phase servo drive SE-Power FS

The safety function “Safe Stop 1” (SS1, type C) can be requested via various devices ➔ *Figure 8*. The switch S1 in *Figure 8* can be, for example, an emergency stop switch, a safety door switch or a light barrier. The safety request is made in 2-channels via switch S1 and to the safety switching device. The safety switching device switches off the servo drive enable. If the servo drive enable switched off, the movement is automatically delayed and, if the brake is configured, brake activation is expected before the control circuit is switched off. After a time set in the safety switching device, the 2-channel output stage is switched off via STO-A/B. Once the output stage has been switched off, it is output by the floating contact C1-C2.

Notes with regard to a typical circuit:

- The safety switching device used must switch off the servo drive enable (X1-9, DIN5) without a delay and the inputs STO-A and STO-B (X40-1, -3) with a delay.
- The required delay is application-dependent and must be defined specific to the application concerned. The delay must be designed so that the drive is decelerated to zero, even at maximum speed, via the quick stop ramp in the SE-Power FS , before STO-A/B are switched off.
- The electrical installation is executed in accordance with the requirements of EN 60204-1. For example, the safety switching device and the servo drive are located in the same control cabinet, so that faults can be excluded for a cross-circuit or earth fault between the cables (acceptance test on the control cabinet for faultless wiring).
- The typical circuit exhibits a 2-channel structure, which is suitable for categories 3 and 4 with additional measures.
- Which additional measures are required depends on the range of applications and the safety concept of the machine.

6 Commissioning

Note

Danger in the event of loss of the safety function!

Lack of the safety function can result in serious, irreversible injuries, e.g. due to uncontrolled movements of the connected actuators.

❖ Operate the safety module only:
- in a built-in condition and
- when all safety measures have been implemented.

❖ Validate the safety function to complete commissioning ➔ *Section 6.4*.

Incorrect wiring, use of an incorrect safety module or external components that were not selected according to the safety category, result in loss of the safety function.

- Carry out a risk evaluation for your application and select the circuitry and components accordingly.

- Note the examples ➔ *Section 5.3*.

6.1 Before commissioning

Perform the following steps to prepare for commissioning:

1. Ensure that the safety module is correctly mounted (see *Section 5.1*).
2. Check the electrical installation (connecting cable, pin allocation, see *Section 5.2*). Are all protective earth conductors connected?

6.2 DIP switch setting

DIP switches for activating and controlling the fieldbus configuration are located on the safety module.

The functionality of the DIP switch is dependent of the fieldbus interface used.

Set the DIP switches as described in the documentation for the servo drives SE-Power FS or the corresponding fieldbus-specific product manuals see *1.1 Documentation*.

6.3 Parameterisation with the Afag SE-Commander

Functional safety depends on modifications being traceable. To guarantee this, the specifications for module type, serial number and version are stored in the integrated Functional Safety Module SE-Power FS Safety Module. These data are stored in the servo drive SE-Power FS as comparison values, enabling a modification to the components to be detected.

When a modification is detected, e.g. a module replacement, a non-acknowledgeable error is triggered. To be able to place the application with the servo drive back in operation, the modification must be “configured”. That means, the modification must be explicitly accepted or confirmed. With the integrated Functional Safety Modules SE-Power FS Safety Module STO and SE-Power FS Safety Module MOV these traceable modifications relate to a module replacement.

The configuration is performed in the window **Safety module** of the Afag SE-Commander, see *Section 6.3.3 Window “Safety module”.*

The Afag SE-Commander parameterisation software has been expanded for the use of the SE-Power FS series of servo drives with an integrated Functional Safety Module.

The main additions are:

- Type indication of the integrated Functional SE-Power FS Safety Module
- Status indication for the state machine of the firmware in the basic unit SE-Power FS
- Functions for configuring the combination of integrated Functional Safety Module SE-Power FS Safety Module and servo drive SE-Power FS
- Support of the specified warnings and error messages

The integrated functional SE-Power FS Safety Module STO itself does not have to be parameterised.

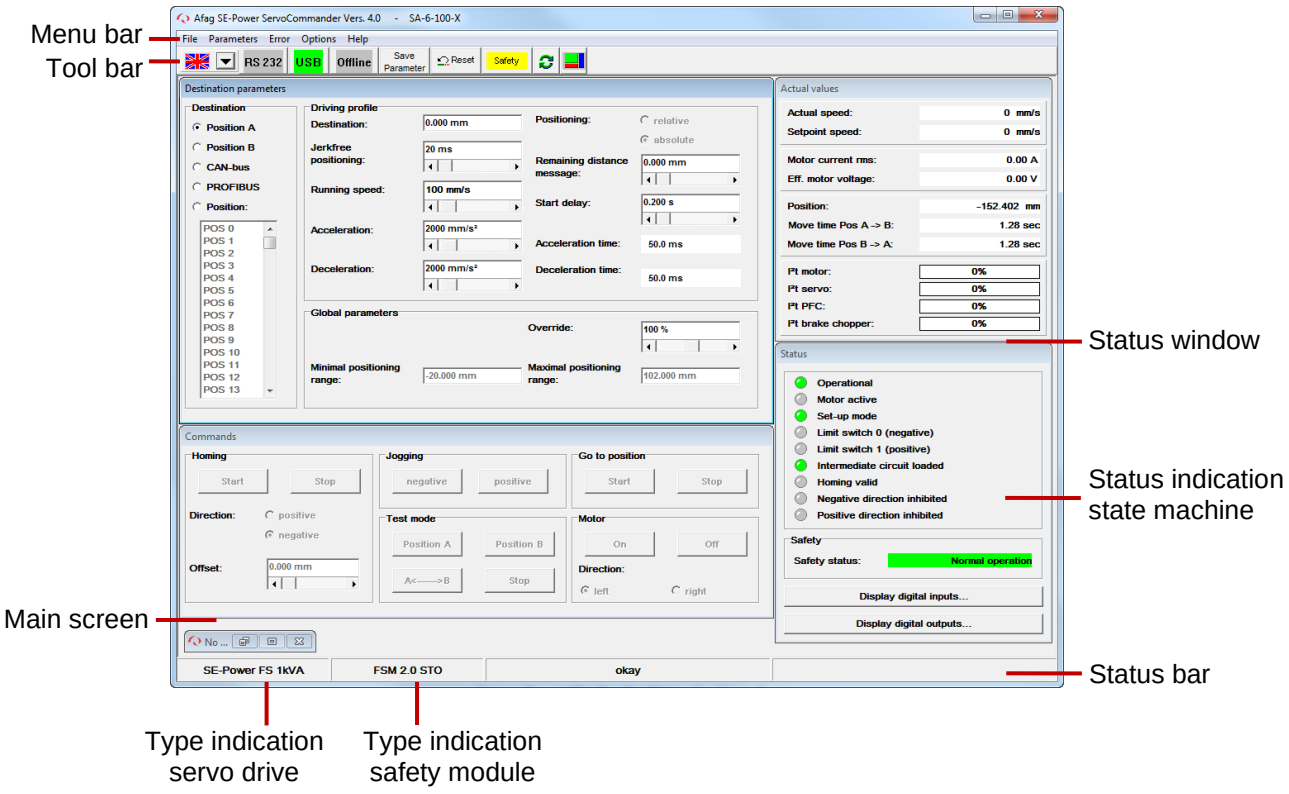


Figure 9: Indication of the type of safety module and extended status window

6.3.1 Type indication servo drive and safety module

At the lower edge of the MSC main screen, there is a **status bar**. It shows the type of the servo drive and the type of the integrated Functional SE-Power FS Safety Module, see *Figure 9.*

Additionally, type, serial number and version are indicated in the window **Safety module**; see *Section 6.3.3 Window "Safety module".*

6.3.2 Status indication of the state machine

The **Status window** (i.e. the window that is permanently displayed in the online mode) has been extended by the **status indication of the state machine**. It shows the status of the functional safety in the firmware of the SE-Power FS basic unit, see *Figure 9.*

This is not the status indication of the SE-Power FS Safety Module STO itself. Here, the status of the state machine within the SE-Power FS resulting from the evaluation of the driver supply voltages by the SE-Power FS Safety Module STO is displayed. Independently of the display the power end stage of the SE-Power FS may be already safely switched off by the Functional SE-Power FS Safety Module STO, see also *Section 6.3.3.3 Status-LEDs.*

In addition, the status of the internal state machine is indicated in the window **Safety module**; see *Section 6.3.3 Window "Safety module"*.

6.3.3 Window "Safety module"

In order to use the SE-Power FS servo drives with an integrated Functional Safety Module, the window **Safety module** has been added to the Afag SE-Commander parameterisation software.

This window can be opened either via the menu **Parameters – Functional safety – Status** or via the **Safety** button in the quick-access toolbar below the menu bar, see *Figure 10.*

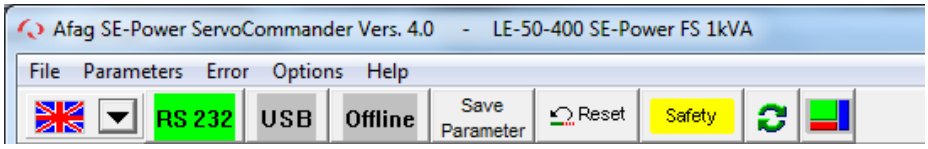


Figure 10: Quick-Access Toolbar with the button "Safety"

In order to emphasise its importance in view of the functional safety, the **Safety** button is yellow.

The appearance of the window **Safety module** depends on the Functional Safety Module currently integrated. *Figure 11* shows the module types SE-Power FS Safety Module STO and SE-Power FS Safety Module MOV as examples.

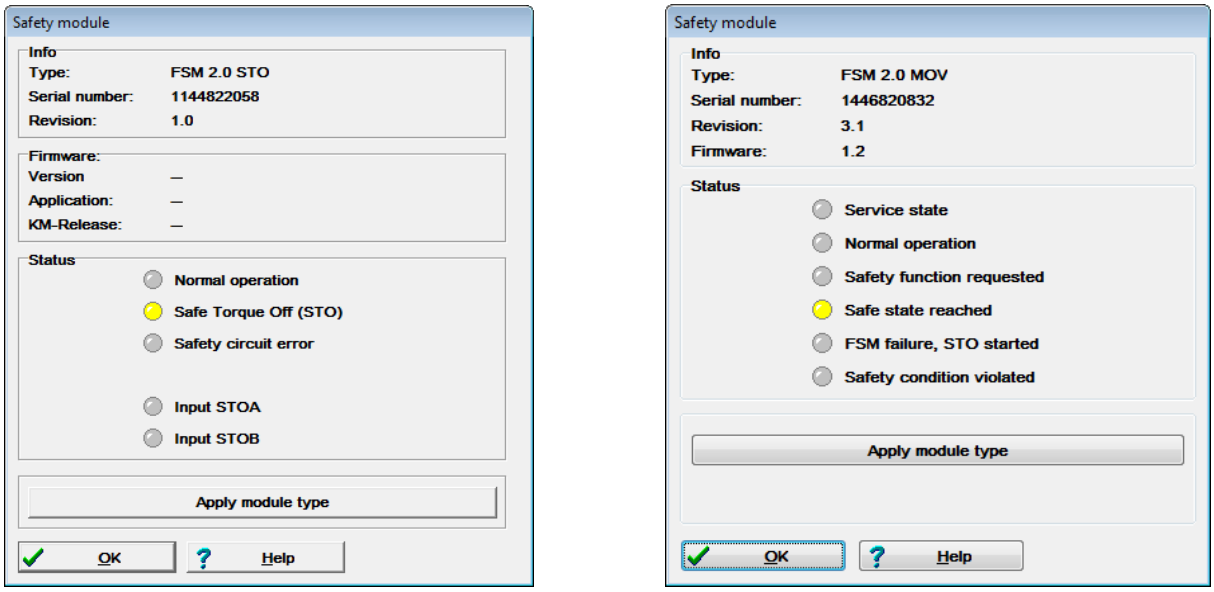


Figure 11: Window “Safety module” STO (left) and MOV (right)

The window “Safety module” is divided into different fields:

6.3.3.1 Info

This field displays the device data that have been stored on the Functional Safety Module during factory commissioning:

- Type:

  Exact type designation, for example, „FSM 2.0 – STO“

- Serial number:

  The serial number is assigned during production and is stored on the module. The serial number is unique for a product of the applicable type.

- Revision:

  Revision number of the hardware

6.3.3.2 Firmware

The Functional SE-Power FS Safety Module STO does not contain any firmware. Therefore, this field does not display any information for this module type. The firmware is only displayed for the SE-Power FS Safety Module MOV.

6.3.3.3 Status-LEDs

The upper three LEDs show the state of the state machine within the basic unit SE-Power FS, see *Table 8.* The state is read out from the basic unit SE-Power FS via communication objects and then displayed.

The lower two LEDs display the status of the driver supply voltage.

Status display	Meaning	State
○ Normal operation ○ Safe Torque Off (STO) ○ Safety circuit error	All LEDs Off: The Functional Safety Module is not initialized / not operational.	--
○ Normal operation ○ Safe Torque Off (STO) ○ Safety circuit error	Normal operation, which is "non-safe state". The safety module FSM 2.0 – is initialized error-free and operational.	Z2, Z3
○ Normal operation ○ Safe Torque Off (STO) ○ Safety circuit error	Safe state" SAFE TORQUE OFF, this means that the power output stage of the basic unit SE-Power FS is reliably switched off.	Z1
○ Normal operation ○ Safe Torque Off (STO) ○ Safety circuit error	The safety conditions are violated. The detected state of the two driver supply voltages does not comply with any of the defined valid states. The PWM has been deactivated, the power output stage is not reliable switched of, and that means that the system is in a "non-safe state".	Z4

Table 8: Meaning of the LEDs for the status display in the window “Safety module”

6.3.3.4 Apply module type

In the lower part of the window **Safety module** you find the button **Apply module type**:

Click on this button to confirm a module replacement. Thereby, the integrated functional safety is parameterised or projected. An existent error message due to a module replacement will not be generated again after Save and Reset.

6.4 Function test, validation

Note

The STO function must be validated after the installation and after changes to the installation.

This validation must be documented by the person performing commissioning. To assist you with the commissioning, questions for risk minimisation are summarised below in the form of sample checklists.

The checklists below are no substitute for safety training.
No guarantee can be provided for the completeness of the checklist.

No.	Questions	Correct		Completed
1.	Were all operating conditions and interventions taken into account?	Yes ☐	No ☐	☐
2.	If the “3-step method” for risk minimisation was applied, i. e. 1. Inherently safe design, 2. Technical and possibly additional safety measures, 3. User information on the residual risk?	Yes ☐	No ☐	☐
3.	Were the hazards eliminated or the hazard risk reduced as far as practically possible?	Yes ☐	No ☐	☐
4.	Can it be guaranteed that the implemented measures will not pose new hazards?	Yes ☐	No ☐	☐
5.	Have the users been adequately informed and warned about the residual risks?	Yes ☐	No ☐	☐
6.	Can it be guaranteed that the operators’ working conditions have not deteriorated due to the safety measures taken?	Yes ☐	No ☐	☐
7.	Are the safety measures taken mutually compatible?	Yes ☐	No ☐	☐
8.	Was adequate consideration given to the potential consequences of using a machine designed for commercial/industrial purposes in a non-commercial/industrial area?	Yes ☐	No ☐	☐
9.	Can it be guaranteed that the implemented measures will not severely impair the machine’s ability to perform its function?	Yes ☐	No ☐	☐

Table 9: Questions for validation in accordance with EN ISO 12100-1:2010 (example)

No.	Questions	Correct		Completed
1.	Has a risk assessment been conducted?	Yes ☐	No ☐	☐
2.	Have an error list and a validation plan been drawn up?	Yes ☐	No ☐	☐
3.	Was the validation plan, including analysis and inspection, processed and a validation report compiled? The validation procedure must include the following inspections as a minimum:	Yes ☐	No ☐	☐
	a) Component check: Is the SE-Power FS used with the FSM 2.0 – STO (inspection using the rating plates)	Yes ☐	No ☐	☐
	b) Is the wiring correct (check against the wiring diagram)?	Yes ☐	No ☐	☐
	– Have any short-circuit bypasses been removed?	Yes ☐	No ☐	☐
	– Has a safety switching device been wired to X40?	Yes ☐	No ☐	☐
	– Is the safety switching device certified and wired in accordance with the application's requirements?	Yes ☐	No ☐	☐
	c) Functional inspections:	Yes ☐	No ☐	☐
	– Pressing the emergency stop button on the unit. Is the drive shut down?	Yes ☐	No ☐	☐
	– If only STO-A is activated - is the drive shut down immediately and the "discrepancy time violation" error (Display 52-1) reported in the SE-Power FS after the discrepancy time has lapsed?	Yes ☐	No ☐	☐
	– If only STO-B is activated - is the drive shut down immediately and the "discrepancy time violation" error (Display 52-1) reported in the SE-Power FS after the discrepancy time has lapsed?	Yes ☐	No ☐	☐
	– Is a short circuit detected between STO-A and STO-B or has a suitable fault exclusion been defined?	Yes ☐	No ☐	☐
	– Only when using a safety switching device with analysis of the feedback contact C1/C2: Is the drive shut down on a short-circuit from C1 to C2?	Yes ☐	No ☐	☐
	– Is a restart inhibited? I.e. no movement occurs when the emergency stop button is pressed and the enable signals are active unless a start command is acknowledged beforehand.	Yes ☐	No ☐	☐

Table 10: Questions for validation in accordance with EN ISO 13849-1 and 2 (example)

7 Operation

7.1 Obligations of the operator

The operational capability of the safety equipment must be checked at adequate intervals. It is the responsibility of the operator to choose the type of check and time intervals in the specified time period. The check must be made in a way that proves proper functioning of the safety equipment in interaction with all components.

7.2 Maintenance and care

The safety module does not require any maintenance.

7.3 Protective functions

7.3.1 Voltage monitoring

The input voltages at STO-A and STO-B are monitored. If the input voltage at STO-A or STO-B is too high or too low, the driver supply for the power semiconductors of the servo drive are safely switched off. The power output stage (PWM) is thus switched off.

7.3.2 Protection against overvoltage and reverse polarity

The control inputs STO-A and STO-B are protected against overvoltage and reverse polarity of the control voltage ➔ *Section 9.1.4, Table 21*.

The 24 V DC supply voltage for the servo drive routed to [X40] is short-circuit resistant.

7.4 Diagnostics and troubleshooting

7.4.1 Status indicators

7.4.1.1 Display on the safety module

Der Betriebszustand wird direkt an der zweifarbigen LED des Sicherheitsmoduls angezeigt.

LED	Status	Description
Off	Not safe = STO status not active	Safety module or servo drive has no operating voltage.
Green	Not safe = STO status not active	The power output stage in the servo drive for supply of the motor can be active or inactive.
Yellow	Safe = STO status active	The power output stage in the servo drive for supply of the motor is switched off safely.

Table 11: LED- display on the safety module

7.4.1.2 Display on the servo drive

Display	Description
	"H": The servo drive is in the "safe status". This does not have the same meaning as the information on the status of the safety function STO (Safe Torque Off). This can only be read off on the LED of the safety module. No special display is intended for the "unsafe status"; the normal status displays of the servo drive are represented.

Table 12: Seven segment display on the servo drive

7.4.2 Error messages

When an error occurs, the servo drive shows an error message cyclically in the seven-segment dis-play on the front of the servo drive. The error message consists of an E (for Error), a main index (xx) and sub-index (y), e.g.: E 5 1 0. Warnings have the same number as an error message. The difference is that a warning is displayed with a prefixed and suffixed hyphen, e.g. - 1 7 0 -. *Table 13* lists the error messages that are relevant for the functional safety in combination with the SE-Power FS Safety Module STO.

For more information about other error messages, please refer to the corresponding documentation, for example the relevant product manuals, the software manual or the fieldbus- specific product manuals. See *1.1 Documentation*.

Where an error message cannot be acknowledged, the cause must first be remedied in accordance with the recommended measures. Then reset the servo drive, and check whether the cause of the error, and the error message, has been eliminated.

Error message		Meaning of the error message	Measures
Main index	Sub index		
51 [1]	0	No / unknown safety module – No safety module or unknown module type detected	❖ Install a safety module or fieldbus activation module appropriate for the firmware and hardware. ❖ Load a firmware suitable for the safety module or fieldbus activation module; see type designation on the module.
	1	Safety module: Faulty driver supply – Internal voltage error of the safety module or fieldbus activation module	❖ Module presumably defective. If possible, replace with another module.
	2	Safety module: Different module type – Type or version of the module does not fit the design	❖ For module replacement: Module type not yet in design. Accept installed safety module or fieldbus activation module, see *Section 6.3.3*.
	3	Safety module: Different module version – Module type or version is not supported.	❖ Install a safety module or fieldbus activation module appropriate for the firmware and hardware. [2] ❖ Load a firmware suitable for the module; see type designation on the module. [2]
52	1	Safety module: Discrepancy time expired	❖ Control ports STO-A and STO-B are not actuated simultaneously. ❖ Control ports STO-A and STO-B are not wired in the same way. ❖ Check discrepancy time.
	2	Safety module: Failure of driver supply with active PWM	❖ The safe status was requested with enabled power output stage. Check link to the safety-oriented interface.
1) The messages of error group 51 cannot be acknowledged.			

Table 13: Error messages relating to the safety module

8 Conversion and module replacement

8.1 Safety module replacement

8.1.1 Repair

Repair of the module is not permissible. If necessary, replace the complete module.

8.1.2 Removal and installation

Information on removing and installing the safety module can be found here:

- Mounting/dismounting the safety module, see *Section 5.1*.
- Accept the serial number of the replaced safety module, see *Section 6.3.3.*

8.2 Decommissioning and disposal

Observe the information for dismantling the safety module in *Section 5.1*.

8.2.1 Disposal

Observe the local regulations for environmentally appropriate disposal of electronic modules.

8.3 Replacing the previous series SE-Power with the SE-Power FS

8.3.1 SE-Power

The devices of the previous SE-Power series have an integrated STO “Safe Torque Off” in accordance with EN ISO 13849-1, Cat. 3 / PL d. The two-channel arrangement required by the STO function is achieved via two separate switch-off paths:

1. Switch-off path: Output stage enable via [X1.21], switch-off of the power output phase (PWM signals disabled). The power semiconductor drivers are no longer activated by pulse pat-terns.
2. Switch-off path: Power supply to the six output stage power semiconductors IGBTs via [X3] is interrupted by means of a relay. The driver supply for the power semiconductors (IGBT optocouplers) is disconnected by means of a relay. This prevents the pulse pattern (PWM signals) reaching the power semiconductors.

The SE-Power also has a floating feedback contact ([X3] Pins 5 and 6) which, as a diagnostics output, indicates the presence of the driver supply.

8.3.2 SE-Power FS

Devices of the SE-Power FS series feature, in combination with the SE-Power FS Safety Module, have the safety function STO “Safe Torque Off” in accordance with EN 61800-5-2 SIL3, and/or EN ISO 13849-1, Cat. 4 / PL e. The two switch-off paths are realised via the control ports STO-A [X40.1] and STO-B [X40.3]. The potential-free feedback contact ([X40] Pins 5 and 6) is also present.

8.3.3 Modifications to the connection wiring

Converting an existing application with STO from SE-Power to SE-Power FS requires the following modifications to be made to the connection wiring:

- 1. Switch-off-path:
  Retain output stage enable wiring [X1.21] and route in parallel to STO-A [X40.1].
  Connect GNDA [X40.2] to 0 V [X40.8] to link the reference potential.
- 2. Switch-off-path:
  Now route driver supply wiring [X3.RELAY] to STO-B [X40.3].
  Connect GNDB [X40.4] with 0 V [X40.8] to link the reference potential.
- Feedback contact:
  Relay connection for the feedback contacts [X3.5] and [X3.6] to [X40.5] and [X40.6].

Note

During operation, the feedback contacts on the SE-Power and the SE-Power FS show compatible behaviour.

When the logic supply (24 V) is switched off, they behave differently:

- SE-Power: Contact closed.
- SE-Power FS: Contact open.

8.3.4 Information for configuration

The SE-Power FS exhibits a higher performance than the SE-Power. Use of this feature represents an essential modification to the machine.

Note

The parameter set of the SE-Power must be transferred with the same values to the parameter block of the SE-Power FS. If these values are increased, which in turn poses a higher risk, a new risk assessment must be performed on the machine.

Note

Once the servo drive has been replaced, the safety function must be validated in accordance with the machine manufacturer’s specifications.

9 Technical appendix

9.1 Technical data

9.1.1 Safety engineering

Safety indicators			
Safety function		STO	– Safe Restart Interlock (STO, Safe Torque Off) to EN 61800-5-2 with SIL3 – Safe Restart Interlock (STO, Safe Torque Off) to EN ISO 13849-1 with category 4 and PL e
SIL		SIL 3 / SIL CL 3	Safety integrity level according to EN 61800-5-2
Category		4	Classification in category in accordance with EN ISO 13849-1
PL		Pl e	Performance level in accordance with EN ISO 13849-1
DCavg	[%]	97,5	Average diagnostic coverage
HFT		1	Hardware failure tolerance
SFF	[%]	99,2	Safe Failure Fraction
PFH		$1{,}07 \times 10^{-10}$	Probability of dangerous Failure per Hour
PFD		$2{,}3 \times 10^{-5}$	Probability of dangerous Failure on Demand
T	[Years]	20	Proof Test Interval Duration of use in accordance with EN ISO 13849-1
MTTFd	[Years]	100	Mean time to dangerous failure Calculated at 1450 years, limited to 100 years

Table 14: Technical data: Safety indicators

Safety specifications	
Product type testing	The functional safety equipment of the product was certified by an independent testing authority in accordance with *section 3.1.4,* see EC product type test certificate.
Certificate-issuing authority	TÜV 01/205/5443.00/15
Reliable component	Yes

Table 15: Technical data: Safety specifications

9.1.2 General

Mechanical		
Length/width/height	[mm]	approx. 112,6 x 87,2 x 28,3
Weight	[g]	approx. 75
Slot		Slot for Functional Safety Modules
Note on materials		RoHS- compliant

Table 16: Technical data: Mechanical

Certifications (SE-Power FS Safety Module STO for servo drives SE-Power FS)	
CE marking	In accordance with EU EMC Directive
	In accordance with EU machine directive
	The device is intended for industrial use. Measures for interference suppression may need to be implemented in residential areas.

Table 17: Technical data: Certifications

9.1.3 Operating and environmental conditions

Transport		
Temperature range	[°C]	–25 … +70
Air humidity	[%]	0 ... 95, at max. 40 °C ambient temperature
Maximum transportation duration	[Weeks]	Maximum 4 weeks over the entire product life cycle

Table 18: Technical data: Transport

Storage		
Storage temperature	[°C]	–25 … +55
Air humidity	[%]	5 ... 95, non-condensing or protected against condensation
Permissible altitude	[m]	< 3000 (above sea level)

Table 19: Technical data: Storage

Ambient conditions		
Ambient temperature	[°C]	0 … +40 (outside the servo drive housing)
Cooling		By means of ambient atmosphere in the servo drive, no forced ventilation
Permissible setup altitude	[m]	< 2000 (above sea level)
Protection class		IP20 (mounted in the SE-Power FS).
Air humidity	[%]	Relative air humidity up to 90 %, non-condensing
Degree of contamination in accordance with EN 61800-5-1		2
		The integrated safety equipment requires compliance with degree of contamination 2 and thus a protected fitting space (IP54). This must always be ensured through appropriate measures, e.g. through installation in a control cabinet.

Table 20: Technical data: Ambient conditions

9.1.4 Electrical data

Control ports STO-A, 0V-A / STO-B, 0V-B [X40]		
Nominal voltage	[V]	24 (related to 0V-A/B)
Voltage range	[V]	19,2 … 28,8
Permissible residual ripple	[%]	2 (related to nominal voltage 24 V)
Overvoltage discharge	[V]	31 (disconnect in case of error)
Nominal current	[mA]	20 (typical; maximum 30)
Starting current	[mA]	450 (typical, duration approx. 2ms; max. 600 at 28.8 V)
Input voltage threshold		
Switching on	[V]	approx. 18
Switching off	[V]	approx. 12,5
Switching time from high to low (STO-A/B_OFF)	[ms]	10 (typical; maximum 20 at 28,8 V)
Switching time from low to high (STO-A/B_ON)	[ms]	1 (typical; maximum 5)
Maximum positive test impulse length at logic 0	[µs]	< 300 (related to nominal voltage 24 V and intervals > 2 s between impulses)

Table 21: Technical data: Electrical for ports STO-A and STO-B

Switch-off time to power output stage inactive and maximum tolerance time for test pulse											
Input voltage (STO-A/B)	[V]	19	20	21	22	23	24	25	26	27	28
Typical switch-off time (STO-A/B_OFF)	[ms]	4,0	4,5	5,0	6,0	6,5	7,0	7,5	8,0	8,5	9,5
Maximum tolerance time for test pulse at 24 V signal	[ms]	<2,0	<2,0	2,0	2,5	3,0	3,5	4,5	5,0	5,5	6,0

Table 22: Typical switch-off time and minimum tolerance time for test pulse (OSSD signals)

Feedback contact C1, C2 [X40]		
Version		Relay contact, normally open
Max. voltage	[V DC]	< 30 (overvoltage-proof up to 60 V DC)
Nominal current	[mA]	< 200 (not short circuit proof)
Voltage drop	[V]	≤ 1
Residual current (contact opened)	[µA]	< 10
Switching time closing (T_C1/C2_ON)	[ms]	< (STO-A/B_OFF 1) + 5 ms)
Switching time opening (T_C1/C2_OFF)	[ms]	< (STO-A/B_ON 1) + 5 ms)
1) STO-A/B_OFF, STO-A/B_ON ➔ *Table 21*		

Table 23: Technical data: Electrical data of the feedback contact C1/C2

Auxiliary supply 24V, 0V [X40] – output		
Version		Logic supply voltage routed out of the servo drive (Feed in at [X9], not additionally filtered or stabilised). Reserve polarity protected, overvoltage-proof up to 60 V DC.
Nominal voltage	[V]	24
Nominal current	[mA]	100 (short circuit proof, max 300 mA)
Voltage drop	[V]	≤ 1 (for nominal current)

Table 24: Technical data: Electrical data of the auxiliary supply output

Electrical isolation	
Electrically isolated potential ranges	STO-A / 0V-A
	STO-B / 0V-B
	C1 / C2
	24V / 0V (Logic supply to the servo drive)

Table 25: Technical data: Electrical isolation [X40]

Cabling		
Max. cable length		
Unscreened	[m]	30
Screened	[m]	> 30
Screening		When wiring outside the control cabinet, use screened cable. Guide screening into the control cabinet / attach to the side of the control cabinet.
Cable cross section (flexible conductors, wire end sleeve with insulating collar)		
One conductor	mm²	0,25 … 0,5
Two conductors	mm²	2 x 0,25 (with twin wire end sleeves)
Tightening torque M2	[Nm]	0,22 … 0,25

Table 26: Technical data: Cabling to [X40]

10 Glossary

Term/abbreviation	Description
CCF	Common Cause Failure in accordance with EN ISO 13849-1
DC avg	Average Diagnostic Coverage in accordance with IEC 61508 and EN 61800-5-2.
HFT	Hardware Fault Tolerance in accordance with IEC 61508.
Cat.	Safety category in accordance with EN ISO 13849-1, Stages 1-4.
MTTFd	Mean Time To dangerous Failure: Time in years up to the first dangerous failure occurs with 100 % probability in accordance with EN ISO 13849-1.
EMERGENCY SWITCHING OFF	In accordance with EN 60204-1: Electrical safety in case of emergency by switching off the electrical energy to all or part of the installation. EMERGENCY SWITCHING OFF is to be used where a risk of electric shock or other electrical risk exists.
Emergency stop	In accordance with EN 60204-1: Functional safety in an emergency by bringing a machine or movable parts to a standstill. Emergency stop is used to stop a process or a motion if this creates a danger
OSSD	Output Signal Switching Device: Output signals with 24 V cycle rates for error detection.
PFD	Probability of Failure on Demand in accordance with IEC 61508.
PFH	Probability of Dangerous Failures per Hour in accordance with IEC 61508.
PL	Performance Level in accordance with EN ISO 13849-1: Stages a … e.
SFF	Safe Failure Fraction [%] in accordance with IEC 61508.
Safety switching device	Device for executing safety functions or restoring the machine to a safe status after the power supply to dangerous machine functions has been switched off. The desired safety function is achieved only in combination with other measures, although switch-off can occur on a servo drive, for example.
SIL	Safety Integrity Level, discrete stages for defining the requirements for the safety integrity of safety functions in accordance with IEC 61508, EN 62061 and EN ISO 13849.
SIL CL	Maximum SIL that can be required from a sub-system.
SS1	Safe Stop 1, according to EN 61800-5-2.
STO	Safe Torque Off in accordance with EN 61800-5-2.
T	Duration of use in accordance with EN ISO 13849-1.

Table 27: Terms and abbreviations

Afag Automation AG
Luzernstrasse 32
CH-6144 Zell

Schweiz

Tel.: +41 (0)62 – 959 86 86
Fax.: +41 (0)62 – 959 87 87
e-mail: sales@afag.com
Internet: www.afag.com