

AXIA AGILE

Functional Safety Manual

Frequency inverter 400 V
0.25 kW ... 15 kW



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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:

<i>AXIA</i> Operating Instructions	Function of frequency inverter.
Quick Start Guide <i>AXIA</i>	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

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 functions of frequency inverters of the *AXIA* Agile series. 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.



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



For safe commissioning and operation of the AXA (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 AXA series.

1.3 Target Group

This manual is aimed at individuals with the qualification level "Qualified Electricians" and higher. For more information   "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]).
-  AXA GettingStarted VEC50B
-  AXA Technical Data VEC509

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 charging

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.

Danger of equipment falling down/over, e.g. during transport

Center of gravity is not the middle of the electrical cabinet modules.

2.5 Safety and warning signs on 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 documentation

Example	Font style	Use
1234 / 0x1234	bold	Representation of parameter numbers / object numbers
<i>Parameter / Object</i>	inclined, font: Times New Roman	Representation of parameter names / object designations
01234	Courier new	Representation of parameter values / object values

2.7 Directives and guidelines to be adhered to by the operator

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/operating staff's responsibilities

2.8.1 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.

2.8.2 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 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 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.

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 in combination with third-party products

- Please note that 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.
- 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, for more information   4 "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:

- Disconnect
- Secure to prevent restarting
- check for absence of voltage,
- carry out earthing and short-circuiting
- 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.
- Individuals unfamiliar 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



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.



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 of 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 accordance 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 when the function STO is no longer requested. 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.

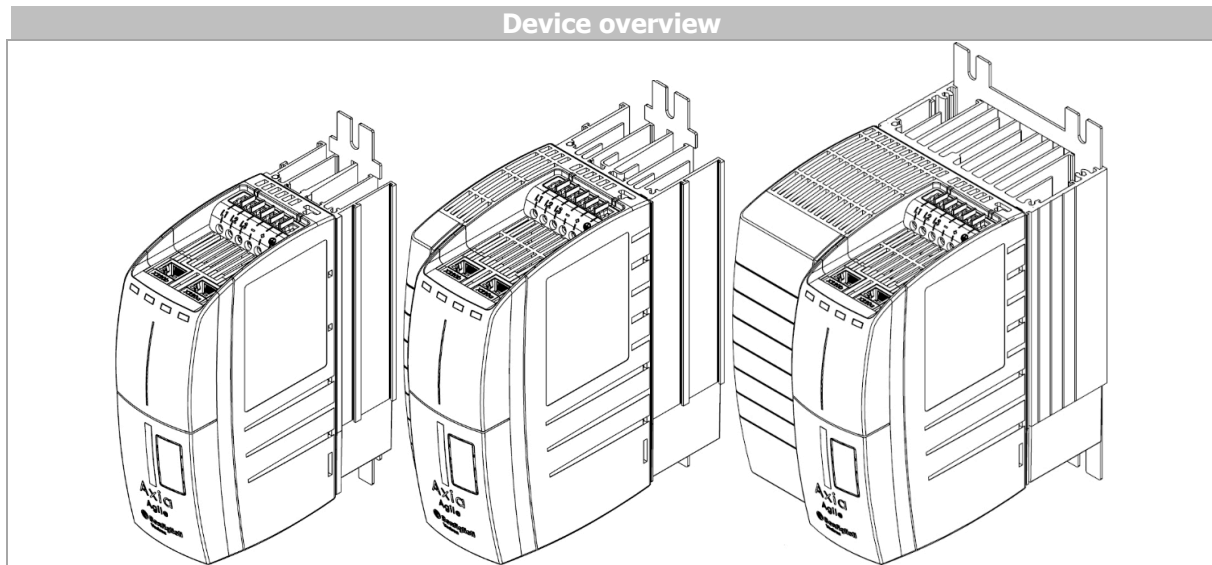
- Do not touch live terminals.



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.



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.
- Conductive contamination is 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

Connecting / disconnecting while the inverter is connected to live voltage can destroy the inverter.



- Disconnect the frequency inverter from the power supply before performing work on the inverter. Working under live voltage is not permissible.
- Handle the inverter with care to prevent mechanical damage
- Do not touch the PCB visible when the covers are taken off, otherwise components may be damaged.

CAUTION!

Loosing the safety functionality

Swapping the CBO (Control Board) of Standard or Advanced product variant with that of a Basic variant will result in loss of safety functionality.



- By default, the functional safety is on board in the frequency inverter of the corresponding variant. Exchanging CBOs is not permitted.

NOTICE

By default, the functional safety is on board in the frequency inverter.

For further details   the operating instructions document VEC5en1-.

The AXA series inverters do not feature the option of exchanging a safety function by swapping a controller board.

3.2 Mechanical Installation

By default, the frequency inverters of degree of protection IP20 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.
- IP54 housing/cabinet" is required. Alternatively, "a controlled environment without conductive pollution".
- Overhead installation or installation in horizontal position is not permissible.



NOTICE

Validating the safety function

It is required the safety function to be validated within the application.

- The user validates the safety function within the application.   7 for more information.

4 Electrical installation

CAUTION!



Destroying inverter

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 inverter.

- Use wire-end-ferrules and/or other suitable mitigation measures.

4.1 Control Terminals

The X811 terminal is implemented in the variants Standard, Enhanced and Advanced.

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.



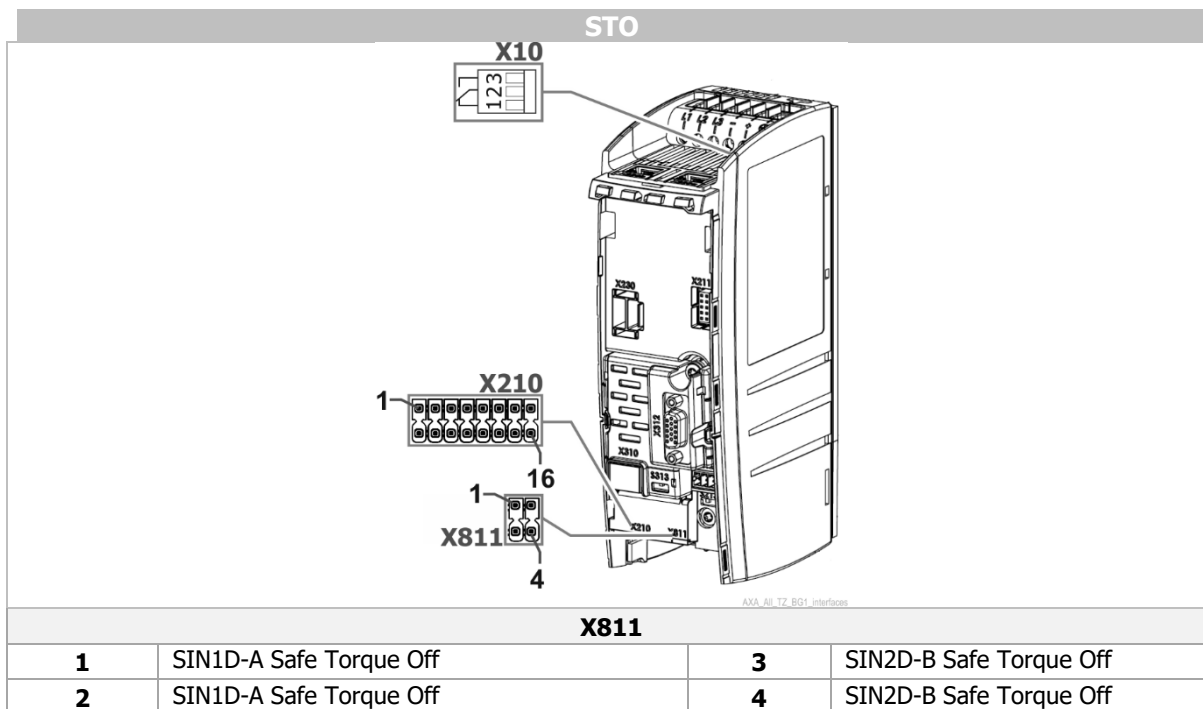
There are two application modes for the control terminals:

- a) Using external safety switching devices with OSSD outputs
- b) Using passive sensors with external SELV/PELV supply

Requirements to be met by installation

- If work is to be carried out on live components, it must be possible to disconnect the machine from mains supply by means of a main switch.
- According to EN 61800-5-2 a fault exclusion can be considered with one of the following possibilities:
 - The conductor is installed permanently and protected against external damage with a cable duct or reinforcement, for example.
 - Single multi-conductors are used.
 - The conductors are situated in an electrical cabinet.
 - The conductors are shielded independently and have grounding.
 - If applicable, the requirements of EN 60204-1 must be considered to install the connectors correctly.
- IP54 housing/cabinet" is required. Alternatively, a controlled environment without conductive pollution.
- Only use voltage sources with safe disconnection (SELV/PELV) according to VDE0100. Comply with the specifications stated below.
- The frequency inverters may be supplied with OSSD pulsed signals (max. test pulse width 0,8 ms at control voltage <20 V). Cross-fault detection via pulsed signals can be used. The signal cables between the safety control equipment and AXA must either be physically separate from one another or suitable, cross-fault-proof cables.
- Comply with applicable EMC instructions stated in the operating instructions.
- After installation, check the safety function and error reaction and issue an acceptance report.
- Interrupting the STO signals prevents the motor from starting. According to EN 60204-1, STO must not be released during an impending endangerment.
- Also comply with the instructions on external safety control equipment.
- During commissioning, check the safety function.

Select the dimensions of the safety application such that for the STOA and STOB inputs, the input current is available in each case in accordance with the operating instructions (typically: 2 mA). If more than one frequency inverter is connected to one safety control device, the safety control device must provide sufficient power for all of them.



Technical data of control terminals

Inputs: Low Signal: DC 0 V...5 V, High signal: DC 11 V...30 V, response time: max. 40 ms, EN 61131-2 type 3 compatible, OSSD compatible (pulse length <800 us, repetition rate > 500 ms)

Conductor cross-section: The signal terminals are suitable for the following cable sizes:

Type	Ferrule type	Cross section [mm ²]
Solid	-	min. 0.2 max. 1.5
Stranded	-	min. 0.2 max. 1.5
Flexible	with ferrule without plastic sleeve	min. 0.25 max. 1.5
Flexible	with ferrule with plastic sleeve	min. 0.25 max. 0.75

OSSD – test pulse detection

All the digital STO inputs of the inverter detect OSSD test pulses. In the application modes a), the corresponding external sensor output can be applied to the STO terminals.

Inputs

STO:

SINxD-A - input A for the activation of the STO function

SINxD-B - input B for the activation of the STO function

Error acknowledgement:

For error acknowledgement, the digital input IN4D (X210.9) must be parametrized via object **0x2612**. The single-pole error acknowledgement input must be actuated with a pulsed signal (low->high->low), where the pulse length must be between 100 ms and 5000 ms.

WARNING



Safety function failure

Passive encoders/sensors with external SELV/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.

[SYSR-AXAMAN-4](SAS-AXA-113)<T> Error acknowledge SELF / PELV



For error acknowledgement use passive sensors with external SELV/PELV power supply

4.2 External 24 V power supply

[SYSR-AXAMAN-1](SAS-AXA-59)<T> PELV / SELV

By connecting an external power supply of DC 24 V +20/-15% to X210, the function of inputs and outputs as well as the communication can be parameterized and maintained, even when mains voltage is off.

Requirements to be met by external power supply	
Input voltage range	DC 24 V +20/-15%
Rated input current	Max. 0.9 A
Peak inrush current	Typically: < 5 A
External fuse	Via standard fuse elements for rated current, characteristic: slow
Safety	Safety extra low voltage (SELV/PELV) according to EN 61800-5-1

6 Commissioning

WARNING



Moving components

Any alterations of 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.

The inverter comes preconfigured with default safety object values set in the firmware. In most cases, no extra steps are required for commissioning.

However, some applications will require the default values in safety objects to be altered 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.
- During commissioning, the user must test and verify the safety function.

7 Function Overview

Further normative reference

The STO function listed in this document is suited for applications corresponding to EN ISO 13849-1, IEC 62061 and IEC 61508.

The following prerequisites apply for the various safety functions:

Function	PFHd	SFF	Risk mitigation	Restart-block / -release
STO (IEC 61508)	$1,37 \cdot 10^{-9}$	98,89%	SIL 3/PLe Cat3	(external)
STO (IEC 62061)	$2,58 \cdot 10^{-9}$	98,89%	SIL 3/PLe Cat3	(external)

Proof-Test Interval is 20 years and Service life is 20 years.

NOTICE

Safety definition / Time behavior

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

- Reaction time of the device = max. 40 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
- Consider this information while planning.

7.1 STO - Safe Torque Off



WARNING

Moving components

Whenever external loads 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.

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 (see Fig. 1) at the inverter motor output.

The STO state is triggered by various causes:

- By deactivating the dedicated two-channel input of the safe drive (e.g. via actuating an emergency-stop actuator/device)
- Due to internal faults

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 motor and its connected drive train coast to standstill if no other external braking measures are in place.

Relevant objects

Index	Designation	Min	Max	Default
0x3E60	Debouncing time	0 [ms]	12 [ms]	4 [ms]
0x3E61	Discrepancy time	100 [ms]	5000 [ms]	500 [ms]

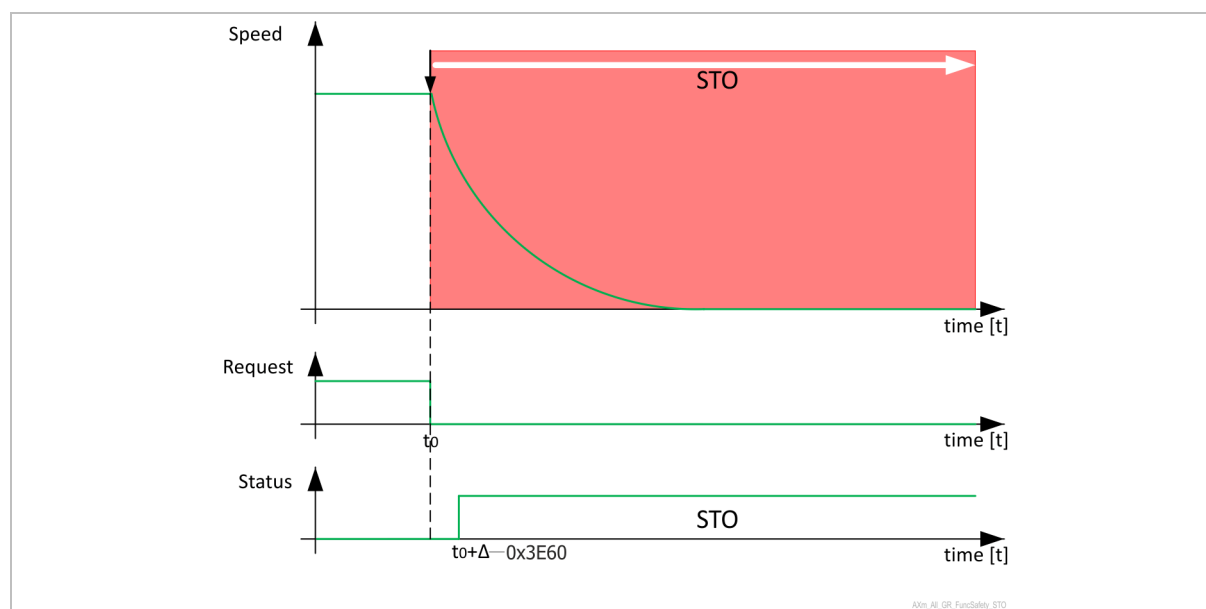


Figure 1: Safety function STO

Via the object **0x3E60** *Debouncing time* you can configure a delay for the status feedback (0x6640) of the safety function.

8 Application Examples

The following examples illustrate the method of functioning of the "Safe Torque Off" and "Safe Stop 1 (SS1)". According to EN 60204-1, stop functions are divided into different categories. Stop categories 0 and 1 can be realized using suitable safety switching devices.



- Please consider the current capacity of the frequency inverter (and the current requirements of the safety control device).

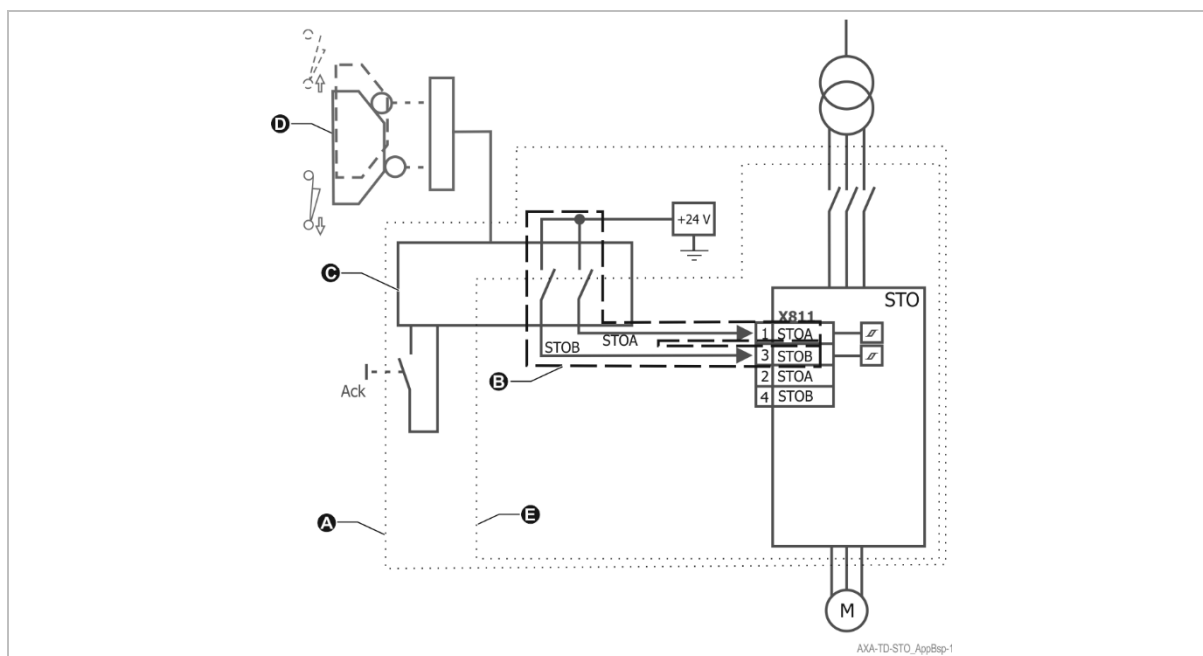
8.1 STO according to Stop Category 0

8.1.1 STO direct stop

The application example shows the minimum circuitry for AXIA frequency inverters for realization of the safety function STO "Safe Torque Off" with an emergency stop device in a common electrical cabinet according to EN ISO 13849-1 PL e, IEC 61508 SIL 3.

If the emergency stop device with two stop channels is actuated, both stop paths STOA and STOB of the frequency inverter are interrupted. The integrated safety function is activated.

A (non-safe) feedback to a process controller can be implemented, for example, via a connected field bus (this functionality is implemented in the main device providing the field bus). If STO is requested, the overriding controller has no more influence on the pulse block in the frequency inverter.



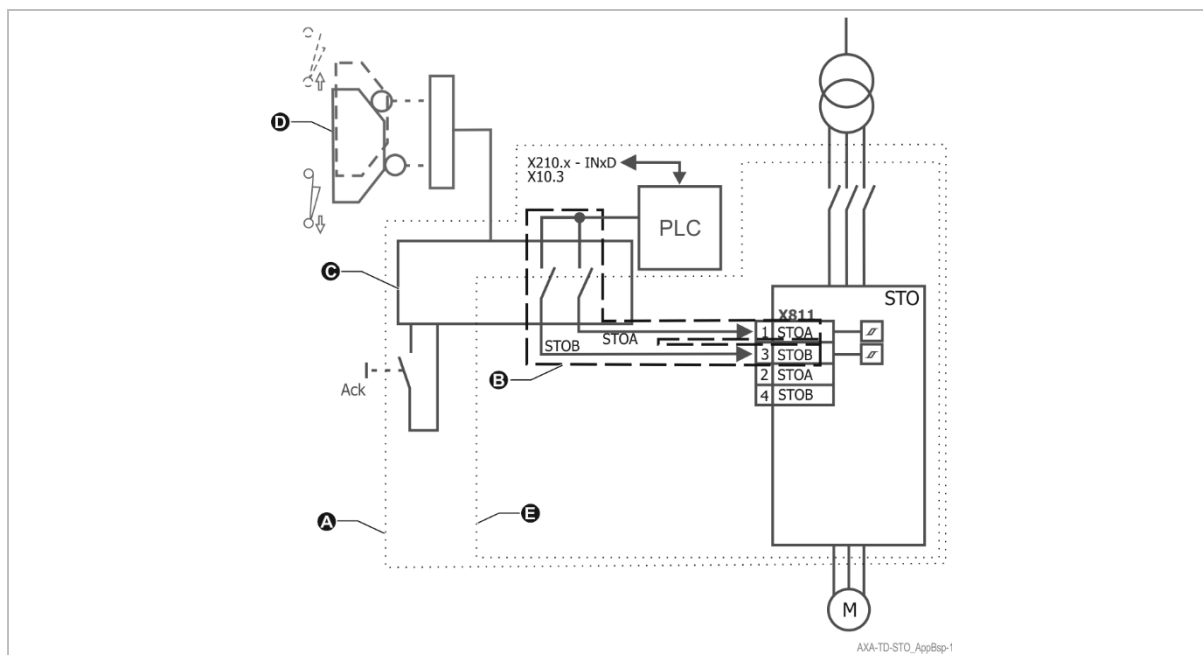
A	Electrical cabinet	D	Actuator
B	Safety circuit	E	Inverter
C	Emergency stop device		

8.1.3 STO direct stop with Feedback to PLC

The application circuit shows drive control with PLC and safety equipment as per EN ISO 13849-1 PL e, DIN EN 61800-5-2 SIL 3. A PLC does the process control of the frequency inverter and can start the drive profiles using commands.

When the emergency stop device is actuated with two shutdown channels, e.g. via the safety door, the two release paths of the Safety equipment are interrupted. In this way, the control voltage on the STOA and STOB of the frequency inverter is interrupted. The integrated safety function according to SIL 3 is requested as per EN 61800-5-2 when the inverter release is interrupted.

The safety equipment monitors the function of the S1 and S2 switches.



A	Electrical cabinet	D	Actuator
B	Safety circuit	E	Inverter
C	Emergency stop device		

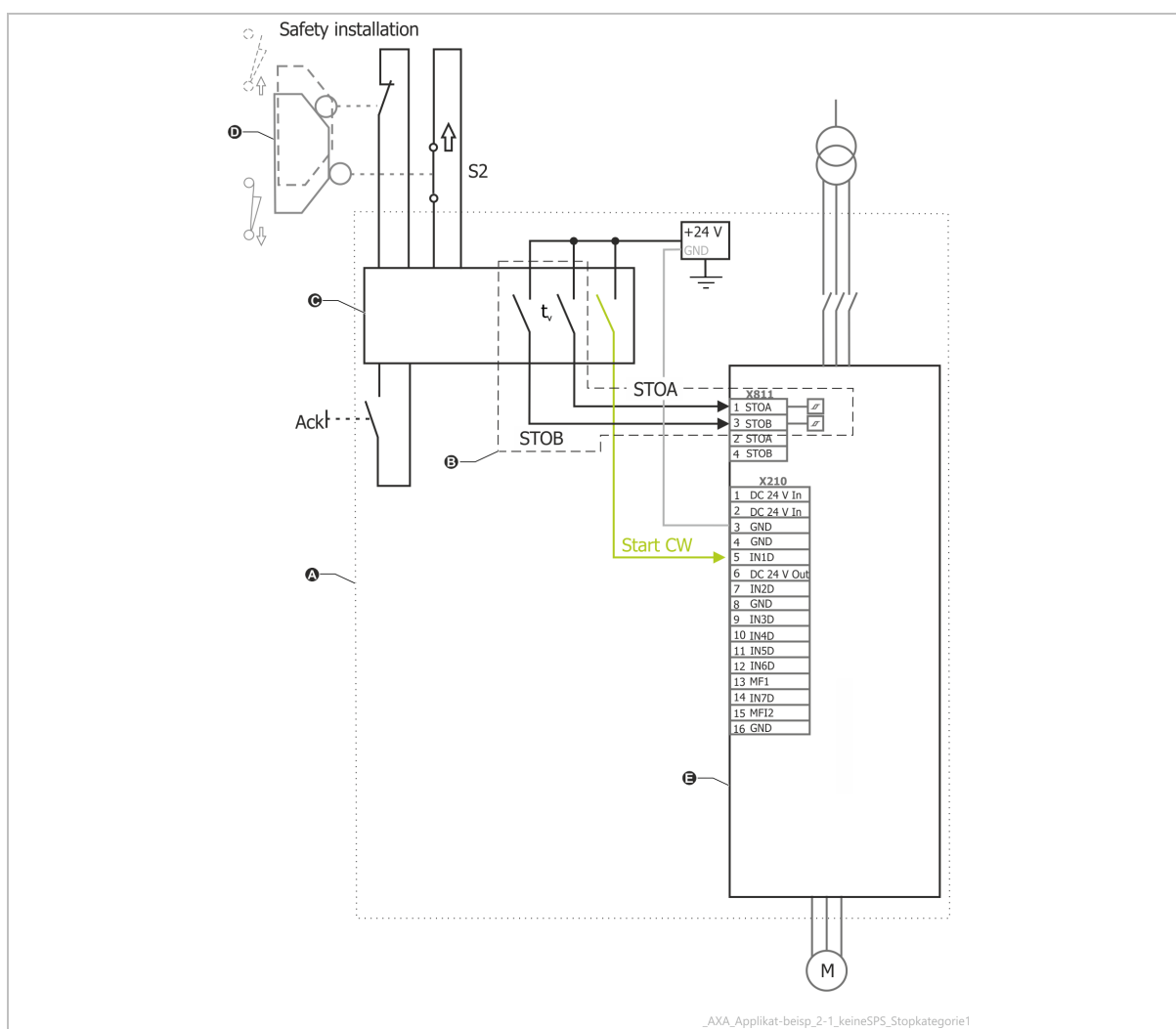
8.2 SS1 according to Stop Category 1

8.2.1 SS1 Direct Stop

The Application example shows the minimum circuitry for AxiaAgile inverter for realization of the safety function Safe Stop 1 (SS1) with an emergency stop device in a common electrical cabinet according to EN ISO 13849-1 PL d and Category 3 or IEC 61508 SIL 2.

When the emergency stop device is actuated, the travel command "Start CW" is reset first. After a delay t_v , the contacts on the safety switch interrupt the two enable paths STOA and STOB of the frequency inverter and the integrated safety function is triggered. The delay time is set on the safety control device and must be selected according to the application. The defined delay time has to be slightly higher than the shutdown time.

A (non-safe) feedback to a process controller can be implemented, for example, via a connected field bus. If STO is requested, the overriding controller no longer has influence on the inverter release in the frequency inverter.



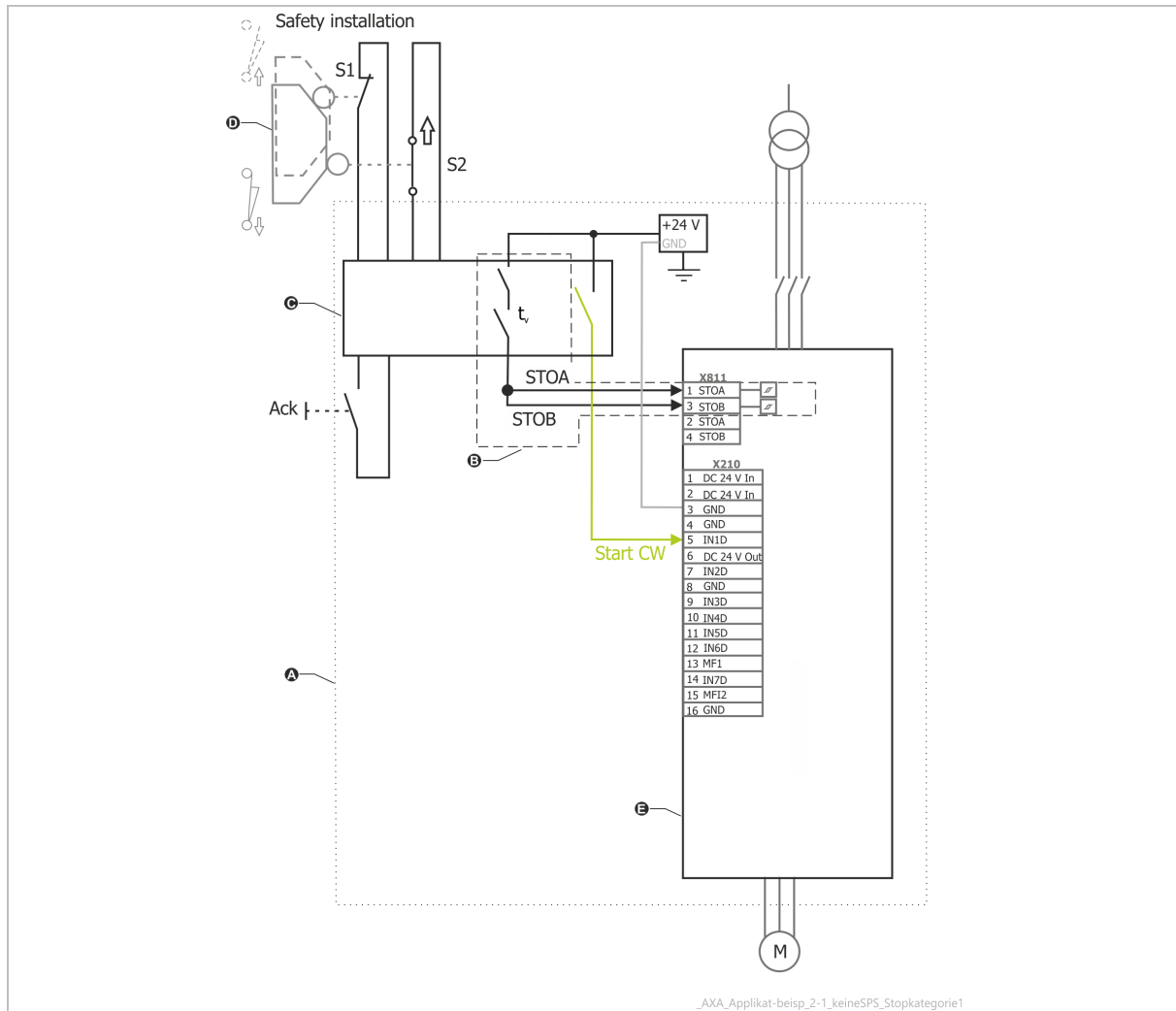
A	Electrical cabinet	D	Actuator
B	Safety circuit	E	Inverter
C	Emergency stop device		

8.2.2 SS1 Direct Stop with error exclusion "short circuit" in the cabinet

The application circuit shows a drive control system according to EN ISO 13849-1 PL d and Category 3 or IEC 61508 SIL 2 with PLC and safety module. Safety control equipment with one enable path and interconnection line is implemented instead of safety control equipment with two enable paths.

Comply with the following conditions:

- Safety control equipment and inverter have to be placed in the same cabinet.
- Error exclusion in case of short circuit has to be ensured for wiring between safety control equipment and inverter (for example insulated conductor).



A	Electrical cabinet	D	Actuator
B	Safety circuit	E	Inverter
C	Emergency stop device		

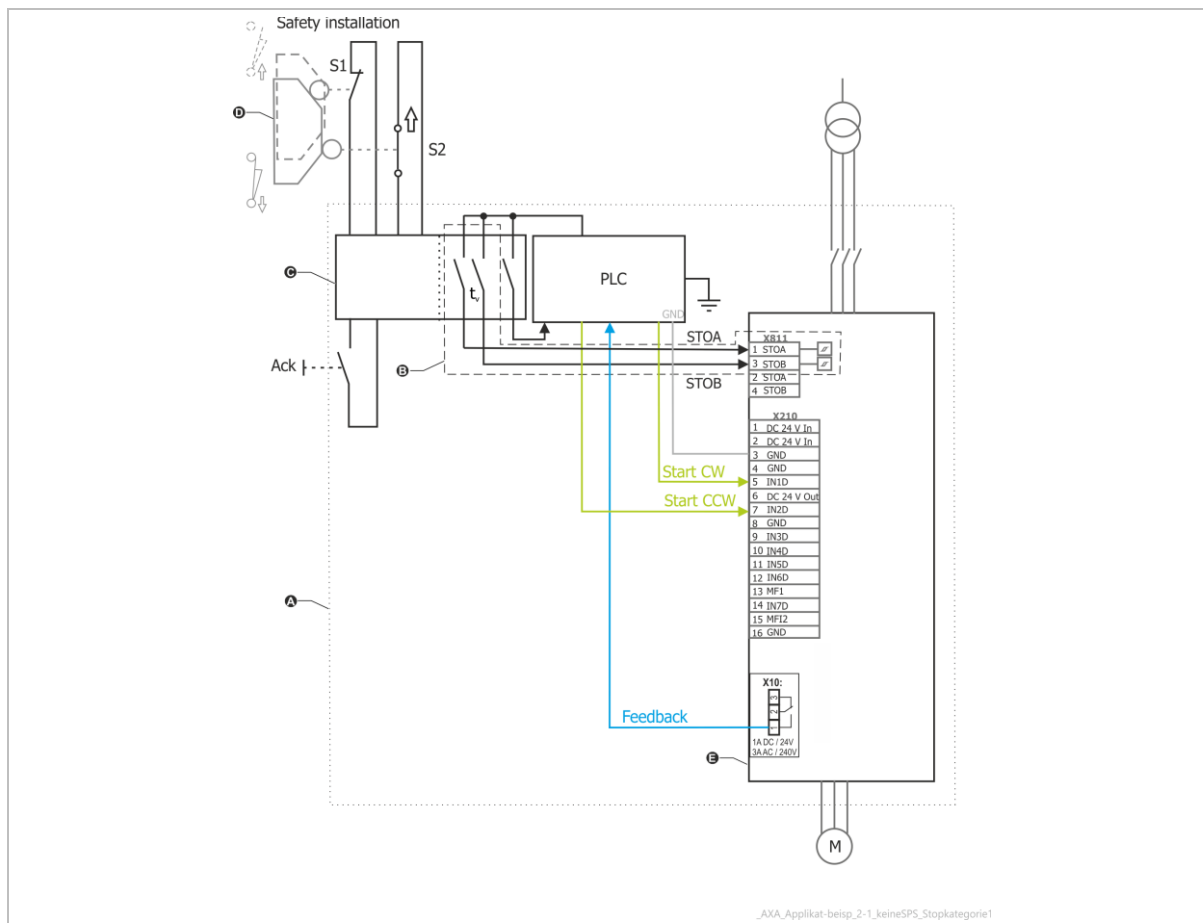
8.2.3 SS1 Direct Stop with Feedback to PLC

The application example shows a drive control system with PLC and safety module according to EN ISO 13849-1 PL d and category 3 or IEC 61508 SIL 2. A PLC performs the process control of the frequency inverter and can start the drive profiles via commands.

If the protective device is actuated, e.g. safety door open, the release paths of the safety module are interrupted.

The PLC is triggered first, that the safety function was actuated, which then decelerates the motor by resetting the start command ("Start CW" or "Start CCW"). After the delay time t_v has elapsed the control terminals connected to STOA and STOB interrupt the inverter release of the inverter and the internal safety function STO is triggered by interrupting the inverter release.

The safety module monitors the function of the switches S1 and S2 which are located outside of the electrical cabinet.



8.3 Group Stop, SS1

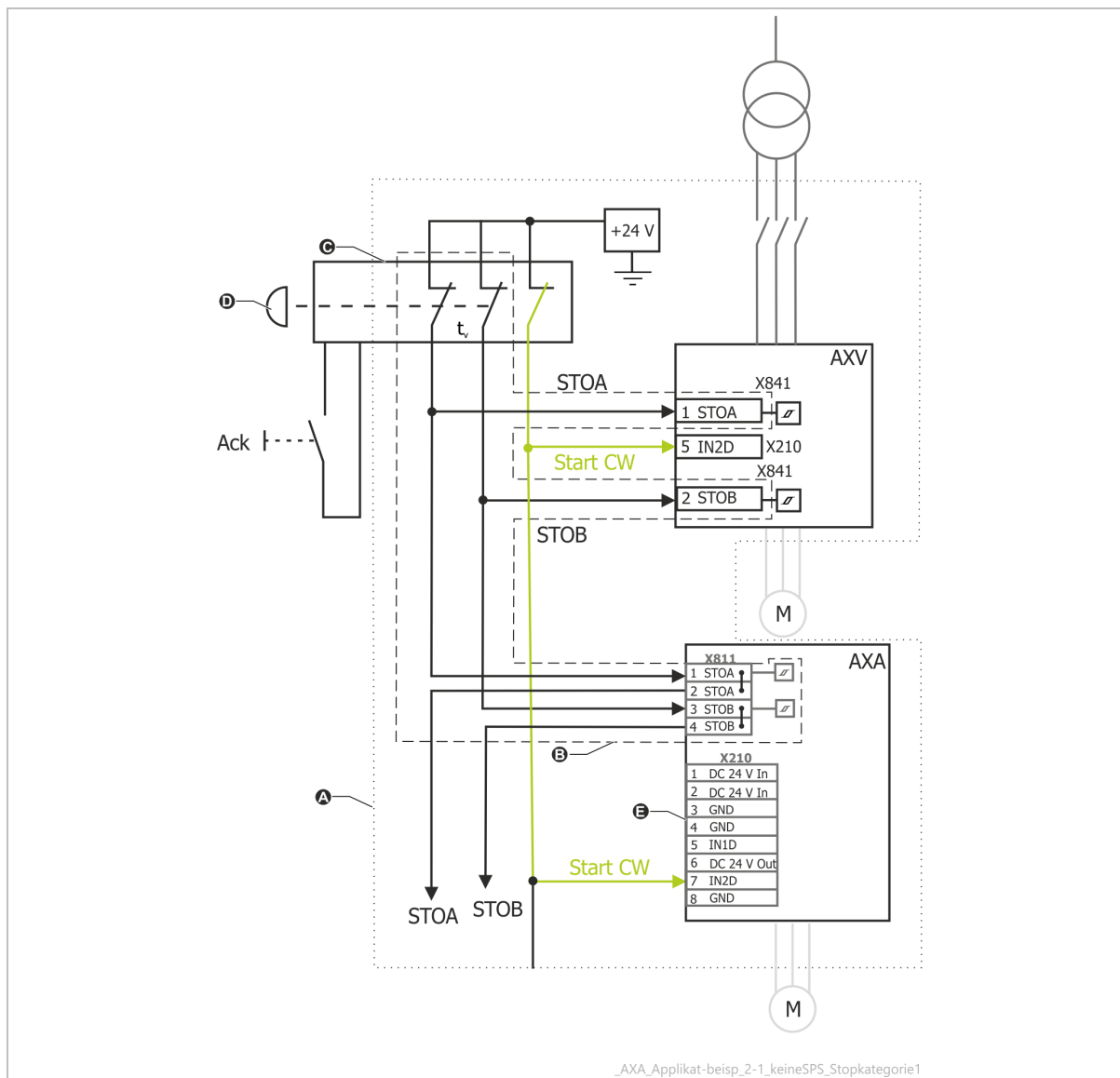
The application circuit shows a drive control system with a safety module according to EN ISO 13849-1 PL d and Category 3 or IEC 61508 SIL 2.

If the protective device is actuated, e.g. emergency stop switch, the enable paths of the safety module are interrupted. At first, the travel signal "Clockwise" is reset. Then, the motors are decelerated in a controlled way. After a delay t_v , the controller enable signal of the frequency inverters is interrupted via the disconnection of the control voltages from STOA and STOB and the integrated safe pulse block is activated.

Note, that with high current demand a fuse leading to the safety contacts might be necessary according to the instructions of the safety device manufacturers.

The external DC 24 V supply must be dimensioned accordingly, see chapter 4.2.

In group stop setups, pulsed signals could lead to more frequent false positives.



A	Electrical cabinet	D	Emergency Stop switch
B	Safety circuit	E	Inverter
C	Emergency stop device		

9 Operational diagnosis and error diagnosis

Fault ID	Name
F1200	General Safety Fault
F1205	Discrepancy Monitoring STO Inputs
F1209	SS1-t Supervision
F1210	Discrepancy Monitoring SBC Inputs
F12A1	Overtemperature 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
F12AA	Unsupported Safety Board Version
F12AF	3V Supply Exceeds Limits
F12B4	Control Flow Error
F12B5	Cycle Time Monitoring Error
F12C0	Invalid Parameter-Set
F12C2	Softerror Detection Parameter-Set
F12C4	Safe State during Write Access
F12C6	Invalid Serial Number
F12C9	Safety Application Out of Date
F12D0	STO Diagnostic Error

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 STO status, etc.) might be missing.

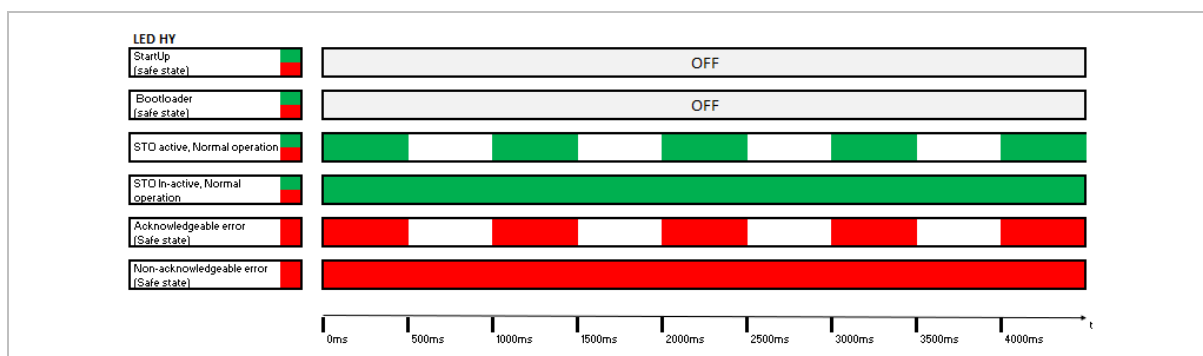
- The user must take this into consideration.

NOTICE

Reaction time

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

Status output via device LEDs (green and red LED):



NOTICE

The status output via the LEDs is NOT safe!

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/ Sub-index	Name	Value Range	Default Value	Data Type	Description
0x3E21 ⁽¹⁾	Serial number	full value range of the data type		uint32_t	Serial number of AXA assembly. NOT SAFE DATA Format: AYYWWNNNN (A-Manufacture place number/YY-Year/WW-Week/NNNN-consecutive increment number 4-digit) Example: 020220001 -> first module produced in week 22 of 2020.
0x2625 ⁽¹⁾	Current fault / error code	full value range of the data type		uint16_t	Current fault. NOT SAFE DATA
0x3E60 ⁽³⁾	Debouncing time	0,2,4,6,8,10,12	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.
0x3E0F.1	Input 1	0 / 1		uint8_t	SIN1D-A input state, in case no current safety error present
0x3E0F.2	Input 2	0 / 1		uint8_t	SIN1D-B input state, in case no current safety error present
0x3E0F.3	Input 3	0 / 1		uint8_t	Error acknowledge input state (SIN4D)

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