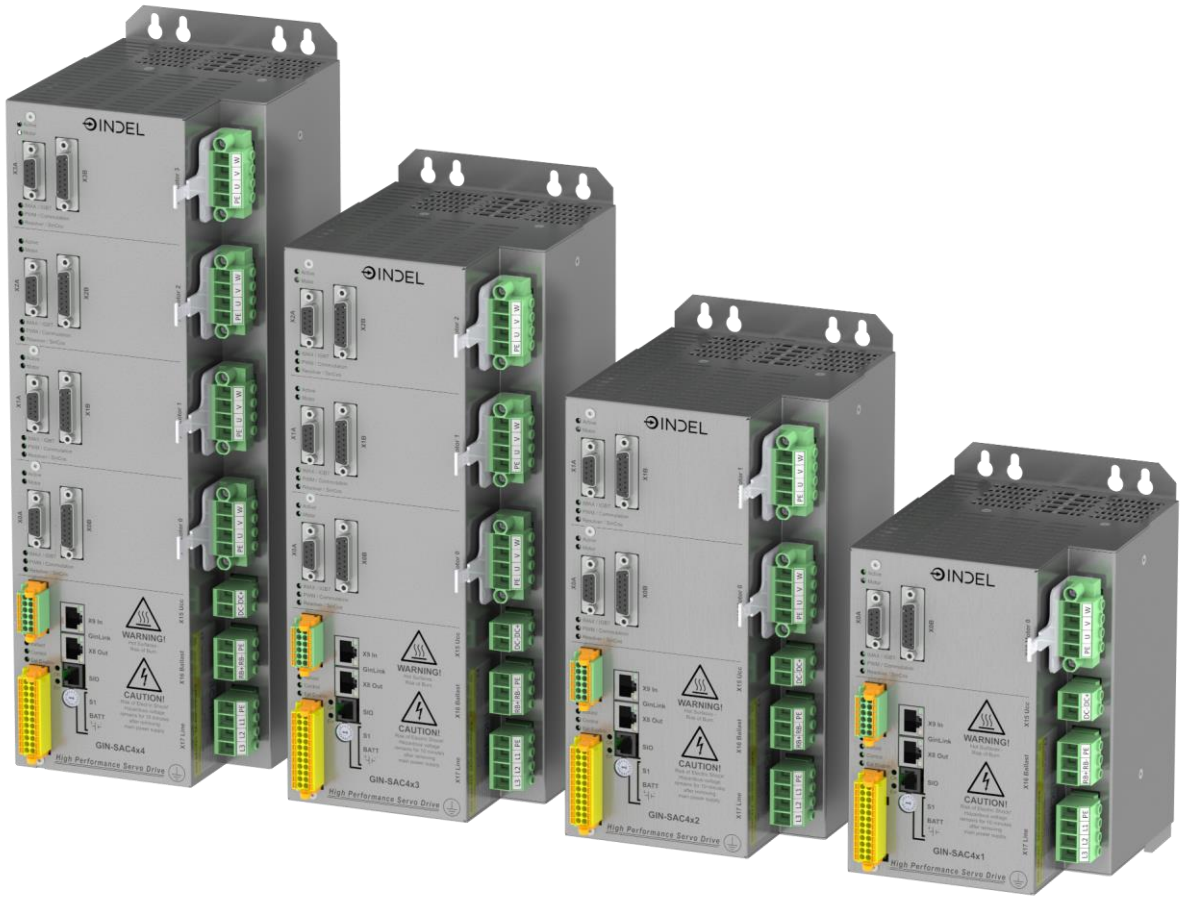
GIN-SAC4xX FS



User Manual

Version: 1.9
Date: 14.09.2023
Language: English
Issue: Translation of the original instructions

Table of contents

1. General

1.1. About This Manual

This user manual describes Indel series **GIN-SAC4xX** servo drives with the **FS** (**F**unctional **S**afety) option. This document is a translation of the German version of the original user manual.

1.2. About Indel Series GIN-SAC4xX Servo Drives with the FS Option

Indel series **GIN-SAC4xX** servo drives with the **FS** (**F**unctional **S**afety) option are intended for controlled actuation of up to four servo motors with safe monitoring of resolvers or sin/cos encoders. In addition to the motor actuation, safety subfunctions STO, SS1-t, SS2-t, SOS and SLS are available.

Indel servo drives are designed for industrial use, which is subject to applicable standards and regulations.

1.3. Distribution and Support

1.3.1. Manufacturer

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1.3.2. Support

Indel AG offers you comprehensive technical support:

- Hardware and software engineering
- Support via Team Viewer all over the world
- On-site technical support all over the world
- On-site commissioning of control systems and drives

1.4. Disclaimer

The documentation has been compiled to the best of our knowledge and belief. The described products, however, are subject to continuous development and improvement. Therefore, the documentation should never be deemed complete. All information contained in the documentation is provided without any guarantee. We reserve the right to make any changes, at any time and without prior notice. No claims may be made based on any changes to already delivered products.

1.5. Copyright

1.6. Documentation Revisions

Revision	Date	Author	Comment
Rev 0.1	25.09.2016	Thomas Jericke	Creating the document based on the GIN-SAC4xX manual.
Rev 0.2	30.09.2016	Thomas Jericke	Corrections after review
Rev 0.3	03.10.2016	Thomas Jericke	Corrections after second review
Rev 0.4	18.11.2016	Thomas Jericke	· Subsection Calculation of the Signal Strength Limit added. · Logic power supply of 24 V -15% +25% corrected to 24 V -15% +20% · Note on error codes of the safe input added. · Note on the use of test signals for STO in a ring circuit added. · Subsection on the unconfiguring of modules added. · Release numbers of the required software added. · Note on the verification of the SS1 and SS2 functions after making changes to the functional system (e.g. updates).
Rev 0.5	22.12.2016	Thomas Jericke	· Installation Regulations diagram replaced with a true-to-scale version. · EC declaration of conformity added. · Notes on low SOS limits added.
Rev 0.6	15.02.2017	Thomas Jericke	· Introductory description of the unit added. · Safety functions converted to safety subfunctions, SS1-t and SS2-t introduced following the new version of 61800-5-2 (2016). · Verification screenshot updated. · Warning against hot surfaces added. · Over-voltage category increased from II to III. · Standards updated and supplemented. · Error list updated.
Rev 0.7	28.02.2017	Thomas Jericke	· AllSchedTestIncomplete error in error code per class.
Rev 0.8	22.03.2017	Thomas Jericke	· Various spelling errors corrected. · Section 2.3.14 Protection Against Easy Circumvention deleted. · Safety instructions on the use of ring circuits added. · Safety note added that the GIN-SAC4xX's carrier signals must be used for resolvers. · Requirements for the use of resolvers or sin/cos encoders corrected and supplemented. · Diagrams for the STO, SS1-t and SS2-t safety subfunctions added. · Indication of the PFD value deleted. · Notes on DC motors corrected and supplemented.
Rev 0.9	13.04.2017	Thomas Jericke	· Requirement added that before the start-up of encoders the wiring must be checked. · Note on the use of the response times of safety subfunctions added. · Additional note on the use of gearboxes and drive

Revision	Date	Author	Comment
			belts added. · Note on permanent loading of the safety function added. · Text and notes on STO acknowledgement added. · New error codes of STO acknowledgement added. · Correct release of INCOServer V provided. · Additional note that GIN-SAC4xX FS may be used only in control cabinets with ingress protection IP54.
Rev 1.0	12.05.2017	Thomas Jericke	· Signed EC declaration of conformity added. · Notes on acceleration monitoring added. · Document approval: reference to Draft deleted.
Rev 1.1	15.06.2017	Max Bleuler	· Old Indel logo replaces with a new one · New URL links in section 2.3.11
Rev 1.2	21.08.2017	Thomas Jericke	· Corrected the order of the Inputs on the wiring examples at Section 5.5.4 and 5.8. · Corrected Star marking at Section 5.10 fromSS1-t to SLS. · Added Explanation of the helmet symbol of the Indel Axis Tool at Section 6.3.8. · Added reference to the Indel Online-Documentation of the Software configuration at sections 6.3.8 and 7.1.
Rev 1.3	07.10.2020	Max Bleuler	· Updated EC declaration of conformity at Section 12.1
Rev 1.4	18.11.2020	Simon Bärtschi	· Converted Document into MS Word · Added Picture to Frontpage · Section 4: added SAC4x2 Type · Section 4.3: updated Type plates with the new INDEL Logo · Section 9.2: updated Views of the Device Frontplate · Section 2.2.7: copied Residual Current Circuit Breaker informations from the STO Device Manual · Section 8.3.5.4: Added feature BissC und EnDat 2.2 · Section 5.7: non safe Output Contact. Use States closed /Open instead High/Low · Section 8.3.7: Normal Digital In/Outputs are useable as General Purpose IOs · Section **Fehler! Verweisquelle konnte nicht gefunden werden.**: added CB Certificate · Improved spelling errors · New Section 4.2 Optional Accessories · Section 8.5 Informations according US market
Rev 1.4	13.01.2021	Thomas Jericke	· Correction of Spelling Errors and Units with Micro (u zu µ).
Rev 1.4	22.06.2021	Simon Bärtschi	· Release of this English Version of the User Manual
Rev 1.6	15.09.2021	Simon Bärtschi	· Correction of Sincos interpolation Resolution from 10 Bit to 12 Bit. 8.3.6.1, 9.10.1, 9.10.4.1, 9.10.4.2

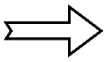
Revision	Date	Author	Comment
			• Correction of Safety Inputs minimal High Voltage from 11V to 16V. Sections 5.4.1, 5.5.1
Rev. 1.6	15.09.2021	Max Bleuler	• Updated EC declaration of conformity in section 12.1
Rev 1.7	24.05.2022	Simon Bärtschi	• Added Short Circuit Current Rating of mains supply in section 8.3.2
Rev 1.8	30.09.2022	Max Bleuler	• Updated EC declaration of conformity in section 12.1
Rev 1.9	14.09.2023	Michael Fischer	• Updated EC declaration of conformity in section 12.1

1.7. Definition Used

Definition	Meaning
DC	Diagnostic coverage
+DC / -DC	Intermediate circuit for servo drive tapping
EMC	Electromagnetic compatibility
ESD	Electrostatic discharge
Feedback	Position sensor
Feldbus Master	GinLink fieldbus master
FIT	Failure In Time, 1 FIT = 10^{-9} Errors/h
GinLink	Indel fieldbus, based on 1GBit/s Ethernet
GIN-SAC4xX	Designation for the whole GIN-SAC4 series
GIN-SAC4xX FS	Designation for the whole GIN-SAC4 series with functional safety
GIN-SAC4x4 FS	Designation for a GIN-SAC4 with four output stages and functional safety
GIN-SAC4x3 FS	Designation for a GIN-SAC4 with three output stages and functional safety
GIN-SAC4x2 FS	Designation for a GIN-SAC4 with two output stages and functional safety
GIN-SAC4x1 FS	Designation for a GIN-SAC4 with one output stages and functional safety
Hardware	Electronical or mechanical Hardware Component
IGBT	Insulated Gate Bipolar Transistor
INCOServer V	Indel Connectivity Server of the fifth generation: service program to manage communication between the PC and an Indel control unit
Indel Cockpit	Program to start up, maintain and operate Indel control units
Indel Safety Configurator	Safety configuration Software Application
INOS	Indel Operating System: operating system of Indel functional control units
Interface	Interface
IP-Adresse	Internet Protocol address
LAN	Local Area Network
LED	Light Emitting Diode
Linux	Open-source operating system
MTTFd	Mean Time to Dangerous Failure
OSSD	Output Signal Switching Device
PC	Personal computer
PE-Leiter	PE conductor (PE = Protective Earth)
PELV	Protective Extra Low Voltage
PFH	Probability of Failure per Hour
PFHd	Probability of Dangerous Failure per Hour
PL	Performance Level (as defined in EN ISO 13849-1)
PWM	Pulse Width Modulation
RAM	Random Access Memory (main memory of the microcontroller)
Safe-AxControl	Built-in Safety module for STO and safe inputs and outputs

Definition	Meaning
Safe-AxMonitor	Built-in Safety module for SOS and SLS axis monitoring
SELV	Safety Extra Low Voltage
SIL	Safety Integrity Level as defined in IEC61508
sin	Sine
SLS	Safely Limited Speed
SS1-t	Safe Stop 1 type C
SS2-t	Safe Stop 2 type C
STO	Safe Torque Off
Muting	No subfunction monitoring
Software	Microcontroller program
SOS	Safe Operation Stop
Target	Communication endpoint in the Indel cockpit
URL	Uniform Resource Locator
Windows	Microsoft® operating system

1.8. Symbols used

	**Danger** The symbol stands for information the non-observance of which may result in death or immediate severe damage.
	**Danger due to electricity** The symbol stands for information the non-observance of which may result in bodily injury due to electricity.
	**Warning** The symbol stands for information the non-observance of which may result in severe bodily injury or substantial property damage.
	**Attention** The symbol stands for information the non-observance of which may result in bodily injury or property damage.
	**Important user tip** The symbol stands for important user tips, which should all be followed**.**
WWW.	**Hyperlink** It stands for a hyperlink to a file or information on the Web.
	**Reference** Reference to an internal section of the documentation**.**

1.9. Formats Used

The decimal point is used as a decimal separator throughout the entire document. To avoid confusion, the comma is used as a thousand's separator (ISO 80000-1):

e.g.: 1,009.700,001

Hexadecimal numbers are indicated by a preceding '0x':

e.g.: 0x1EE3

Dates are presented in dd.mm.yyyy or yyyy-mm-dd format.

e.g.: 01.09.1974 bzw. 1974-09-01

1.10. Units Used

The following abbreviations are used with units.

Abbreviation	Meaning
°	Degree (degree measures)
A	Ampere
A_{RMS}	Ampere root mean square (effective Current)
anno	Year
°C	Centigrade
F	Farad
g	Gravitational acceleration (9.8 m/s2)
h	Hour
H	Henry
Hz	Hertz
kg	Kilogram
m	Metre
min	Minute
müM	Metre above sea level
Ω	Ohm
s	Second
V	Volt
V_{AC}	AC voltage
V_{DC}	DC voltage
W	Watt

1.11. Prefixes Used

The following prefixes are used with units.

Abkürzung	Name	Faktor
M	Mega	1,000,000
k	Kilo	1,000
m	Milli	0.001
µ	Micro	0.000,001

2. Safety

2.1. User Inspection Upon Receipt

Upon receipt of the shipment and before every start-up the GIN-SAC4x4 should be checked for its integrity and completeness. In particular the following properties need to be verified:

- Completeness and correctness of the shipment contents (see section 4.1)
- Correct type identification on the drive (see section 4.3)
- Integrity of the housing, plugs and socket jacks
- No loose parts or detached screws

Under no circumstances may damaged or incorrect drives be used. This might result in severe bodily injury and property damage.

2.2. Safety Instructions

No claim is made that these safety instructions are complete. In case of any questions, ambiguities or problems, please do not hesitate and contact us.

2.2.1. Qualified Personnel

All transport, installation, start-up and maintenance works may only be carried out by qualified professionals. Qualified professionals include persons who are familiar with the transport, assembly, installation, start-up and operation of the product and possess the relevant qualifications. National and international accident prevention regulations and standards should be followed. The safety instructions, connection data (rating plate and documentation) and limits set in the technical specifications should be read through and absolutely complied with before the installation and start-up.

2.2.2. Documentation

Before the installation and start-up, carefully read this documentation and that referred to herein. Improper handling may result in bodily injury or property damage. The technical specifications, connection data and environmental conditions must absolutely be complied with.

2.2.3. Electrostatic Discharge Protection

Servo amplifiers have electrostatically sensitive components, which may be damaged if improperly used. Discharge your body before you touch a servo amplifier.
Avoid contact with highly insulating materials (synthetic fibre, plastic film, etc.). Once a servo amplifier is deenergised, place it on a conductive surface. Do not touch the drive's connector contacts, connected cables and strip conductor tabs.

2.2.4. Protection against contact with electrical parts

The operation of servo amplifiers requires that some parts carry more than 50 V_{AC}, i.e. low voltages. Touching such parts can result in life-threatening electric shocks. There is a risk of death or severe bodily injury.

Before switching on the drive, always make sure that it is properly connected to the PE conductor. Earth should always be connected, even if the drive is only activated for a short time.

Before energising live parts carrying more than 50 V_{AC} take appropriate measures to protect them against direct contact.

If the motor does not rotate, the terminals can also carry hazardous voltages. It is therefore forbidden to touch the terminals when they are energised.
Before starting any work on the drive, disconnect it from the mains and protect it against inadvertent actuation.

Touching any live parts (e.g. terminals) may result in death or severe injury or property damage.
Never cut the electrical connections of the modules when they are energised. Under unfavourable circumstances, light arcs may occur, injuring people and damaging materials such as contacts.

2.2.5. Switching Off

After the mains power supply is switched off, residual voltage may still exist for some minutes. Measure the intermediate circuit voltage and wait until it drops below 50V.

2.2.6. High Voltage and Insulation Resistance Testing

At the mains and the motor terminals of the drive no high voltage or insulation resistance test may be conducted, otherwise the drive is destroyed.

2.2.7. Residual Current Circuit Breaker (RCCB)

When this product is supplied by a 3 phase mains supply, a defect can cause a DC Current at the protective earth conductor (PE). If an RCCB is installed in the grid connection system, only “RCCB Type B” are allowed.
Only type B universal current-sensitive Residual Current Circuit Breakers may be used.

2.2.8. Opening the Unit

Under no circumstances may the GIN-SAC4xX FS be opened. Touching live parts of the GIN-SAC4x4 may result in death, severe bodily injury or property damage. Once opened, the GIN-SAC4xX must not be used any more even if it is reassembled.

2.2.9. Safe Torque Off

The STO safety subfunction described in section 5.10.1 has the form of a safe pulse lock.

	You should not activate the safety subfunction to deenergise the drive. Activation of the safety subfunction does not provide any protection against electric shock.

2.3. Safety Regulations

When installing and using Indel drives to implement a safe drive shutdown under stop category 0, 1 or 2 as defined in EN 60204-1 or safety subfunction STO, SS1-t, SS2-t, SOS and SLS as defined in EN-61800-5-2 and a fail-safe protection against inadvertent restart as defined in EN ISO 13849-1 cate-gory 3/PL d, all the regulations specified in this manual and those referred to herein must absolutely be observed.

2.3.1. Hazard Analysis

The machine manufacturer must conduct a hazard analysis for the machine and take appropriate measures so that no bodily injury or property damage could be caused by any unpredictable movement.

Possible risks are also described in other places throughout this document. All notes on hazards, warnings, precautions and information must be followed.

2.3.2. Coasting

If, based on the use, hazards occur due to coasting, additional precautions must be taken (e.g. movable shields with guard locking) to cover a hazard place as long as there is any hazard for persons or property. It should be noted that drive coating is possible even if there is no mechanical brake or the brake is defective.

2.3.3. Brake Resistor / Ballast Resistor

The brake resistor is not actuated by Indel servo drives in safe mode. If the brake resistor is defective or wrong, the motor does not stop within an expected timeframe. In a worst-case scenario, this may result in bodily injury and property damage.

2.3.4. Residual Energy in the Intermediate Circuit

Residual energy in intermediate circuit capacitors can be retained up to ten minutes after the power supply is switched off (after the main or the main contactor is opened). It is possible to move the motor with this residual energy. Under such circumstances hazardous situations may occur. If some extra ex-ternal capacitor modules are used, it takes proportionately longer until intermediate circuit capacitors are discharged.
The drives are provided with the following warning note.

2.3.5. Hot Surfaces

If the exposure of the GIN-SAC4x4 FS's output stages is continually high, in some places the housing may reach temperatures of up to 80°C.
The drives are provided with the following warning note.

2.3.6. Guards

Where a Guard is required as a measure to reduce risks, pursuant to EN ISO 13855 it should be considered if an additional guard locking is needed.

Depending on the defined safety subfunction, EN ISO 14119 should be observed.

2.3.7. Protection Against Dangerous Movements

Incorrect motor actuation may result in undesired and hazardous movements.

- Incorrect installation
- Faulty design
- Defective or incomplete wiring
- Defective equipment or cabling
- Incorrect software actuation

Basically, once the drive is switched on, it should be expected to move. People and equipment can be protected by taking higher-level measures and properly using the drive's integrated safety subfunctions. Appropriate measures should be taken to safeguard the movement area of machinery. It is strictly forbidden to remove, bridge or bypass any safety devices. The machine should be furnished with a sufficient number of easily accessible emergency stop switches. The provisions of the EN ISO 13850 standard have to be complied with.

2.3.8. Suspended Loads

For suspended loads, additional measures must be taken to make sure that the axes are held in place. The GIN-SAC4xX FS offers a safe output, which should not be connected to a holding brake, however, as it serves only as a safe input signal for further processing. A suitable actuator circuit is needed to activate a holding brake. Holding brakes offer no protection for decelerating motors.

2.3.9. Logic Power Supply Failure

Failure of the drive's 24V logic power supply may cause the motor to coast to a stop. If it is not allowable, some external measures must be taken to prevent axis coasting.

2.3.10. Mains Power Supply Failure

Failure of the mains power supply or motor power supply may cause the motor to coast to a stop. If intermediate circuit voltage U_{cc} drops below preset limit $U_{cc\,MIN}$, the servo drive indicates an error, and the motors are deenergised.

2.3.11. EMC

For EMC-compliant wiring, see the documents: INDEL Wire Routing Guide and INDEL Installation Guide, as well as all the wiring notes contained in this document.

WWW. INDEL Wiring Guidelines (https://www.indel.ch/Downloads-Indel/Further_Documents/EMC/EMC_Wiring-Guidelines.pdf)

WWW. INDEL Installation Guideline (https://www.indel.ch/Downloads-Indel/Further_Documents/EMC/Aufbaurichtlinie.pdf)

The manufacturer of the machine or plant must take additional measures regarding EMC protection if lower limits are stipulated in the product standard relative to the machine. For machinery that contains multiple Indel servo drives, additional EMC protection measures may be required.

The controller is intended for industrial use. When connecting the controller to the mains, the controller must be preceded by a filter. See also section 9.11.2

	In a residential environment (first environment) this product may generate high-frequency interference, which requires additional suppression measures.

2.3.12. Start-Up

Before the servo drive is switched on, it must be made sure that the unit is properly connected to the earth potential. The earth wires must in any case be provided, even if the drive is going to be used only for testing purposes.

 DANGER	Control and power lines may carry voltage even if the motor is not moving. It is forbidden to touch live connections. Before any work is done on the drive, they must be disconnected from the mains and safeguarded against inadvertent restart.

The start-up, including that of safety subfunctions, should be documented. Basically, when the use of Indel servo drives includes safety drive disconnection after safe torque-off (STO), safe type C stop 1 (SS1-t), safe type C stop 2 (SS2-t), safe operating stop (SOS) and safely limited speed (SLS) as defined in EN 61800 Part 5.2 and a fail-safe protection against inadvertent restart as defined in EN ISO 13849 Category 3, start-up tests of the cut-off device and the proper wiring should be provided and documented.

2.3.13. Service Life

The servo drives must be replaced by the manufacturer 15 years after the delivery at the latest. If they are used for more than 15 years, their safe operation cannot be guaranteed. This applies not only for the operating time, but also for any downtime and storage time.

 ATTENTION	Since no repeat test can be conducted for the GIN-SAC4x4 FS, the retesting interval is identical with the service life, which is 15 years.

2.3.14. Liability

The servo drives are generally fail-safe. In case of failure, it is the operator's responsibility to bring the machine/plant to a safe condition.

All diagnostic and monitoring functions can only interrupt the activation of the motor. The motor may go dead then, and it will not be possible to control or brake it any more. Depending on the application, it is necessary to take some additional measures to brake or halt the motor.

Ensuring safety is the operator's responsibility.

2.3.15. Defective Drives

 ATTENTION	Defective and damaged drives may under no circumstances be put into service, as this may result in severe bodily injury and property damage.

2.4. Intended Use

- **Indel series GIN-SAC4xX servo drives may only be used within the specifications set forth in this document and those referred to herein.**
- **The machine may be used as intended provided that it is found to be compliant with the provisions of Machinery Directive 2006/42/EC and EMC Directive 2014/20/EC as amended. Otherwise, no machines furnished with Indel series GIN-SAC4xX servo drives may be put into service.**
- **The maximum cable length of the digital inputs and outputs is 30 metres and that of the motor cable is 20 metres. For longer cables, additional filters must be used to eliminate interference.**
- **Indel series GIN-SAC4xX servo drives may only be used for industrial purposes.**
- **Series GIN-SAC4xX servo drives are intended for integration into stationary electrical machines/plants that are compliant with the Machinery, Low Voltage and EMC Directives.**
- **Indel servo drives must be integrated into an IP54 compliant control cabinet which can only be opened with a separate key or tool. The drives must be built in so that no live parts could be touched.**
- **The environmental conditions specified in section 8.4 on page 117 must absolutely be observed. Measures must be taken, however, to ensure proper ventilation or cooling so that the temperature in the control cabinet is maintained below 40°C.**
- **Series GIN-SAC4xX servo drives may be connected directly to earthed three-phase industrial grid (TN network, TT network with the earthed star point at 400V +10%). Servo drives must not be used in non-earthed and earthed asymmetrical networks.**
- **The machine manufacturer is obliged to conduct a hazard analysis and take appropriate measures to prevent any unpredictable movements from causing any injury or property damage.**
- **The drives must not be used in any explosion hazard areas.**

3. Handling

3.1. Storage

Indel GIN-SAC4xX drives can be stored for up to twelve months, without any restrictions whatsoever. For storage of more than twelve months, the capacitors must be reformed before starting up the drive. In addition, all electrical connections must be cut off and L1/L2 must be supplied with 230 VAC for 20 minutes.

3.2. Maintenance

If the GIN-SAC4xX FS is used as intended, no maintenance is needed. Do not immerse or spray the housing to remove any external contamination. Internal contamination may be removed only by the manufacturer.

3.3. Repair Service

Servo drives must be repaired by the manufacturer. Indel control components can be returned to Indel for repairs. Once the repairs are complete, the configuration files necessary for the operation are deleted from the drive. Save for connectors, no spare parts are available or needed for series GIN-SAC4 FS drives.

	Should the housing of an Indel servo drive be opened, then the warranty be-comes null and void.

3.4. Disposal

The servo drives are made of the following materials:

- Steel housing
- Aluminium cooling elements
- Electronic circuit boards

Individual components have to be disposed of in a professional manner. All servo drives can be re-turned to Indel AG for proper disposal. The cost of transport should be borne by the sender.

4. Product Identification

GIN-SAC4xXs are available in the following various versions.

Type	Option	Article Nr.	Description
GIN-SAC4x4	5A/230V/FS	311349420	Servo drive, functional safety, 1x230Vac/325Vdc, 4 x output stages, total 20Arms direct current, single-core 800MHz ARM, 8MB of flash memory, 256MB of RAM, GinSlave
GIN-SAC4x4	5A/230V/PRO/FS	311349425	Servo drive, functional safety, 1x230Vac/325Vdc, 4 x output stages, total 20Arms direct current, dual-core 800MHz ARM, 8MB of flash memory, 256MB of RAM, 0.5MB of NVRAM, GinSlave/GinMaster, SD card adapter
GIN-SAC4x4	5A/400V/FS	311349440	Servo drive, functional safety, 3x400Vac/565Vdc, 4 x output stages, total 20Arms direct current, single-core 800MHz ARM, 8MB of flash memory, 256MB of RAM, GinSlave
GIN-SAC4x4	5A/400V/PRO/FS	311349445	Servo drive, functional safety, 3x400Vac/565Vdc, 4 x output stages, total 20Arms direct current, dual-core 800MHz ARM, 8MB of flash memory, 256MB of RAM, 0.5MB of NVRAM, GinSlave/GinMaster, SD card adapter
GIN-SAC4x3	5A/230V/FS	311349320	Servo drive, functional safety, 1x230Vac/325Vdc, 3 x output stages, total 15Arms direct current, single-core 800MHz ARM, 8MB of flash memory, 256MB of RAM, GinSlave
GIN-SAC4x3	5A/230V/PRO/FS	311349325	Servo drive, functional safety, 1x230Vac/325Vdc, 3 x output stages, total 15Arms direct current, dual-core 800MHz ARM, 8MB of flash memory, 256MB of RAM, 0.5MB of NVRAM, GinSlave/GinMaster, SD card adapter
GIN-SAC4x3	5A/400V/FS	311349340	Servo drive, functional safety, 3x400Vac/565Vdc, 3 x output stages, total 15Arms direct current, single-core 800MHz ARM, 8MB of flash memory, 256MB of RAM, GinSlave
GIN-SAC4x3	5A/400V/PRO/FS	311349345	Servo drive, functional safety, 3x400Vac/565Vdc, 3 x output stages, total 15Arms direct current, dual-core 800MHz ARM, 8MB of flash memory, 256MB of RAM, 0.5MB of NVRAM, GinSlave/GinMaster, SD card adapter
GIN-SAC4x2	5A/230V/FS	311349220	Servo drive, functional safety, 1x230Vac/325Vdc, 2 x output stages, total 10Arms direct current, single-core 800MHz ARM, 8MB of flash memory, 256MB of RAM, GinSlave
GIN-SAC4x2	5A/230V/PRO/FS	311349225	Servo drive, functional safety, 1x230Vac/325Vdc, 2 x output stages, total 10Arms direct current, dual-core 800MHz ARM, 8MB of flash memory, 256MB of RAM, 0.5MB of NVRAM, GinSlave/GinMaster, SD card adapter
GIN-SAC4x2	5A/400V/FS	311349240	Servo drive, functional safety, 3x400Vac/565Vdc, 2 x output stages, total 10Arms direct current, single-core 800MHz ARM, 8MB of flash memory, 256MB of RAM, GinSlave

Type	Option	Article Nr.	Description
GIN-SAC4x2	5A/400V/PRO/FS	311349245	Servo drive, functional safety, 3x400Vac/565Vdc, 2 x output stages, total 10Arms direct current, dual-core 800MHz ARM, 8MB of flash memory, 256MB of RAM, 0.5MB of NVRAM, GinSlave/GinMaster, SD card adapter
GIN-SAC4x1	5A/230V/FS	311349120	Servo drive, functional safety, 1x230Vac/325Vdc, 1 x output stages, total 5Arms direct current, single-core 800MHz ARM, 8MB of flash memory, 256MB of RAM, GinSlave
GIN-SAC4x1	5A/230V/PRO/FS	311349125	Servo drive, functional safety, 1x230Vac/325Vdc, 1 x output stages, total 5Arms direct current, dual-core 800MHz ARM, 8MB of flash memory, 256MB of RAM, 0.5MB of NVRAM, GinSlave/GinMaster, SD card adapter
GIN-SAC4x1	5A/400V/FS	311349140	Servo drive, functional safety, 3x400Vac/565Vdc, 1 x output stages, total 5Arms direct current, single-core 800MHz ARM, 8MB of flash memory, 256MB of RAM, GinSlave
GIN-SAC4x1	5A/400V/PRO/FS	311349145	Servo drive, functional safety, 3x400Vac/565Vdc, 1 x output stages, total 5Arms direct current, dual-core 800MHz ARM, 8MB of flash memory, 256MB of RAM, 0.5MB of NVRAM, GinSlave/GinMaster, SD card adapter

4.1. Contents

4.1.1. GIN-SAC4x4

When the GIN-SAC4x4 with options 230V/FS, 400V/FS, 230V/PRO/FS and 400V/PRO/FS is ordered, the scope of delivery includes the following:

- GIN-SAC4x4 servo drive
- Mating connector X7:
  DFMC 1.5/6-ST-3.5-LR Phoenix contact with specific Indel labelling
- Mating connector X17:
  PC 4 HV/4-ST-7.62 Phoenix contact with specific Indel labelling
- Mating connector X10, X11, X12, X13
  PC 5/4-STF-SH1-7.62 Phoenix contact with specific Indel labelling
- Mating connector X15
  PC 4 HV/2-ST-7.62 Phoenix contact with specific Indel labelling
- Mating connector X16
  PC 4 HV/3-ST-7.62 Phoenix contact with specific Indel labelling
- Mating connector X100
  DFMC 1.5/12-ST-3.5-LR Phoenix contact with specific Indel labelling

The scope of delivery does not include:

- Male D-Sub Mating connector 9 pole for X0A, X1A, X2A, X3A
- Male D-Sub Mating connector 15 pole for X0B, X1B, X2B, X3B
- Motor configuration files that are absolutely necessary for the operation of motors or axes.
- Safety configuration files that are absolutely necessary for the start-up and safe operation.
- Ethernet cable

4.1.2. GIN-SAC4x3

When the GIN-SAC4x3 with options 230V/FS, 400V/FS, 230V/PRO/FS and 400V/PRO/FS is ordered, the scope of delivery includes the following:

- GIN-SAC4x3 servo drive
- Mating connector X7:
  DFMC 1.5/6-ST-3.5-LR Phoenix contact with specific Indel labelling
- Mating connector X17:
  PC 4 HV/4-ST-7.62 Phoenix contact with specific Indel labelling
- Mating connector X10, X11, X12
  PC 5/4-STF-SH1-7.62 Phoenix contact with specific Indel labelling
- Mating connector X15
  PC 4 HV/2-ST-7.62 Phoenix contact with specific Indel labelling
- Mating connector X16
  PC 4 HV/3-ST-7.62 Phoenix contact with specific Indel labelling
- Mating connector X100
  DFMC 1.5/12-ST-3.5-LR Phoenix contact with specific Indel labelling

The scope of delivery does not include:

- Male D-Sub Mating connector 9 pole for X0A, X1A, X2A
- Male D-Sub Mating connector 15 pole for X0B, X1B, X2B
- Motor configuration files that are absolutely necessary for the operation of motors or axes.
- Safety configuration files that are absolutely necessary for the start-up and safe operation.
- Ethernet cable

4.1.3. GIN-SAC4x2

When the GIN-SAC4x2 with options 230V/FS, 400V/FS, 230V/PRO/FS and 400V/PRO/FS is ordered, the scope of delivery includes the following:

- GIN-SAC4x2 servo drive
- Mating connector X7:
  DFMC 1.5/6-ST-3.5-LR Phoenix contact with specific Indel labelling
- Mating connector X17:
  PC 4 HV/4-ST-7.62 Phoenix contact with specific Indel labelling
- Mating connector X10, X11
  PC 5/4-STF-SH1-7.62 Phoenix contact with specific Indel labelling
- Mating connector X15
  PC 4 HV/2-ST-7.62 Phoenix contact with specific Indel labelling
- Mating connector X16
  PC 4 HV/3-ST-7.62 Phoenix contact with specific Indel labelling
- Mating connector X100
  DFMC 1.5/12-ST-3.5-LR Phoenix contact with specific Indel labelling

The scope of delivery does not include:

- Male D-Sub Mating connector 9 pole for X0A, X1A
- Male D-Sub Mating connector 15 pole for X0B, X1B
- Motor configuration files that are absolutely necessary for the operation of motors or axes.
- Safety configuration files that are absolutely necessary for the start-up and safe operation.
- Ethernet cable

4.1.4. GIN-SAC4x1

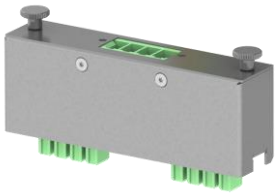
When the GIN-SAC4x1 with options 230V/FS, 400V/FS, 230V/PRO/FS and 400V/PRO/FS is ordered, the scope of delivery includes the following:

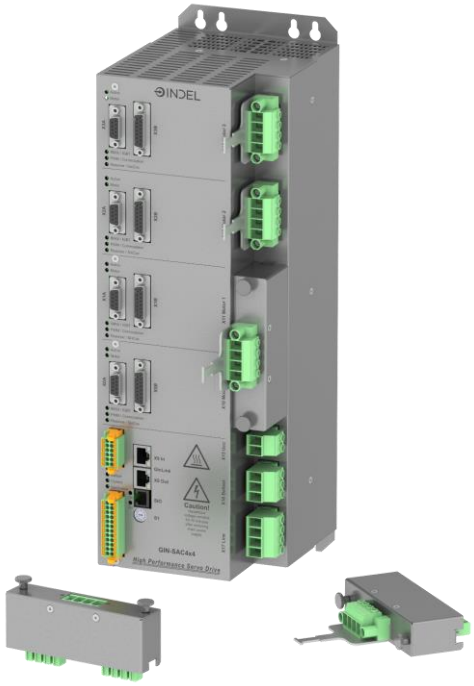
- GIN-SAC4x1 servo drive
- Mating connector X7:
  DFMC 1.5/6-ST-3.5-LR Phoenix contact with specific Indel labelling
- Mating connector X17:
  PC 4 HV/4-ST-7.62 Phoenix contact with specific Indel labelling
- Mating connector X10
  PC 5/4-STF-SH1-7.62 Phoenix contact with specific Indel labelling
- Mating connector X15
  PC 4 HV/2-ST-7.62 Phoenix contact with specific Indel labelling
- Mating connector X16
  PC 4 HV/3-ST-7.62 Phoenix contact with specific Indel labelling
- Mating connector X100
  DFMC 1.5/12-ST-3.5-LR Phoenix contact with specific Indel labelling

The scope of delivery does not include:

- Male D-Sub Mating connector 9 pole for X0A
- Male D-Sub Mating connector 15 pole for X0B
- Motor configuration files that are absolutely necessary for the operation of motors or axes.
- Safety configuration files that are absolutely necessary for the start-up and safe operation.
- Ethernet cable
-

4.2. Optional Accessories

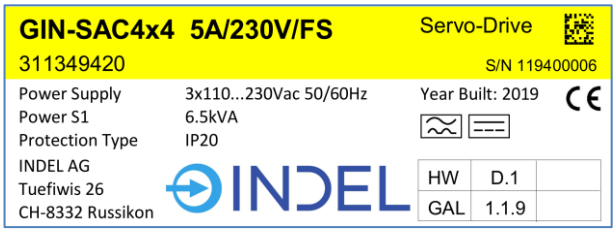
	Type	Article Nr.	Description
	SAC4-AD-2X	611755000	Compact pluggable Adaptor for GIN-SAC4xX devices, connects 2 Motor Outputs in parallel to get higher output motor currents. Installation is toolless by simply plug the adapter onto the SAC and fixing the knurled screw. The original motor connector from the SAC4 is reused as Motor Connector.



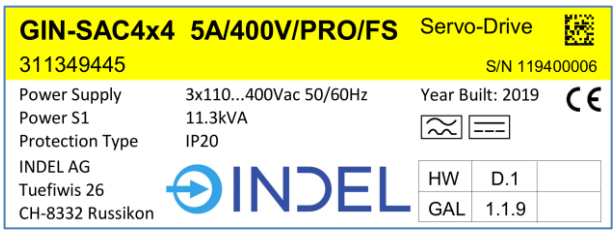
Example usage of SAC4-AD-2X

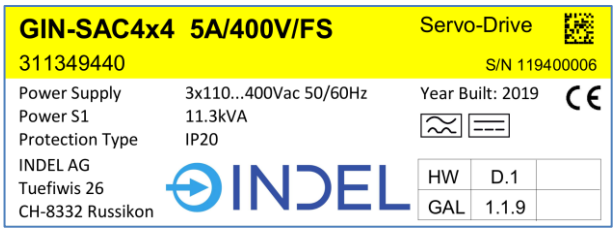
4.3. Rating Plates

4.3.1. GIN-SAC4x4 5A/230V/PRO/FS and GIN-SAC4x4 5A/230V/FS

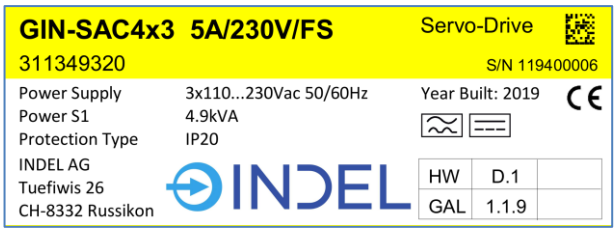


4.3.2. GIN-SAC4x4 5A/400V/PRO/FS and GIN-SAC4x4 5A/400V/FS

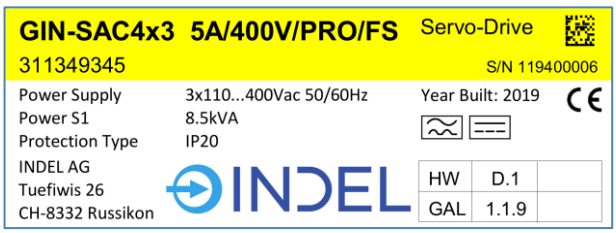


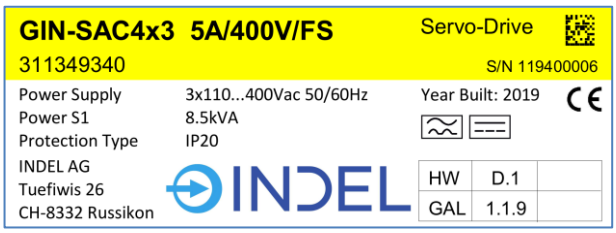


4.3.3. GIN-SAC4x3 5A/230V/PRO/FS and GIN-SAC4x3 5A/230V/FS

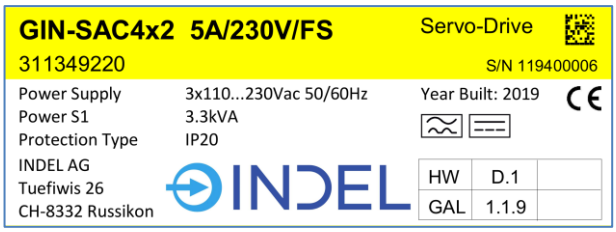


4.3.4. GIN-SAC4x3 5A/400V/PRO/FS and GIN-SAC4x3 5A/400V/FS

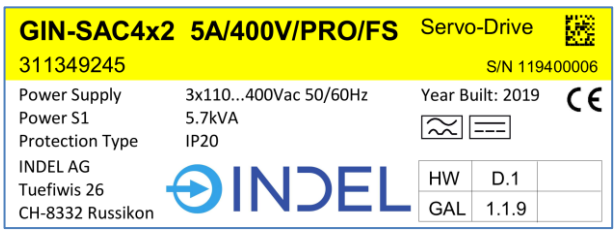


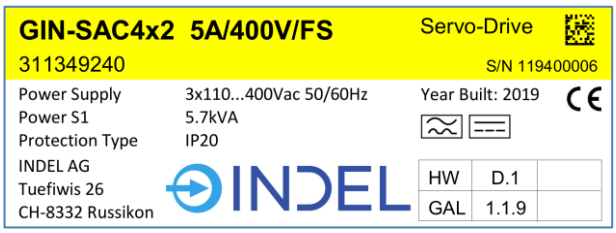


4.3.5. GIN-SAC4x2 5A/230V/PRO/FS and GIN-SAC4x2 5A/230V/FS

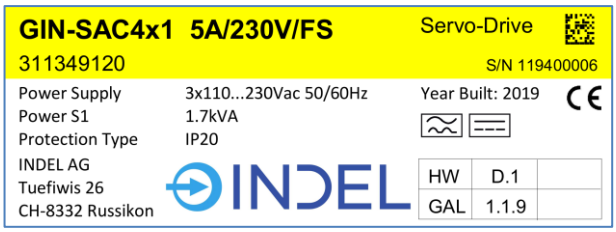


4.3.6. GIN-SAC4x2 5A/400V/PRO/FS and GIN-SAC4x2 5A/400V/FS

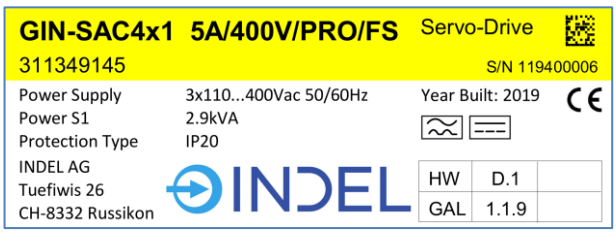


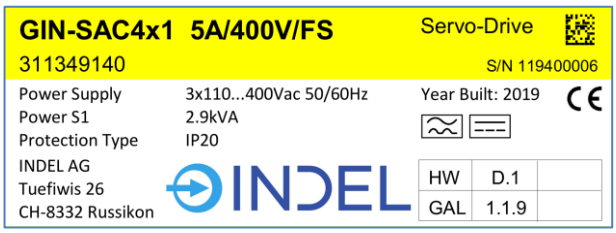


4.3.7. GIN-SAC4x1 5A/230V/PRO/FS and GIN-SAC4x1 5A/230V/FS



4.3.8. GIN-SAC4x1 5A/400V/PRO/FS and GIN-SAC4x1 5A/400V/FS





5. Safety Devices

This section provides a description of the GIN-SAC4xX FS's Safety Devices, including the wiring and proper parametrisation of individual components. The plug and pin assignment of all the connectors can be found in section 9.2.

5.1. Safe-AxControl and Safe-AxMonitor Safety Modules

The Safe-AxControl (311347200) and Safe-AxMonitor (311347300) modules are integrated parts of GIN-SAC4xX FS drives. Each drive comes with one Safe-AxControl module and each axis with one Safe-AxMonitor module.

The Safe-AxControl and Safe-AxMonitor modules are installed permanently and cannot be upgraded or replaced.

The Safe-AxControl and Safe-AxMonitor modules operate together, with the Safe-AxControl module ensuring safe inputs and outputs and pulse pattern inhibition and the Safe-AxMonitor module secure encoder evaluation.

Individual modules are configured as individual devices of a shared node.

5.1.1. Parameters

For all modules, the correct position in the system has to be configured. The position is verified after the module configuration is loaded.

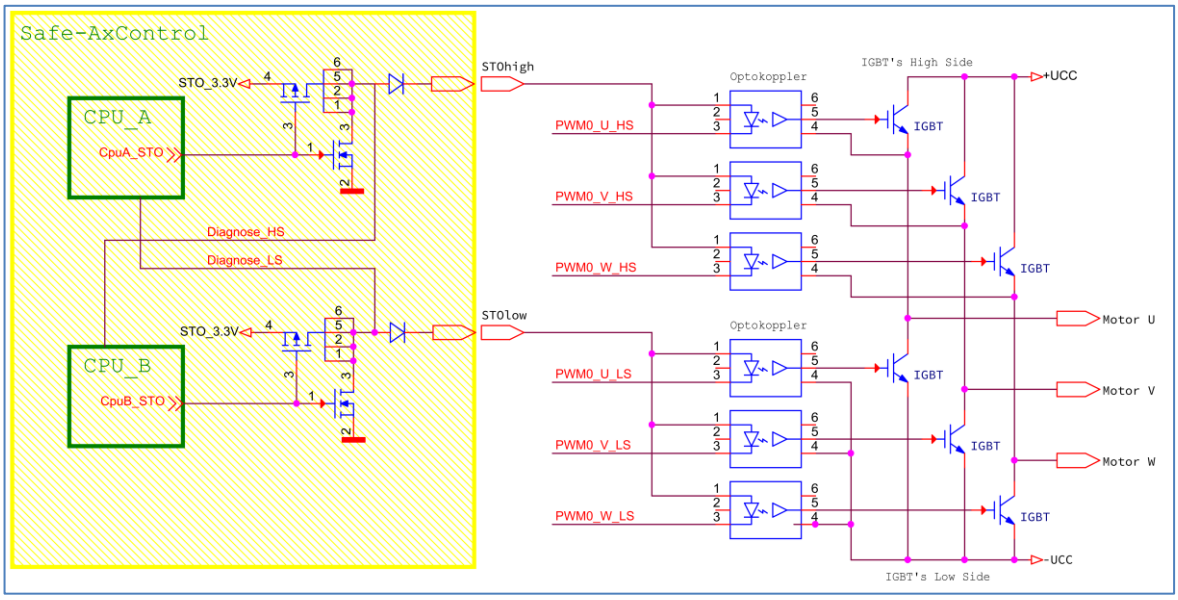
Parameter	Unit	Default Value	Description
Group <Device position>			
Fieldbus position	-	0	Position of the GIN-SAC4xX within the fieldbus.
Axis number	-	0	Axis number of the module in the GIN-SAC4xX. Note: The parameter is available only on the Safe-AxMonitor modules.

5.2. Closed Current Principle

In the GIN-SAC4xX FS, the safety devices of the module operate according to the closed current principle. Whenever a safe input is switched to zero or the current flow is interrupted, an appropriate safety sub-function is activated. This principle has to be also taken into account during wiring and setup, so that it is always switched to the safest of all possible states when a signal drops.

5.3. Safe Pulse Inhibition

The Safe-AxControl module is provided with safe two-channel pulse inhibition. The pulse inhibition is implemented by cutting off the GIN-SAC4xX's photocoupler power supply, which is fully integrated into the drive and requires no wiring. The Safe-AxControl module's pulse inhibition is read back and tested.



5.3.1. Maximum Displacement In Case of Error

DANGER

It should be noted that in case of a multiple error in the IGBT bridge it is possible for the motor to draw closer for a moment. The maximum rotation angle of the motor shaft which occurs during such displacement depends on how many pole pairs the motor has.

For permanently activated servo actuators:

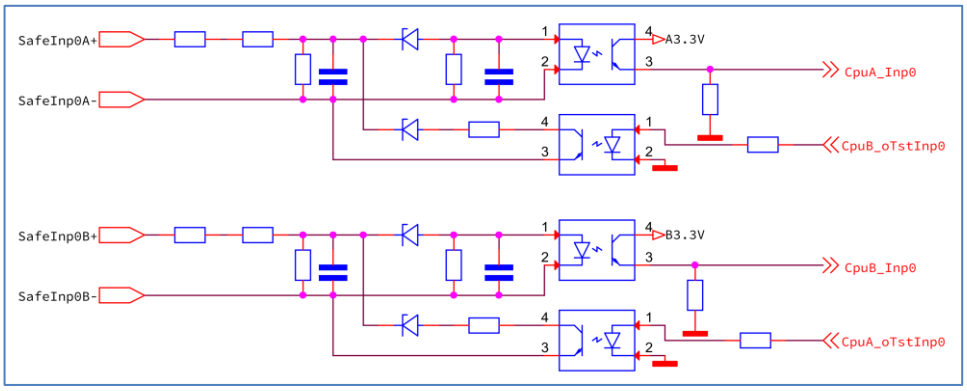
$$\varphi = \frac{360°}{2 \cdot p} \qquad \varphi = \text{angle of ratation}; \quad p = \text{pole pairs}$$

For linear motors:

$$d = \frac{P}{2} \qquad d = \text{linear movement}; \quad P = \text{pole pitch}$$

5.4. Safe Insulated Two-Channel Input: Safe Input 0 (STO)

GIN-SAC4xX FS's safe input 0 (STO) is internally connected to the Safe-AxControl module. This input is intended either for connecting to an emergency stop circuit, door contact, etc. or for connecting the GIN-SAC4xX FS to a higher-level safety controller.



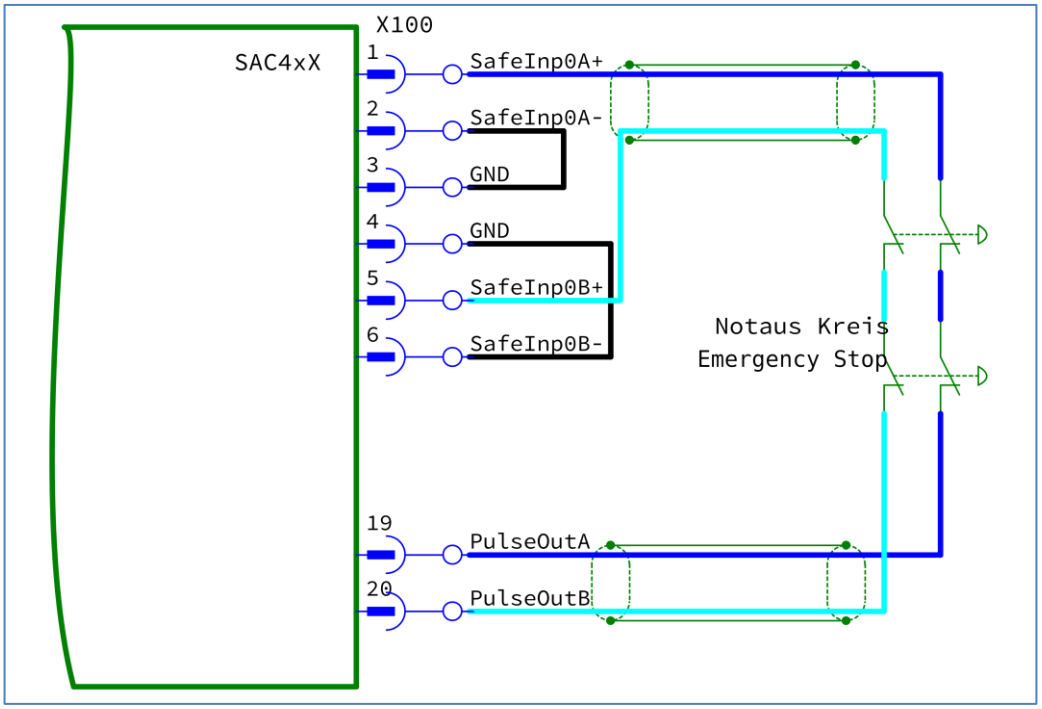
	Input 0 (STO) is absolutely needed for drive clearance, and cannot be disabled. If input 0 (STO) is missing or falls to low, the Safe-AxControl module triggers the STO function. High State must be applied to the input 0 (STO) and the Confirm Command must be applied to reset the pulse inhibition.

5.4.1. Parameters

Parameter	Minimum	Maximum
Input Voltage <Logic High>	16 V	30 V
Input Current <Logic High>	2 mA	15 mA
Input Voltage <Logic Low>	-3 V	5 V
Input Current <Logic Low>	None	15 mA
Interference filter	None	1 200 µs
Test pulse filter on one channel	None	10 ms
Allowable inconsistency between channels	None	1 s

5.4.2. Connection to an Emergency Stop Circuit

To connect passive safety switches such as emergency stop buttons, the GIN-SAC4xX FS's test pulse outputs have to be used. Input 0 (STO) A is then connected to pulse output A and input 0 (STO) B to pulse output B. The Input 0 (STO) configuration parameter must be set to Pulsed. The negative terminals of safe input 0 (STO) must be connected to the GIN-SAC4xX FS's ground.



DANGER	If more of the GIN-SAC4xX FS's inputs are used in pulsed form, then each different input must be wired with a separate cable. Otherwise undetectable cross-circuits may occur between various inputs (0-3) of the same channel (A/B) and fault exclusion as defined in EN ISO 13849-2:2012 must be provided.
DANGER	If the lines are laid outside the control cabinet, some additional measures must be taken (e.g. shielding or special cable sheathing).
DANGER	If the GIN-SAC4xX FS's cross-fault recognition is used, the Input 0 (STO) parameter must be set to Pulsed.
DANGER	The GIN-SAC4xX FS's pulse outputs may be wired only to the safe inputs of Indel devices.
DANGER	The maximum allowable cable length of the safe digital inputs is 30 metres. If longer cables are used, additional measures (such as filters) must be taken to suppress interference. The selection of such measures is subject to a security assessment.
	The maximum rated current of the test pulse outputs is 50mA

5.4.3. Connection to a Higher-Level Safety Controller

If input 0 (STO) is actuated by a higher-level control unit, a two-channel output (OSSD) must be used. The negative terminals of input 0 (STO) must be wired back to the earth (GND) or the relevant negative terminal of the safe outputs.

DANGER	When wiring input 0 (STO) to a safe output, the safety instructions of the relevant output module should be observed

DANGER	No cross-fault recognition is executed by the GIN-SAC4xX if a signal other than that of its own test outputs is used. Cross-circuit recognition should be carried out by the output module. Otherwise fault exclusion as defined in EN ISO 13849-2:2012 has to be performed.

	If a foreign signal is used, the Input 0 (STO) parameter must be set to <<Non Pulsed>>.

	If test pulses are used to test the external device's signals, the test pulses of both channels must be time-shifted, and the test pulse may drop to ‹low› for 10ms at the longest. If this is not observed, the input state switches to ‹low›, and a parameterised safety subfunction becomes active.

5.4.4. Parameters

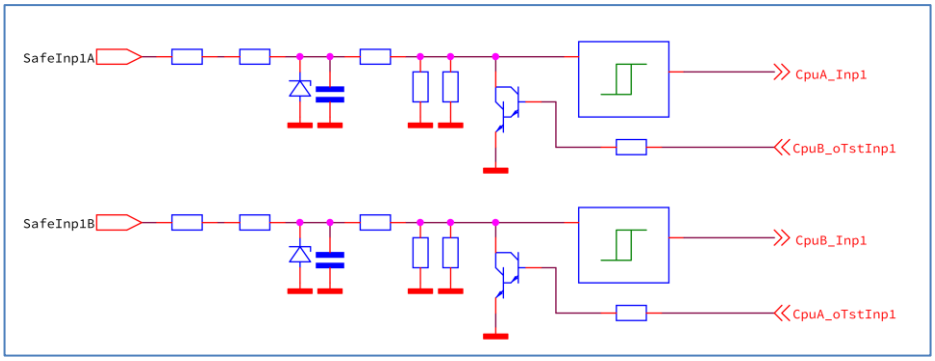
Parameter	Unit	Default Value	Description
Group ‹Input Configuration› on Safe-AxControl			
Input 0 (STO)	Pulsed / Non pulsed	Pulsed	Defines if the test pulse verification of input 0 is active. Note: Input 0 cannot be disabled

5.5. Safe Two-Channel Inputs 1-3

The GIN-SAC4xX FS's safe inputs 1-3 are intended for defining the active safety level during operation. How to calculate the safety level based on input signals is described in section 5.16. Safe inputs 1-3 are processed by the Safe-AxControl module.

	The safe inputs must be used in ascending order (without gaps).

If multiple GIN-SAC4xXs are connected in a ring circuit, then a GIN-SAC4x4's safe output is to be wired to safe input 3 of each next GIN-SAC4x4, input 3 will be ignored when subsequently calculating the safety level.



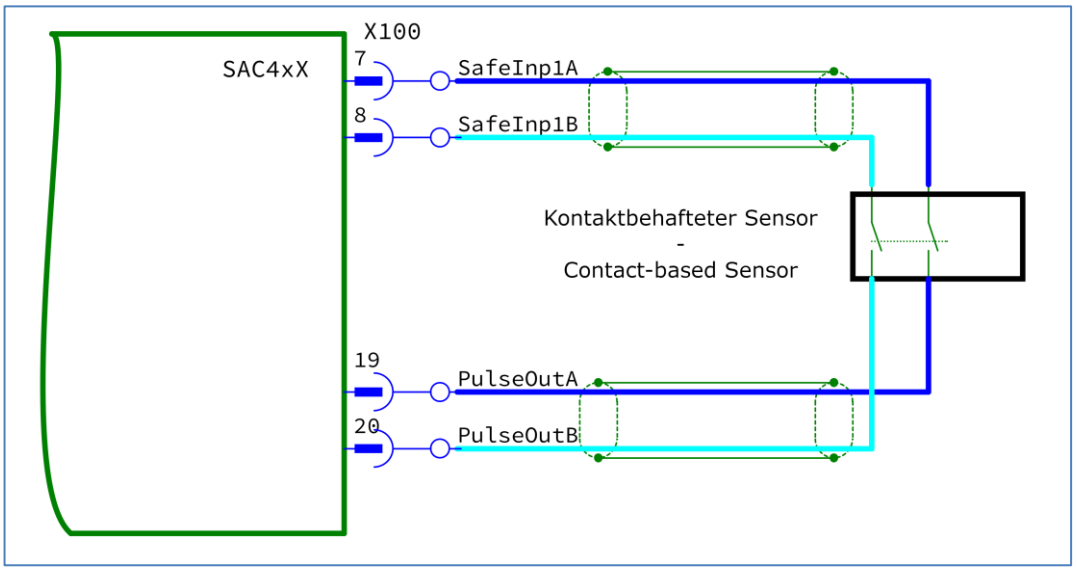
DANGER	If they are not used, the safe inputs must be disabled in the setup of the Safe-AxControl module.

5.5.1. Parameters

Parameter	Minimum	Maximum
Input Voltage <Logic High>	16 V	30 V
Input Current <Logic High>	2 mA	15 mA
Input Voltage <Logic Low>	-3 V	5 V
Input Current <Logic Low>	-	15 mA
Interference filter	-	1 200 µs
Test pulse filter on one channel	-	10 ms
Allowable inconsistency between channels	-	1 s

5.5.2. Connection to Two-Channel Contact based Sensors

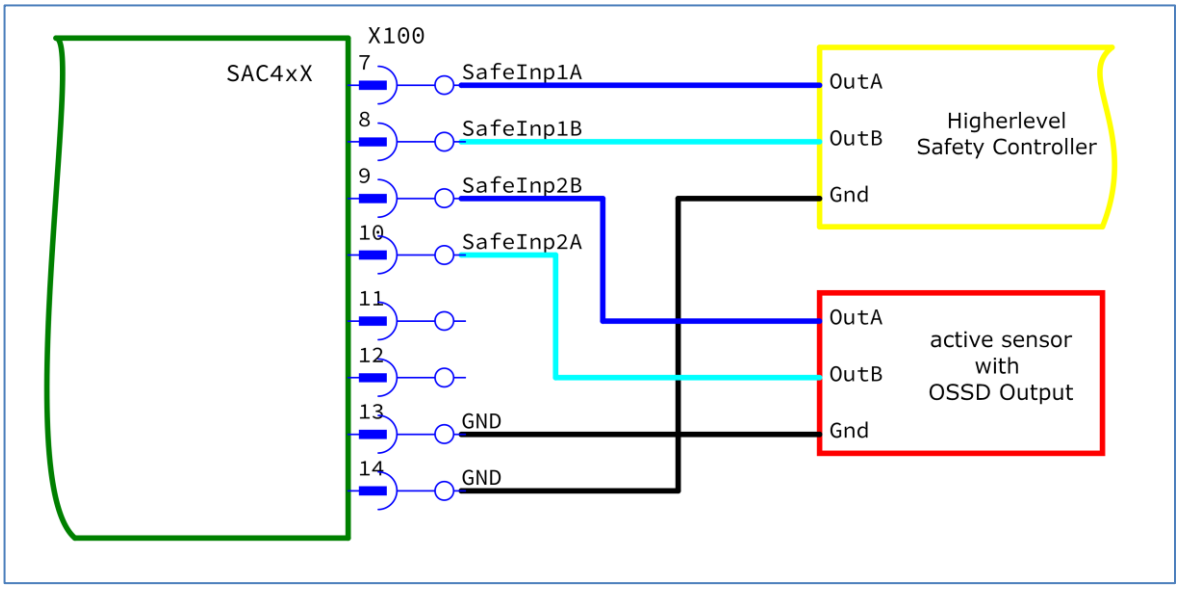
When connecting to passive Contact based Sensors such as guard door or protective hood safety switches, the GIN-SAC4xX FS's test pulse outputs must be used. Channel A of the input is then connected to pulse output A and channel B of the input to pulse output B. The setup parameter 1-3 must be set to Pulsed.



DANGER	If more of the GIN-SAC4xX FS's inputs are used in pulsed form, then each different input must be wired with a separate cable. Otherwise undetectable cross-circuits may occur between various inputs (0-3) of the same channel (A/B) and fault exclusion as defined in EN ISO 13849-2:2012 must be provided.
DANGER	If the lines are laid outside the control cabinet, some additional measures must be taken (e.g. shielding or special cable sheathing).
DANGER	If the GIN-SAC4xX FS's cross-fault recognition is used for safe inputs 1-3, the relevant input's Input X parameter must be set to Pulsed.
DANGER	The GIN-SAC4xX FS's pulse outputs may be wired only to the safe inputs of Indel devices.
DANGER	The maximum allowable cable length of the safe digital inputs is 30 metres. If longer cables are used, additional measures (such as filters) must be taken to suppress interference. The selection of such measures is subject to a security assessment.
	The maximum rated current of the test pulse outputs is 50mA.

5.5.3. Connection to a Safe Two-Channel Output

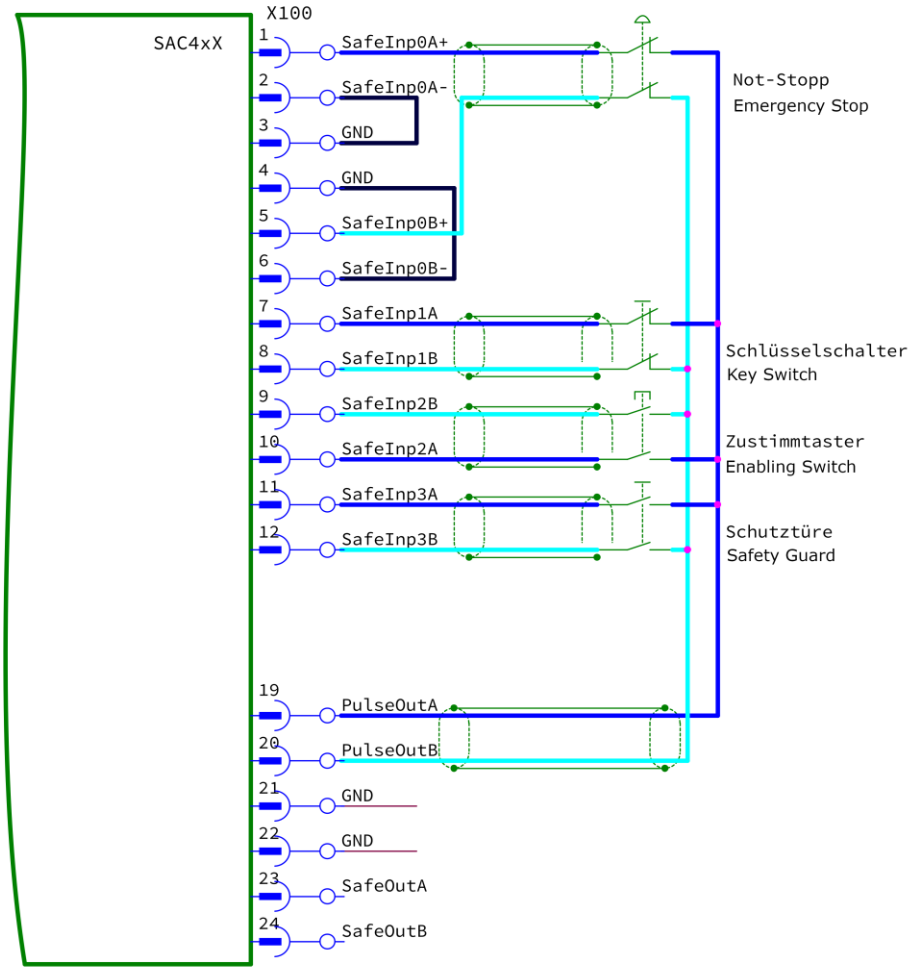
Safe inputs 1-3 can be connected to a safe two-channel output (OSSD). This enables to connect active sensors such as light curtains or a higher-level control unit. In addition the SAC4xX's GND terminals and the safety controller or active sensor must be directly connected with each other.



DANGER	When wiring inputs 1-3 to a safe output, the safety instructions of the relevant output module should be observed.
DANGER	No cross-fault recognition is executed by the GIN-SAC4xX if a signal other than that of its own test outputs is used. Cross-circuit recognition should be done by the output module. Otherwise fault exclusion as defined in EN ISO 13849-2:2012 has to be performed.
DANGER	If any input is unused (not wired), it must be set up as ‹inactive›. Then the signal of such an input permanently takes the state ‹low›.
ATTENTION	Safe inputs 1-3 are **not** potential-free. Make sure that the same potential is available to both the GIN-SAC4xX FS and the connected output.
	If a foreign signal is used, the Input 0 (STO) parameter must be set to <<Non Pulsed>>.
	If test pulses are used to test the external device's signals, the test pulses of both channels must be time-shifted, and the test pulse may drop to ‹low› for 10ms at the longest. If this is not observed, the input state switches to ‹low›, and a parameterised safety subfunction becomes active.

5.5.4. Use of Pulse Signals for Multiple Inputs

If the pulse signals provided by the GIN-SAC4xX FS are used for more than one input pair, correct wiring must be insured.



DANGER	Lines that use the same pulse signals must not be laid in a shared cable be-cause a possible cross-fault may be missed.

5.5.5. Error Recognition by the Safety Module

When the pulse signals provided are used, the Safe-AxControl module inside the GIN-SAC4xX FS recognises external errors at the inputs as follows.

Error	Recognition	Note
24V contact at the input	Yes	
Earth contact at the input when the contact is closed	Yes	
Earth contact at the input when the contact is open	**No**	**If the closed current principle is observed this error poses no hazard**
Wire breakage when the contact is closed	Yes	
Wire breakage when the contact is open	**No**	**If the closed current principle is observed this error poses no hazard**
Pulse signal cross-fault of another channel (A or B) at the input	Yes	
Pulse signal cross-fault of the same channel (A or B) at the input	**No**	**It must be excluded by the wiring**
Earth contact at the pulse output	Yes	
24V contact at the pulse output	Yes	
Cross-fault between pulse outputs	Yes	

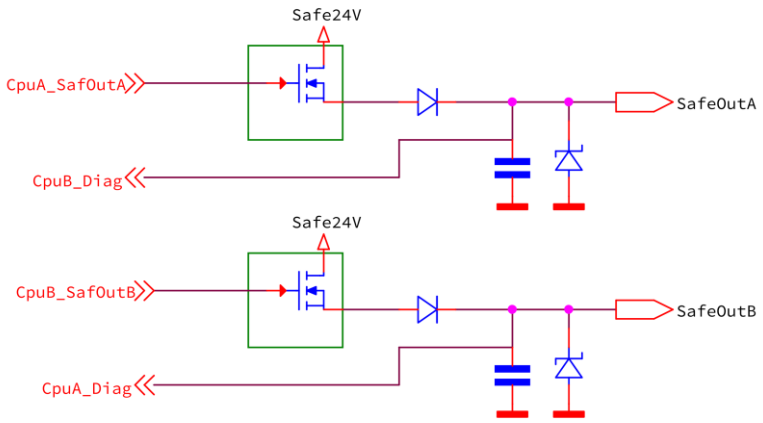
The error code of the error recognition defines the input number. This corresponds to the location of the error recognition, which does not have to match the error location. When localising errors all inputs should be switched one after another to ‹high› to find the exact location.

5.5.6. Parameters

Parameter	Unit	Default value	Description
Group ‹Input Configuration› on Safe-AxControl			
Input 1	Pulsed / Non-pulsed / Inactive	Inactive	Defines if input 1 is active with pulse monitoring, active without pulse monitoring or inactive.
Input 2	Pulsed / Non-pulsed / Inactive	Inactive	Defines if input 2 is active with pulse monitoring, active without pulse monitoring or inactive
Input 3	Pulsed / Non-pulsed / Inactive	Inactive	Defines if input 3 is active with pulse monitoring, active without pulse monitoring or inactive Note: When <<ring wiring>> is active, this parameter is disabled because input 3 is used for the ring circuit.

5.6. Safe Two-Channel Output

The GIN-SAC4xX is provided with a safe two-channel output for status feedback of the safe pulse inhibition. In the standard configuration (without a ring wiring) the output state corresponds to pulse pattern clearance. This means that the output switches to ‹low› whenever the module changes to the ‹STO› or error state.



DANGER	The safe two-channel output must not be used directly for motor or safety brake actuation.

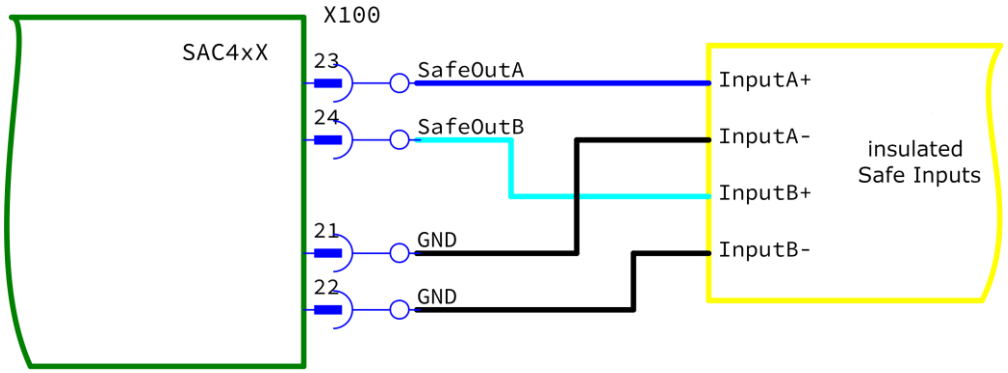
DANGER	The maximum allowable cable length of the safe digital outputs is 30 metres. If longer cables are used, additional measures (such as filters) must be taken to suppress interference. The selection of such measures is subject to a security assessment.

	If the safe output is not used, it must be disabled in the setup of the Safe-AxControl.

5.6.1. Parameters

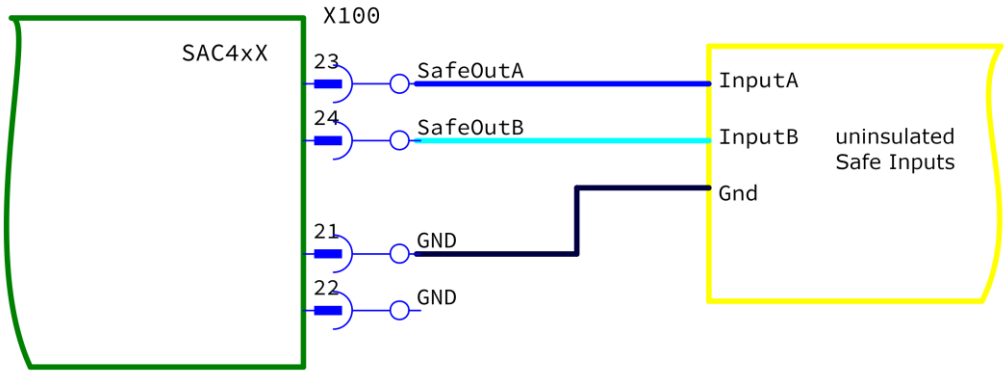
Parameter	Minimum	Maximum
Voltage output ‹high›	19 V	30 V
Voltage output ‹low›	0 V	5 V
Current	None	500 mA
Capacitive load	None	10 nF
Test pulse length	200 µs	800 µs
Test pulse interval per channel	1 s	60 s

5.6.2. Connection to an insulated Safe Input



DANGER	If the safe output is connected to an insulated input, the negative terminal of the safe input must be wired back to the GIN-SAC4xX FS's GND.

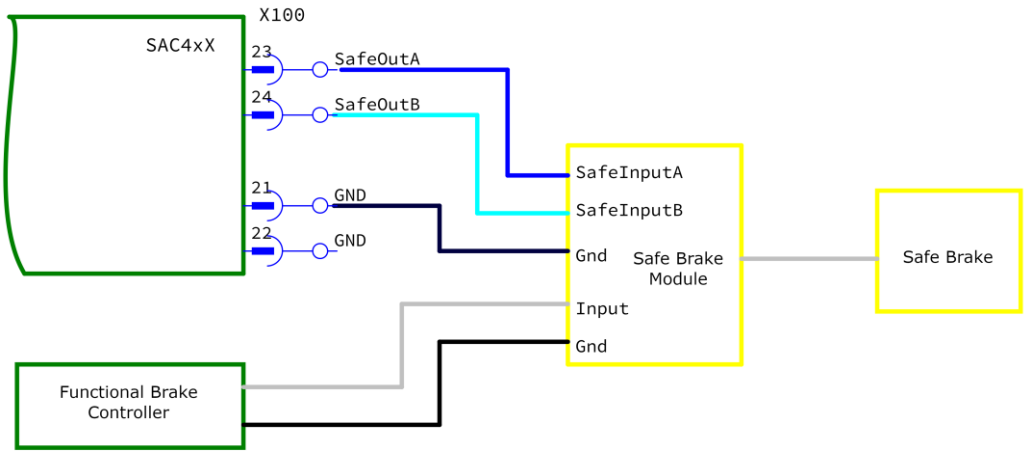
5.6.3. Connection to an Uninsulated Safe Input



DANGER	If the safe output is connected to an uninsulated input, the groundwires of the GIN-SAC4xX FS and the input module must be additionally connected with each other because otherwise in case of Wire breakage at the GIN-SAC4xX FS's earth (single error) current flows through the safe output in disabled state.

5.6.4. Connection to a Safe Brake Control Unit

If the safe output is used as a brake control unit, a brake control module should be installed between the output and the brake. In addition to the safe brake control unit, the functional control unit's brake clearance must usually be connected to the brake module.



DANGER	If the safe brake module is provided with insulated inputs, the ground wires of both channels should be connected to the GIN-SAC4xX.

5.6.5. Error Recognition by the Safety Module

The GIN-SAC4xX FS's Safe-AxControl module monitors the safe two-channel output with test pulses. This enables to detect the following external errors.

Error	Recognition	Note
24V contact at the output	Yes	
Earth contact at the output if the output is enabled	Yes	
Earth contact at the output if the output is disabled	**No**	**If the closed current principle is observed this error poses no hazard**
Wire breakage	**No**	**If the closed current principle is observed this error poses no hazard**
Cross-fault between channels A and B if the output is enabled	Yes	
Cross-circuit between output A and B if the output is disabled	**No**	**If the closed current principle is observed this error poses no hazard**
24V contact at the earth	**No**	**To exclude a hazard, the output's ground wire must be connected to that of the actuated input**

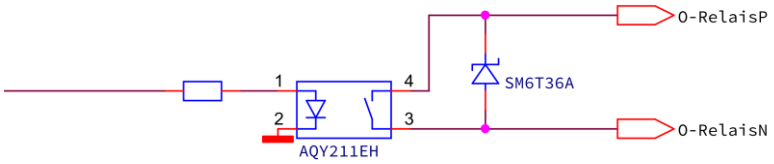
5.6.6. Parameters

Parameter	Unit	Default Value	Description
Group ‹Output Configuration› on Safe-AxControl			
Output	Inactive / Active	Inactive	Defines if the safe output is inactive or active. Note: If <ring wiring> is active, this parameter is disabled because the output is used for the ring circuit.

5.7. Non-Safe One-Channel Insulated Output

In addition to the safe two-channel output, the GIN-SAC4xX is provided with a non-safe one-channel insulated output provided as a contact switch.
It can be used as a feedback channel at a higher-level control unit. Similar to the safe output, the non-safe output reflects the state of the photocoupler power supply.

The output contact is <open> or <high resistant> when the safe pulse inhibition is cleared for normal operation and the contact is <closed> or <low resistant> whenever the pulse inhibition is active in STO-State.

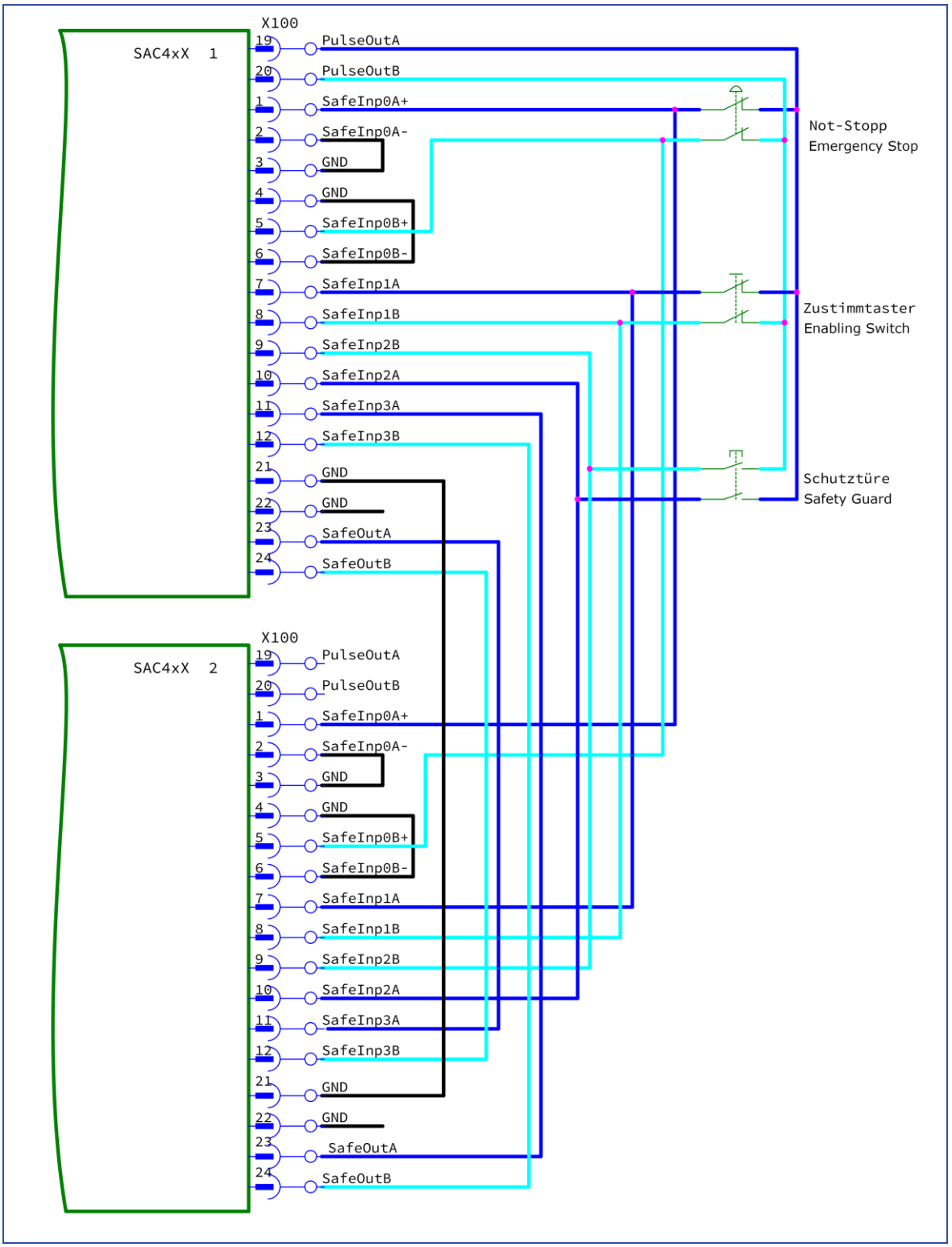


5.7.1. Parameters

Parameter	Typically	Maximum
Voltage		30 V
Load current		500 mA
Resistance when the output is ‹closed›	0.25 Ω	0.5 Ω
Leakage current when the output is ‹open›		1 µA

5.8. Ring Wiring of Multiple GIN-SAC4xX FSs

It is possible to operate multiple GIN-SAC4xX FSs together by connecting them into a ring. The safe output is then wired to safe input 3 of the next GIN-SAC4xX FS. The last GIN-SAC4xX FS is subsequently connected back to the first one. With the ring wiring in place, all drives are brought into ‹STO› state whenever any of the GIN-SAC4xX FS's safety subfunctions is violated.



The safety components installed must be connected to all GIN-SAC4xX FSs. For cross-fault recognition, however, only one drive per channel supplies test pulses.

In the safe configuration the ‹ring wiring› option must be enabled on all GIN-SAC4xX FSs.

 DANGER	A safe response time of 3 275µs must be added per each connected GIN-SAC4xX FS. The total safe response time must not exceed the required safe process safety time (PST).

 DANGER	When assessing the safety of GIN-SAC4xX FSs in a ring wiring, all mesh-connected GIN-SAC4xX FS should be regarded as if they were serially connected functional blocks.

 DANGER	The ring wiring is subject to all the safety regulations regarding input and output wiring which are defined in this document.

	If the ring wiring option is enabled, the test pulses of the first GIN-SAC4xX in the fieldbus should be used, where possible, for all STO inputs that require test pulses. Thus test signals can be available already when other GIN-SAC4xXs switch into operating state.

5.8.1. Parameter

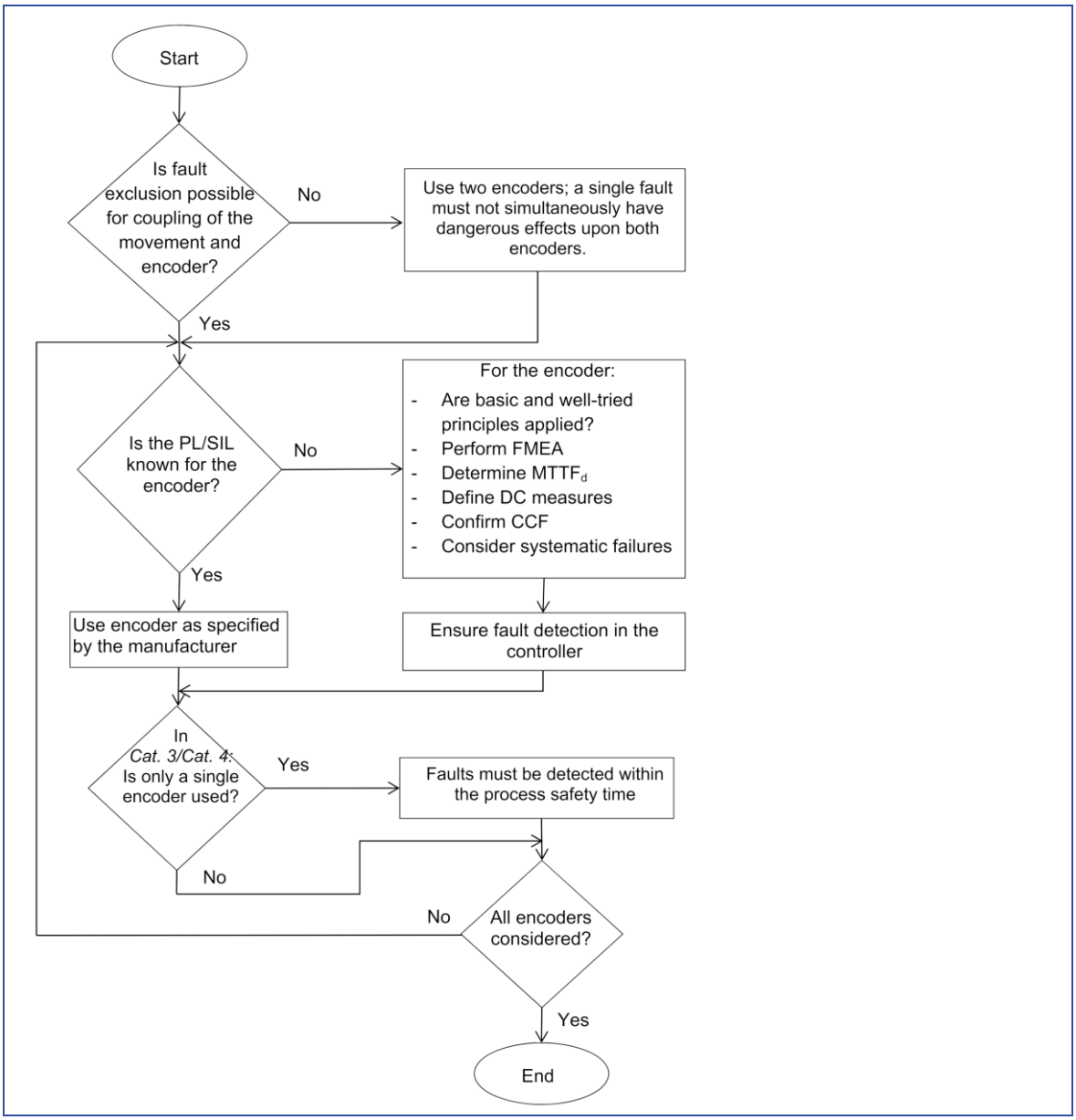
Parameter	Unit	Default Value	Description
Group ‹General configuration› on Safe-AxControl			
Ring wiring	Disabled / Enabled	Disabled	Defines if the ring wiring is active.

5.9. Safe Encoder Evaluation and Monitoring

The GIN-SAC4xX FS drive is provided with one permanently built-in Safe-AxMonitor module per axis, which allows safe assessment and monitoring of each resolver or sin/cos encoder.

5.9.1. Integration into the Safety Chain

To integrate an encoder into the safety chain, please refer to the relevant diagram shown in the IFA Guide https://www.dguv.de/medien/ifa/en/pub/rep/pdf/reports2013/ifar0713e/safe_drive_controls.pdf.
The predefined procedure must be performed for each application once again.



DANGER	Before connecting an encoder for safe monitoring, the user must perform a risk assessment. The correct selection, installation and maintenance of the encoder are the user's responsibility. Both the requirements of this manual and those of the encoder manufacturer should be observed.

DANGER	The following information and tests are necessary for standard encoders: • Have basic and established principles been used? • (Kat.) FMEA of the safety structure should be performed • Failure rate of the components ($MTTF_d$ or FIT) • Diagnostic coverage (DC) • Avoidance of common cause failures (CCFs) • Allow for systematic failures • Is error exclusion available for the coupling between the driven axis and the encoder?

5.9.2. GIN-SAC4xX FS's Error Recognition If Resolvers Are Connected

If a resolver is used for safe axis monitoring, the axis's Safe-AxMonitor module monitors the signal for the following criteria:

- The signal strength ($\sin^2 + \cos^2$) is within the predefined tolerance.
- The signal value within the maximum of the modulation signal is inversely proportional to that within the minimum of the modulation signal.

The table below lists external errors that can be detected in the recognition mode.

Error	Effect
Wire breakage in the rotor winding (transmitting part).	No magnetic field, therefore no electric current. No signal is received by the sine and the cosine windings of the stator.
Short-circuit in the rotor winding (transmitting part).	No magnetic field, therefore no electric current. No signal is received by the sine and the cosine windings of the stator.
Partial short-circuit in the rotor winding (transmitting part).	Change in voltage, therefore change in the amplitude of the sine and the cosine signals.
Wire breakage in the transformer part of the rotor.	No signal is received by the sine and the cosine windings of the stator.
Short-circuit in the transformer part of the rotor.	No signal is received by the sine and the cosine windings of the stator.
Partial short-circuit in the transformer part of the rotor.	Change in voltage, therefore change in the amplitude the sine and the cosine signals.
Wire breakage between the rotor and the transformer windings.	No magnetic field, therefore the signal cannot be transmitted back to the stator.
Wire breakage in the exciter winding (transformer part).	No electric current, therefore no magnetic field. No signal is received by the sine and the cosine windings.
Short-circuit in the exciter winding (transformer part).	No electric current, therefore no magnetic field. No signal is received by the sine and the cosine windings.
Partial short-circuit in the exciter winding (transformer part).	Change in voltage, therefore change in the amplitude of the sine and the cosine signals.

Error	Effect
Wire breakage in the sine winding.	Sine signal set to 0.
Short-circuit in the sine winding.	Sine signal set to 0.
Partial short-circuit in the sine winding.	Lower signal amplitude.
Wire breakage in the cosine winding.	Cosine signal set to 0.
Short-circuit in the cosine wind-ing.	Cosine signal set to 0.
Partial short-circuit in the cosine wind-ing.	Lower signal amplitude.
Single short-circuit between the exciter winding at the stator and the sine wind-ing.	No or only weak signal in the cosine winding.
Single short-circuit between the exciter winding at the stator and the cosine winding.	No or only weak signal in the sine winding.
Short-circuit between the exciter wind-ing at the stator and the sine winding (two short-circuits, bridging, multiple er-ror).	No signal in the cosine winding.
Short-circuit between the exciter wind-ing at the stator and the cosine winding (two short-circuits, bridging, multiple er-ror).	No signal in the sine winding.
Stator rotation.	Now the mechanical error is recognised only indirectly. As the signal lines are interrupted, no valid signal is ap-plied.
Short-circuits between the stator lines and the motor housing.	Depending on how the input circuit of the analogue evaluation is structured, the error does not matter (as no potential shift occurs). Short-circuits occur as long as the input circuit requires permanent potential assign-ment.
Cross-circuit of the exciter signal to an external signal.	No signals at the sine and the cosine windings.
Cross-fault of the sine signal to an exter-nal signal.	Sinusoidal signal set to a static value.
Cross-fault of the cosine signal to an ex-ternal signal.	Cosine signal set to a static value.

In case of restart the standby state of the axis monitoring first switches to ‹ready› if a ‘not equal to 0 volt’ signal has been measured on both channels. Upon restart all axes must have been at least once outside a zero passage before a safety subfunction can be required. An initial direct activation of the axes in SLS or SOS state is impossible during the zero passages of the sine and the cosine signals.

Only the exciter signals provided by the GIN-SAC4xX may be used for resolver exciting.

5.9.3. Requirements for the Use of Resolvers

The table below lists undetectable resolver errors. The measures specified in the Requirement column should be performed by the user or encoder manufacturer.

Error	Effect	Requirements
Slippage of the load axis	No or false position/Movement recorded	The resolver should be firmly fixed to the drive shaft. In variable transmissions or belt drives the resolver must be attached to the load axis as there is usually no fixed linkage between the drive and the load functions.
Slippage of the rotor on the shaft	No or false position / Movement recorded	The resolver must be connected to the drive shaft by a form or force fit. The fit should be so arranged that it is overdesigned at least by the factor defined in DIN EN 61800-5-2.
Short-circuit at a phase shifter's output	No error detected. No or false position / Movement recorded	It is not allowed to use phase shifters in the safety chain.
Stator rotation	No or false position / Movement recorded	The stator should be connected with a short cable so that a rotation can be immediately recognised by the cable being torn off.
Sine and cosine signals reversed	Direction of rotation wrongly recognised	Before start-up it should be checked that the signal wiring is correct.

5.9.4. Parameters of the Safe Evaluation of Resolvers

All errors are recognised within the process safety time provided that all requirements have been met.

Safety integration level (SIL) as defined in IEC 61508: 3
Diagnostic coverage (DC): High (99%)
Category as defined in EN ISO 13849-1: 3

The performance level (PL) achieved is dependant on the mean time to failure ($MTTF_d$) of each encoder channel and should be provided by the manufacturer for integration purposes.

MTTFd per Channel	Performance Level Achieved
3 years ≤ MTTFd ‹ 6 years	PL b
6 years ≤ MTTFd ‹ 14 years	PL c
14 years ≤ MTTFd ‹ 62 years	PL d
62 years ≤ MTTFd ‹ 100 years	PL e

Specific data to calculate the performance level can be found in Annex K to the EN ISO 13849-1 standard.

5.9.5. GIN-SAC4xX FS's Error Recognition If Sin/cos Encoders Are Connected

If a sin/cos encoder is used for safe axis monitoring, the axis's Safe-AxMonitor module monitors the signal for the following criteria:

- The signal strength ($\sin^2 + \cos^2$) is within the predefined tolerance.
- The maximum velocity jump between two scans is 500Hz (only if the safety subfunction is active).
- The maximum standstill is 24 hours (only if the safety subfunction is active).

The table below lists external errors that can be detected by monitoring the signal strength.

Error	Effect
Failure of the light source's power supply.	The optical ASICs or photodiodes receive no more signals, and no sine and cosine signals can be generated.
Light source completely or partially defective (change in amplitude also due to change in intensity).	The optical ASICs or photodiodes receive no more signals or the signals are too weak, and no valid sine and cosine signals can be generated.
Failure of the receiver's power supply.	No valid sine and cosine signals are generated.
Signal error. Either the sine or the cosine signal is erroneous.	The sine or cosine signal is missing or there is a static signal.
Failure of the signal line from the receiver to the decoder due to wire breakage.	The sine or cosine signal is missing.
Failure of the signal line from the receiver to the decoder due to line short-circuit.	At least one signal is missing or there is a static signal.
Due to external temperature increases or imbalance that can affect the radial air gap. between the sender and the receiver.	Sine/cosine signal compromised or completely absent.
Failure of the power supply.	The encoder has no power supply and delivers no valid sine/cosine signals
Sine/cosine signal at the amplifier output short-circuited.	An undefined signal transmitted to the evaluation unit. Signal sequence evaluation disturbed or impossible.
Interruption of one of the signals inside the signal preconditioning unit	Only one signal transmitted to the evaluation unit. Signal sequence evaluation disturbed or impossible.
Complementary signal pair's output signal (sin+ / sin-) or (cos+ / cos-) missing or too weak.	Evaluation unit's sine or cosine signal amplitude not equal. Signal sequence evaluation disturbed or impossible.
Decrease or increase in signal amplification.	Sine or cosine signal amplitude too high / too low. Signal sequence evaluation disturbed or impossible.
Spurious oscillations at one or multiple outputs.	Sine and/or cosine signal form changed in an undefined way.

Error	Effect
Change in phase shift between output signals.	Sine and/or cosine signal form shifted due to the evaluation unit's error. Angle-dependant signal sequence evaluation impossible.
Static signal at inputs and outputs, single or multiple signals, amplitude in the range of power supply.	Both or one signal missing.
Static signal at inputs and outputs, multiple signals. Amplitude in the range of power supply for velocities exceeding 500Hz.	Both signals missing.
Static signal at inputs and outputs, single signals. Amplitude in the range of power supply.	One signal missing.
Change in signal form.	Signal distorted, invalid values
Code disc error: Damage to the material measure or mask.	If the measuring stick is broken, no modulation of projected light is performed or it is performed incorrectly. No sine or cosine signal is generated.
Code disc error: Contamination of the materi-al measure or mask.	If the measuring stick is soiled, no modulation of projected light is per-formed or it is performed incorrectly. No sine or cosine signal is generated.
The material measure dissolves when being moved and provides an invalid signal.	Wrong position information is transmitted to the evaluation unit.
Static signal at inputs and outputs, single signals, amplitude in the range of power supply during encoder standstill.	Wrong position information is transmitted to the evaluation unit.
Short-circuit between any two connection line wires.	Erroneous readings are supplied.
Any of the connection line wires interrupted.	Erroneous readings are supplied.
Static signals 0 or 1 at inputs and outputs, single signals or at the same time at multiple inputs/outputs.	Erroneous readings are supplied.
Interruption or high-impedance state at a single or multiple inputs/outputs.	Erroneous readings are supplied.
Increase or decrease in output amplitude	Erroneous readings are supplied.

The listed errors refer to sin/cos encoders with optoelectronic positioning. If an encoder based on other physical principles (magnetism) is used, a separate error analysis is necessary. For this purpose, Indel should in any case be contacted.

The maximum velocity jump corresponds to an acceleration von 2.5 MHz/s^2.

The velocity jump monitoring can be triggered despite strong impacts and vibrations on the axis, even if the encoder shows no defect

5.9.6. Requirements for the Use of Rotary Sin/cos Encoders

The table below lists undetectable errors of rotary sin/cos encoders. The measures specified in the Requirement column should be performed by the user or encoder manufacturer.

Error	Effect	Requirement
The material measure dissolves when being moved and provides signals that are not proportional to the encoder rotation.	No or false Position / Movement recorded	Error exclusion against the loosening of the material measure. The fastening of the material measure must allow for the overstress stipulated in DIN EN 61800-5-2.
The material measure dissolves during encoder standstill.	No or false Position / Movement recorded	Error exclusion against the loosening of the material measure. The fastening of the material measure must allow for the overstress stipulated in DIN EN 61800-5-2.
Static signal at inputs and outputs, individual or multiple signals, amplitude in the range of power supply during encoder standstill.	Wrong position information transmitted to the evaluation unit. The error can-not be detected during standstill.	A movement of at least one period is required within 24 hours before or when a safety sub-function is requested. The movement must be ensured by the application or user. (Monitored by the safety module)
Loosening of the (rotor) shaft connection	Due to an erroneous encoder signal, no rotational movement can be recorded.	The sin/cos encoder (rotor) should be firmly fixed to the drive shaft. In variable transmissions or belt drives the sin/cos encoder auf die load axis must be attached to the load axis as there is usually no fixed linkage between the drive and the load functions. Error exclusion against the loosening of the shaft connection. The shaft connection must allow for the overstress stipulated in DIN EN 61800-5-2.
Loosening of the stator	Due to an erroneous encoder signal, no rotational movement can be recorded.	Error exclusion against the loosening of the stator. The stator must allow for the over-stress stipulated in DIN EN 61800-5-2. If screws are used for fastening, the stator must be fitted to the housing with more than one screw.
Short-circuit at a phase shifter's output	No error detected. No or false Position / Movement recorded	It is not allowed to use phase shifters in the safety chain.
Sine and cosine signals reversed	Direction of rotation wrongly recognised	Before start-up it should be checked that the signal wiring is correct.

	The encoder detects errors by checking amplitudes and quadratures. It is not allowed to use encoders with signals that are synthetically generated or derived from each other. The sine and the cosine signals must be generated independently from each other. If this feature is not documented, the encoder manufacturer has to be contacted.

	The Safe-AxMonitor module monitors the standstill duration before or when a safety subfunction is requested, and after a lapse of 24 hours indicates that the safety subfunction has been violated. Thus a safe pulse inhibition (STO) is triggered.

	Upon restart the standstill duration is assumed to be 24 hours. It is why each monitored axis with a sin/cos encoder must be moved by at least an encoder period before a safety subfunction is requested for the first time. An initial direct activation of the axes in SLS or SOS state is impossible.

5.9.7. Requirements for the Use of Linear Sin/cos Encoders

The table below lists die undetectable errors of linear sin/cos encoders. The measures specified in the Requirement column should be performed by the user or encoder manufacturer.

Error	Effect	Requirement
The material measure dissolves when being moved and provides signals that are not proportional to the encoder rotation.	No or false position / Movement recorded	Error exclusion against the loosening of the material measure. The fastening of the material measure must allow for the overstress stipulated in DIN EN 61800-5-2.
The material measure dissolves during encoder standstill.	No or false position / Movement recorded	Error exclusion against the loosening of the material measure. The fastening of the material measure must allow for the overstress stipulated in DIN EN 61800-5-2.
Static signal at inputs and outputs, individual or multiple signals, amplitude in the range of power supply during encoder standstill	Wrong position information transmitted to the evaluation unit. The error cannot be detected during standstill.	A movement of at least one period is required within 24 hours before or when a safety subfunction is requested. The movement must be ensured by the application or user. (Monitored by the safety module)
Loosening of the material measure fastening	Due to an erroneous encoder signal, no more movement can be recorded.	Error exclusion against the loosening of the material measure. The fastening of the material measure must allow for the overstress stipulated in DIN EN 61800-5-2. If screws are used for fastening, the material measure must be fitted with more than one screw.

Error	Effect	Requirement
Loosening of the scanning carriage	Due to an erroneous encoder signal, no more movement can be recorded.	Error exclusion against the loosening of the material measure. The fastening of the material measure must allow for the overstress stipulated in DIN EN 61800-5-2. If screws are used for fastening, the scanning carriage must be fitted with more than one screw.
Static offset of the material measure	No or false position is recorded	Error exclusion against the loosening of the material measure. The fastening of the material measure must allow for the overstress stipulated in DIN EN 61800-5-2. If screws are used for fastening, the material measure must be fitted with more than one screw.
Short-circuit at the output of a phase shifter	No error detected. No or false movement recorded	It is not allowed to use phase shifters in the safety chain.
Sine and cosine signals reversed	Direction wrongly recognised	Before start-up it should be checked that the signal wiring is correct.

	The encoder detects errors by checking amplitudes and quadratures. It is not allowed to use encoders with signals that are synthetically generated or derived from each other. The sine and the cosine signals must be generated independently from each other. If this feature is not documented, the encoder manufacturer has to be contacted.

	The Safe-AxMonitor module monitors the standstill duration before or when a safety subfunction is requested, and after a lapse of 24 hours indicates that the safety subfunction has been violated. Thus a safe pulse lock (STO) is triggered

5.9.8. Parameters of the Safe Evaluation of Sin/cos Encoders

If the tolerance of the safe position exceeds ± ½ of the period, the diagnostic coverage is conservatively DC=99% provided that all the requirements specified in this document have been met and a signal strength tolerance of not more than 40% is set (standard value).

Signal tolerance:	≤ 40%
Diagnostic coverage (DC):	High (99%)
Category as defined in EN ISO 13849-1:	3

The performance level (PL) achieved is dependent on the mean time to failure ($MTTF_d$) of each encoder channel and should be provided by the manufacturer for integration purposes.

$MTTF_d$ per channel	Performance Level Achieved
3 years ≤ MTTFd ‹ 6 years	PL b
6 years ≤ MTTFd ‹ 14 years	PL c
14 years ≤ MTTFd	PL d

If a signal tolerance is set within a range from 40% to 50%, only a medium DC and consequently category 2 can be achieved.

Signal tolerance: 40% - 50%
Diagnostic coverage (DC): Medium (90%)
Category as defined in EN ISO 13849-1: 2

$MTTF_d$ per channel	Performance Level Achieved
3 years ≤ MTTFd ‹ 6 years	PL a
6 years ≤ MTTFd ‹ 13 years	PL b
13 years ≤ MTTFd ‹ 37 years	PL c
37 years ≤ MTTFd	PL d

	The safety parameters achieved are dependent on the encoder used and the configurated signal tolerance.

	When the SOS function is enabled, moving the axis by a half period poses no risk.

	When the SLS function is enabled, moving the axis by a half period with a too high velocity poses no risk.

Specific data to calculate the performance levels can be found in Annex K to the EN ISO 13849-1 standard.

5.9.9. Calculation of the Signal Strength Limit

Signal strength limits are calculated based on the specified tolerance of squared signal strengths. Thus the following limits apply and are monitored.

$$Minimum\ signal\ strength := \sqrt{preset\_signal\_strength^2 \times \left(1 - \frac{tolerance}{100}\right)}$$

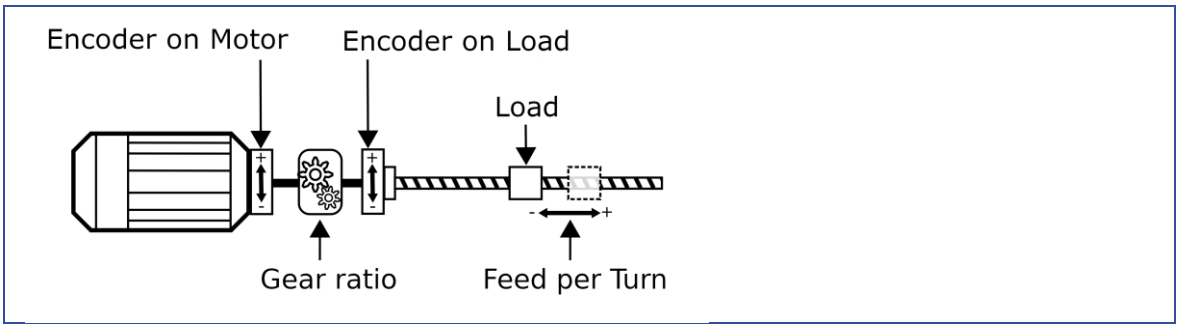
$$Maximum\ signal\ strength := \sqrt{preset\_signal\_strength^2 \times \left(1 + \frac{tolerance}{100}\right)}$$

The table below shows limits for typical tolerances of 40% and 49% for various levels in 100mV steps.

Predefined signal strength [mV]	Tolerance of 40%		Tolerance of 49%	
	Minimum	Maximum	Minimum	Maximum
500	387	592	357	610
600	465	710	428	732
700	542	828	500	854
800	620	947	571	977
900	697	1065	643	1099
1000	775	1183	714	1221
1100	852	1302	786	1343
1200	930	1420	857	1465

5.9.10. Scaling of the Measuring System

The scaling of the measuring system defined the relationship between movement information provided by the encoder and the physical movement of the monitored axes. In addition, the setup of the Safe-AxMonitor modules offers a series of parameters to define this relationship. The diagram below shows it schematically.



If a gearbox or any other form of transmission is used, it should be checked whether the encoder is situated on the load or motor. If the encoder is fitted to the motor, the transmission has to be set up.
For linear movements, the distance by which the load is moved at one spindle turn should be defined as <feed per turn>. For rotary movements, either 360° or one turn should always be set as <feed per turn>.

The encoder resolution is specified in (sine) <periods per turn>. If a linear encoder is used, the number of periods within an axial <feed per turn> must be specified as «Periods per turn».

$$\boldsymbol{Periods\ per\ turn} := \boldsymbol{periods\ per\ unit\ x\ feed\ per\ turn}[\boldsymbol{unit}]$$

If a linear motor is used, the <feed per turn> corresponds to the length of a complete field turn of the motor.

DANGER	The correct parametrisation of the measuring system's scaling should be validated during start-up by running against and verifying a number of positions.

DANGER	In variable transmissions or belt drives the encoder must be attached to the load axis as there is usually no fixed linkage between the drive and the load functions. In fixed transmissions the transmission is subject to a safety evaluation.

	Setting up negative gradients or translations is not allowed. If the direction of movement is inversely proportional to that of signal recording, the Direction parameter must be changed to Reversed.

5.9.11. Parameters

Parameter	Unit	Default value	Description
Group ‹Axis configuration› on Safe-AxControl			
Axis 0	Mute / Monitored	Monitored	Defines if axis 0 is monitored. If an axis is muted, it is not affected by the SLS and the SOS functions. Note: Absent axes must be explicitly set to «Mute».
Axis 1	Mute / Monitored	Monitored	Defines if axis 1 is monitored. If an axis is muted, it is not affected by the SLS and the SOS functions. Note: Absent axes must be explicitly set to «Mute».
Axis 2	Mute / Monitored	Monitored	Defines if axis 2 is monitored. If an axis is muted, it is not affected by the SLS and the SOS functions. Note: Absent axes must be explicitly set to «Mute».
Axis 3	Mute / Monitored	Monitored	Defines if axis 3 is monitored. If an axis is muted, it is not affected by the SLS and the SOS functions. Note: Absent axes must be explicitly set to «Mute».
Group ‹Axis configuration› on Safe-AxMonitor			
Feedback type	Resolver / SinCos	SinCos	Type of the monitored encoder.
Feedback position	On motor / On load	On load	Defines if the encoder is situated on the motor axis or load. Note: Relevant only if a ‘not equal to 1’ gear ratio is present.
Direction	Direct / Inverted	Direct	Defines the sign of the calculated position and velocity in relation to the encoder direction.
Unit	Degree / Turns/ Meter / Millimetre	Degree	Defines the units in which the “Feed per Turn” and the safety subfunction limits are specified.
Periods per turn	#	1	Number of encoder periods per motor turn. For linear motors, the number of periods per field turn should be specified.
Feed per turn	Unit	1	Axial feed per motor turn Note: The unit corresponds to the value set in the Unit parameter.
Gear ratio	-	1	Translation ratio between the motor and the load axes. Note: If the encoder position is ‹On the load›, this parameter is disabled.

Parameter	Unit	Default value	Description
Group ‹Signal configuration› on Safe-AxMonitor			
Speed filter	ms	No filter	Defines the time span across which the speed is averaged by the speed filter.
Signal strength	mV (peak to peak)	1000	Maximum peak to peak sine and cosine signal levels. Note: If the type of encoder is set to Resolver, this parameter is disabled.
Signal tolerance	%	40	Maximum allowable signal strength tolerance calculated based on the total of the squares: sin^2+cos^2

5.10. Implemented Safety Subfunctions

The following safety subfunctions are implemented by the Safe-AxControl and the Safe-AxMonitor modules in accordance with EN ISO 13849-1 PL e and EN 61508/EN 62061 SIL 3.

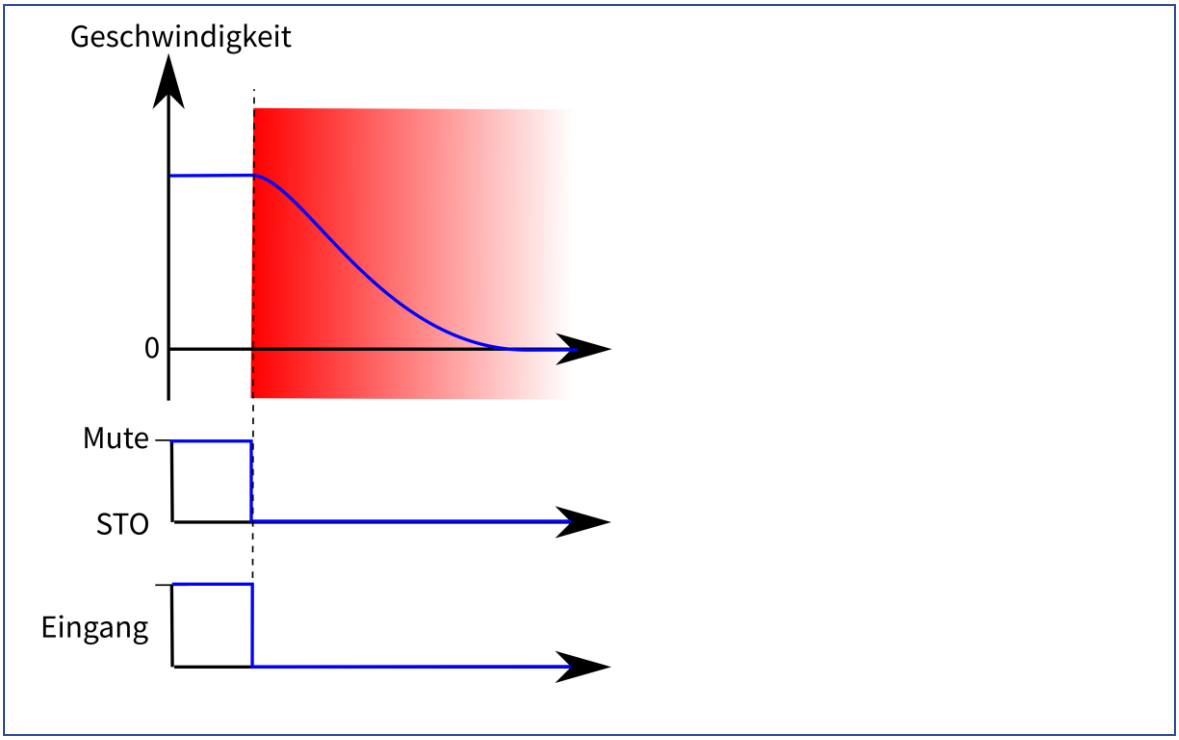
- STO: Safe Torque Off (STO)
- SOS: Safe Operation Stop (SOS)*
- SS1-t: Safe Stop 1 Type C (time-monitored)*
- SS2-t: Safe Stop 2 Type C (time-monitored)*
- SLS: Safely Limited Speed

A safe encoder evaluation is needed for the functions marked with an asterisk (*) to be supported.

The actually achieved safety integration and performance levels of the safety subfunctions are dependent on the peripheral used and its integration. In particular, this concerns the selection and installation of safety switches and position encoders.

5.10.1. STO: Safe Torque Off

With the STO safety subfunction, it is possible to bring the drive motor into de-energised state. Thus the motor is deprived of torque, and consequently of force. The power supply is interrupted using safe pulse inhibition. Since the drive cannot produce any more torque, no dangerous movement can occur either. Axes with hanging loads attached must be additionally secured. How the STO function is implemented is described in section 5.3.



The STO function with uncontrolled shutdown is configured by specifying a zero STO delay time (0) in the Safe-AxControl module. The STO function is triggered when safe input 0 (STO) falls to low or falls below the safety level set in the Minimum Active Stage parameter.

DANGER	The activation of the STO function for a moving axis makes its lag as it is not actively braked by the motor. If this poses a safety risk, some additional precautions (e.g. mechanical brakes) have to be taken.

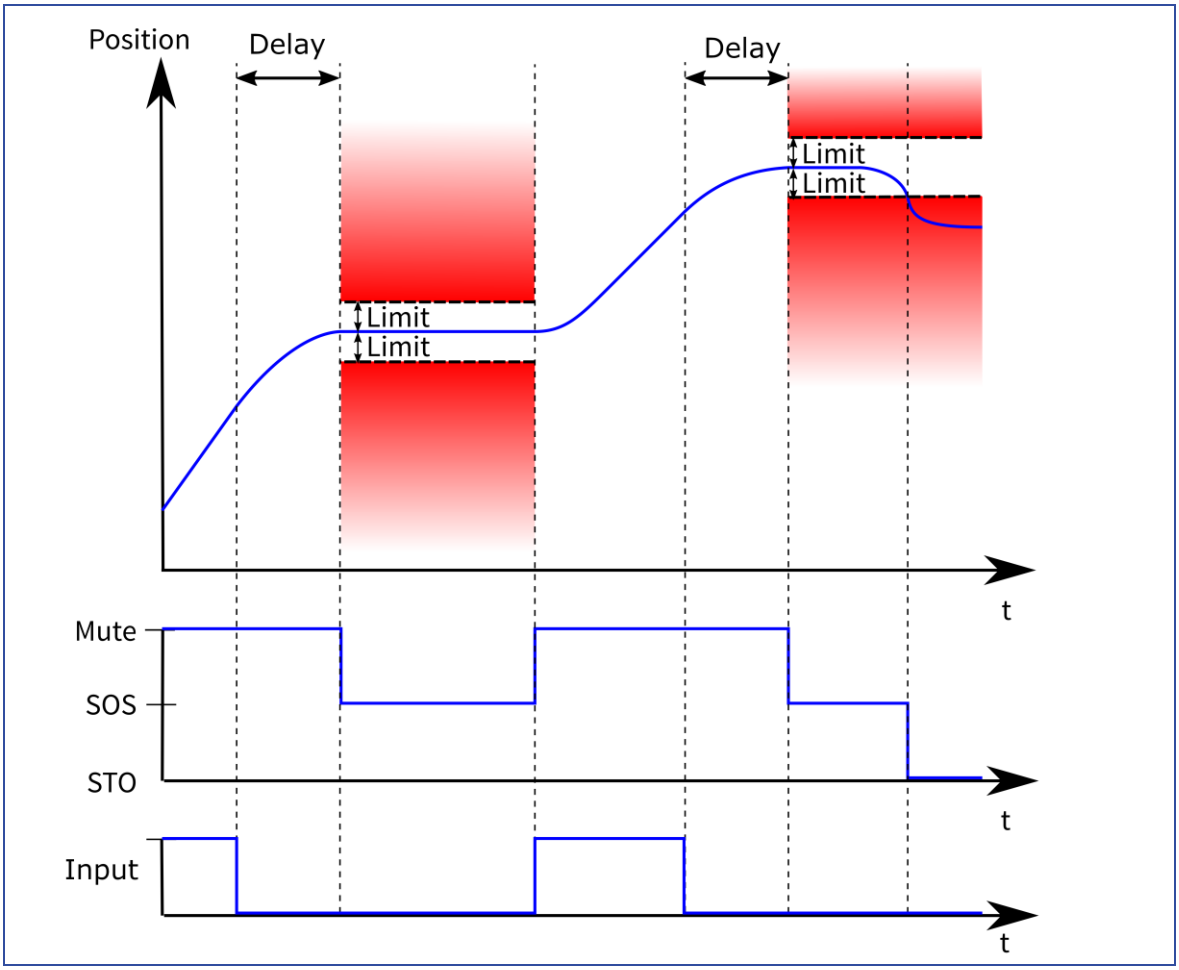
DANGER	In the STO function motors are free of torque, and any external force may result in a dangerous axis movement. If this poses a safety risk, some additional precautions (e.g. holding brakes) have to be taken.

	The STO function always affects all of a GIN-SAC4xX's axes.

	You can leave the STO function once the cause for triggering the function has been removed and subsequently acknowledged (protection against restart).

5.10.2. SOS: Safe Operating Stop

The SOS function monitors and prevents leaving the configurated tolerance range of the halting position. The motor can still be regulated in the function. Thus the motor can be held in position even despite exposure to external forces.



The SOS function is configured by setting one of the SOS safety subfunctions for the axis's required safety level in the Safe-AxMonitor module. The tolerance range is set by selecting an appropriate Limit parameter.

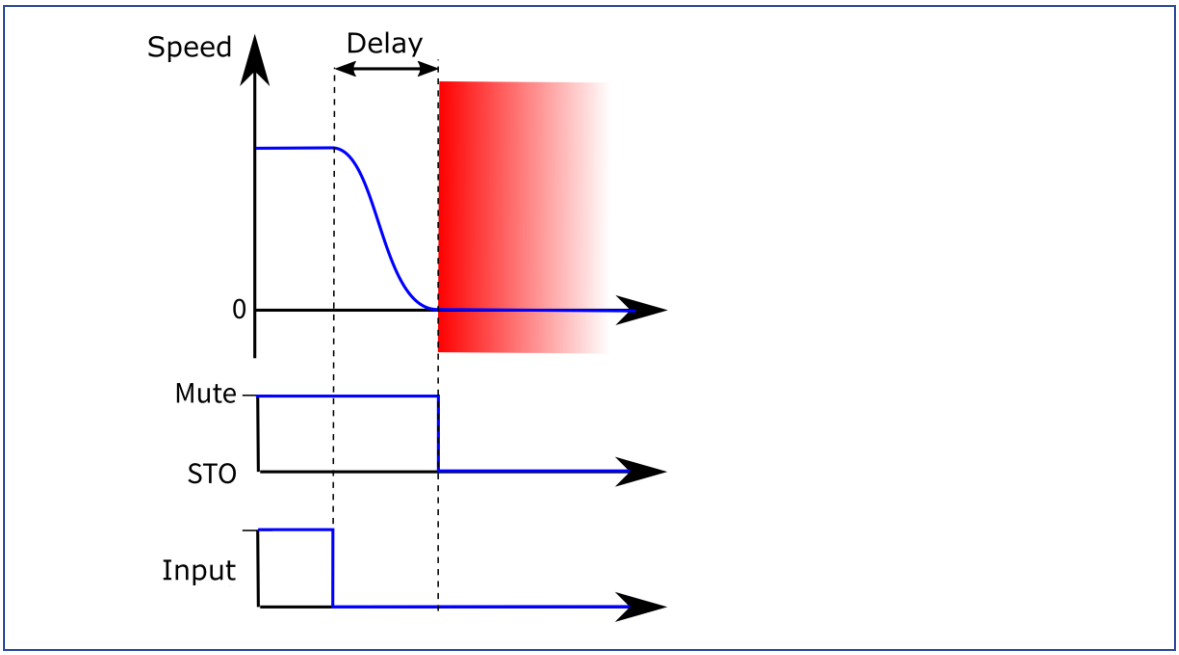
DANGER	If any of the GIN-SAC4xX's axes is found to have exceeded the tolerance range, all axes of the drive switch to STO state. The relevant safety regulations of the STO function should be observed for all axes (section 5.10.1 on page 67).

	A violation of the SOS function can be acknowledged only if the axis is put back into its original position or you have left the SOS function.

	If the safe SOS position has low limits, signal noise may lead to erroneous detection that the position has been exceeded. To prevent this, you should select such a resolution and translation ratio that the position limit is at least 5° on the encoder. The minimum practicable limit can vary depending on signal quality.

5.10.3. SS1-t: Safe Stop 1 Type C (Time-Delayed)

The SS1-t function features controlled axis shutdown with time-delayed triggering of the STO function.



The SS1-t function with controlled shutdown is configured by setting, in the Safe-AxControl module, a STO delay time of more than 0 (zero). The SS1-t function is triggered whenever safe input 0 (STO) is deenergised.

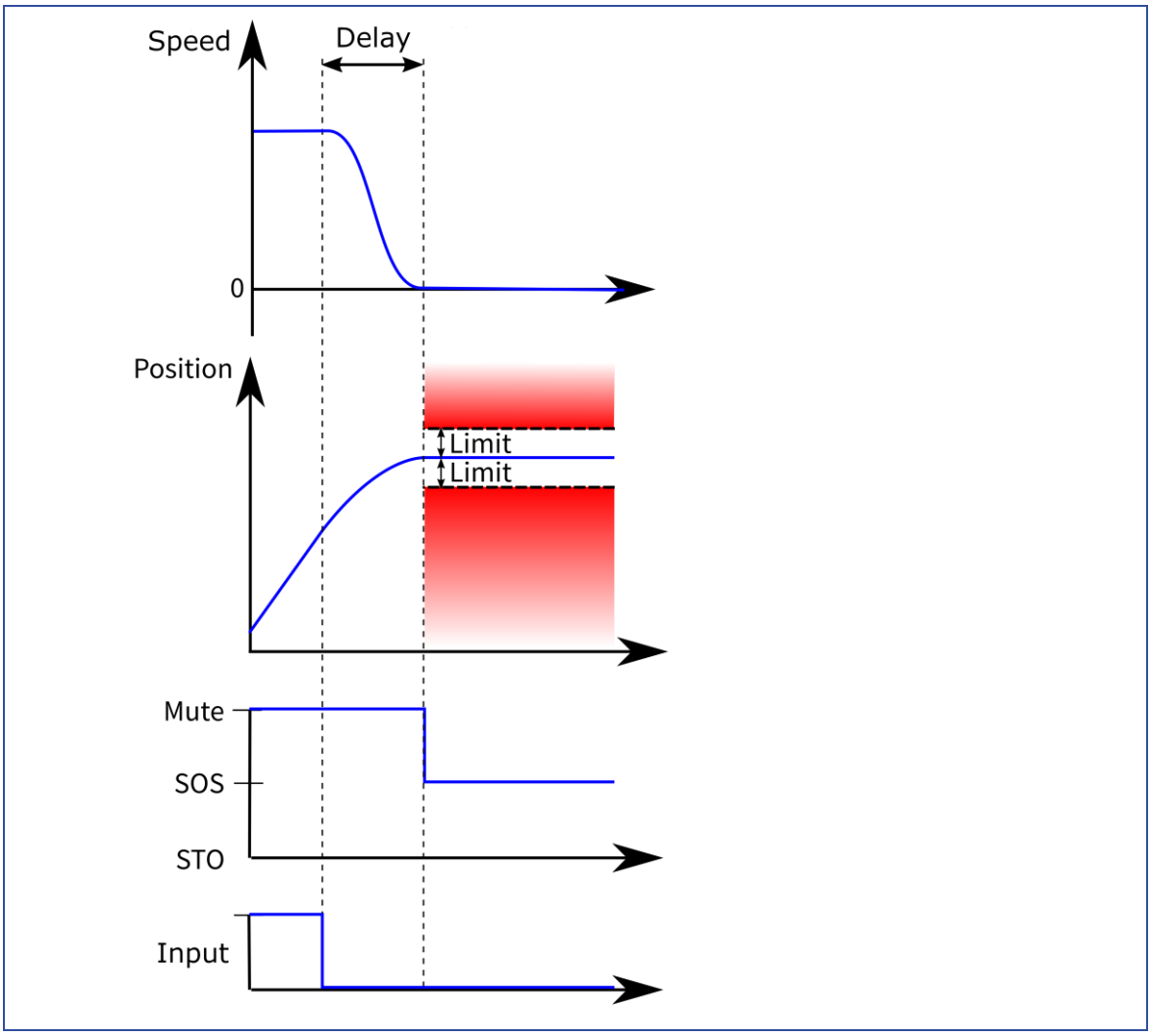
DANGER	To ensure its controlled shutdown, the delay time must correspond to an axis's maximum braking time. The delay time (t) can be estimated based on the brake acceleration (a) and maximum velocity (vmax). $t := v_{max} / a$

DANGER	If a short time is set, the GIN-SAC4xX may already switch to STO state before reaching a complete standstill. This would make the axis coast to stop.

DANGER	Upon expiry of the delay time all of the GIN-SAC4xX's axes switch to STO state. The relevant safety regulations of the STO function should be observed for all axes (5.10.1 on page 67).

5.10.4. SS2-t: Safe stop 2 Type C (Time-Delayed)

The SS2-t Type C function features controlled axis shutdown with time-delayed triggering of the STO function.



The SS2-t function with controlled shutdown is configured by setting, in the Safe-AxMonitor module, a SOS delay of more than 0 (zero). The SS2-t function is triggered whenever the preset safety level is achieved.

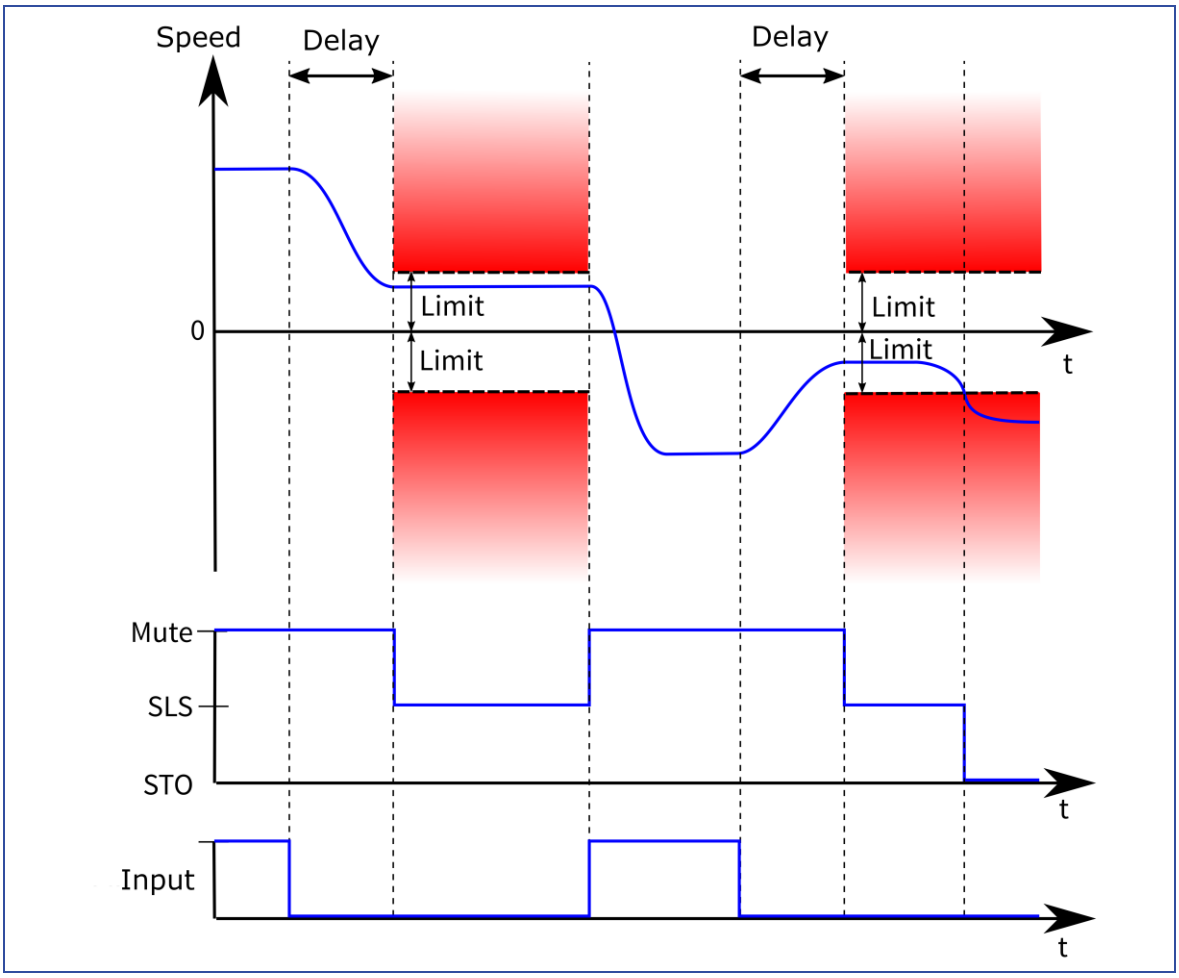
DANGER	To ensure its controlled shutdown, the delay time must correspond to an axis's maximum braking time. The delay time (t) can be estimated based on the brake acceleration (a) and maximum velocity (vmax). $t := v_{max} / a$

DANGER	If any of the GIN-SAC4xX's axes is found to have exceeded the tolerance range, all axes of the drive switch to STO state. The relevant safety regulations of the STO function should be observed for all axes (5.10.1 on page 67).

	The SS2-t function operates for each axis separately. It must be configured for each Safe-AxMonitor module separately.

5.10.5. SLS: Safely Limited Speed

The SLS function monitors and prevents the configured velocity limit from being exceeded. The motor can still be regulated in the function.



The SLS function is configured by setting one of the SLS safety subfunctions for the axis's required safety level in the Safe-AxMonitor module. The maximum velocity is set by selecting an appropriate Limit parameter.

DANGER	If any of the GIN-SAC4xX's axes is found to have exceeded the safe velocity, all axes of the drive switch to STO state. The relevant safety regulations of the STO function should be observed for all axes (5.10.1 on page 67).

	A violation of the SLS function can be acknowledged only if the axis velocity once again falls below the velocity limit or you have left the SLS function.

	If the safe slow velocities have low limits, signal noise may lead to erroneous detection of too high velocities. To prevent this, you should select such a resolution and translation ratio that the limit's input frequency is at least 1Hz. The minimum practicable limit can vary depending on signal quality

5.11. Safety Subfunction Parameters

The safety parameters are dependant on the safety modules that are needed for the implementation of a safety subfunction. Therefore, except for STO and SS1-t, the parameters for all functions depend on how many axes the drive has. The specified values always refer to a complete device.

5.11.1. STO and SS1-t Functions

The STO and the SS1-t functions are implemented directly on the Safe-AxControl. They require no safe axis evaluation, therefore all parameters are identical for all available GIN-SAC4xX models. All values are maximum ones, and whether or not they can be reached depends on the wiring.

Parameter	GIN-SAC4x1 FS, GIN-SAC4x2 FS, GIN-SAC4x3 FS, GIN-SAC4x4 FS
Safety category as defined in EN ISO 13849-1	Kat 3
Performance level as defined in EN ISO 13849-1	PL e
Safety integrity level as defined in EN 62061	SIL 3
PFHd (Probability of Dangerous Failure per Hour)	3.8×10^{-9} [1/h]
SFF (Safe Failure Fraction)	93.7 %
DC (Diagnosis Coverage)	92.4 %
MTTFd (Mean time to dangerous Failure)	164 [anno]
CCF (Common Cause Failure)	2 %

5.11.2. SS2-t, SOS and SLS Functions

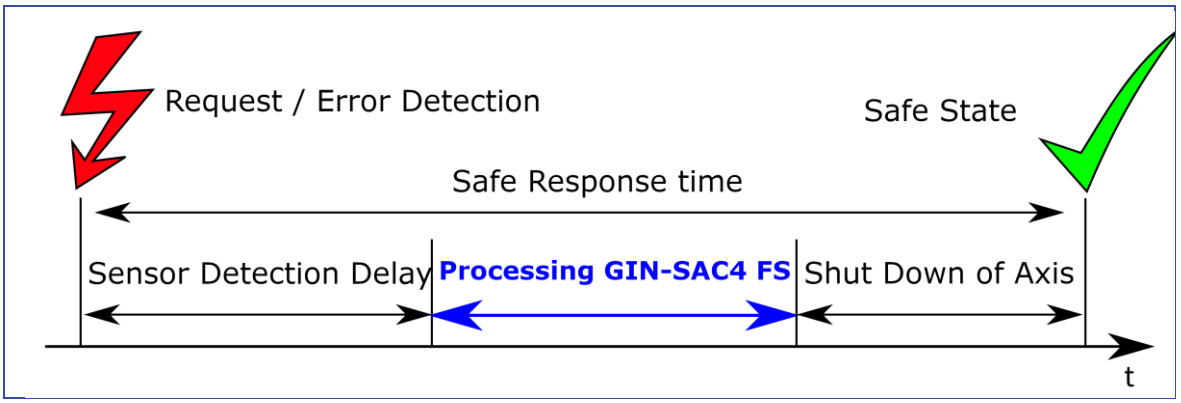
The SS2-t, the SOS and the SLS functions require safe axis evaluation, which is available on the Safe-Ax-Monitor module. Hence, some parameters vary for available GIN-SAC4xX models. All values are maximum ones, and whether or not they can be reached depends on the wiring. In particular, the instructions contained in section 5.5 should be observed

Parameter	GIN-SAC4x1 FS	GIN-SAC4x2 FS	GIN-SAC4x3 FS	GIN-SAC4x4 FS
Safety category as defined in EN ISO 13849	Kat 3	Kat 3	Kat 3	Kat 3
Performance level as defined in EN ISO 13849	PL e	PL e	PL e	PL e
Safety integrity level as defined in EN 62061	SIL 3	SIL 3	SIL 3	SIL 3
PFHd (Probability of dangerous Failure per Hour)	9.9×10^{-9} [1/h]	1.7×10^{-8} [1/h]	2.4×10^{-8} [1/h]	3.2×10^{-8} [1/h]
MTTFd (Mean time to dangerous Failure)	92 [anno]	64 [anno]	49 [anno]	40 [anno]
SFF (Safe Failure Fraction)	96.7 %	96.6 %	96.5 %	96.5 %
DC (Diagnosis Coverage)	92.4 %	92.4 %	92.4 %	92.4 %
CCF (Common Cause Failure)	2 %	2 %	2 %	2 %

DANGER	Encoder parameters should be taken into account when determining the actual parameters for a complete safety chain. To this end, the instructions contained in section 5.9 on page 53 should be observed.

5.12. Safe Response Time

The safe response time is deemed to be the time from when a safety subfunction is requested or an error is detected to when safe state is enabled.



The figure shows the total response time divided into delay times of the sensor, those of the GIN-SAC4xX FS's safety modules and those of axis shutdown.

DANGER	All the data provided below refers only to the response time of the GIN-SAC4xX FS (marked in blue and bold in the diagram). The delay caused by sensors and the time needed to shut down the axis must absolutely be taken into account when evaluating the safe response time.

5.12.1. Maximum Safe Response Time of the GIN-SAC4xX

Regardless of the active safety subfunction and its parameters, the maximum response time is lower than 10ms plus the configurated delay time of the function. The maximum response time can be precisely defined based on the function and its parameters, which can be found in the following sections.

DANGER	The total safe response time must not exceed the required safe process safety time (PST).

	The specified response times always refer to a dangerous situation because otherwise the safety system, except for the STO and the SS1-t functions, does not intervene.

	The following sections specify the maximum response times of individual safety subfunctions. They should be taken into account only if a response time of less than 10 ms is required for a specific safety subfunction.

5.12.2. Requirement of the STO Safety Subfunction

The maximum response time of the STO function is 3,275 µs.

5.12.3. Requirement of the SS1-t Safety Subfunction

The maximum response time of the SS1-t function is 3,275 µs plus the configurated delay time.

5.12.4. Requirement of the SS2-t Safety Subfunction

The maximum response time of the SS2-t function or the time of response to the SOS activation is 4,075 µs plus the configurated delay time.

5.12.5. Response When the SOS Safety Subfunction Is Active

When the SOS function is active, the maximum response time is 3,075 µs.

5.12.6. Requirement of the SLS Safety Subfunction

To define the time of response to the SLS function, the higher of the following two values must be used.

1. 4,275 µs plus the configurated delay time
2. 3,075 µs plus the configurated velocity filter time

5.12.7. Response When the SLS Safety Subfunction Is Active

When the SLS function is active, the maximum response time is 3,075 µs plus the configurated velocity filter time.

5.12.8. Response in Case of Encoder Failure (Movement)

If the axis moves, the maximum time of response to encoder failure is 3,075 µs after a lapse of half an encoder period.

	As some errors are identifiable only within certain ranges of encoder periods, a movement corresponding to the maximum of a half encoder period cannot result in any hazard.

	The safe response time required by the application must be longer than that to encoder failure.

5.12.9. Response at Ring Wiring

The maximum response time for ring wiring is 3,275 µs per drive in a ring.

5.13. Requirements for the Use of Safety Modules

The Safe-AxControl and the Safe-AxMonitor modules can only be used as part of a properly functioning Indel control system. It must meet at least the software requirements:

- «INOS» (Indel Realtime-OS) Revision 2.14.2.7471 or higher
- «GIN-SAC4xX» Motorsystem Revision 7.4.6.1040 or higher
- «Indel Safety Configurator» Revision 1.0.0.133 or higher
- «Indel Tools Setup» Revision 16.11 or higher
- «INCOServer V» (Indel Connectivity Server) Revision 1.0.0 or higher

No safety module can be configured if the system requirements are not fulfilled. Safety modules remain in setup state, which prevents their operation.

5.14. Module States

The table below shows all main states the safety modules can go into.

State	Number	Description	Safe State
Startup	0	Initialisation and initial test of the module	Yes
Configuring	1	Module configuration	Yes
Operating	2	Operating state	No
Error	3	Standard error state	Yes
Fatal	4	Fatal error state	Yes

Below you can find an explanation of individual states. In the Fail Safe column it is indicated in which states the module switches to a safe state.

5.14.1. Startup State

Once the operating voltage is reached or the module is reset, its hardware is initialised and tested. Excluded are components that are dependant on the setup.

5.14.1.1 Substates

None.

5.14.2. Configuring State

In Configuring state a complete setup of the module is performed, including setup verification. Setup dependant components are initialised.

5.14.2.1 Substates

Substates	Number	Description
Startup	0	The module reads the configuration history from the internal memory.
Waiting	1	The module is waiting until the configuration is loaded into the GIN-SAC4xX FS's memory.
Verifying	2	The module is waiting until the configuration is acknowledged by the user.
Updating	3	The new configuration is stored in the configuration history.
Configured	4	The module is configured.
Unconfigured	5	The module is marked as unconfigured.
Error	6	A configuration error has been detected.

The Verifying and the Updating states are activated only if the module loads a new configuration. A configuration is new when it is different from the last one that has been verified.

5.14.3. Operating State

The Operating state stands for the operation of the module. Safe outputs and the clearance of pulse inhibition can be activated only in this state. The process map of the inputs and outputs (including encoder evaluation) is calculated only in this state.

5.14.3.1 Substates

The substates of Operating state depend on the module.

Substates of the Safe-AxControl module

Substates	Number	Description
Connecting	0	The module starts communication with all configured Safe-Ax-Monitor modules. It is waiting until communication with all modules is established.
Waiting for Power	1	The module is waiting until safe outputs are supplied with operating voltage.
Ready	2	The module is waiting for clearance from the ring circuit.
Active	3	The pulse inhibition is cleared (disabled), axes can be enabled.
StoDelay	4	The STO function has been activated with time delay (SS1-t), the module is waiting until the delay time expires.
Sto	5	The module activated pulse inhibition after the STO function had been requested.
Error	6	An error has been detected.

Ready state can be achieved only after a ring circuit is configured.

Substates of the Safe-AxMonitor Module

Substates	Number	Description
Not-Ready	0	Safe encoder evaluation is not ready.
Ready	1	Safe encoder evaluation is ready.

5.14.4. Error State

If any error is detected in the wiring, configuration or hardware, the module switches to Error state. The module can leave this state only by means of a restart (reset).

In case of fatal errors a root cause analysis must be performed. If any safety-relevant component or device is found to be defective, the operation of the application must be immediately stopped and the whole device replaced.

Error states are read by the functional control system and can be indicated and acknowledged by means of the Indel cockpit.

5.14.4.1 Substates

None.

5.14.5. Fatal State

The module switches to fatal state whenever an error is detected which prevents further execution of the program. In particular, they include microcontroller downtimes or power supply outage.

In case of fatal errors a root cause analysis must be performed. If any safety-relevant component or device is found to be defective, the operation of the application must be immediately stopped and the whole device replaced.

Error states are read by the functional control system and can be indicated and acknowledged by means of the Indel cockpit.

5.14.5.1 Substates

None.

5.15. Fail Safe States

The safety modules are designed so that they spontaneously go into safe state once they become inactive. On the Safe-AxControl module this is implemented in such a way that all safety-relevant outputs are powered from a circuit that is deenergised when it is not excited. The Safe-AxMonitor module reaches the fail-safe state when it no longer answers queries from the Safe-AxControl module.

	If a drive's Safe-AxMonitor module configured as monitored switches to fail safe state, the drive's Safe-AxControl module also goes into Error fail safe state.

	Pulse inhibition is active in all fail safe states. No motor connected to this drive produces torque. The safe output is set to ‹low› (0 V).

5.16. Safety Levels

The GIN-SAC4xX FS's safety modules make it possible to define up to eight safety levels. For each safety level, one safety subfunction per axis or Safe-AxMonitor module can be configured.

	The requested safety level is calculated in the Safe-AxControl module and affects the whole drive. The current safety subfunction (except for STO) is determined in the Safe-AxMonitor module and operates for each axis separately

The Safe-AxControl module calculates the current safety level based on the state of inputs 1-3. You can choose from two procedures to determine safety levels. You can define them using the Safety Level Selection parameter in the Safe-AxControl module's configuration.

5.16.1. Priority Selection

If priority selection is enabled, the requested safety level always corresponds to the active input with the highest number. If the input signal at all safe inputs is ‹low›, the safety level is 0 (zero).
The table below shows the requested safety level depending on safe input signals.

Input 1	Input 2	Input 3	Safety Level
low	low	low	0
high	low	low	1
low	high	low	2
high	high	low	2
low	low	high	3
high	low	high	3
low	high	high	3
high	high	high	3

The priority definition of safety levels is particularly suitable for directly connecting cascaded protections. The table below provides a fictitious example of a wiring.

Input	Safety Protection Element
1	Enabling button
2	Light curtain
3	Safety cover contact switch

Protections must always be connected to the inputs according to their efficiency, namely so that the protection with the lowest efficiency is connected to input 1.

5.16.2. Binary Selection

If priority selection is configured, the requested safety level corresponds to the value of the inputs as a binary number consisting of the signals:

Safety level := Input[1] + Input[2] × 2 + Input[3] × 4
The table below shows the requested safety level depending on safe input signals:

Input 1	Input 2	Input 3	Safety Level
low	low	low	0
high	low	low	1
low	high	low	2
high	high	low	3
low	low	high	4
high	low	high	5
low	high	high	6
high	high	high	7

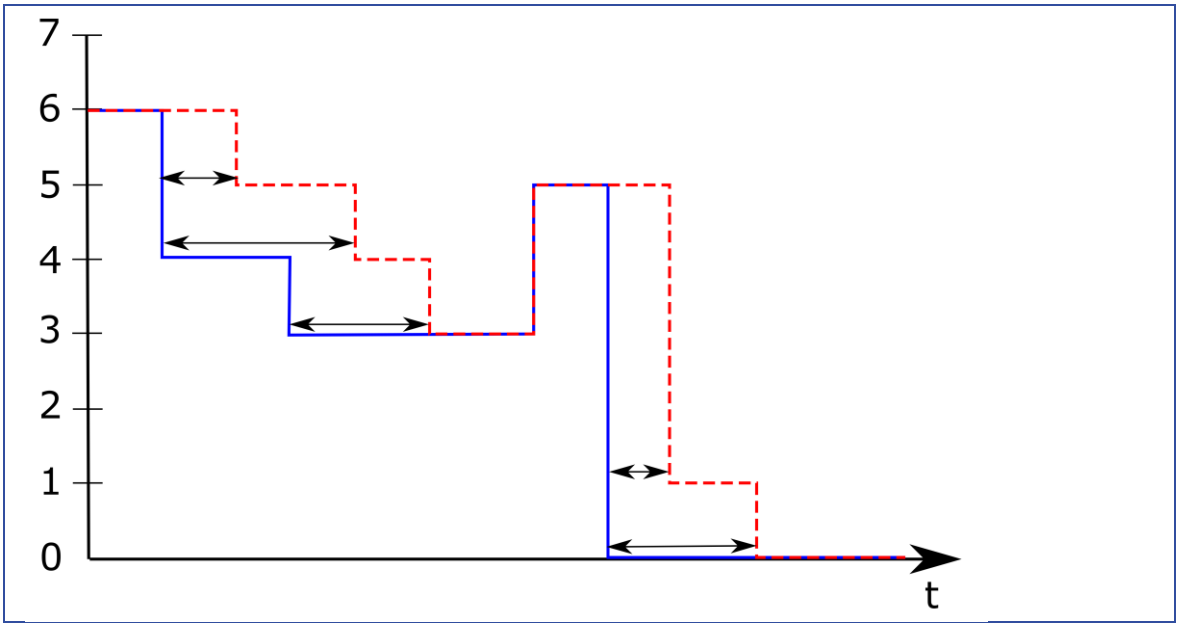
5.16.3. Parameters

Parameter	Unit	Default value	Description
Group ‹General configuration› on Safe-AxControl			
Safety level selection	Priority / Binary	Priority	Defines if the active safety level is calculated based on the priority or the binary value of the inputs.

5.17. Active Safety Subfunction

The active safety subfunction is defined by the current safety level and its configuration. A function can be configured for each axis and each level.

The configurated delay times are then measured for each safety subfunction separately. Therefore, a change from a higher level to a lower one can result in multiple changes of active safety subfunctions.



The blue continuous line stands for the calculated safety level. The red dotted line indicates the active safety subfunction. The arrows refer to the length of delay times configurated for the relevant function. If a lower level has a shorter delay time than a higher one, a directly lower level is selected.

Switching to higher levels always takes place directly and without delay.

DANGER	If any function is triggered by the monitoring of a protection (e.g. cover, light curtain), there should be a safety distance between the protection and the danger zone so that the danger zone cannot be reached within the delay time.

5.17.1. Parameter

Parameter	Unit	Default value	Description
Group ‹General Configuration› on Safe-AxControl			
Minimal active level	-	0	Minimum safety level so that the drive is active. For all lower safety levels, the STO function/SS1-t (after expiry of a parameterised delay) is triggered.
Group ‹Timing Configuration› on Safe-AxControl			
STO-Delay	ms	0	Delay from when the STO function/SS1-t is requested to the activation of pulse inhibition.

Parameter	Unit	Default value	Description
Group ‹General Configuration› on Safe-AxControl			
Group ‹Safety level X› (with X := 0 upto 7) on Safe-AxMonitor			
Safety Sub-function	Mute / SLS / SOS	Mute	Safety subfunction of the relevant safety level. When muting is enabled, no safety sub-function is monitored for this and all higher levels. Note: This parameter is disabled if a lower level is set to ‹Muting›.
Limit	Unit/s (for SLS) Unit (for SOS)	0	Limit of the configurated safety subfunction. For SOS: Maximum distance to the position on activation. For SLS: Maximum allowable velocity. Note: The unit corresponds to the value set in the Unit parameter.
Delay	ms	0	Delay time between changing from a higher level to this level and the activation of the configurated safety subfunction.

5.18. Error Codes

The table below provides a complete listing of all error codes returned by the safety modules.

No.	Error	Description	Possible Reason
Internal Hardware Errors		Microcontroller Errors	
0	OK	No Error	No error
1	AllHwStackFailOverflow	Memory stack overflow before initialisation	Software error
2	AllHwStackFailInit	Start-up memory stack test could not be initialised	Software error
3	AllHwStackFailInitTest	Memory stack overflow during start-up detected	Software error
4	AllHwStackFailSetup	Initialisation of the periodic stack test failed	Software error
5	AllHwStackFail	Memory stack overflow during the periodic test detected	Software error
6	AllHwCPUFailInit	CPU error during start-up detected	Software error
7	AllHwCPUFailFirst	Start-up CPU test could not be completed	Hardware defect
8	AllHwCPUFail	CPU error during the periodic test detected	Hardware defect
9	AllHwMemoryFailInit	Memory error during start-up test detected	Hardware defect
10	AllHwMemoryFailSetup	Initialisation of the periodic memory test failed	Software error
11	AllHwMemoryFail	Memory error during the periodic test detected	Hardware defect
12	AllHwFirmwareFailInit	Firmware error during start-up detected	Hardware defect
13	AllHwFirmwareFailSetup	Initialisation of the periodic firmware test failed	Software error
14	AllHwFirmwareFail	Firmware error during the periodic test detected	Hardware defect
15	CpuBDevHwRevInputs	Hardware revision inputs have been wrongly wired	Hardware defect

No.	Error	Description	Possible Reason
Synchronisation Errors		Synchrony Error Between Both Module Controllers	
20	CtrlSynchSafetyState	Safety state between CPU A and B different	Secondary error
21	AllSynchSchedState	Scheduler state between A and B different	Secondary error
22	AllSynchTwin	Cycle synchronisation failed	Secondary error
23	AllSynchClock	Cycle times between A and B different	Hardware defect
24	AllSetClockFail	System clock could not be correctly configured	Hardware defect
Internal Communication Errors		Communication Errors Between Both Controllers	
30	AllIntCommDma13Enabled	SPI DMA 1 stream 3 could not be switched off in time	Secondary error
31	AllIntCommDma14Enabled	SPI DMA 1 stream 4 could not be switched off in time	Secondary error
32	CpuAIntCommToXInput	Timeout when waiting for the chip selection input in the SPI exchange	Secondary error
33	CpuAIntCommToXTx	Timeout during transmission to the SPI exchange	Secondary error
34	AllIntCommToXRx	Timeout during reception in the SPI exchange	Secondary error
35	CpuAIntCommToIntInput	Timeout when waiting for the start DMA's chip selection input	Secondary error
36	AllIntCommToIntTx	Timeout during transmission to the SPI DMA	Secondary error
37	CpuAIntCommToExtInput	Timeout when waiting for the start DMA's chip selection input during transmission of external data	Secondary error
38	AllIntCommToExtTx	Timeout during transmission to the SPI DMA during transmission of external data	Secondary error
39	AllIntCommToExtRx	Timeout during reception in the SPI DMA during transmission of external data	Secondary error
40	AllIntCommExtAddressMismatch	Address of external data between CPU A and B different	Secondary error
41	MoniDevScDma20Enabled	SPI DMA 2 Stream 0 could not be switched off in time	Secondary error
42	CtrlIntCommInputs	Error during transmission of safe input values	Secondary error
External Communication Errors		Communication Errors Between Controller A and the GIN-SAC4	
50	CpuAExtCommDma12Enabled	SPI DMA 1 Stream 2 could not be switched off in time	Secondary error
51	CpuAExtCommDma15Enabled	SPI DMA 1 Stream 5 could not be switched off in time	Secondary error
52	CtrlMoniCommTo	Timeout of connection to the Safe-AxMonitor module	Secondary error
53	CpuAExtCommToDmaFinished	Timeout during transmission of external data to the SPI DMA	Secondary error
54	CtrlExtCommRandomNumber	Error during generation of random numbers for the safe protocol	Hardware defect
Scheduler Errors		Scheduler Sequence Errors	
55	CtrlDevInpTestIncomplete	Input device tests could not be completed within one hour.	Software error
56	CtrlDevOutTestIncomplete	Output device tests could not be completed within one hour.	Software error
57	CtrlDevStoTestIncomplete	STO device tests could not be completed within one hour.	Software error
58	CtrlDevFsTestIncomplete	Fail safe device tests could not be completed within one hour.	Software error
59	MoniDevScTestIncomplete	Sin/cos device tests could not be completed within one hour.	Software error
60	AllSchedTestMaxCycState	Number of cycles per scheduler step exceeded	Software error
61	AllSchedTestMaxCycLoop	Number of cycles per scheduler run exceeded	Software error
62	AllSchedTestIncomplete	Number of cycles for a complete module test exceeded	Software error
63	AllMgrCtTestIncomplete	CPU test manager tests could not be completed within one hour	Software error
64	AllDevPomTestIncomplete	Power monitoring device tests could not be completed within one hour	Software error
65	AllMgrRpTestIncomplete	Reporting manager tests could not be completed within one hour	Software error
66	AllContConfTestIncomplete	Configuration container tests could not be completed within one hour	Software error

No.	Error	Description	Possible Reason
Software Errors		Software Errors Captured by Defensive Programming	
70	MoniMgrAmSafetyLevel	Too high safety level requested	Software error
71	AllMgrConfigState	Configuration manager is in invalid state	Software error
72	CtrlMgrImcState	Intermodular communication manager is in invalid state	Software error
73	AllDevPomInit	Initialisation error of the power monitoring device	Software error
74	AllMgrRpState	Reporting manager is in invalid module state	Software error
75	CpuAMgrRpStep	Reporting manager is in invalid state (step)	Software error
76	MoniDevResInit	Initialisation error of the resolver device	Software error
77	MoniDevScInit	Initialisation error of the sin/cos device	Software error
78	MoniDevScNonexQuad	Non-existent quadrant in the encoder value	Software error
79	CtrlSelectionConfigError	Selection method has an invalid value	Software error
80	MoniResSpeedFilterSize	Resolver velocity filter has an invalid size	Software error
81	MoniResNonPosTimeDiff	Time difference between two measurements is not positive	Software error
82	AllStartupErrorSize	Buffer size of error values were exceeded during start-up	Software error
Configuration Errors		Configuration Errors	
90	AllConfigLengthWrong	Configuration data length is wrong	Configuration error
91	AllConfigCrcWrong	CRC configuration is wrong	Configuration error
92	AllConfigProductIdWrong	Product ID in the configuration is wrong (the configuration is not intended for this type of module)	Configuration error
93	AllConfigVersionWrong	Configuration version is not supported	Configuration error
94	AllConfigFieldbusPosWrong	Preset feldbus position does not match the actual position	Configuration error
95	AllConfigContainerDamaged	Stored configuration data is damaged	Soft RAM error
96	MoniConfigAxisNumber	Preset axis number does not match the actual axis number	Configuration error
97	MoniConfigInvalidLimit	Preset limit of a safety subfunction is invalid	Configuration error
98	MoniConfigInvalidSafetyFunction	Invalid safety function configured	Configuration error
99	MoniConfigInvalidTolerance	Preset signal tolerance invalid	Configuration error
100	MoniConfigInvalidSignalStrength	Preset signal level invalid	Configuration error
Hardware Trap Errors		The processor has triggered a trap interrupt	
110	AllCycleOverrun	The system clock interrupt has triggered a watchdog	Software error
111	AllTrapNmi	A non-maskable interrupt has occurred	Software error
112	AllTrapHardFault	Hard fault interrupt has occurred	Software error
113	AllTrapMemManage	Memory management error interrupt has occurred	Software error
114	AllTrapBusFault	Bus error interrupt has occurred	Software error
115	AllTrapUsageFault	Process usage error has occurred	Software error
Power Supply Errors		Power Supply Error Detected by the Voltage Measurement	
120	AllPowerError24VTooLow	24 Volt power supply too low	Wiring error
121	AllPowerError24VTooHigh	24 Volt power supply too high	Wiring error
122	AllPowerError3_3VTooLow	3.3 Volt power supply too low	Hardware defect
123	AllPowerError3_3VTooHigh	3.3 Volt power supply too high	Hardware defect
124	AllPowerErrorGNDTooHigh	Earth measurement too high	Hardware defect
125	AllAdcMalfunction	ADC malfunction	Hardware defect
126	AllAdc24VDiffTooLarge	CPU A and CPU B power supply measurement shows a too high difference	Hardware defect
127	CtrlAdcSafe24VDiffTooLarge	CPU A and CPU B safe 24V power supply shows a too high difference	Hardware defect
128	CtrlPowerErrorVRefIntTooLow	Voltage measurement of the internal reference is too low	Hardware defect
129	CtrlPowerErrorVRefIntTooHigh	Voltage measurement of the internal reference is too high	Hardware defect

No.	Error	Description	Possible Reason
Flash Memory Errors		Internal Flash Memory Errors	
130	AllFlashReadError	Flash memory read access error	Software defect
131	AllFlashEraseError	Flash memory sector erasure error	Hardware defect
132	AllFlashWriteError	Flash memory write access error	Hardware defect
Safe-AxControl Hardware Errors		Safe-AxControl Module Hardware Errors	
140	CtrlInputInternal	Internal input test has detected an error	Hardware defect
141	CtrlInputExternalFB	Test pulse output is ‹high› despite being switched off	Wiring error
142	CtrlInputExternal0	External input test has detected an error at input 0	Wiring error
143	CtrlInputExternal1	External input test has detected an error at input 1	Wiring error
144	CtrlInputExternal2	External input test has detected an error at input 2	Wiring error
145	CtrlInputExternal3	External input test has detected an error at input 3	Wiring error
146	CtrlInputInconsistent0	Deviation between the channels of input 0 detected	Wiring error
147	CtrlInputInconsistent1	Deviation between the channels of input 1 detected	Wiring error
148	CtrlInputInconsistent2	Deviation between the channels of input 2 detected	Wiring error
149	CtrlInputInconsistent3	Deviation between the channels of input 3 detected	Wiring error
150	CtrlOutputInter-nalOffIsHigh	Internal output test has detected a too high voltage despite the output being switched off	Hardware defect
151	CtrlOutputExter-nalOffTooHigh	External output test has detected a too high voltage despite the output being switched off	Wiring error
152	CtrlFailSafeNoDrop	Fail safe voltage has not passed the fail safe test	Hardware defect
153	CtrlFailSafeSkip	Fail-Safe Test was skipped too many times	Wiring error
154	CtrlSafe24VDiffTooLarge	Voltage drop across the fail safe circuit is too extensive	Hardware defect
155	CtrlSafe24VCycleTime-TooLarge	Time between fail safe voltage monitoring tests is too long	Software error
156	CtrlStoOnTooLow	STO voltage in enabled state is too low	Hardware defect
157	CtrlStoOnTooHigh	STO voltage in enabled state is too high	Hardware defect
158	CtrlStoTestTooLow	STO voltage during the test pulse is too low	Hardware defect
159	CtrlStoTestTooHigh	STO voltage during the test pulse is too high	Hardware defect
160	CtrlStoOffTooHigh	STO voltage in disabled state is too high	Hardware defect
161	CtrlFailSafeInitHigh	Initial fail safe test has detected an error	Hardware defect
162	CtrlOutputInternal-PulseIsHigh	Internal output test has detected a too high voltage during the pulse test	Hardware defect
163	CtrlOutputExternal-PulseIsHigh	External output test has detected a too high voltage during the pulse test	Wiring error
164	CtrlOutputInternalOnIsLow	Internal output test has detected a too low voltage despite the output being switched off	Hardware defect
165	CtrlOutputExternalOn-TooLow	External output test has detected a too low voltage despite the output being switched off	Wiring error
166	CtrlOutputExternalOn-TooHigh	External output test has detected a too high voltage despite the output being switched off	Wiring error
167	CtrlSafetyState-TooManyConfirms	Too many acknowledgements detected	Wiring error
168	CtrlSafetyStateCycleTime-TooLarge	Time between acknowledgement state updates is too long	Software error
Safe-AxMonitor Hardware Errors		Safe-AxControl Module Hardware Errors	
180	MoniResolverInconsistency	No consistent values could be read from the ADC registers	Hardware defect or configuration error
181	MoniResolverTrigger-Missing	No resolver trigger received	Hardware defect or configuration error
182	MoniResolverS2C2TooLow	Sine square plus cosine square of resolver signals too low	Wiring error
183	MoniResolverS2C2TooHigh	Sine square plus cosine square of resolver signals too high	Wiring error
184	MoniSinCosS2C2TooLow	Sine square plus cosine square of SinCos signals too low	Wiring error
185	MoniSinCosS2C2TooHigh	Sine square plus cosine square of SinCos signals too high	Wiring error
186	MoniSinCosS2C2TooLow-Speed	Sine square plus cosine square of sin/cos signals too low at high velocity	Wiring error
187	MoniSinCosAlignment	Misalignment errors between digital and analogue sin/cos evaluation	Wiring error

No.	Error	Description	Possible Reason
188	MoniSinCosEncoderStep	One-step principle of the sin/cos encoders violated	Wiring error
189	MoniPosSpeedDiffTooLarge	Velocity Measurement of CPU A and CPU has to high difference	Hardware defect
190	MoniPosPosDiffTooLarge	Position Measurement of CPU A and CPU has to high difference	Hardware defect
191	MoniPosS2C2DiffTooLarge	Sine square + cosine square of CPU A and CPU B show a too high difference	Hardware defect
192	MoniSinCosAdcDmaError	DMA error during ADC sin/cos measurement	Hardware defect
193	MoniFeedbackOff-setTooHigh	Feedback offset voltage too high	Hardware defect
194	MoniFeedbackOff-setTooLow	Feedback offset voltage too low	Hardware defect
195	MoniFeedbackOff-setDiffTooLarge	Feedback offset voltage measured for CPU A and CPU B shows a too high difference	Hardware defect
196	MoniSinCosAcceleration-TooLarge	Feedback acceleration too high	Hardware defect
197	MoniSinCosAccelD-iffTooLarge	Feedback acceleration measured for CPU A and CPU B shows a too high difference	Hardware defect
198	MoniResolverPosNegAmpl	Measurement difference between the positive and negative amplitudes of the resolver carrier signal is too large	Hardware defect
199	MoniSafetyLevelIncon-sistency	Safety level difference between CPU A and CPU B	Hardware defect
200	MoniAxisMonitoringState	Axis monitoring state has assumed an invalid state	Software error

5.18.1. Error Handling

If a safety module detects any error, the GIN-SAC4xX may be put into operation once again after the detected error is examined and eliminated. The table below defines the measures to be taken de-pending on the probable error cause.

Error Cause	Description	Measure
Hardware defect	The safety module has detected an internal defect.	The defect should be reported to Indel AG. The GIN-SAC4xX FS needs to be re-placed. The defective drive must be re-turned to the manufacturer for analysis
Software error	The software has detected an invalid state which is most likely to have been caused by a pro-gramming error.	The error should be reported to Indel AG. The user provides the manufacturer with state-related information and an occur-rence report.
Soft RAM error	A memory cell has been cor-rupted during operation.	The error should be reported to Indel AG. If the error persists, the GIN-SAC4xX needs to be replaced.
Wiring error	External error or defect in the wiring or external hardware.	The wiring and any connected external modules have to be verified and corrected. Once the error has been eliminated, the safety functions should be put to a start-up test or revalidation
Configuration error	The configuration is invalid or corrupted.	The configuration should be verified and corrected. Once the error has been elimi-nated, a start-up test should be conducted.
Secondary error	Error that usually occurs due to an error on another safety mod-ule or another microcontroller of the module.	Errors of all other GIN-SAC4xX modules must be checked. Identified errors should be subsequently measured. If only second-ary errors are detected on a GIN-SAC4xX, In-del AG should be contacted.

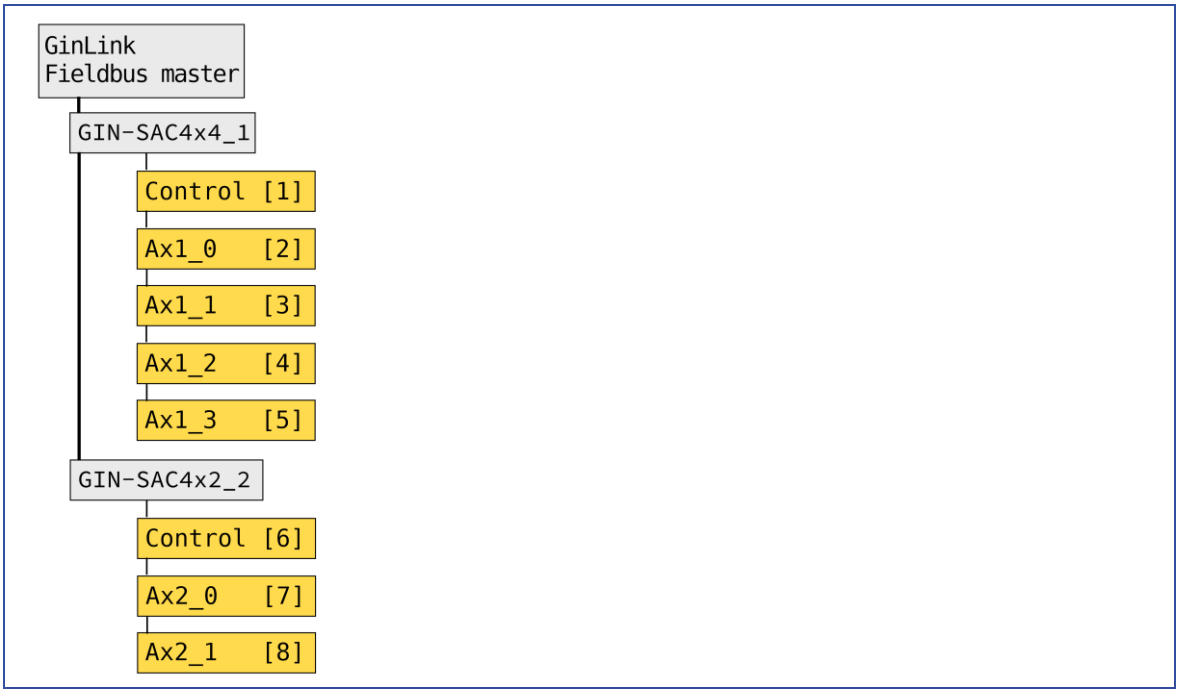
If the GIN-SAC4xX detects any error, the drive may resume its operation only after the error is eliminated. Under no circumstances may damaged drives be put into operation again. This might result in severe bodily injury and property damage.

6. Configuration of the Safety Modules

This section describes how to configure the GIN-SAC4xX FS's safety modules. How to set up the functional control system can be found in the start-up manual. Only the most important steps of safety set-up are described here.

6.1. Definition of the System Topology

The set-up of the safety modules is based on a specific system topology. It is defined in XML format in the device-map.xml file, which is stored in the project configuration folder. The topology file comprises all equipment connected to the fieldbus. In addition to the equipment, the setup of the safety modules requires definition of the safety modules used with the GIN-SAC4xX. The following fictitious topology example serves as an illustration.



The safety modules are highlighted in yellow. The consecutive number in square brackets stands for the unique identification number (UID) of the module. The following listing shows a correct topology file for this topology.

```
<?xml version="1.0" encoding="utf-8" standalone="yes"?>
<!--
            trans-table-name="device-map"
-->
<!-- List of Devices on the GinLink -->
<Devices>
            <!-- GIN-SAC4x4 FS -->
            <Device Type="GIN" ProductCode="311349345">
               <Name>GIN-SAC4x4_1</Name>
               <Address>
                      <MAC>undefined</MAC>
               </Address>

               <!-- List of the Safety-Modules inside the Drives -->
               <Devices>
                      <!-- Safe-AxControl -->
                      <Device Type="COP" ProductCode="311347200">
                             <Name>Control</Name>
                             <Address>
                             <!-- Safe-AxControl is always on Base-address 8 -->
                                    <COP>0x8</COP>
                             </Address>
                             <!-- Unique Number of this safety Module -->
                             <UID>1</UID>
                      </Device>

                      <!-- Safe-AxMonitor 0 -->
                      <Device Type="COP" ProductCode="311347300">
                             <Name>Ax1_0</Name>0
                             <Address>
                                    <COP>0x0</COP>
                             </Address>
                             <!-- Unique Number of this safety Module -->
                             <UID>2</UID>
                      </Device>

                      <!-- Safe-AxMonitor 1 -->
                      <Device Type="COP" ProductCode="311347300">
                             <Name>Ax1_1</Name>
                             <Address>
                                    <COP>0x1</COP>
                             </Address>
                             <!-- Unique Number of this safety Module -->
                             <UID>3</UID>
                      </Device>

                      <!-- Safe-AxMonitor 2 -->
                      <Device Type="COP" ProductCode="311347300">
                             <Name>Ax1_2</Name>
                             <Address>
                                    <COP>0x2</COP>
                             </Address>
                             <UID>4</UID>
                      </Device>

                      <!-- Safe-AxMonitor 3 -->
                      <Device Type="COP" ProductCode="311347300">
                             <Name>Ax1_3</Name>
                             <Address>
                                    <COP>0x3</COP>
                             </Address>
                             <!-- Unique Number of this safety Module -->
                             <UID>5</UID>
                      </Device>
                      <!-- End of Safety Modules -->
               </Devices>
            </Device>
```

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… Continues

```
            <!-- GIN-SAC4x2 FS -->
            <Device Type="GIN" ProductCode="311329345">
               <Name>GIN-SAC4x2_2</Name>
               <Address>
                      <MAC>undefined</MAC>
               </Address>

               <!-- List of the Safety-Modules inside the Drives -->
               <Devices>
                      <!-- Safe-AxControl -->
                      <Device Type="COP" ProductCode="311347200">
                             <Name>Control</Name>
                             <Address>
                             <!-- Safe-AxControl is always on Base-address 8 -->
                                    <COP>0x8</COP>
                             </Address>
                             <!-- Unique Number of this safety Module -->
                             <UID>6</UID>
                      </Device>

                      <!-- Safe-AxMonitor 0 -->
                      <Device Type="COP" ProductCode="311347300">
                             <Name>Ax2_0</Name>
                             <Address>
                                    <COP>0x0</COP>
                             </Address>
                             <!-- Unique Number of this safety Module -->
                             <UID>7</UID>
                      </Device>

                      <!-- Safe-AxMonitor 1 -->
                      <Device Type="COP" ProductCode="311347300">
                             <Name>Ax2_1</Name>
                             <Address>
                                    <COP>0x1</COP>
                             </Address>
                             <!-- Unique Number of this safety Module -->
                             <UID>8</UID>
                      </Device>
                      <!-- End of Safety Modules -->
               </Devices>
            </Device>
</Devices>
```

The system topology defined in the device-map.xml file provides the basis for the configuration of the safety modules, but it is not itself part of the safe configuration file.

6.2. Creating and Editing the Safe Configuration File

ATTENTION

Safe configuration files may only be created and edited by developers who:

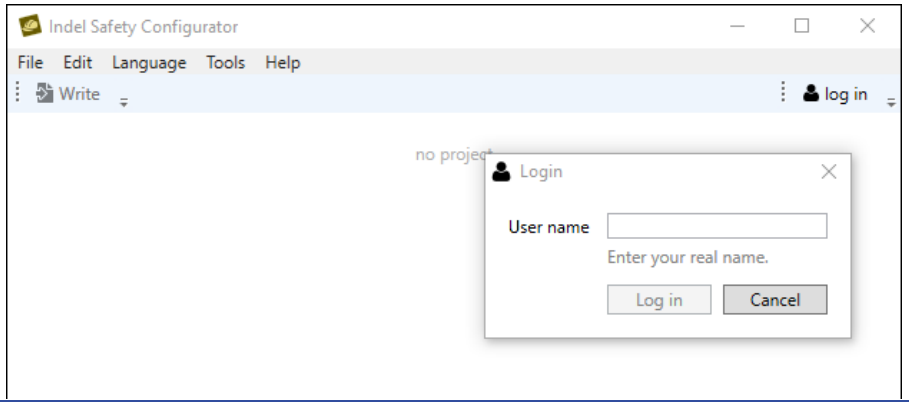
- Are familiar with applicable safety standards
- Have been trained by Indel AG in how to deal with safety modules
- Know how to use them, especially as far as their safety structure is concerned.

6.2.1. Prerequisite

You need a Windows PC with installed Indel Safety Configurator to create the safety configuration. Which release is needed is defined in section 5.13.

6.2.2. Login

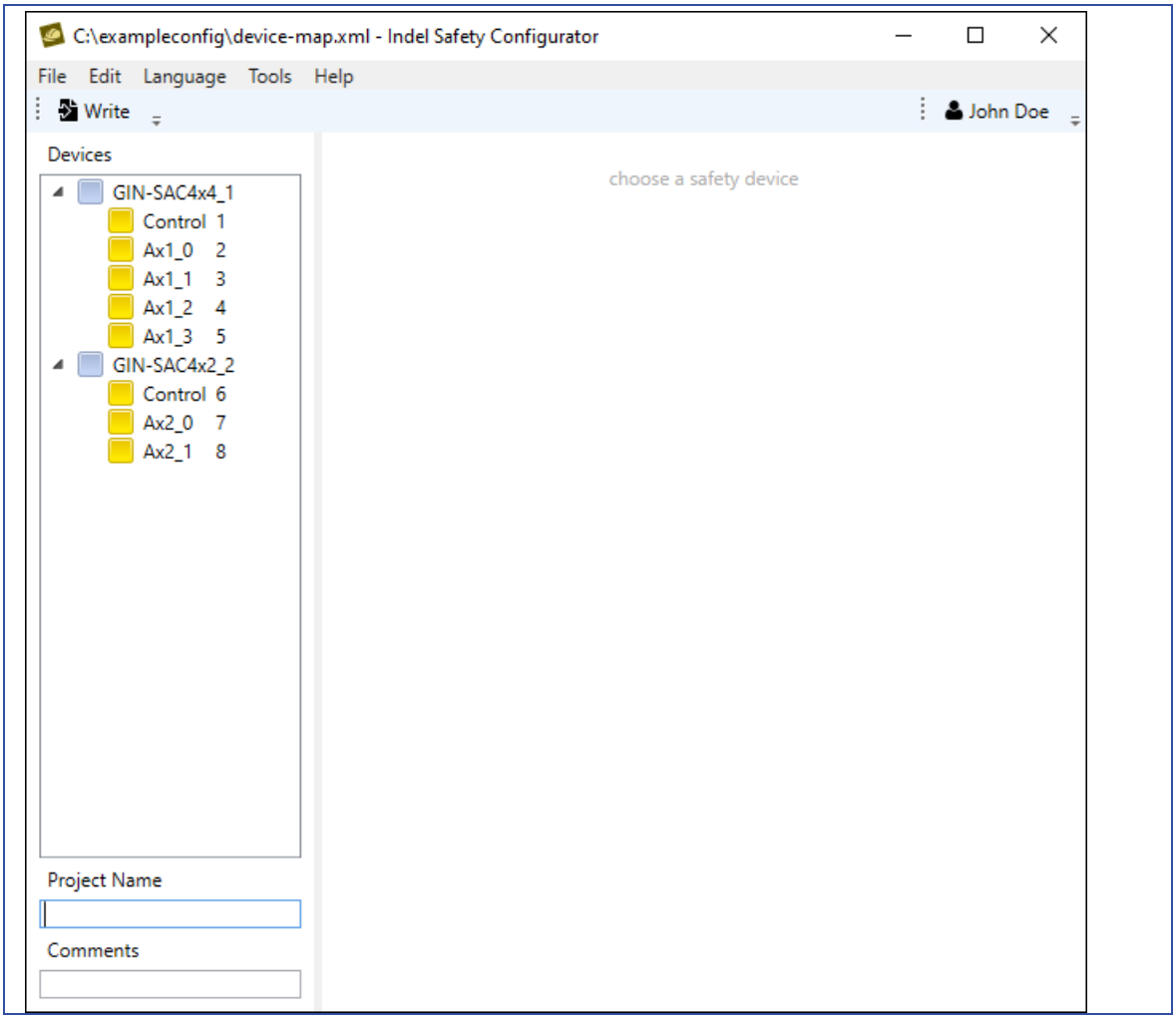
You must log in into the Indel Safety Configurator if you want to create or edit the configuration. For this purpose, use the <log in> button in the right upper corner.



For the <User name> always use your complete name or a clearly assigned user name.

6.2.3. Opening the System Topology File

To create or edit the safe configuration, you have to open the device-map.xml file of the relevant project.
Select the <Open> item in <File> or press Ctrl + O and select the correct file in the dialogue box.
Now Indel Safety Configurator creates a configuration where all parameters are set to standard.



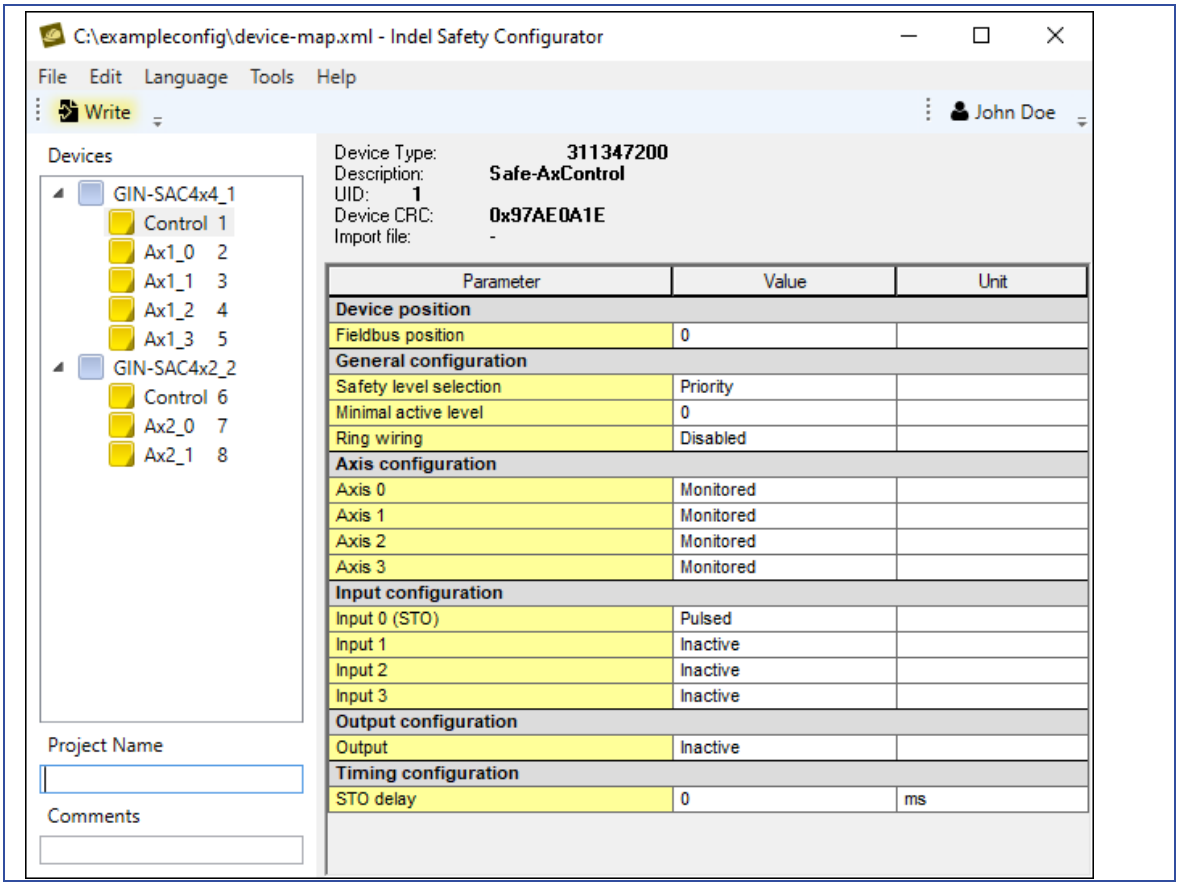
Once the configuration is generated, you should verify the topology of the created safety configuration.
The following items need to be verified:

- All of the system's GIN-SAC4xX FSs are listed and named in accordance with the wiring diagram.
- Each GIN-SAC 4x4 FS has its own control safety module of Safe-AxControl type.
- Each monitored axis is present, properly named and listed under a correct GIN-SAC4xX FS name, and the module is of Safe-AxMonitor type.

ATTENTION	A newly created configuration may be used for the start-up only after all parameters are verified for their correctness.

6.2.4. Parametrisation

To ensure the proper operation of the safety modules, all parameters must necessarily be correctly set. Therefore, after the creation of the safety configuration each safety module and each of its parameters must be systematically checked.
For this purpose, the first safety module needs first to be selected in the tree diagram. In the right-side half a matrix of all parameters appears.



All parameters must be verified and set depending on the application. The explanations and safety instructions contained in section 5 should be observed.

Once all parameters of a module have been correctly set, another module has to be selected and its parameters have to be correctly set. This should be repeated until all modules are configured.

6.2.5. Additional Information

There are two fields under the tree view of the equipment where you should enter some additional information:

- Project name: This name is stored in the configuration file and should be assigned to the project (plant, machine, etc.).
- Comment: This field can be freely used for entering other configuration data.

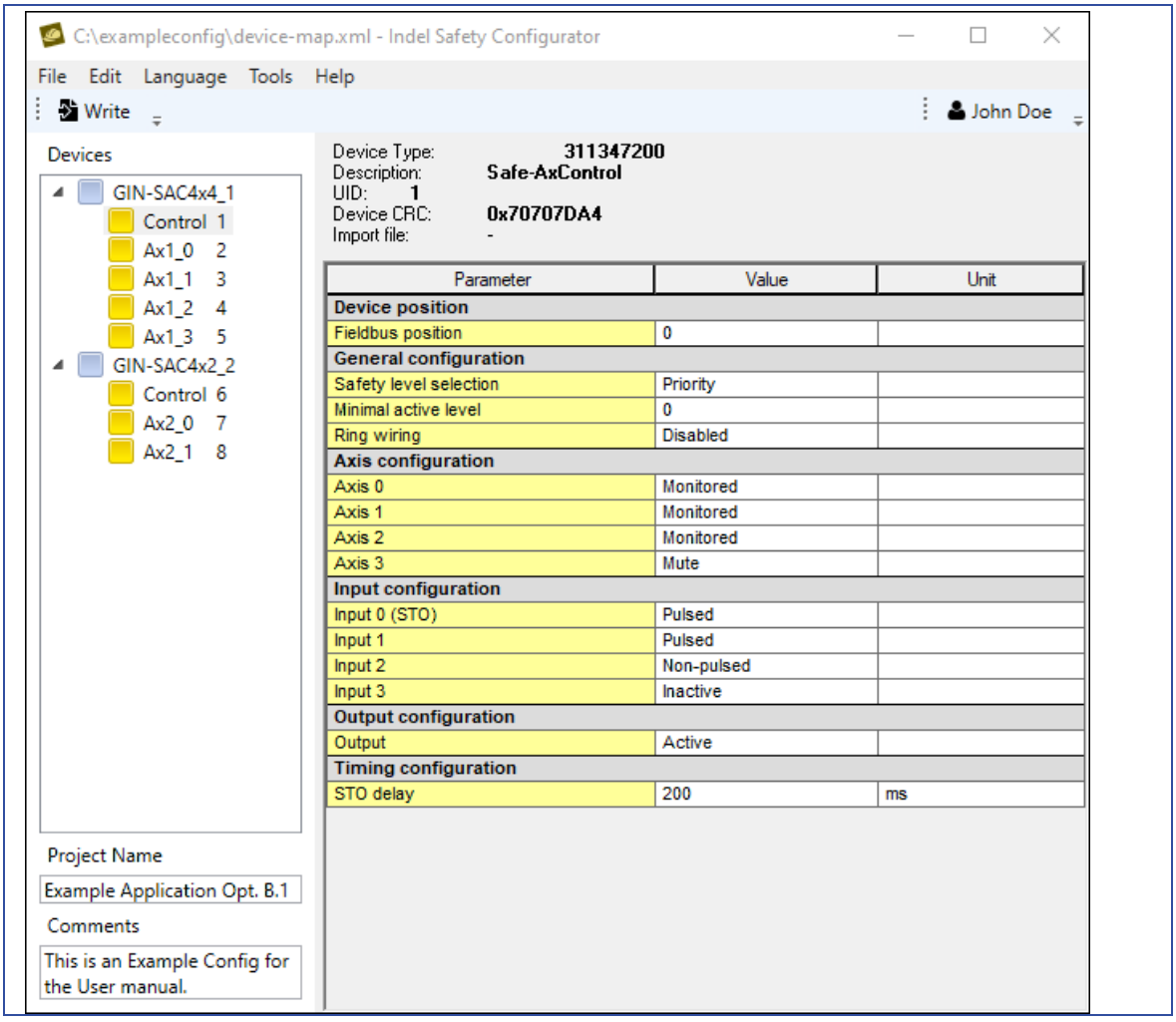
	The project name should be used to assign a safety configuration to the project. This is especially helpful when you want to retrace any safety configuration.

6.2.6. Creating the Configuration File

Once all parameters are correctly set, you can compose a configuration file for the safety modules. This file should be created in Indel image format. For this purpose, press the Write button in the left upper corner or select the <Write Indel-Image> item from the <File> menu.

The Indel image will be saved together with a .csv parameter file in the configuration folder next to the device-map.xml file.

	If any parameter or additional information has been changed, the <Write> button is highlighted in yellow and the right lower corner of the safety device is dark coloured in the tree diagram. If you leave Indel Safety Configurator without pressing the <Write> button, a dialogue box appears which asks you whether or not the changes should be saved in the configuration file.



6.2.7. Archiving Safe Configuration Files

If you want to analyse any hazardous occurrence and restore existing systems, access to the safe configuration in use is absolutely necessary. This is why all configurations in use need to be archived. Most preferably, a version management system should be used for this purpose.

Before start-up the following files of the acknowledged configuration should be archived:

- device-map.xml
- ch.indel.safety.config.csv
- ch.indel.safety.config.img
- SafetyConfiguratorProject.isc
- SafetyConfiguratorProject.sg

6.3. Loading and Verifying the Safe Configuration

ATTENTION	Safe configurations may be loaded and verified only by authorised support personnel who are familiar with the application and the safety subfunctions used.

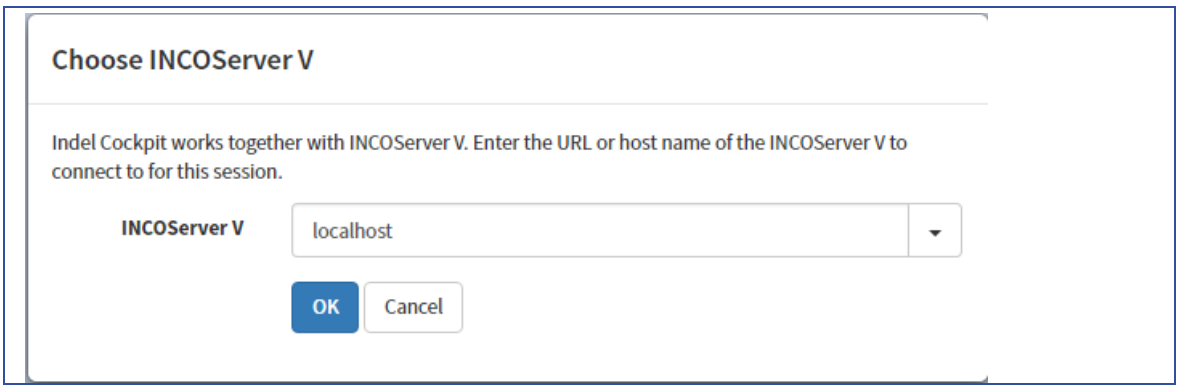
Before start-up the configuration file created with Indel Safety Configurator must be loaded into the system and verified using the Indel Cockpit.

6.3.1. Prerequisite

You need a Windows or Linux PC with installed Indel Cockpit and installed and configured INCOServer V to load and verify the safety configuration. The required release is defined in section 5.13.

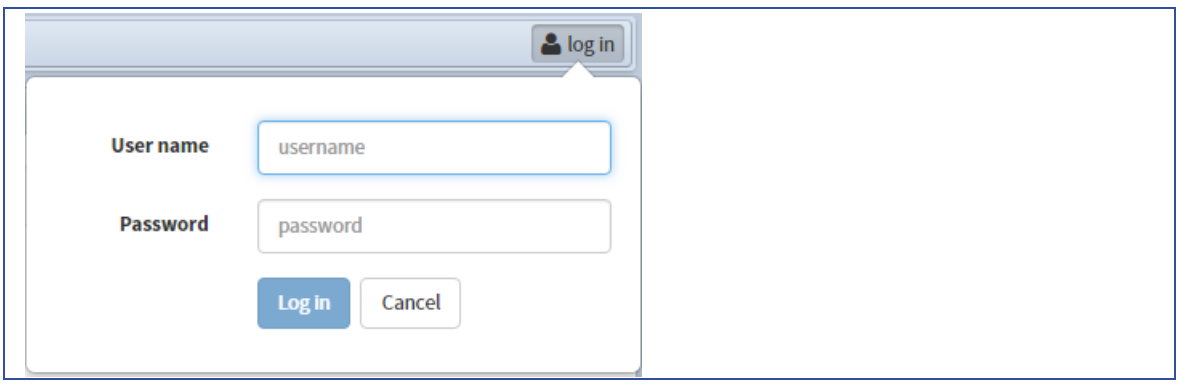
6.3.2. Connecting to INCOServer V

Once Indel Cockpit is started, INCOServer V at which the system is running must be selected. INCOServer V usually runs on the PC connected directly to the system. If Indel Cockpit is started on that PC, localhost must be entered as an address for INCOServer V. Otherwise the IP address or URL of the computer where INCOServer V has been started must be entered.



6.3.3. Registration

The safety configuration can be verified only for registered users. You can register by pressing the Log in button in the right upper corner of Indel Cockpit. Users can be created only by the system administrator.

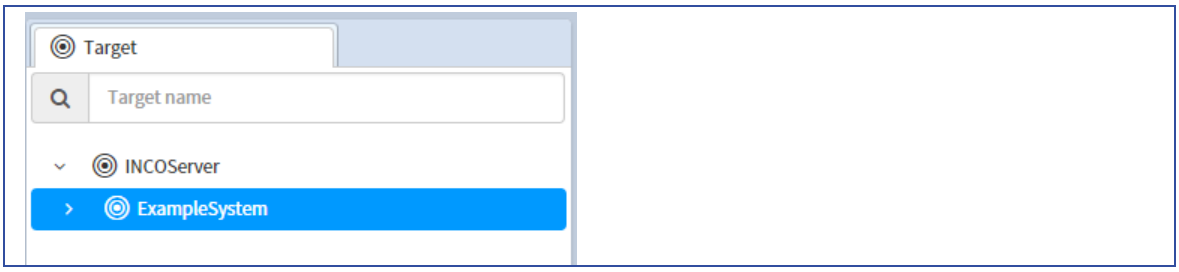


6.3.4. Selecting Commissioning Dashboard

The GIN-SAC4xX's safety modules are completely started up in Indel Cockpit's Commissioning Dashboard. You can select from the main menu in the left upper corner.

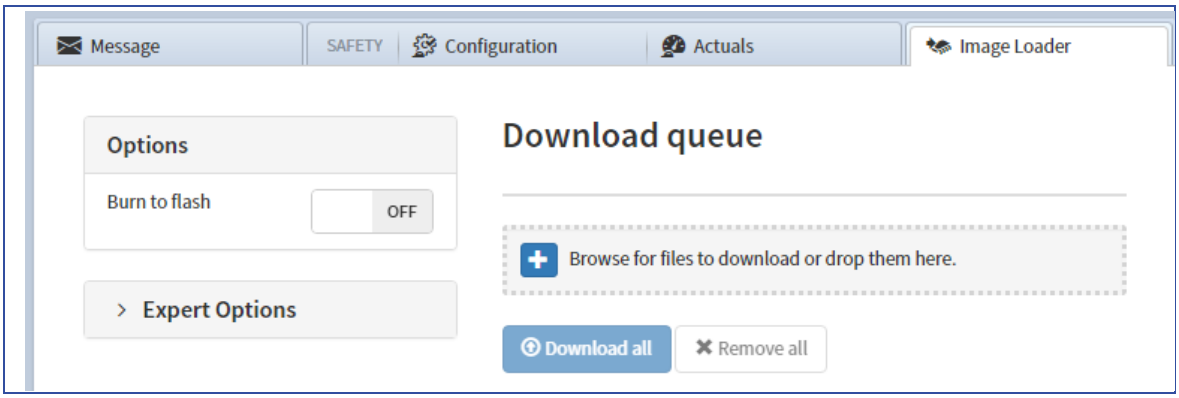
6.3.5. Selecting the System

Before the configuration is loaded, the relevant target has to be selected. The fieldbus master of the system to which one or more GIN-SAC4xXs are connected should be selected as the master.
In addition, you need to select the target name of the system on the left side where targets are selected.

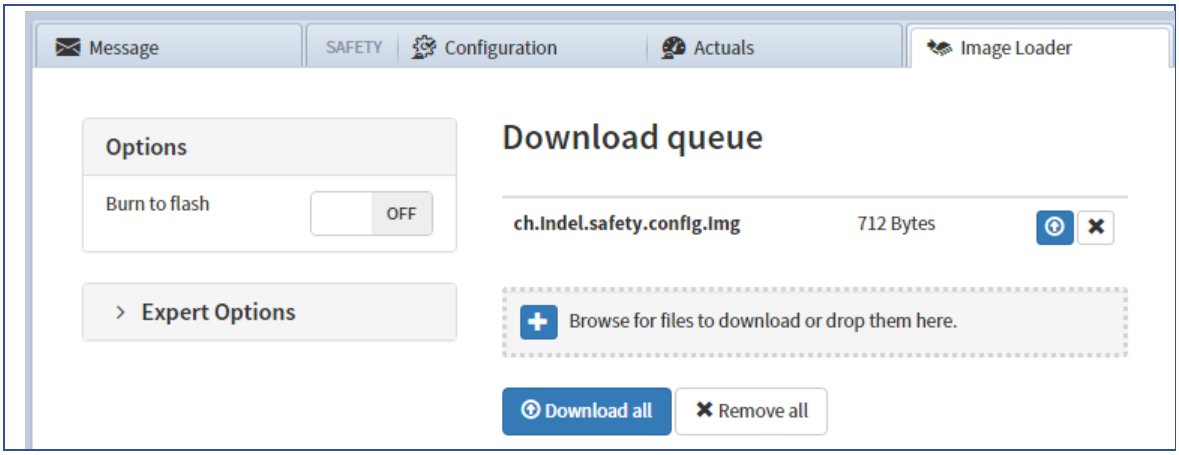


6.3.6. Loading the Configuration for Verification Purposes

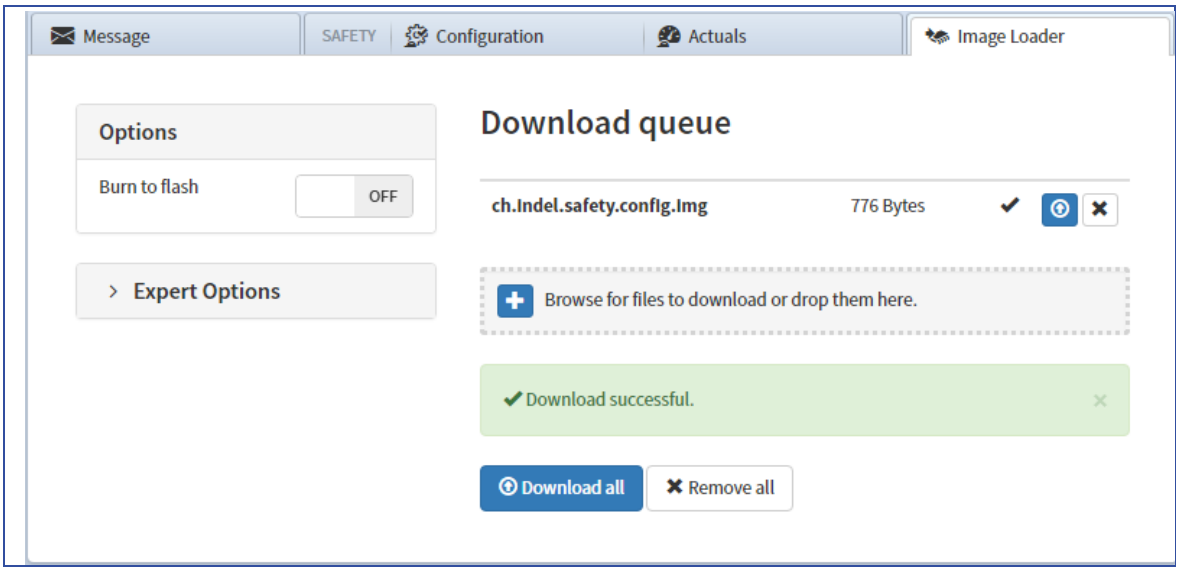
To load the safety configuration, use Indel Cockpit's image loader tool. For this purpose, select the Image Loader tab on the right side.



Subsequently, the safe configuration file ch.indel.safety.config.img created for this system in Indel Safety Configurator must be selected. For this purpose, either press the ‹+› button and select the file in the OPEN… dialogue box or move the file into the circled area using drag and drop.



Once the file is added, it appears in the download queue. Make sure that the Burn to flash option is set to Off and press the Download all button to load the safety configuration into the system. If the loading process is successful, the safety configuration is automatically distributed across all connected GIN-SAC4xX FSs.



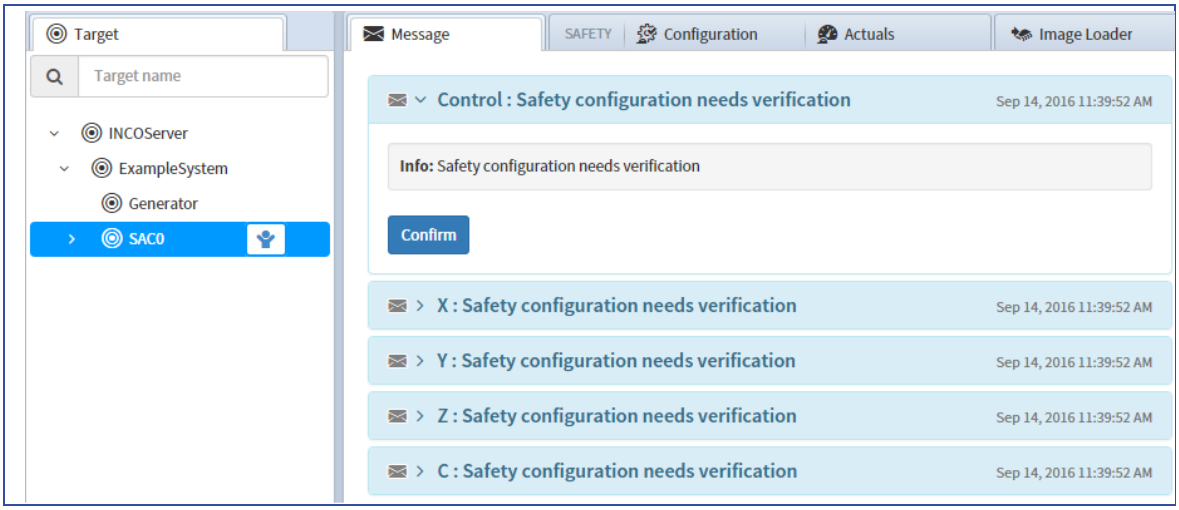
WARNING	The safe configuration may be burnt (permanently saved) only after all safety subfunctions used are retrieved and tested at least once.

6.3.7. Verifying the Configuration

After a new safe configuration file is loaded, it has to be verified once by a registered user. If user verification is needed, this is reported in Indel Cockpit with a blue user symbol in the target view.

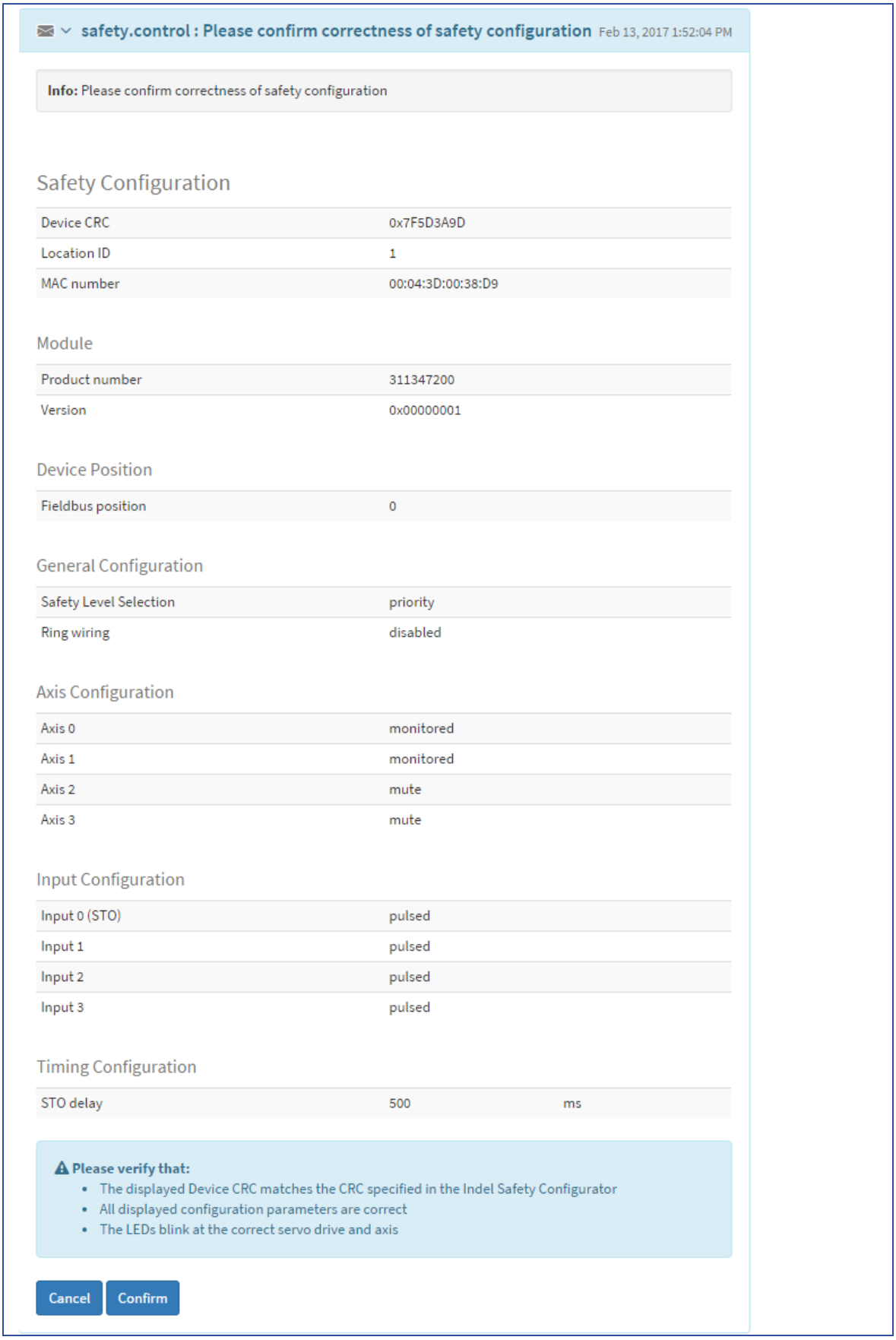
If you click the symbol, the first GIN-SAC4xX is selected where configurations need to be verified. Alternatively, the target showing modules to be verified can also be selected manually.

Once the target is changed, in the Message tab a message is shown for each safety module to be verified. To verify the safety configuration, you have to open the message in the message list and press the Confirm button.



- Only one safety module at a time can be verified.
  This is meant to exclude any mistakes.

After the Confirm button is clicked, a list of all configuration parameters is shown for this safety module.



In addition to the indication of the parameters, the following of the GIN-SAC4xX's LEDs flash:

- When the Safe-AxControl module is being verified: ‹UCC›, ‹Ballast›, ‹Control› and ‹Extern Enable›
- When the Safe-AxMonitor module is being verified: ‹Active›, ‹Motor›, ‹IMAX / IGBT›, ‹PWM / Communication› and ‹Resolver / SinCos› of the relevant axis.

ATTENTION	The following must be verified before a safety configuration is confirmed: · All configuration parameters are correct and/or the CRC of the loaded configuration is identical with the configuration created for this module in Indel Safety Configurator. · The LEDs are flashing at the correct GIN-SAC4xX and at the correct module or the correct axis.

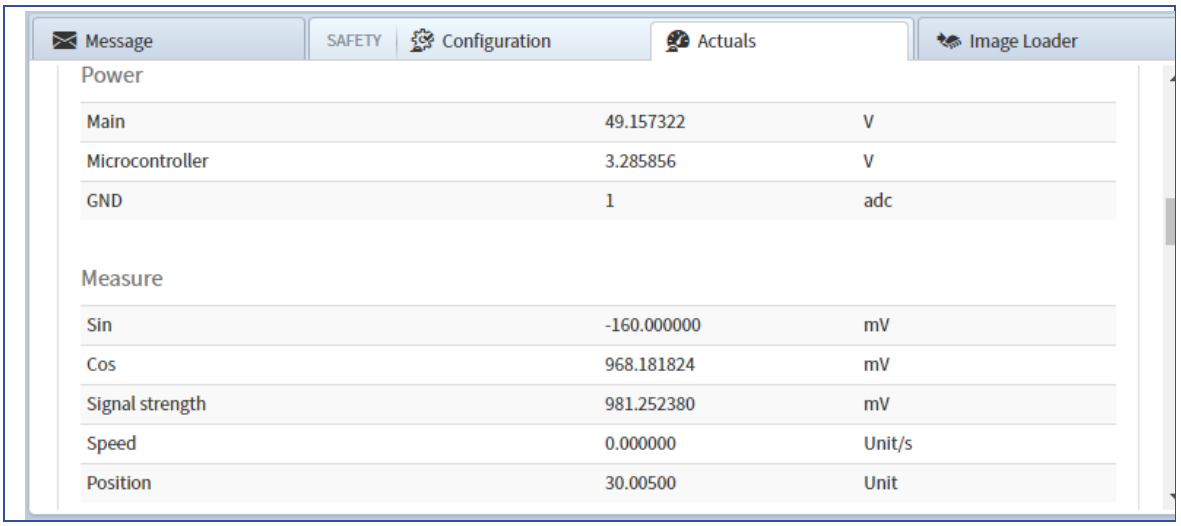
	The safety configuration can be confirmed only after the expiration of a timer. This timer prevents the Confirm button from being clicked without first reading the message.

6.3.8. Verifying the Safety Subfunctions

After the safety configuration is verified for its correctness, all configurated safety subfunctions must be retrieved and verified once for each module or axis before proceeding with the initial start-up.

For the STO and SS1-t functions, it is sufficient that they are retrieved when the axis is active so that it could be verified that the module switches to STO state within the required response time and the torque of the axes is switched off.

For all axes, at least two positions should be approached. You need to check if the distances between the positions of the safety module are correctly captured. It is thus verified that the axis's real encoder resolution is consistent with the configuration. The current position can be found in the Actuals tab in the field CPU A ➔ Measure ➔ Position. The position shown is not absolute, therefore only differences of position can be verified.



For the SS1-t and SS2-t functions, it should be checked that the functional system brings the axes, when needed, to a halt by controlled braking.

For the SOS and SLS functions, apart from the fact whether the function is required it should also be verified that the GIN-SAC4xX switches to STO state when the limit is exceeded. Since the application usually prevents the limit from being exceeded, the functional monitoring must be disabled. The functional monitoring can be deactivated in the Indel Axis Tool. Use the Button with the Helmet Symbol for this purpose.

This may vary depending on the application. In case of doubts, please contact the system administrator or Indel.

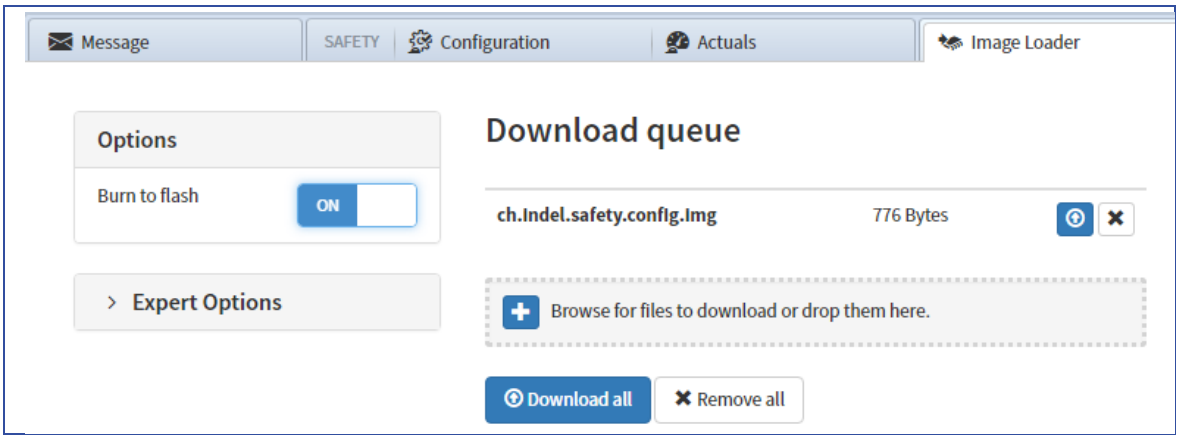
ATTENTION	When a system is started up for the first time, the following steps should be taken to verify the safety subfunctions: · For each GIN-SAC4xX, the STO or SS1-t function must be retrieved when the axis is active. It should be checked that they are executed within the required response time. · For each axis, at least two positions must be approached to make sure that the differences in position are correct. · For each axis, all configurated safety subfunctions must be retrieved. for the SS1-t and SS2-t functions, it must be verified that the functional system provides a brake ramp. · Apart from the requirement, the configurated limit must be exceeded by the application. It should be checked that the GIN-SAC4xX FS switches to STO state within the required response time after the limit is violated.

ATTENTION	Verifying a safety function is a dangerous process. During the verification of safety subfunctions no person may stay around the danger zone.

WWW.	The Documentation for the functional Speed and position monitoring is located in the Indel Online Help under the following URL: https://doc.indel.ch/doku.php?id=software:embedded:inos:safety

6.3.9. Permanently Loading the Safety Configuration

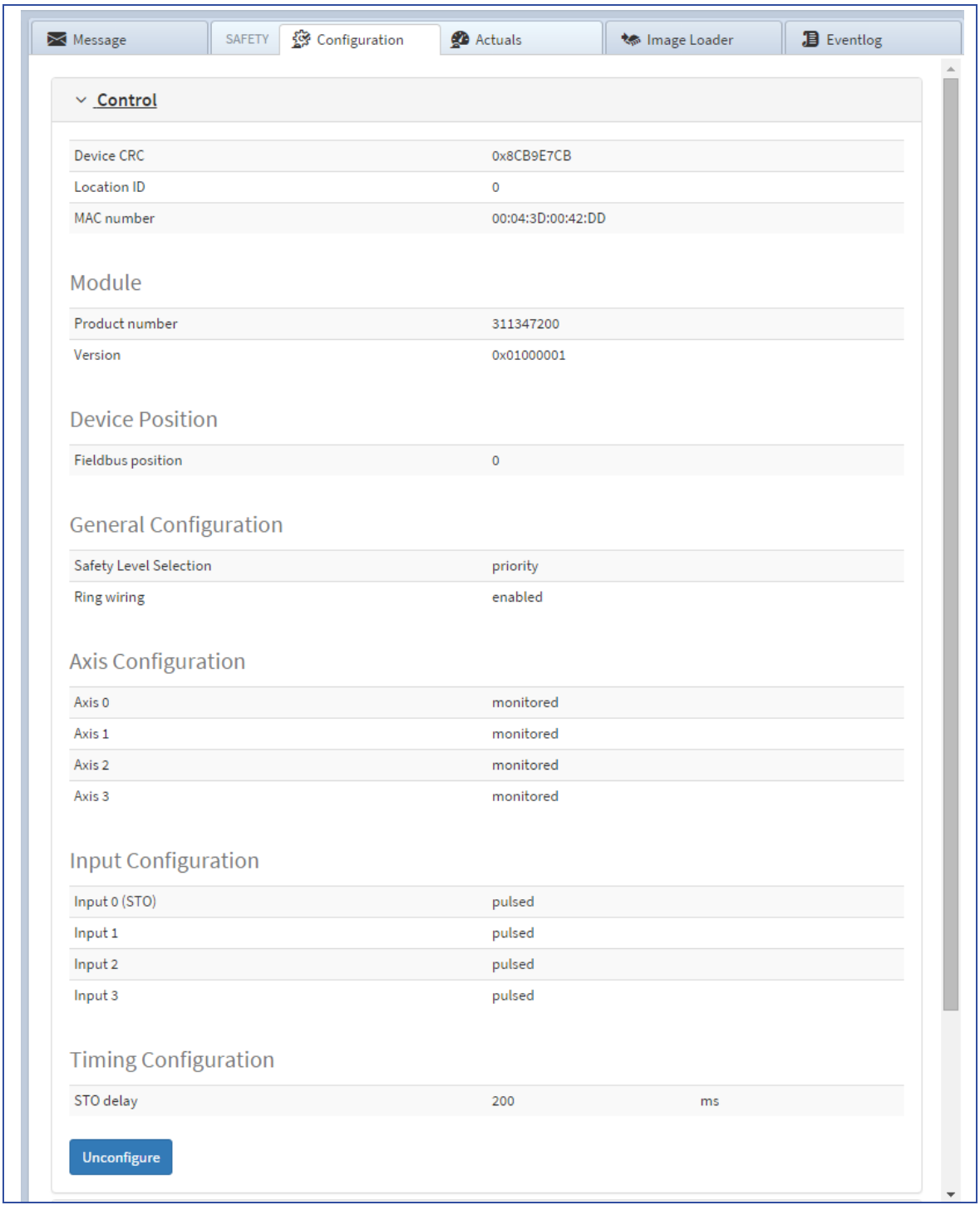
Once all configurations and safety subfunctions are verified, the configuration can be loaded permanently. It is then burnt into the flash memory of the fieldbus master. For this purpose, download the configuration once again using the Image Loader tool, but this time with the Burn option activated. This step completes the start-up of the safety modules.



	In this step only the previously verified safety configuration can be loaded. If a new configuration is selected, it is not accepted by the safety modules. Then the verification must be repeated.

6.3.10. Unconfiguring Safety Modules

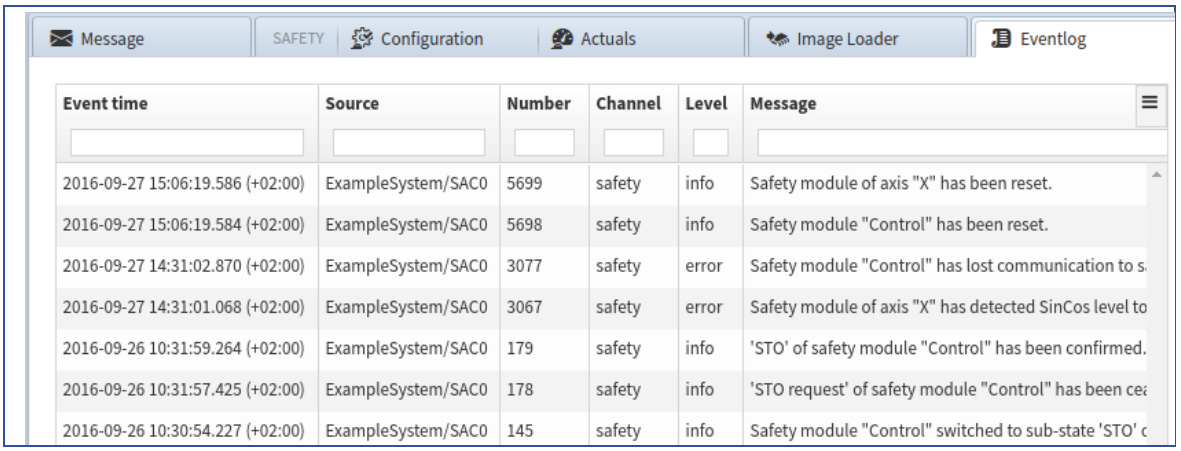
Should any error be found during the verification or operation of the safety modules, then the acknowledgement of the configuration has to be deleted. The unconfigure button in the Configuration tab of Indel Cockpit's Safety Tools is provided for this purpose. This function cancels the verification of the configuration and the module switches to unconfigured state.



ATTENTION	Should the configuration of any safe module be found to contain any error, then the acknowledgement of its configuration must be immediately deleted.

6.3.11. Event Log on INCOServer V

In the Eventlog tab events of all systems configured for the related INCOServer V are shown. All safe-ty-related events are shown in the safety channel.



	With filters in the column header, you can reduce the table to major entries, especially when you set the safety channel in the Channel column and the system name in the Source column.

	In the table menu (in the right upper corner) there are some other functions such as sorting and selection of the columns to view. In addition, all data shown here can be exported as a CSV file.

6.3.12. Configuration Log on the Safety Module

In addition to INCOServer V's event log, a CRC log of the recent five configurations is stored on the safety modules. In Indel Cockpit the configuration log can be found in the Actuals tab.

	CRCs can also be found in the log of the safety modules of new GIN-SAC4xXs. They are identical with the CRCs of the configurations used in the final acceptance test.

6.3.13. Replacing the Drive

If a GIN-SAC4xX FS is to be replaced, all safety modules and safety subfunctions of this drive must be verified once again. The safety configuration does not need to be reloaded because it is stored on the fieldbus master.

	Only a drive of the same type can be used for the replacement. The safety modules accept no configurations for other types.

6.3.14. Replacing the Fieldbus Master

When the fieldbus master is replaced, the safety configuration must be reloaded. If the configuration remains identical, no verification must be repeated.

6.3.15. Changing the Configuration

If any other configuration is needed, the whole configuration must be reloaded. However, only safety modules with changed parameters need to be verified.

7. Integration into the Functional System

The integration of the safety modules into a higher-level functional system is part of Indel operating system INOS. To ensure proper actuation of the safety modules, all GIN-SAC4xX FSs and safety modules must be properly entered in the device topology of the device-map.xml file. An example file is shown in section 6.1.

7.1. Axis Shutdown with the SS1-t and SS2-t Functions

The SS1-t and SS2-t safety subfunctions are implemented in the GIN-SAC4xX FS as type C. This means that the axis shutdown is the responsibility of the functional part of the control system. The safety modules monitor only the shutdown time and, after its expiration, they switch to STO or SOS state.

	The axis shutdown performed by the functional control system must be verified after every software or hardware modification. This also applies for software or firmware updates.

WWW.	The Documentation for the functional Speed and position monitoring is located in the Indel Online Help under the following URL: https://doc.indel.ch/doku.php?id=software:embedded:inos:safety

7.2. Acknowledgement of STO Requirements

In case of requirement for the STO function (e.g. when an emergency stop is triggered), the axes can be reactivated only after such requirement is cancelled and acknowledged. This additional acknowledgment is meant to protect against inadvertent restart. STO queries are acknowledged via the functional system. In the application acknowledgements can be given by pressing the relevant button in a graphic user interface or a physical acknowledgement button. Then two edge transitions must be detected by the functional system and forwarded to the safe system. These edges correspond to the pressing of the button and the subsequent release of the button. The interface for acknowledgement of STO requirements is provided for the application by Indel operating system INOS. The functions SAFETY.ConfirmSTO1 and SAFETY.ConfirmSTO2 are used for this purpose.

	Acknowledgement of STO queries cannot be automatic, but it must always be done by pressing the relevant button.

	If an oscillation of the input cannot be excluded, the acknowledgement button must be detected with an sampling frequency of at least 20 Hz.

7.3. Resetting the Safety Modules

The safety modules can be reset via a function. A restart is needed when another configuration needs to be loaded or the module has detected an error. The interface for resetting safety modules is provided for the application by Indel operating system INOS.

The modules cannot be reset automatically, but they need to be initiated by the user. If a safety module detects an error, the application must indicate it to the user.

8. Technical Description

8.1. SAC4xX Option PRO

Every SAC4xX with the PRO option is furnished with a dual core processor. This makes it possible to control the motor using one core while the other one can be used for a customer-specific application. In simpler applications, the GIN-SAC4xX can also be used at the same time as a Master or GinLink Master.

8.2. Options-Knob

Every SAC4xX is provided with an options knob (S1). It selects the mode in which state the Master is booted. The table below shows various states of the options knob and possible combinations.

If the LAN interface is activated, it is automatically enabled at socket jack X8 ‘GinLink Out’

Knob Position	Emergency System	GinLink Master [1)]	LAN	Default IP	Note
0x0					Standard Slave
0x1		X	X		
0x2		X	X	X	
0x3	X				
0x4			X		Standard Stand-Alone
0x5	X		X		
0x6			X	X	
0x7	X		X	X	
0x8 … 0xF	Reserved				

1) Only SAC4xX with Option PRO support the GinLink Master feature.

8.3. Technical Specifications

8.3.1. General

General Specs		GIN-SAC4xX	
		230 V	400 V
Vibration max		Sine, 10 Hz to 150 Hz, Amplitude 0.075 mm	
Shock max		1 g	
Emitted interference with mains filter		EN 61800-3, Category C2 (Industrial)	
Interference immunity with mains filter		EN 61800-3, second environment (Industrial)	
Electrical safety (electrical clearances)		EN 61800-5-1	
Weight GIN-SAC4x4	kg	7.04	
Weight GIN-SAC4x3	kg	5.70	
Weight GIN-SAC4x2	kg	4.45	
Weight GIN-SAC4x1	kg	3.12	

8.3.1.1 Leakage Current

The Leakage Current of the complete Drive Systems is a combination of these components:

- Leakage Current caused by the supplementary Mains Filter.
- Leakage Current of the SAC4xX, caused by its internal Y-Capacitors.
- Leakage Current caused by the parasitic capacity of the motor cable.
- Leakage Current component with PWM Frequency caused by the parasitic capacity of the motor cable

Typical Leakage Current of an SAC4x4 operated on a 1ph 230V / 50Hz Line

Leakage Current of the SAC4x4, 50 Hz component: 2.0 mA
Leakage Current motor cable per meter, 50 Hz component: 0.012 mA / m
+ Component of the Mains Filter
+ Component with PWM-Frequency

Typical Leakage Current of an SAC4x4 operated on 3ph 400V / 50Hz Mains

Leakage Current of the SAC4x4, 50 Hz component: 1.0 mA
Leakage Current motor cable per meter, 50 Hz component: 0.015 mA / m
+ Component of the Mains Filter
+ Component with PWM-Frequency

Note:
The leakage Current Specification of Mains filter is typically specified on a symmetric 3 phase Mains Voltage. A missing Supply Phase can increase the Leakage Current a lot. This situation can occur by mechanical switches that do not synchronously connect/disconnect all 3 Supply Phases.

8.3.2. Mains Connection and Intermediate Circuit

Rated Data		GIN-SAC4xX	
		230 V	400 V
Rated single-phase connection voltage	V_{AC}	1 x 110$_{-10\%}$ ... 230$_{+10\%}$	1 x 110$_{-10\%}$ ... 400$_{+10\%}$
Rated three-phase connection voltage	V_{AC}	3 x 110$_{-10\%}$ ... 230$_{+10\%}$	3 x 110$_{-10\%}$ ... 400$_{+10\%}$
Rated Power S1 SAC4x4 230V/400V 3ph	kVA	6.5	11.3
Rated Power S1 SAC4x3 230V/400V 3ph	kVA	4.9	8.5
Rated Power S1 SAC4x2 230V/400V 3ph	kVA	3.3	5.7
Rated Power S1 SAC4x1 230V/400V 3ph	kVA	1.7	2.9
DC- Power Off Overvoltage Limit	V_{DC}	400	800
Maximum mains asymmetry		± 3%	
Nominal Mains frequency	Hz	50...60	
Intermediate circuit capacity SAC4x4	µF	3760	940
Intermediate circuit capacity SAC4x3	µF	2820	705
Intermediate circuit capacity SAC4x2	µF	1880	470
Intermediate circuit capacity SAC4x1	µF	940	235
Allowable types of mains Earthed star point		TT, TN	
Power Cycle Duty interval	s	> 10	
External Fuse SAC4x4, max.	AT	25 A	
External Fuse SAC4x3, max.	AT	16 A	
External Fuse SAC4x2, max.	AT	16 A	
External Fuse SAC4x1, max.	AT	16 A	
Switch-on current	A	< 2	
Overvoltage category		III (EN 61800-5-1)	
Maximum Short Circuit Current Rating of Mains Circuit	A	5000	

See section 9.4 on page 128 and section 9.5 on page 129

The SAC4xX Devices require an external Mains-Filter and an external Fuse. The specified current ratings in the table are maximum values.
Depending on the specific target application of the Drive it is valid to use a fuse and filter with lower current rating.

The Device is designed to be operated on Mains Circuit that cannot deliver more than a maximum Short Circuit current of 5000 A.

8.3.3. Output Stage Rated Currents

The tables below show theoretically possible rated and maximum currents of the output stages. The data has been calculated theoretically only. Therefore, each load must always be tested by the user. Especially the environmental conditions specified in section 8.4 should be strictly observed.

Rated Currents		GIN-SAC4x4	
		230 V	400 V
I_{NENN} at 8 kHz PWM frequency	A_{RMS}	22	
I_{MAX} at 8 kHz PWM frequency	A_{RMS}	33	
I_{NENN} at 12 kHz PWM frequency	A_{RMS}	18	
I_{MAX} at 12 kHz PWM frequency	A_{RMS}	27	
I_{NENN} at 16 kHz PWM frequency	A_{RMS}	13	
I_{MAX} at 16 kHz PWM frequency	A_{RMS}	19.2	
I_{NENN} at 24 kHz PWM frequency	A_{RMS}	9	
I_{MAX} at 24 kHz PWM frequency	A_{RMS}	13.5	
I_{NENN} at 32 kHz PWM frequency	A_{RMS}	6	
I_{MAX} at 32 kHz PWM frequency	A_{RMS}	9	
I_{MAX} Ballast IGBT	A	24	
Minimum external ballast resistor	Ω	15	30
Maximum power loss Drive	W	250	

The drives may be operated with I_{MAX} for 5 seconds.

Rated Currents		GIN-SAC4x3	
		230 V	400 V
I_{NENN} at 8 kHz PWM frequency	A_{RMS}	16.5	
I_{MAX} at 8 kHz PWM frequency	A_{RMS}	24.5	
I_{NENN} at 12 kHz PWM frequency	A_{RMS}	13.5	
I_{MAX} at 12 kHz PWM frequency	A_{RMS}	20	
I_{NENN} at 16 kHz PWM frequency	A_{RMS}	10	
I_{MAX} at 16 kHz PWM frequency	A_{RMS}	14.5	
I_{NENN} at 24 kHz PWM frequency	A_{RMS}	6.5	
I_{MAX} at 24 kHz PWM frequency	A_{RMS}	10	
I_{NENN} at 32 kHz PWM frequency	A_{RMS}	4.5	
I_{MAX} at 32 kHz PWM frequency	A_{RMS}	6.75	
I_{MAX} Ballast IGBT	A	24	
Minimum external ballast resistor	Ω	15	30
Maximum power loss Drive	W	185	

The drives may be operated with I_{MAX} for 5 seconds.

Rated Currents		GIN-SAC4x2	
		230 V	400 V
I_{NENN} at 8 kHz PWM frequency	A_{RMS}	11	
I_{MAX} at 8 kHz PWM frequency	A_{RMS}	16.5	
I_{NENN} at 12 kHz PWM frequency	A_{RMS}	9	
I_{MAX} at 12 kHz PWM frequency	A_{RMS}	13.5	
I_{NENN} at 16 kHz PWM frequency	A_{RMS}	6.7	
I_{MAX} at 16 kHz PWM frequency	A_{RMS}	9.6	
I_{NENN} at 24 kHz PWM frequency	A_{RMS}	4.5	
I_{MAX} at 24 kHz PWM frequency	A_{RMS}	6.7	
I_{NENN} at 32 kHz PWM frequency	A_{RMS}	3	
I_{MAX} at 32 kHz PWM frequency	A_{RMS}	5.5	
I_{MAX} Ballast IGBT	A	24	
Minimum external ballast resistor	Ω	15	30
Maximum power loss Drive	W	130	

The drives may be operated with I_{MAX} for 5 seconds.

Rated Currents		GIN-SAC4x1	
		230 V	400 V
I_{NENN} at 8 kHz PWM frequency	A_{RMS}	5.5	
I_{MAX} at 8 kHz PWM frequency	A_{RMS}	8.25	
I_{NENN} at 12 kHz PWM frequency	A_{RMS}	4.5	
I_{MAX} at 12 kHz PWM frequency	A_{RMS}	6.75	
I_{NENN} at 16 kHz PWM frequency	A_{RMS}	3.25	
I_{MAX} at 16 kHz PWM frequency	A_{RMS}	4.8	
I_{NENN} at 24 kHz PWM frequency	A_{RMS}	2.25	
I_{MAX} at 24 kHz PWM frequency	A_{RMS}	3.38	
I_{NENN} at 32 kHz PWM frequency	A_{RMS}	1.5	
I_{MAX} at 32 kHz PWM frequency	A_{RMS}	2.25	
I_{MAX} Ballast IGBT	A	24	
Minimum external ballast resistor	Ω	15	30
Maximum power loss Drive	W	65	

The drives may be operated with I_{MAX} for 5 seconds.

8.3.4. Controller Logic Power Supply

Logic power supply		GIN-SAC4xX	
		230 V	400 V
Operating voltage		24 $V_{DC\ -15\%...+25\%}$ (SELV / PELV)	
External protection	A	8, fast type	
Current consumption	A	< 2 [1)]	
Maximum potential between GND and earth	V_{DC}	50 [2)]	

1) The resulting current consumption depends on the additional connected Components like Feedback Systems and Load on Safety-Outputs.
2) It is recommended to connect GND to Earth at the Power Supply Output

See section 9.6 on page 129.

8.3.5. Motor

Motor		GIN-SAC4xX	
		230 V	400 V
Minimum inductance ph-ph	mH	1	
Minimum resistance ph-ph	Ω	0.2	
Maximum line length without Choke	m	20	
Motor cable		shielded	
Minimum motor rated voltage	V	325	565
Supported types of motor		• DC motors (not for dangerous axes) • Synchronous servo motors • Synchronous linear servo motors • Asynchronous brushless motors	

See section 9.3 on page 126.

DC motors must not be used with the GIN-SAC4xX FS in axes for safety applications understood as functional safety.

For motors with integrated encoders, all the safety requirements specified in section 5.9 on page 53 apply provided that they are used for safe encoder evaluation.

8.3.6. Feedbacks

8.3.6.1 SinCos

Sin/Cos Interface		GIN-SAC4xX	
		230 V	400 V
Level	V_{RMS}	1	
Differential input resistance	Ω	120	
Maximum input frequency	kHz	200	
Minimum input frequency for safely-limited speed (SLS)	Hz	1	
5V output maximum current load	mA	200	
12V output maximum current load	mA	200	
Analogue input resolution	Bit	16	
Analogue input processing	Bit	12	
Power cable		double shielded, pair twisted	

See section 9.10.1 on page 132

8.3.6.2 Resolver

Resolver Interface		GIN-SAC4xX	
		230 V	400 V
Generator output voltage level	V_{RMS}	4	
Sine/cosine input voltage level	V_{RMS}	2	
Maximum input frequency *	kHz	1	
Minimum input frequency* for safely-limited speed (SLS)	Hz	1	
Analogue input resolution	Bit	16	
Analogue input processing	Bit	16	
Multipolar resolver		yes	
Connection cable		double shielded, pair twisted	

* Input frequency := rotational frequency × number of pool pairs

See section 9.10.2 on page 133.

8.3.6.3 Incremental Encoder

Incremental encoder at the absolute value Interface		GIN-SAC4xX 230 V	GIN-SAC4xX 400 V
Level		RS422	
Input resistance	Ω	120	
Maximum input frequency	MHz	2.5	
5V output maximum current load	mA	200	
12V output maximum current load	mA	200	
Connection Cable		shielded	

See section 9.10.3.1 on page 134.

Incremental encoder at the sin/cos interface		GIN-SAC4xX 230 V	GIN-SAC4xX 400 V
Level		RS422	
Input resistance	Ω	120	
Maximum input frequency	kHz	200	
5V output maximum current load	mA	200	
12V output maximum current load	mA	200	
Connection Cable		shielded	

See section 9.10.3.2 on page 135.

Digital incremental encoders must not be used for safe encoder evaluation. Digital incremental encoders may only be used as additional encoders for the functional system.

8.3.6.4 Absolute value Feedback

The following absolute value feedback systems are supported by the SAC4xX:

- Hiperface See section 9.10.4.1 on page 137
- EnDat 2.1 See section 9.10.4.2 on page 138
- SSI See section 9.10.4.3 on page 139
- BissC See section 9.10.4.3 on page 139
- EnDat 2.2 See section 9.10.4.3 on page 139

Absolute value feedback systems must not be used for safe encoder evaluation. Absolute value feedback systems may only be used as additional encoders for the functional system. If an absolute value feedback is implemented in combination with an analogue sin/cos encoder, the sine/cosine part is subject to the requirements specified in section 5.9 on page 53.

8.3.7. Digital I/Os

Digital Inputs		GIN-SAC4xX	
		230 V	400 V
Input voltage	V_{DC}	$24_{\pm 25\%}$	
Switching threshold	V_{DC}	12	
Analogue input filter	kHz	3	
Input Current at High State	mA	2	

⇨ See section 9.7.1 on page 130.

Digital Outputs		GIN-SAC4xX	
		230 V	400 V
Maximum output current	A	1	
External power supply rated voltage	V_{DC}	$24_{\pm 25\%}$	
Switching delay	ms	0.5	

⇨ See section 9.7.2 on page 130.

8.4. Environmental Conditions

It is the user's responsibility to observe the environmental conditions. Indel disclaims all liability in case of failure to do so.

Ambient temperature during storage	°C	-20…85
Relative humidity during storage, without condensation		95%
Ambient temperature during operation	°C	0…40
Relative humidity during operation, without condensation		80%
Maximum heat sink temperature	°C	80
GIN-SAC4xX ingress protection		IP20
Control cabinet ingress protection		IP54
Installation position		vertical
Allowable installation height without drive capacity reduction	m a.s.l.	1000
Allowable installation height with drive capacity reduction	m a.s.l.	3000 -1.0% / 100m
Pollution Degree		2 (EN 50178)
Overvoltage category		III (EN 61800-5-1)

Series GIN-SAC4xX FS Indel drives must be integrated into an IP54 compliant control cabinet.

8.5. Notes according US-Market

The SAC4xX Servo Drives are **NOT** UL-Certified at the Moment.

The SAC4 Drives went through an IEC CB-Scheme Type examination and fulfil the requirements of the IEC 61800-5-1 product standard. The Type examination was done by TüV Süd. The Certificate is attached in section **Fehler! Verweisquelle konnte nicht gefunden werden.** on page **Fehler! Textmarke nicht definiert.**.

The special requirements of the UL 61800-5-1 were also included into the type examination. The SAC4xX drives technically fulfil the requirements of the UL 61800-5-1 standard.

On request, INDEL can deliver the relevant parts of the SAC4xX Type examination report as Confirmation.

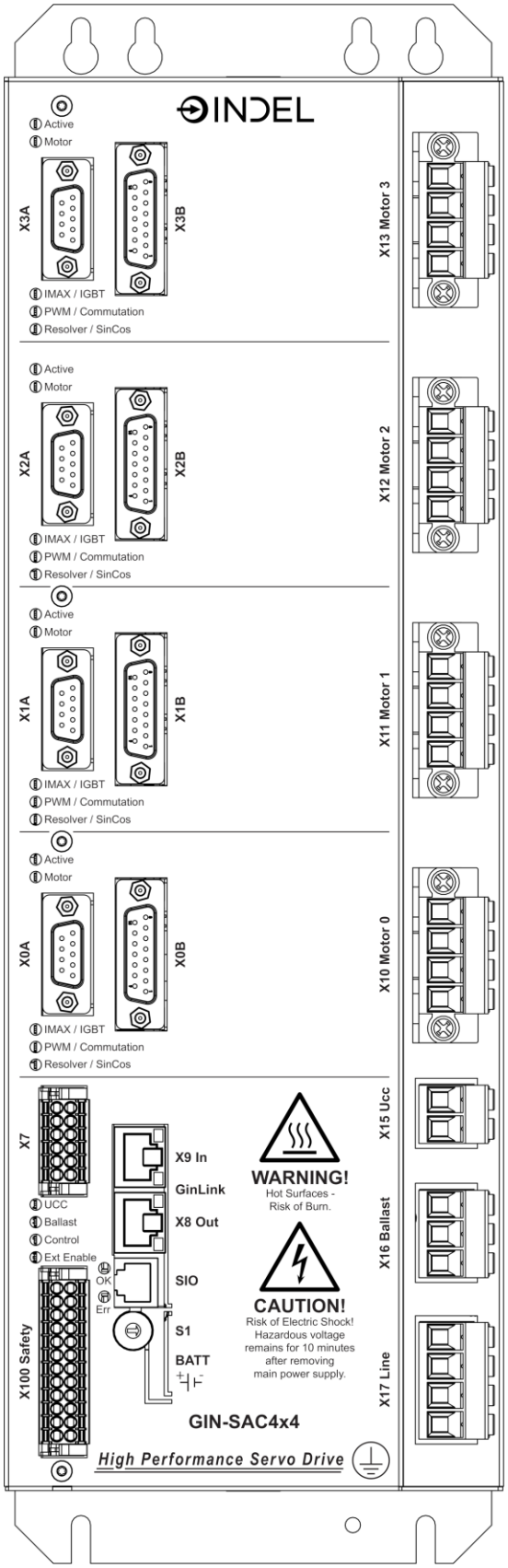
9. Electrical installation

9.1. Notes

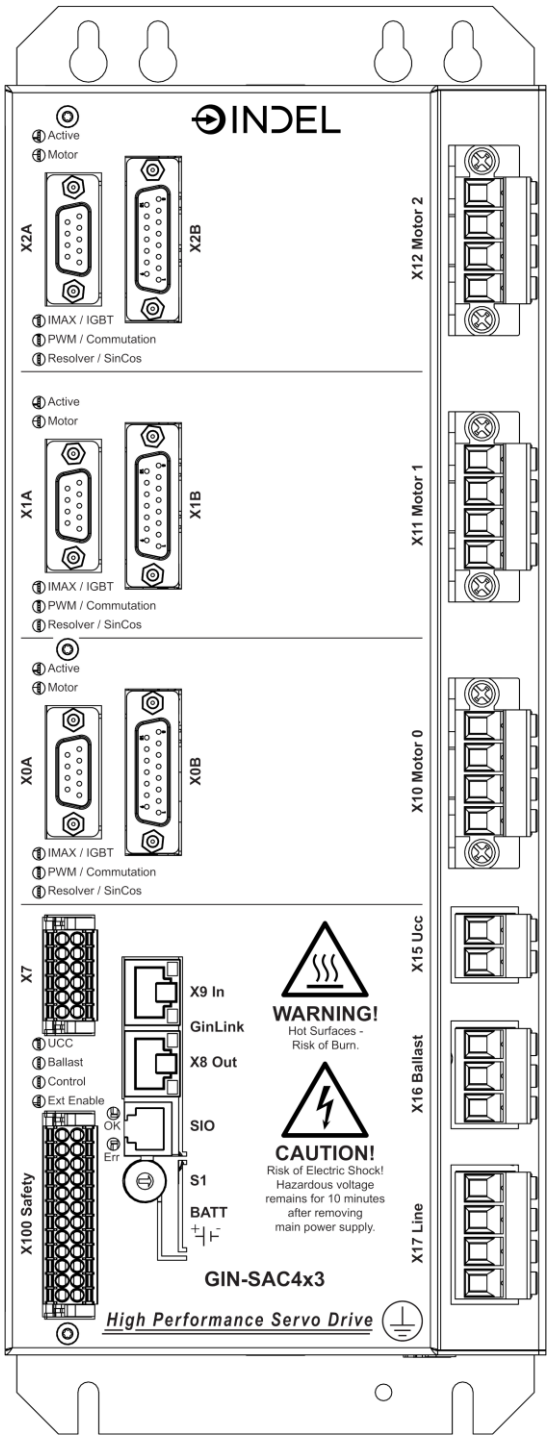
- **The wiring of the drive should take into account the protection of the control cabinet against inadvertent restart.**
- **Applicable national accident prevention regulations should be observed.**
- **The electrical wiring should be installed in accordance with applicable national and international regulations (wire colours, cross-sections, fuses, protective conductor terminal, etc.)**

9.2. SAC4xX Pin Assignment

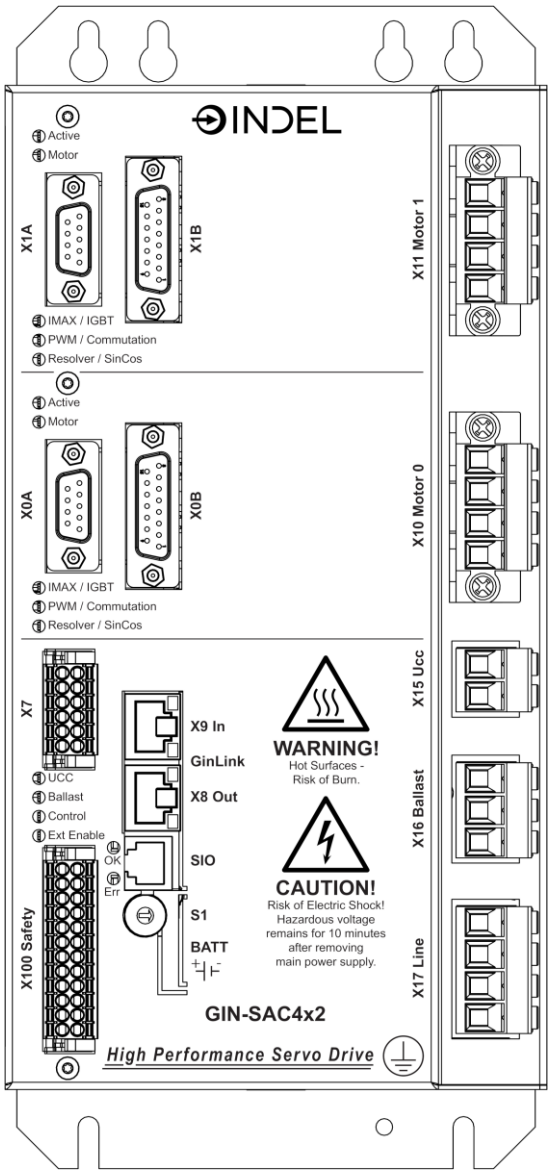
9.2.1. Overview of the GIN-SAC4x4



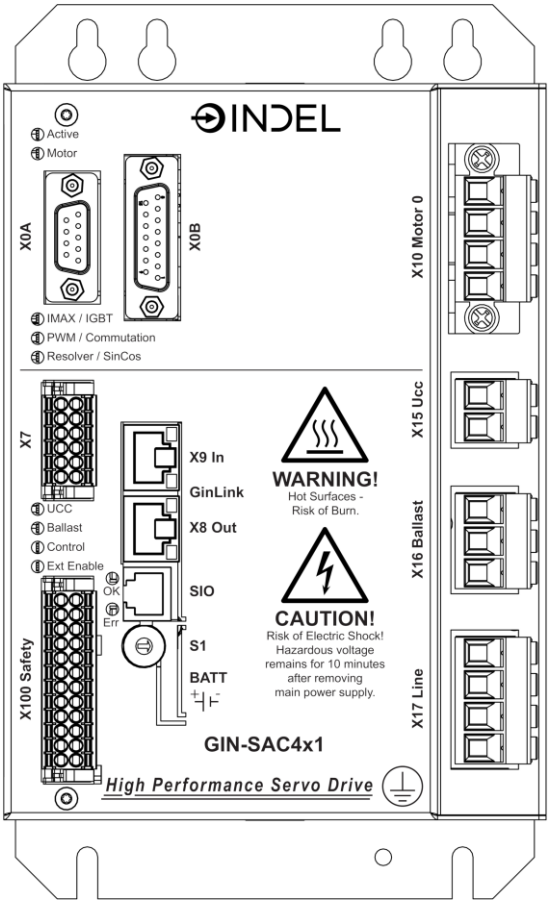
9.2.2. Overview of the GIN-SAC4x3



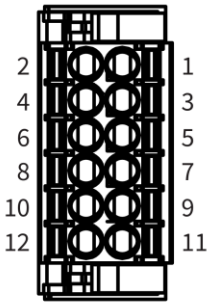
9.2.3. Overview of the GIN-SAC4x2



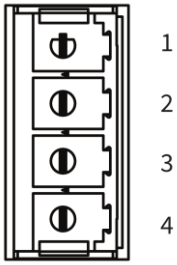
9.2.4. Overview of the GIN-SAC4x1



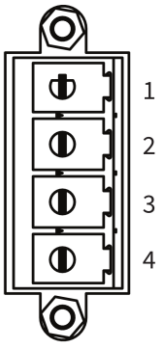
9.2.5. Logic Power Supply / Digital IOs

Connector Name	Figure	Pin No.	Pin Description
X7		1	24 V (Main PWR Supply)
		2	GND
		3	DIN 3
		4	DIN 2
		5	DIN 1
		6	DIN 0 / ext. Enable
		7	DOUT 3
		8	DOUT 2
		9	DOUT 1
		10	DOUT 0
		11	VCC DOUT (DOUT Supply)
		12	GND DOUT

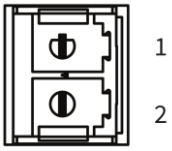
9.2.6. Mains Connection

Connector Name	Figure	Pin No.	Pin Description
X17 Line		1	PE
		2	L1
		3	L2
		4	L3

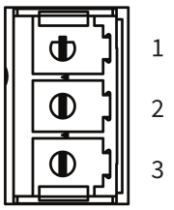
9.2.7. Motor Connections

Connector Name	Figure	Pin-No.	Pin Description
X10 Motor 0 X11 Motor 1 X12 Motor 2 X13 Motor 3		1	W
		2	V
		3	U
		4	PE

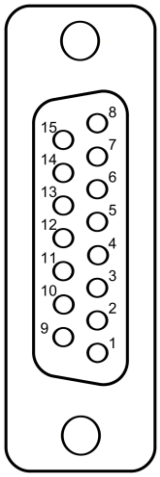
9.2.8. Intermediate Circuit Voltage

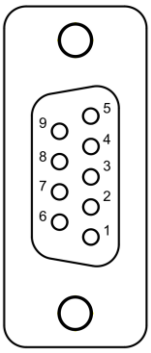
Connector Name	Figure	Pin No.	Pin Description
X15 UCC		1	DC +
		2	DC -

9.2.9. Ballast Resistor

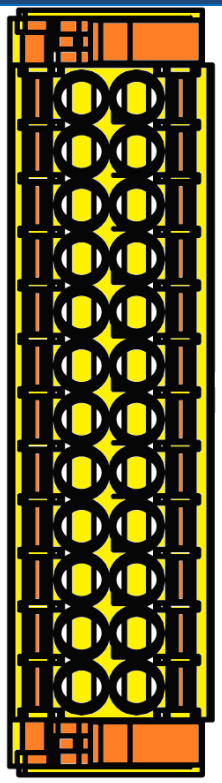
Connector Name	Figure	Pin No.	Pin Description
X16 Ballast		1	PE
		2	RB -
		3	RB +

9.2.10. Feedback Interfaces

Connector Name	Figure	Pin No.	Pin Description
X0B X1B X2B X3B		1	Sin+ (SinCos)
		2	GND
		3	Cos+ (SinCos)
		4	+12V
		5	Data+ (RS422)
		6	Ref+ (RS422)
		7	MTmp
		8	CLK - (RS422)
		9	Sin- (SinCos)
		10	GND
		11	Cos- (SinCos)
		12	+5V
		13	Data- (RS422)
		14	Ref- (RS422)
		15	Clk+ (RS422)

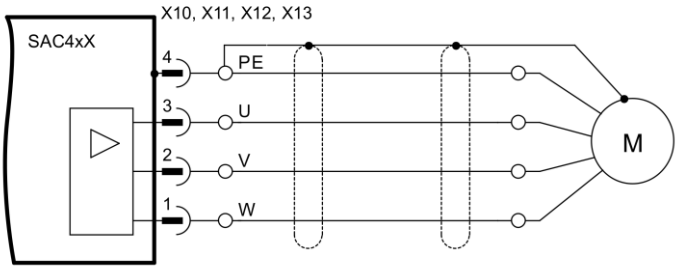
Connector Name	Figure	Pin No.	Pin Description
X0A Resolver 0 X1A Resolver 1 X2A Resolver 2 X3A Resolver 3		1	Shield / Schirm
		2	MTmp+
		3	Cos + (Resolver)
		4	Sin + (Resolver)
		5	Ref+ (Resolver)
		6	MTmp-
		7	Cos- (Resolver)
		8	Sin- (Resolver)
		9	Ref- (Resolver)

9.2.11. Safety

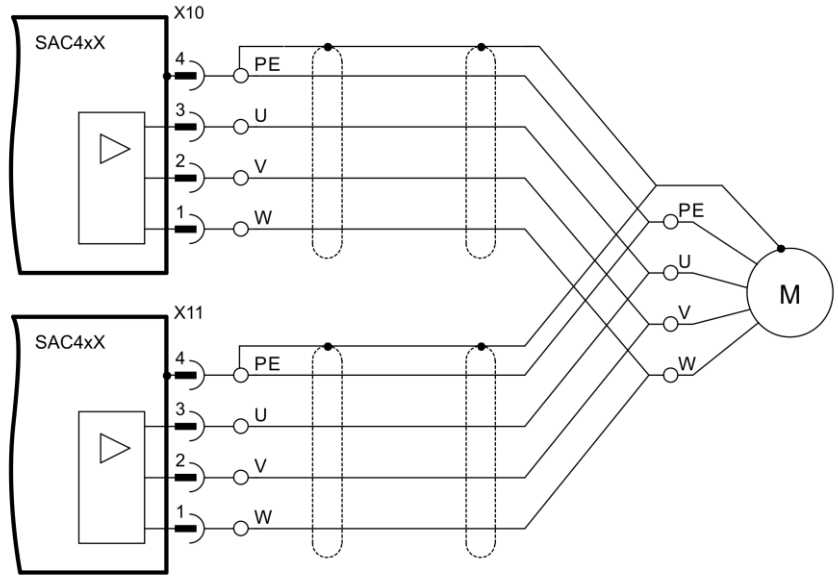
Connector Name	Pin Description	Figure / Pins			Pin Description
X100					
	SafeInp0A-	2		1	SafeInp0A+
	Gnd	4		3	Gnd
	SafeInp0B-	6		5	SafeInp0B+
	SafeInp1B	8		7	SafeInp1A
	SafeInp2A	10		9	SafeInp2B
	SafeInp3B	12		11	SafeInp3A
	Gnd	14		13	Gnd
	K2	16		15	K1
	Gnd	18		17	Gnd
	PulseOutB	20		19	PulseOutA
	Gnd	22		21	Gnd
	SafeOutB	24		23	SafeOutA

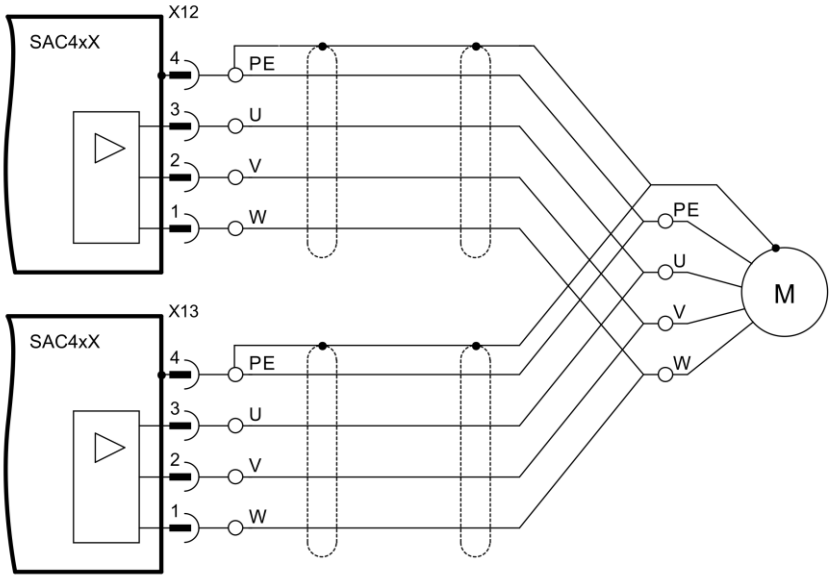
9.3. Motor Connections

9.3.1. Three-Phase Motor to an Output Stage

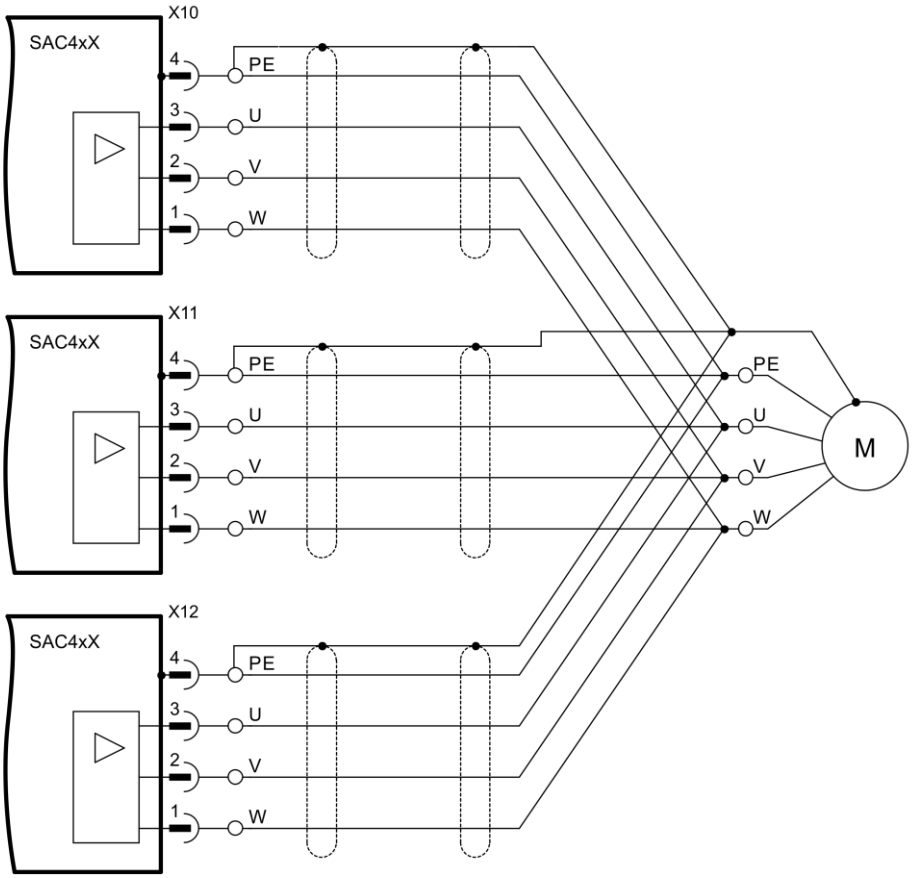


9.3.2. Three-Phasen Motor to Two parallel output Stages

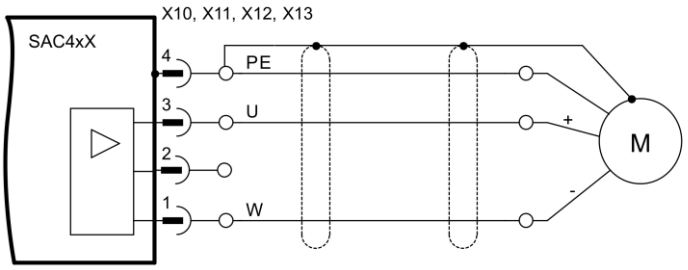




9.3.3. Three-Phase Motor to three parallel output Stages



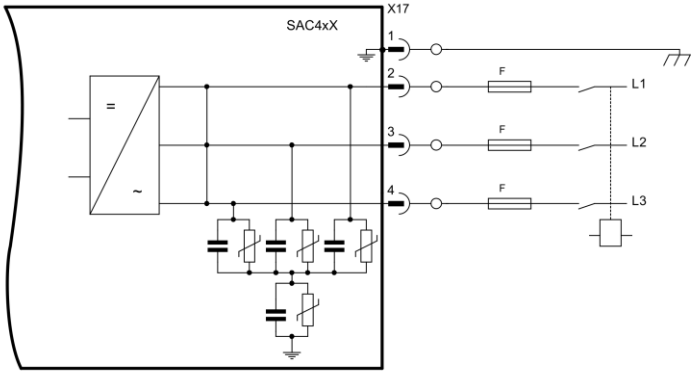
9.3.4. DC-Motor to an Output Stage



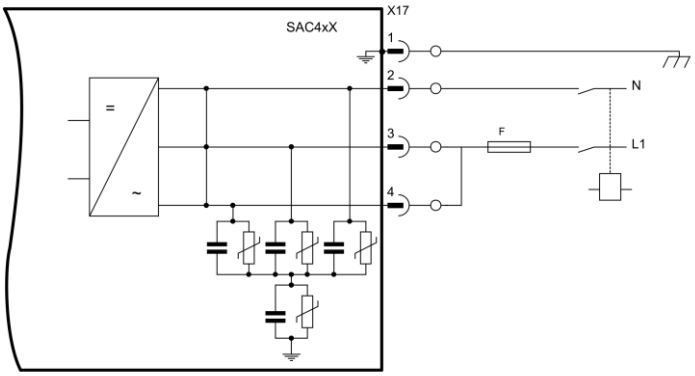
DANGER	DC motors must not be used in the GIN-SAC4xX FS‘s axes for safety applications in terms of functional safety.

9.4. Mains Connection

- Three phase Mains Supply
- Suitable for the GIN-SAC4xX FS/400V



- One-phase Mains Supply
- Suitable for the GIN-SAC4xX FS/230V



An external Fuse and external Mains Filter is necessary for operation. See Section 8.3.2 page 110.

9.5. Intermediate Circuit

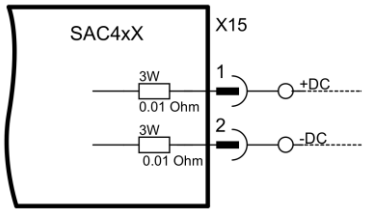
The drive's intermediate circuit power supply is connected to the X15 connector. Thus, intermediate circuits of multiple GIN-SAC4x4 drives can be connected in parallel to share the available DC Capacitors. However, this is allowable only if the mains power supply of all drives is identical. Otherwise, the drives could become damaged. For drives supplied with single-phase power, all drives must be supplied with the same phase. Otherwise, the intermediate circuit voltage could go up and damage the drives due to overvoltage.

ATTENTION

Considering the capacity of intermediate circuits, a maximum of four GIN-SAC4xX drives can be connected in parallel. Otherwise, the switch-on current becomes too high, leaving external contactors glued together or destroyed.

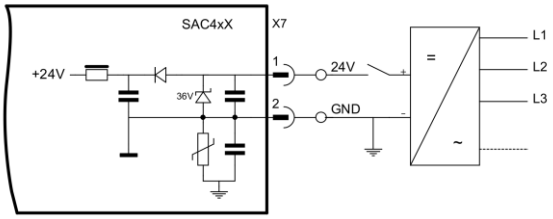
There are two internal resistors to limit equalising currents.

- Parallel connection of intermediate circuits in GIN-SAC4xX drives
- Connection of extra external capacity in case the capacity of an intermediate circuit is not high enough for acceleration phases
- Power supply of intermediate circuits via external DC Power supply



9.6. Logic power supply

To be operational, servo drives need to be supplied with 24V logic voltage, which powers the GIN-SAC4x4 FS's internal electronics, digital outputs and connected encoders.



In case the 24V Power Supply is able to source more than 8 A, a 8 A fuse (or less) is needed. See Section 8.3.4 on page 113.

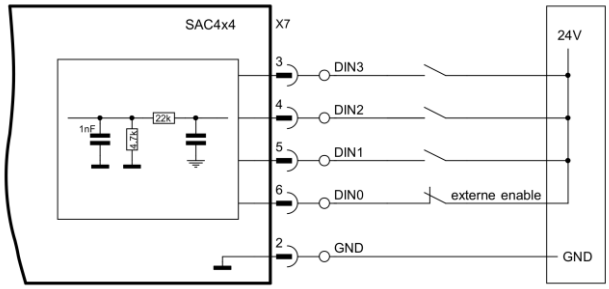
DANGER	Only 24V power supply units that are PELV/SELV compliant under the EN 50178 and EN 60204 standards may be used so that the electrical values for low voltage with safe separation on the safety modules are not exceeded.

9.7. Standard Digital Inputs and Outputs

9.7.1. Inputs

The non-safe digital inputs can be used as additional external Enable to disable the servo drive from outside. If an emergency stop brake ramp is set up, it is triggered once the Enable input is disabled and the motor decelerates.

- DIN0 is used as external Enable for all of the drive's axes
- The reference earth is GND
- No use as a general purpose input

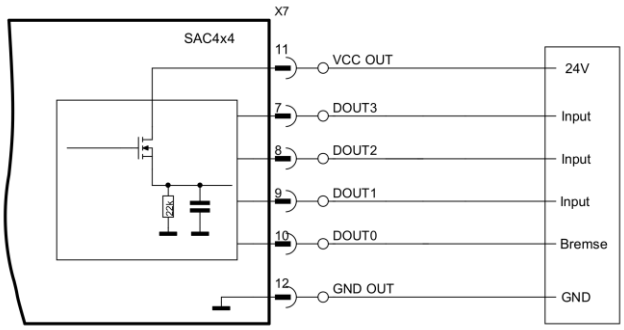


ATTENTION	The maximum allowable cable length of the digital inputs is 30 metres. In case of longer cables, some additional measures must be taken (e.g. a filter) to eliminate interference.

9.7.2. Outputs

The non-safe digital outputs are designed as high-side drivers. The internal FETs are supplied with external 24V power. Power Supply is connected to the VCC_Out Pin.

- Output is configurable to control a holding brake.
- Output is configurable to show reduced current mode State.
- Free assignment between Axis Number and Output Number.
- In parallel the Outputs can be controlled as General Purpose Outputs. (OR-Function).
- The reference earth is GND OUT.



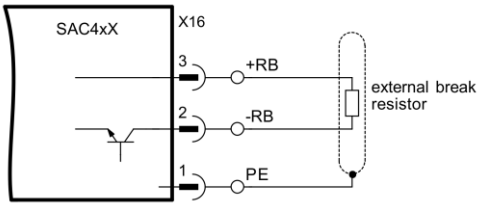
ATTENTION	The maximum allowable cable length of the digital outputs is 30 metres. If longer cables are used, additional measures (such as filters) must be taken to sup-press interference. The selection of such measures is subject to a security assessment.

9.8. Safe Digital Inputs and Outputs

For routing of the safe digital inputs and outputs, the instructions contained in section 5 should be followed.

9.9. External Brake Resistor, aka Ballast Resistor

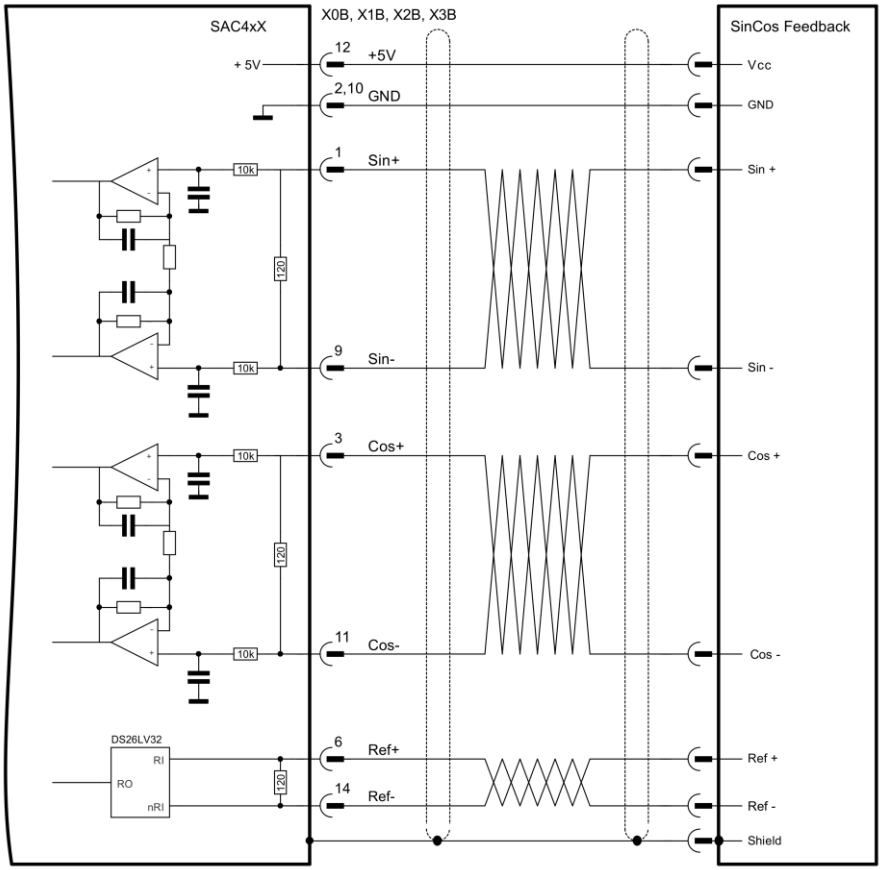
When motors are decelerated, the dynamic energy flows back to the intermediate circuit capacitors. This increases the intermediate circuit voltage. An external brake resistor can be connected to discharge the brake energy and keep the voltage in a safe range.



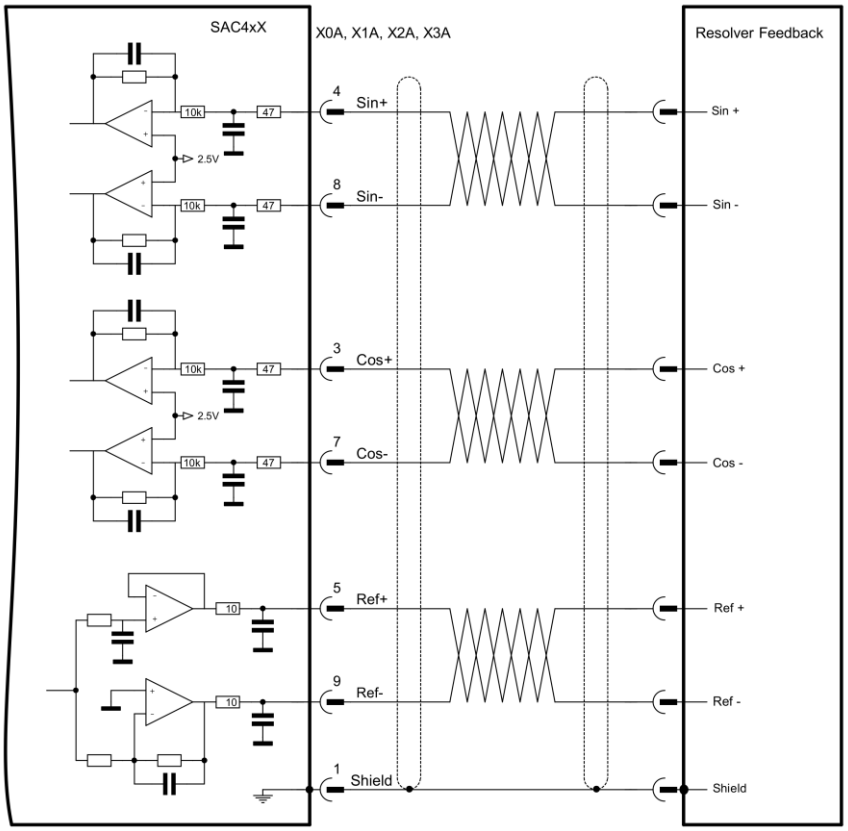
9.10. Feedbacks

9.10.1. SinCos Feedback

- Connection of a standard Sin/cos feedback with 1 V_{RMS} Signal levels
- Power supply of the position encoder via the servo drive
- 16bit ADC resolution of position signals
- Use of 12bit, i.e. 4096 values per sine or cosine periode



9.10.2. Resolver Feedback



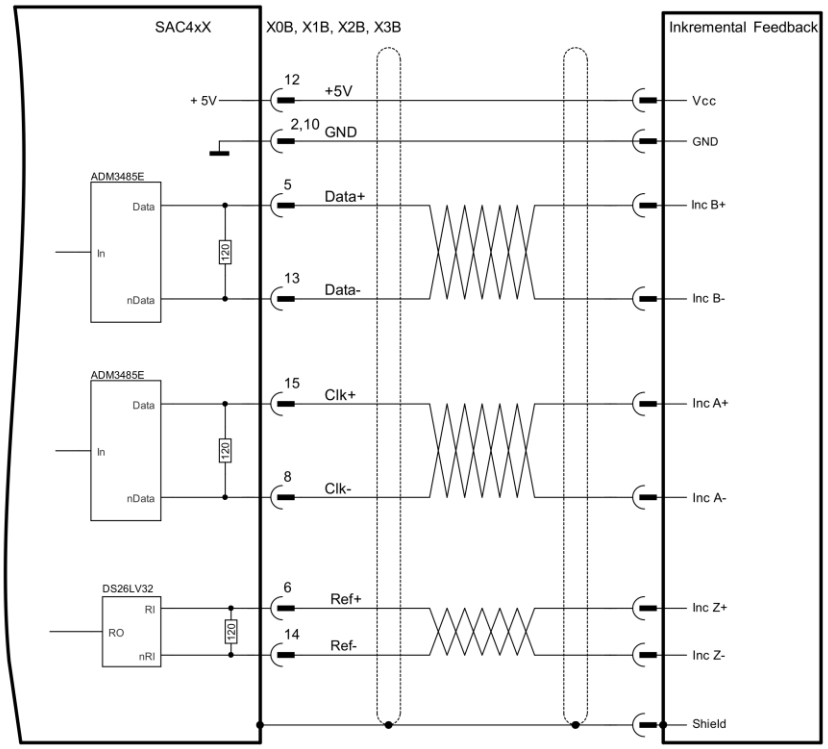
9.10.3. Incremental Encoder Feedback

Incremental encoders can be connected to the servo drive in two different ways: via the sin/cos and the absolute value interfaces. The difference here lies in the signal sampling rate, and consequently in the maximum possible signal frequency of the incremental encoder. Depending on the resolution and occurring velocities, the maximum values are exceeded.

If possible, it is recommended to connect the incremental encoder always to the absolute value feedback.

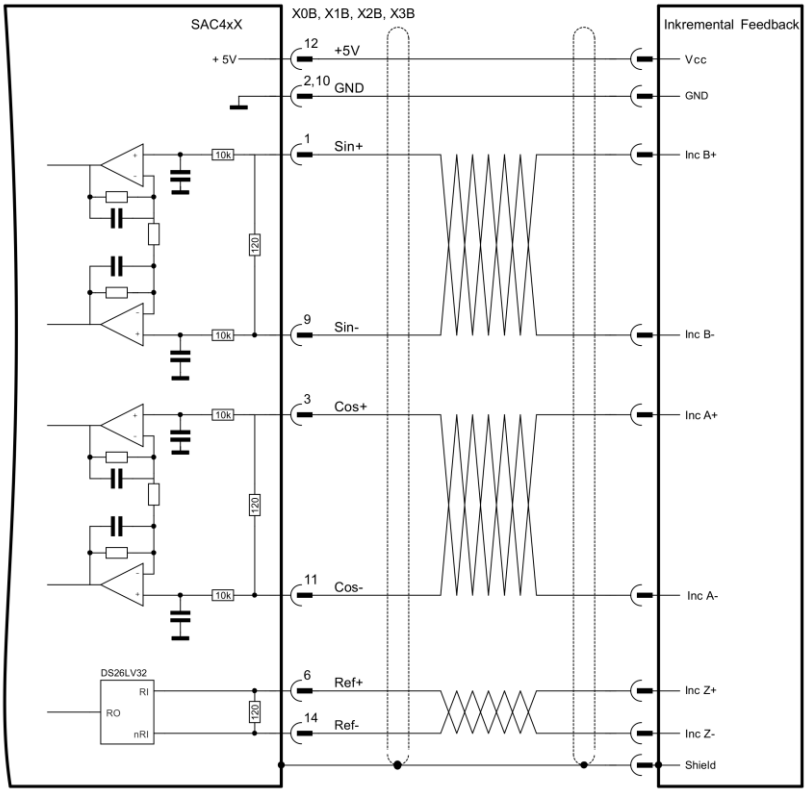
9.10.3.1 Connection to an absolute value Interface

- Maximum output signal limit frequency is 2.5MHz
- RS422 standard with a 120Ω termination resistor
- Connection of single-ended incremental encoders – see section 9.10.3.3 on page 136.



9.10.3.2 Connection to a sin/cos interface

- Maximum input signal limit frequency is 200kHz
- RS422 standard with a 120Ω termination resistor
- Connection of single-ended incremental encoders – see section 9.10.3.3 on page 136.

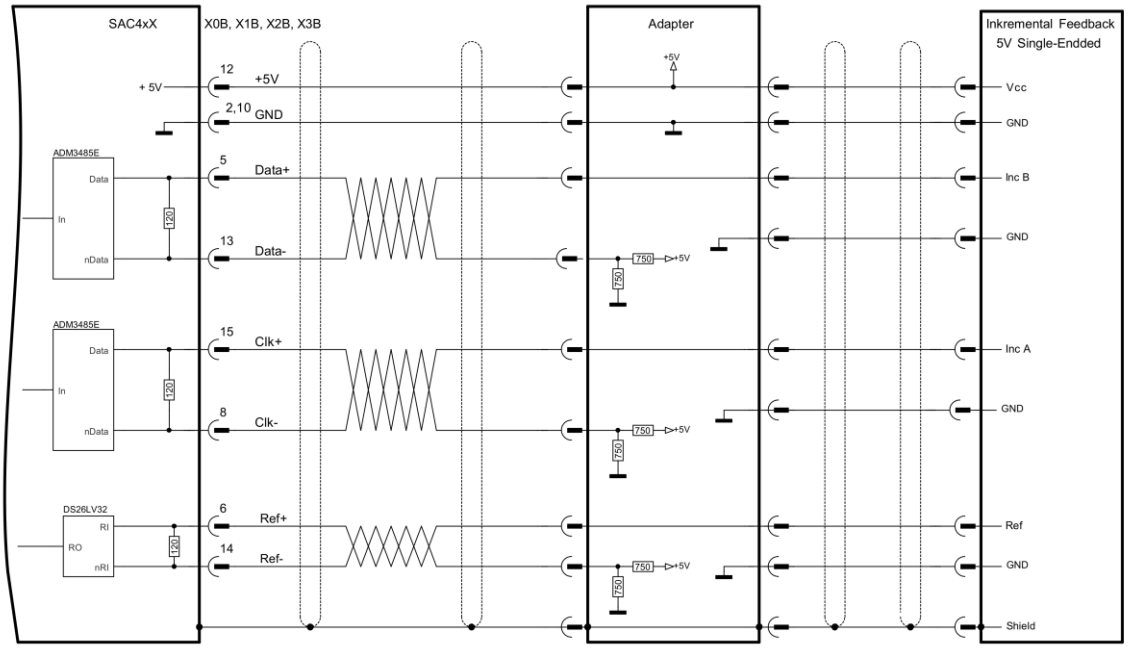


9.10.3.3 Connection to a single-ended incremental encoder

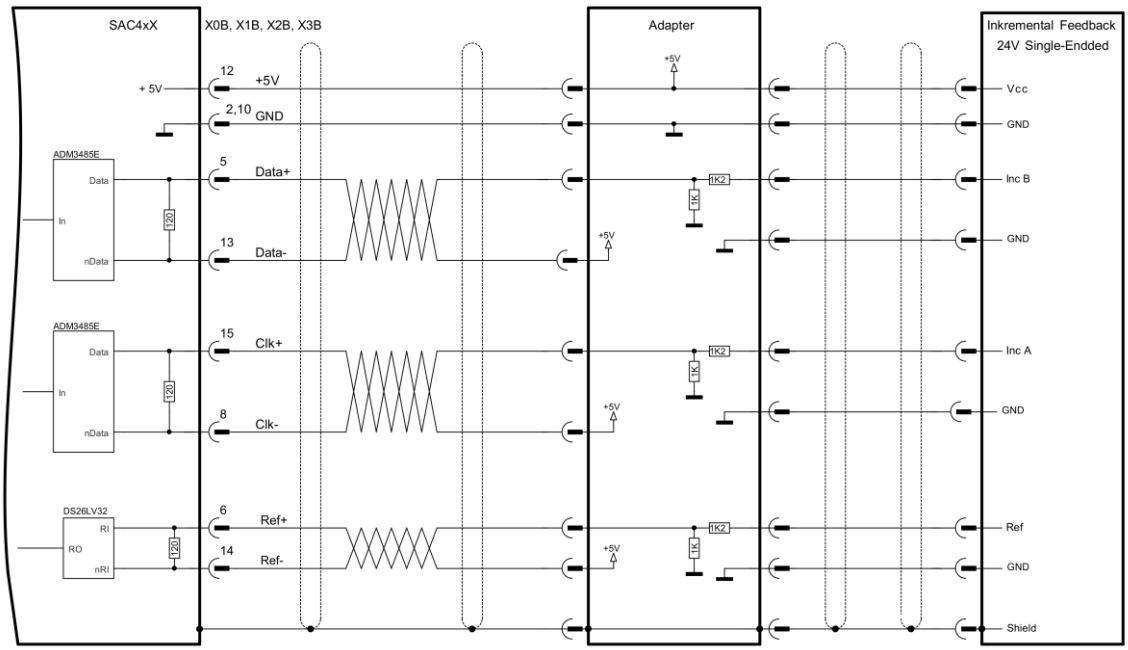
Before connecting incremental encoders with a single-ended interface, you should install a level adjustment. Thus such an encoder can also be used with the absolute value-Interface. For example, the adapter can be integrated into the connector. The encoder must be capable of supplying enough pow-er for the 120Ω termination resistor.

Indel recommends using differential incremental encoders with an RS422 interface compliant with today's industry standard.

- Connection of a 5V single-ended incremental encoder



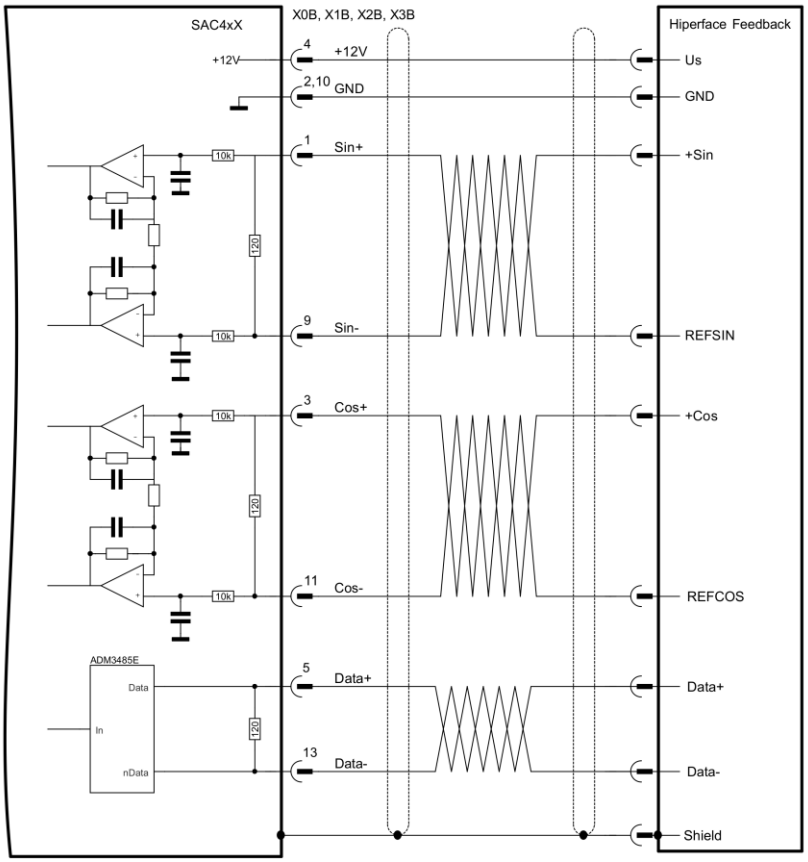
- Connection of a 24V single-ended incremental encoder



9.10.4. Absolute Value Feedbacks

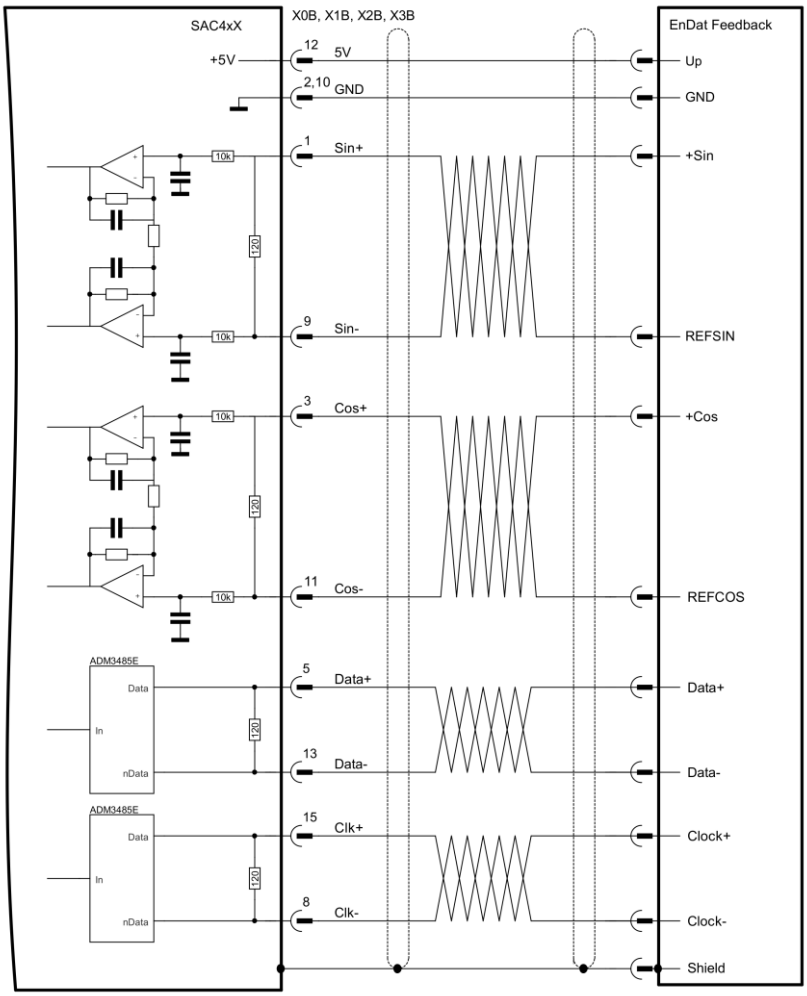
9.10.4.1 Hiperface

- Support of single- and multi-turn encoders
- 16bit ADC resolution measurement of analogue signals
- Use of 12bit, i.e. 4096 values per sine or cosine vibration
- Data line compliant with the RS422/RS485 standard
- Direct power supply of the encoder with 12V voltage

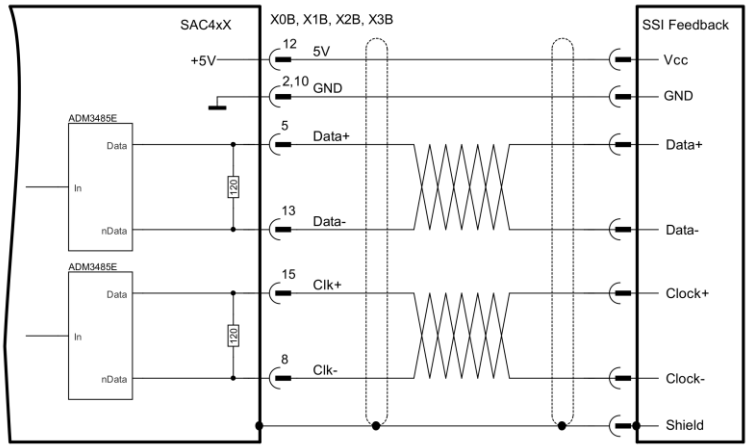


9.10.4.2 EnDat 2.1

- Support of single- and multi-turn encoders
- 16bit ADC measurement of analogue signals
- Use of 12bit, i.e. 4096 values per sine or cosine vibration
- Data and clock line compliant with the RS422/RS485 standard
- Direct power supply of the encoder with 5V voltage



9.10.4.3 SSI / Biss C / EnDat 2.2

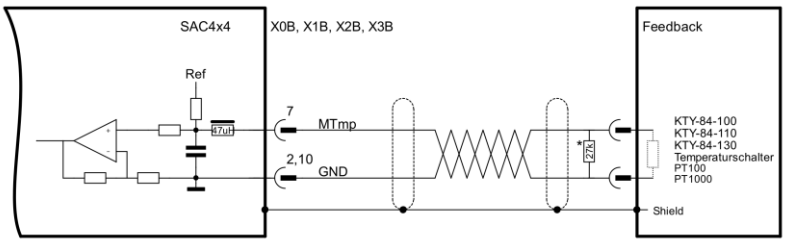


9.10.5. Temperature Sensors

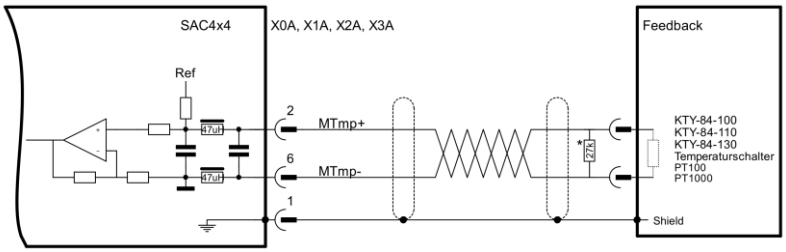
Motors' temperature sensors can be connected directly to the feedbacks.

Temperature sensors built into motor conduits must not be wired to the feedback socket jacks. The insulation class of the socket jacks allows a maximum of 50V.
The sensor needs to be isolated against the motor wires with Double or Reinforced Isolation.

- Connection to feedbacks X1B, X2B, X3B and X4B



- Connection to feedbacks X1A, X2A, X3A and X4A



* In Case a KTY-84-130 Sensor is used, a 27 kΩ Resistor must be connected in parallel.
For the other specified Sensor Types the resistor is not needed.

9.11. Power Supply

9.11.1. Logic Power Supply

For the logic power supply of servo drives, an adjustable 24V power supply unit with sufficient power reserves is recommended. In addition, appropriate mains filters must be used.

For safety-related 24V power supply, the maximum current must be limited to 6A. In case of power failure of the 24V power supply, the motor can coast uncontrolled to a stop. If this uncontrolled coast to a stop is not allowable, external measures must be taken to handle this situation.

Only 24V power supply units that are PELV/SELV compliant under the EN 50178 and EN 60204 standards may be used so that the electrical values for extra low voltage with safe separation on the safety modules are not exceeded.

9.11.2. Mains Connection

Indel Servo Drives may only be operated in earthed TN and TT networks.

The use of delta networks (TN-S networks with earthed phase) or IT networks (insulated earth) is forbidden. Every operation outside TN or TT requires an isolating transformer, with the secondary star point having to be earthed.

An external Mains Filter and Fuse must be provided for operation.

The mains power supply must be provided with a filter so that the EMC limits for emitted interference and interference immunity under EN61800-3 (industrial environment) could be complied with.

The emitted interference of a machine is a combination of all included components. The main factors are the motors, the length and parasitic Capacitance of the Motor cables and the quality of the cable shield earthing and the load on the Indel Servo-Controller.

The use may require emission measurements to ensure compliance with applicable product standards.

9.12. Wiring

9.12.1. GIN-SAC4x4 Wire Cross-Sections

The wire cross-sections should be regarded as references, and always adapted to the prevailing conditions such as cable length and capacity.

Connection	Cross-Section	Type
Mains power supply	4 mm^2	600V, 105°C
DC intermediate circuit brake resistor	4 mm^2	600V, 105°C, shielded
Motor cables up to 20m	2.5 mm^2	600V, 105°C, shielded, capacity ‹ 150 pF/m
Resolver	0.25 mm^2	Double shielded, pair twisted, capacity ‹ 120pF/m
SinCos	0.25 mm^2	Double shielded pair twisted, capacity ‹ 120pF/m
Encoder	0.25 mm^2	Shielded, pair twisted, capacity ‹ 120pF/m
Holding brake	0.75 mm^2	600V, 105°C, shielded
Logic power supply	Up to 2.5 mm^2	60 V
Digital I/Os	Up to 2.5 mm^2	60 V

9.12.2. Routing of Motor Cables

Motor cables must be routed separated from the signal and the mains cables. They must not run over terminals. If a connector is necessary, shielded metal plug connectors can be used. Motor cables must be shielded. The shield of motor cables must be installed in the connector so that all-around contact is ensured.

See also the documentations: INDEL Wire Routing Guide and INDEL Installation Guide.

9.12.3. Routing of the Safe Inputs and Outputs Cables

For the routing of the safe digital inputs and outputs, please follow the safety instructions shown in section 5.

9.12.4. Routing of Sin/Cos, Incremental and Resolver Cables

Resolver and sin/cos feedback signals are extremely prone to interference. This is why such wires should be laid in pair twisted and double shielded cables. Incremental encodes must be wired with shielded cables. The shield must always be provided on both sides.

No encoder cables must be separated to access the control cabinet via terminals. The D-SUB connectors of encoder cables must be screwed to the servo drive. The shield must be attached to metal connector housings.

9.12.5. Potential Equalisation

All shields must always be provided on both sides. To prevent any undesired current leakage over the shield an equipotential bonding conductor should be provided if necessary. Especially in case of larger distances or various power supply systems. See also: Indel Wire Routing Guide.

9.12.6. Connection of the Protective Earth Wire

The earth wire must be routed in accordance with EN 61800-5-1.

Cross-Section of the Mains Wires [mm²]	Minimum Cross-Section of the Relevant Earth Wire [mm²]
S ≤ 16	S
16 < S ≤ 35	16
35 < S	S / 2

9.13. Motor Overload Protection

The motor must be protected by the user against overload. Motors are additionally protected against overload by means of temperature sensors. It is the user's responsibility to apply this type of overload protection.

The motor overload protection is not functionally secured.

9.13.1. I²t Motor Protection

An additional motor overload protection is provided by the I2t cut-off. More details can be found in the start-up manual.

9.13.2. Brake Resistor aka Ballast Resistor

The brake resistor must be protected against thermal overload. Voltages of up to 800V may occur across the brake resistor. The brake resistor must be designed to contain them.

	The brake resistor controller is not functionally secured.

	The brake resistor must be connected with a shielded cable of the required wire cross-section, which depends on the maximum braking efficiency applied.

10. Mechanical Installation

10.1. Notes

The following instructions need to be followed and observed by the user.

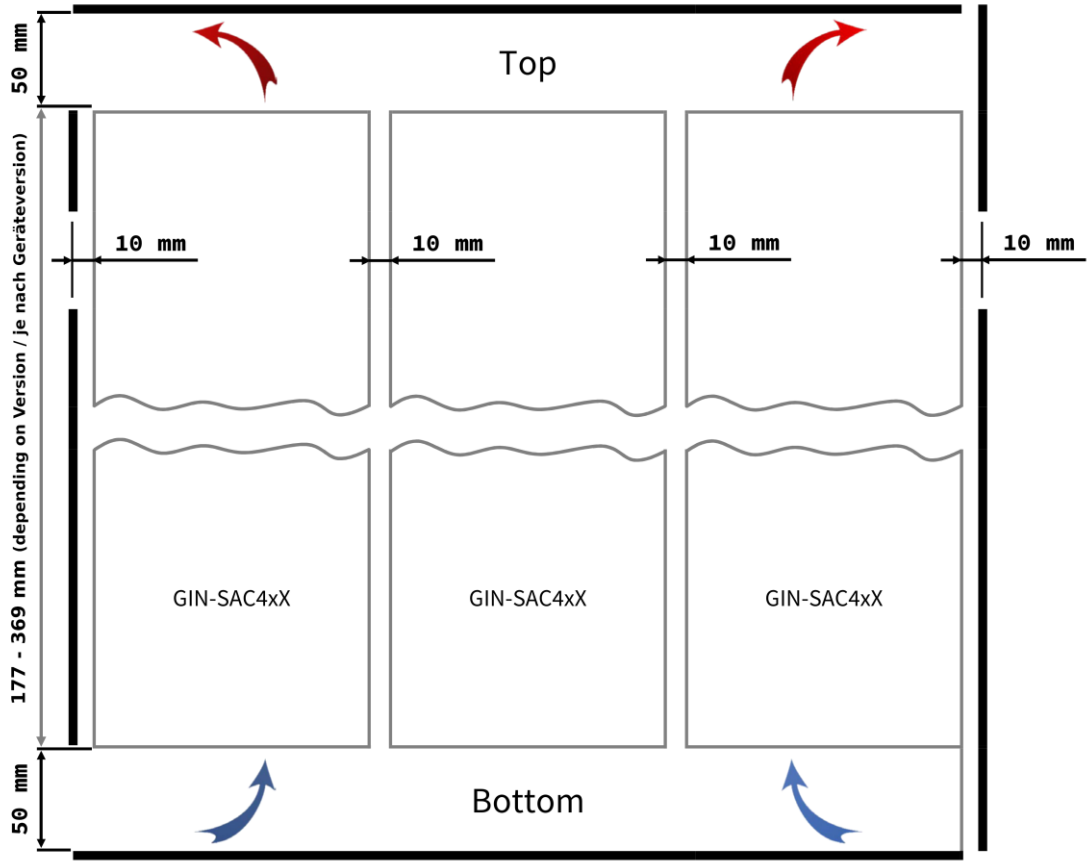
- The installation must be carried out using appropriate tools.
- Equipment may be installed only if it is deenergised.
- It should be made sure that sufficient cooling air is supplied from below the control cabinet.
- The supply air must be filtered so that no dirt particles could penetrate the drives.

If cooling units are used, the following should be observed:

- It should be made sure that cold air ejected by cooling units is not blown directly onto the servo Drives.
- Condensate from cooling units must not trickle into the control cabinet.
- Condensate from cooling units must not drip onto electrical or electronic components.

10.2. Installation Instructions

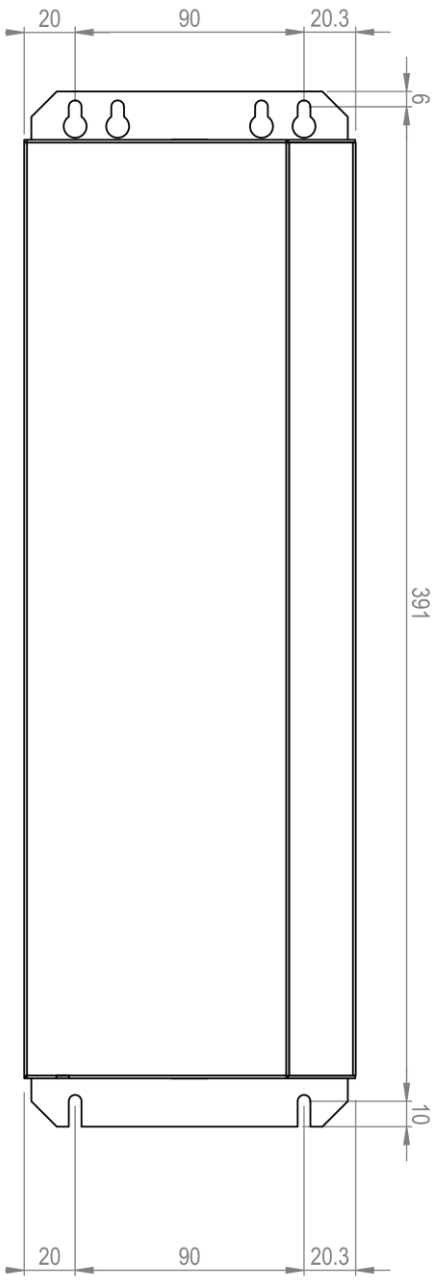
During operation, attention should be paid to sufficient cooling or ventilation of the drives. The environmental conditions specified in section 8.4 should be ensured. The drives must necessarily be installed in vertical position. Heat discharged by the drives is blown away by two integrated fans upwards. The minimum distances specified in the figure below should be observed.



10.3. GIN-SAC4x4

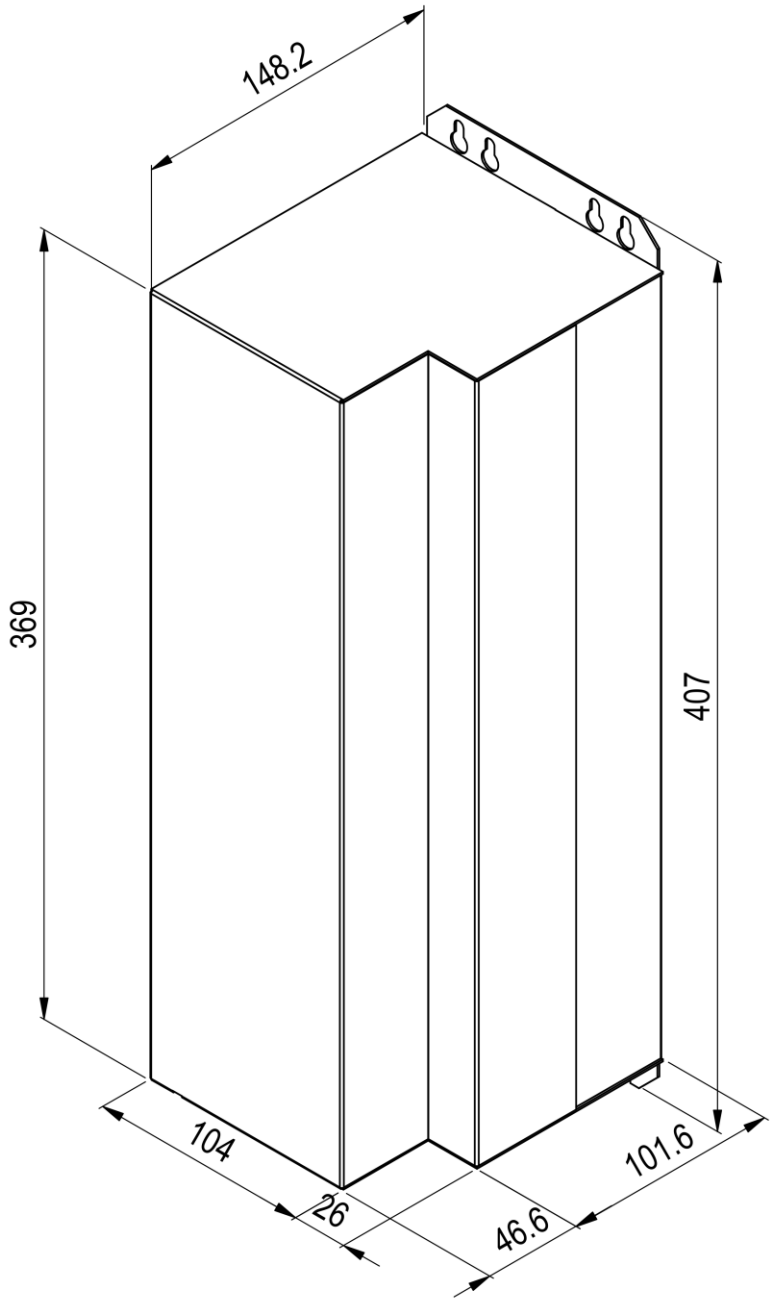
10.3.1. Installation

GIN-SAC4x4 drives must be fastened using at least four M5 cylinder bolts. On the upper side the two holes most left and most right together with the two lower ones should always be used.



Alle Masse in mm
All dimensions in mm

10.3.2. Dimensions

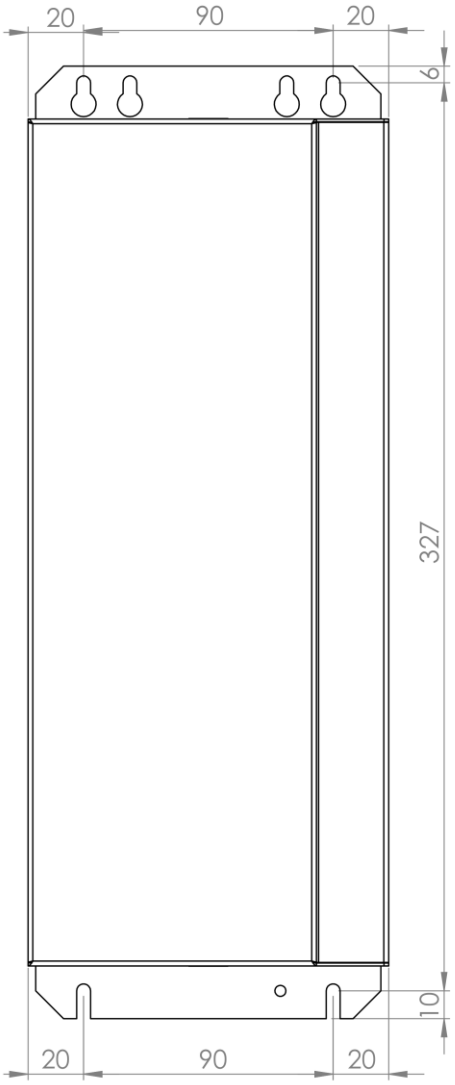


Alle Masse in mm
All dimensions in mm

10.4. GIN-SAC4x3

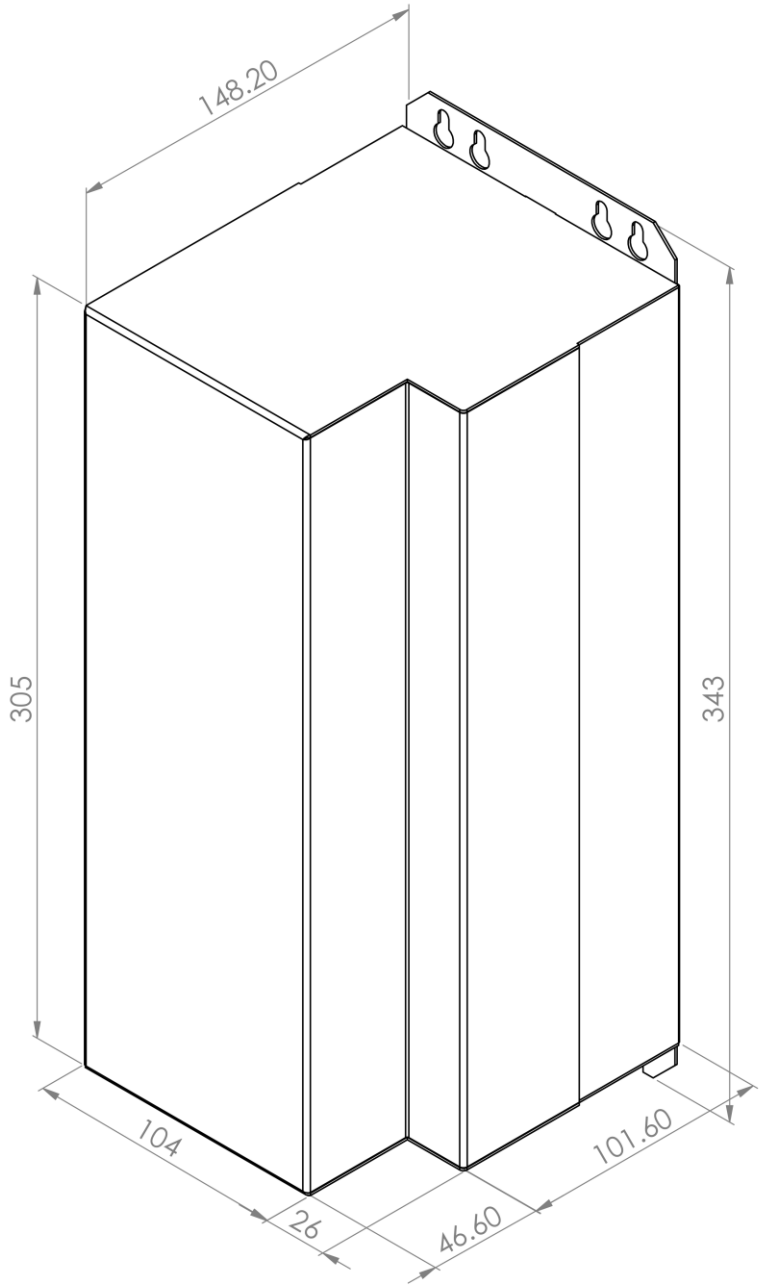
10.4.1. Installation

GIN-SAC4x3 drives must be fastened using at least four M5 cylinder bolts. On the upper side the two holes most left and most right together with the two lower ones should always be used.



Alle Masse in mm
All dimensions in mm

10.4.2. Dimensions

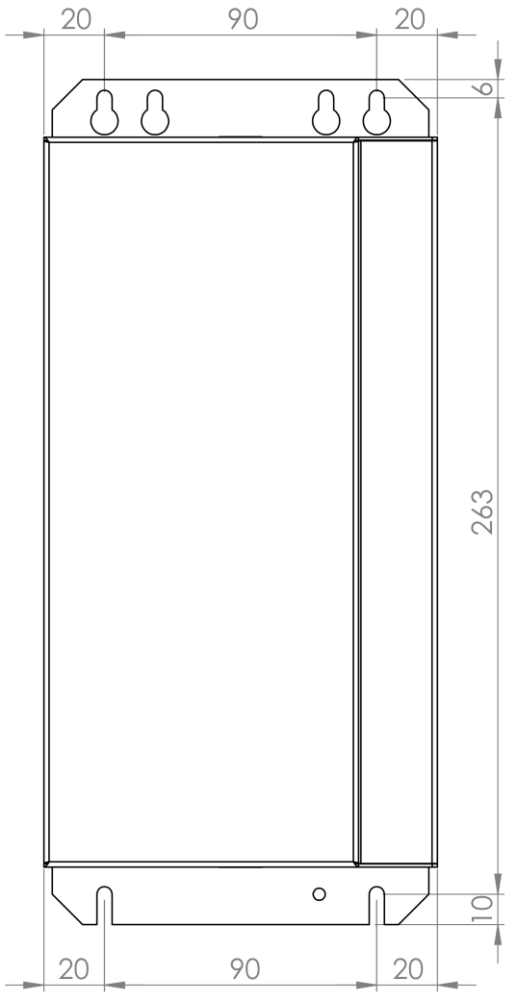


Alle Masse in mm
All dimensions in mm

10.5. GIN-SAC4x2

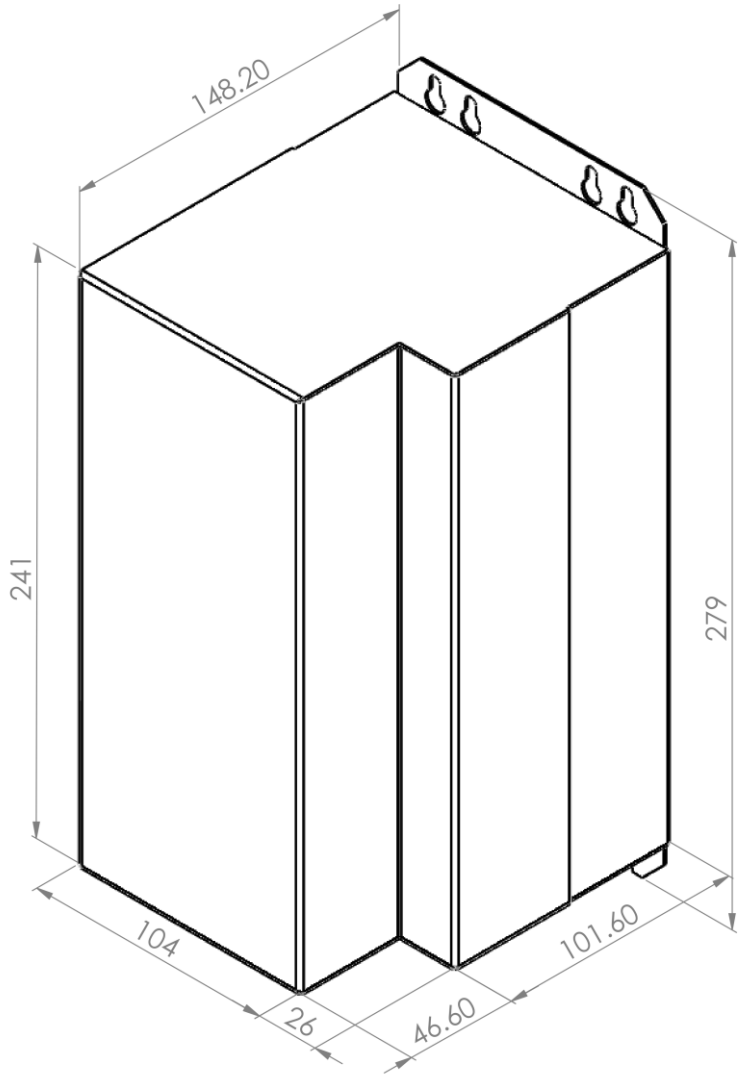
10.5.1. Installation

GIN-SAC4x2 drives must be fastened using at least four M5 cylinder bolts. On the upper side the two holes most left and most right together with the two lower ones should always be used.



Alle Masse in mm
All dimensions in mm

10.5.2. Dimensions

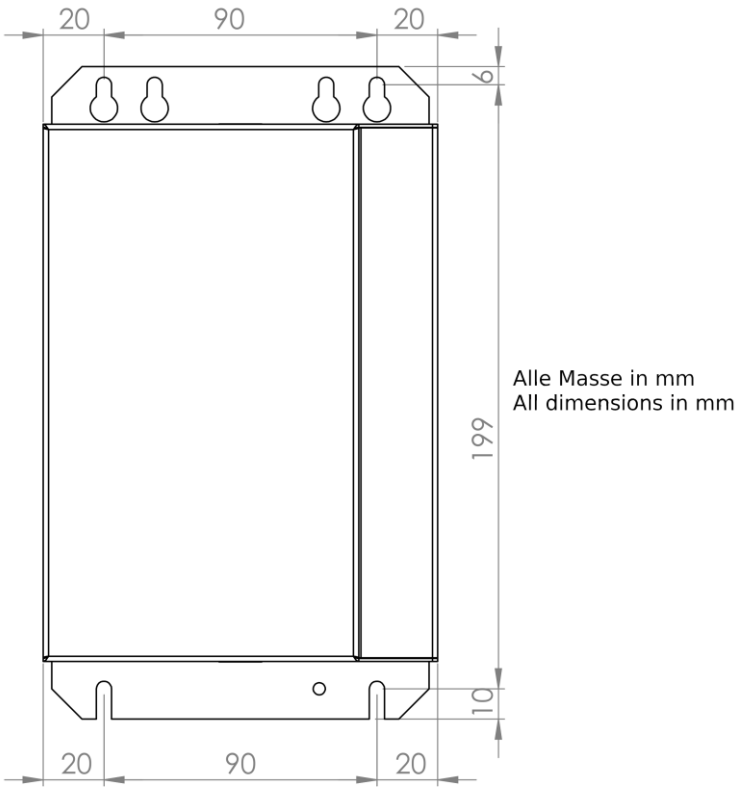


Alle Masse in mm
All dimensions in mm

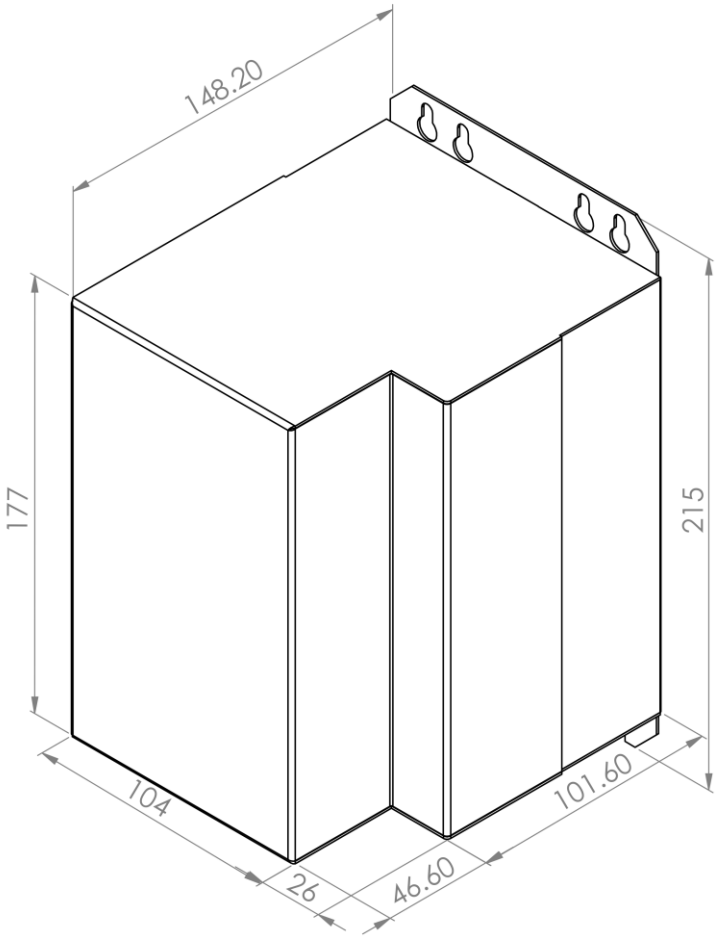
10.6. GIN-SAC4x1

10.6.1. Installation

GIN-SAC4x1 drives must be fastened using at least four M5 cylinder bolts On the upper side the two holes most left and most right together with the two lower ones should always be used.



10.6.2. Dimensions



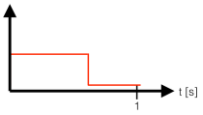
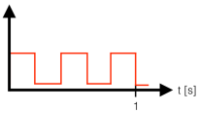
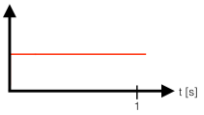
Alle Masse in mm
All dimensions in mm

11. Error Analysis

Basically, a distinction is always made between warnings and errors. When a warning occurs, the controller generally remains operational and active. If an error occurs, the controller is automatically disabled, and the error has to be acknowledged in the software before the controller can be reactivated.

11.1. Status LED

The servo drives are furnished with various LEDs, from which diverse errors and warnings can be read. For a detailed error analysis, an additional Indel tool should be used.

LED	**Flashes as the OK LED does** 	**Flashes approx. 1.5 times per second** 	**Flashes approx. 3 times per second** 	**Is constantly lit** 
Ucc	1.1	1.2	1.3	1.4
Ballast			2.3	
Control			3.3	3.4
Ext Enable				4.4
IMAX / IGBT			5.3	5.4
PWM / Commutation	6.1		6.3	6.4
Resolver				7.4
Active				8.4
Motor		9.2	9.3	9.4

11.2. Error Table

No.	Type	Description	Possible Causes
1.1	Error	Intermediate circuit voltage U_{CC} is lower than the preset $U_{CC\ MIN}$	· No mains power supply · Mains voltage too low
1.2	Warning	Intermediate circuit voltage is lower than $U_{CC\ OK}$	
1.3	Error	Intermediate circuit voltage is higher than $U_{CC\ MAX}$	· The ballast do not work properly · No brake resistor connected
1.4	OK	Intermediate circuit voltage is between $U_{CC\ MIN}$ and $U_{CC\ MAX}$	

No.	Type	Description	Possible Causes
2.3	Error	The brakes do not work properly. Intermediate circuit voltage U_{CC} does not fall, although the brake resistor is switched on	· No brake resistor connected · External power supply, Ucc is bridged

No.	Type	Description	Possible Causes
3.3	Warning	The output stage is warm (approx. 85°C)	· High capacity utilisation and/or · Poor cooling of the controller
3.4	Error	The output stage is too hot (approx. 100°C)	· High capacity utilisation and/or · Poor cooling of the controller

No.	Type	Description	Possible Causes
4.4	OK	Extern Enable Signal liegt an	

No.	Type	Description	Possible Causes
5.3	Warning	I^2t is high (between 100 and 110%) or I_{MAX} has been reached	· The motor needs too much power · I^2t is improperly configured
5.4	Error	I^2t has been exceeded (› 110%)	· The motor needs too much power · I^2t is improperly configured

No.	Type	Description	Possible Causes
6.1	Warning	The PWM modulation reaches 100%	· The intermediate circuit voltage is not enough for the required speed
6.3	Error	The maximum mechanical speed has been reached	· The motor rotates faster than allowed in the Speed Max
6.4	Error	Autocommutation has failed	· Incorrect configuration · Mechanical problem

No.	Type	Description	Possible Causes
7.4	Error	The resolver or sin/cos level is outside the $sin^2cos^2_{Min}$ and $sin^2cos^2_{Max}$ ranges	· Feedback cable broken · Sin/cos ruler soiled · Too large or too small distance between the sensor and the ruler

No.	Type	Description	Possible Causes
8.4	OK	The axis is enabled and controls	

No.	Type	Description	Possible Causes
9.2	Warning	The motor temperature is higher than the preset temperature warning	· The motor is too hot
9.3	Error	The motor temperature is higher than the preset maximum temperature	· The motor is too hot
9.4	Error	Over-current or short-circuit	· The motor is overloaded (the load is too high) · Motor or wiring short-circuit · Defective output stage

12. Related Documents

12.1. EC Declaration of Conformity for GIN-SAC4xX FS

EC Declaration of Conformity

(Original EC Declaration of Confomity)

We,	**INDEL AG** **Tüfiwis 26** **CH-8332 Russikon**
hereby declare that the following products	**Servo Drive** **GIN-SAC4x4 each FS Option** **Part-no. 3113494XX** **SN 123400000 - 124399999** **Servo Drive** **GIN-SAC4x3 each FS Option** **Part-no. 3113493XX** **SN 123400000 - 124399999** **Servo Drive** **GIN-SAC4x2 each FS Option** **Part-no. 3113492XX** **SN 123400000 - 124399999** **Servo Drive** **GIN-SAC4x1 each FS Option** **Part-no. 3113491XX** **SN 123400000 - 124399999**
satisfy all the essential requirements of the following directives:	**2014/35/EU (Low Voltage Directive)** **2014/30/EU (EMC Directive)** **2011/65/EU (RoHS Directive)** **2006/42/EG (Machinery Directive)**
Authorized person	**Arthur Jericke** **Indel AG** **Tufiwis 26** **CH-8332 Russikon** **Switzerland**
Conformity assesment body for EC type-examination	**TÜV Rheinland Industrie Service GmbH** **Certification body for machines (NB No. 0035)** **Alboinstr. 56** **DE-12103 Berlin** **Germany** **Tel.: +49 30 7562-1557, Fax: +49 30 7562-1370** **E-mail: industrie-service@de.tuv.com**
Type-examination certificated no.:	**01/205/5575.00/17 (MRL 2006/42/EG)**
Harmonised standards applied:	**EN 61800-5-1: 2007+A11:2021** **EN 61800-5-2: 2017** **EN 61800-3: 2004 + A1:2012** **EN IEC 63000:2018** **EN 62061: 2005** **EN 60204-1: 2006** **EN ISO 13849-1: 2015**

Russikon, 14.09.2023

Arthur Jericke
CEO

The technical documentation for the product is available from:
Indel AG, Tüfiwis 26, CH-8332 Russikon / info@indel.ch

www.indel.ch
info@indel.ch
Tel: +41 44 956 20 00

Indel AG
Tüfiwis 26
CH -8332 Russikon
Schweiz

12.2. CB Test Certificate

IEC IECEE CB SCHEME

Ref. Certif. No.
DE 3 - A0021

IEC SYSTEM FOR MUTUAL RECOGNITION OF TEST CERTIFICATES FOR ELECTRICAL EQUIPMENT (IECEE) CB SCHEME

CB TEST CERTIFICATE

Product	Power Conversion Equipment
Name and address of the applicant	**Indel AG** Tüfiwis 26 8332 Russikon SWITZERLAND
Name and address of the manufacturer	Indel AG Tüfiwis 26, 8332 Russikon, SWITZERLAND
Name and address of the factory	Indel AG Tüfiwis 26, 8332 Russikon, SWITZERLAND
Ratings and principal characteristics	Complete ratings please see page 2
Trade mark (if any)	Indel
Customer's Testing Facility (CTF) Stage used	CTF STAGE 1
Model/type Ref.	GIN-SAC4xa 5A/b/c/d GIN-SAC4x is product group Where: a is number of motor axes and gerber inputs and can be "1", "2", "3" or "4" b is input voltage and can be "230V" or "400V" c is CPU version and can be empty for Single-Core CPU-Module or "PRO" for Dual-Core CPU-Module d is safety module version and can be empty for relay safety module or "FS" CPU-based safety module with SLS function
A sample of the product was tested and found to be in conformity with	IEC 61800-5-1:2007 IEC 61800-5-1:2007/AMD1:2016
as shown in the Test Report Ref. No. which forms part of this certificate	028-713174177-000

This CB Test Certificate is issued by the National Certification Body

CB 107535 0001 Rev. 00
Date, 2020-03-03

(Abdul Sabbagh)

TÜV SÜD Product Service

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CB-1 03.06

IEC IECEE CB SCHEME

Ref. Certif. No.

DE 3 - A0021

Ratings and principal characteristics (continued)

GIN-SAC4x4 5A/230V and GIN-SAC4x4 5A/230V/PRO

Input-Ratings:	Rated Voltage Rated Frequency	3x 110-230 VAC 50/60 Hz
Output-Ratings:	Power	6.5 kVA

GIN-SAC4x4 5A/400V and GIN-SAC4x4 5A/400V/PRO

Input-Ratings:	Rated Voltage Rated Frequency	3x 110-400 VAC 50/60 Hz
Output-Ratings:	Power	11.3 kVA

GIN-SAC4x3 5A/230V and GIN-SAC4x3 5A/230V/PRO

Input-Ratings:	Rated Voltage Rated Frequency	3x 110-230 VAC 50/60 Hz
Output-Ratings:	Power	4.9 kVA

GIN-SAC4x3 5A/400V and GIN-SAC4x3 5A/400V/PRO

Input-Ratings:	Rated Voltage Rated Frequency	3x 110-400 VAC 50/60 Hz
Output-Ratings:	Power	8.5 kVA

GIN-SAC4x2 5A/230V and GIN-SAC4x2 5A/230V/PRO

Input-Ratings:	Rated Voltage Rated Frequency	3x 110-230 VAC 50/60 Hz
Output-Ratings:	Power	3.3 kVA

GIN-SAC4x2 5A/400V and GIN-SAC4x2 5A/400V/PRO

Input-Ratings:	Rated Voltage Rated Frequency	3x 110-400 VAC 50/60 Hz
Output-Ratings:	Power	5.7 kVA

GIN-SAC4x1 5A/230V and GIN-SAC4x1 5A/230V/PRO

Input-Ratings:	Rated Voltage Rated Frequency	3x 110-230 VAC 50/60 Hz
Output-Ratings:	Power	1.7 kVA

GIN-SAC4x1 5A/400V and GIN-SAC4x1 5A/400V/PRO

Input-Ratings:	Rated Voltage Rated Frequency	3x 110-400 VAC 50/60 Hz
Output-Ratings:	Power	2.9 kVA

All versions

Derating	from 1000 m to 2000 m: output power reduction by 1 % each 100 m
Protection Class:	I
T ambient:	0 to +40 °C
Degree of Protection:	IP 20

CB 107535 0001 Rev. 00
Date, 2020-03-03

TÜV SÜD Product Service

(Abdul Sabbagh)

CB-2 03.06

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13. Standards

The following standards have been used and apply to the use of GIN-SAC4xX FS equipment.

EN 60204-1: 2006 / A1: 2008
Sicherheit von Maschinen - Elektrische Ausrüstung von Maschinen

EN ISO 13850: 2009
Sicherheit von Maschinen –Not-Halt – Gestaltungsleitsätze

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

EN 61800-5-1: 2008
Elektrische Leistungsantriebssysteme mit einstellbarer Drehzahl – Teil 5-1: Anforderungen an die Sicherheit – Elektrische, thermische und energetische Anforderungen

EN 61800-5-2: 2016
Elektrische Leistungsantriebssysteme mit einstellbarer Drehzahl – Teil 5-2: Anforderungen an die Sicherheit – Funktionale Sicherheit

EN 61800-3: 2012
Drehzahlveränderbare elektrische Antriebe – Teil 3:, EMV-Anforderungen einschliesslich spezieller Prüfverfahren

IEC 61784: 2012
Industrielle Kommunikationsnetze –Profile – Teil 3: Funktional sichere Übertragung bei Feldbussen - Allgemeine Regeln und Profilfestlegungen – Teil 5-2: Feldbusinstallation – Installationsprofile für die Kommunikationsprofilfamilie 2

EN 61496-1: 2014
Sicherheit von Maschinen – Berührungslos wirkende Schutzeinrichtungen – Teil 1: Allgemeine Anforderungen und Prüfungen, Version Mai 2014

EN ISO 13849-1: 2015; EN ISO 13849-2: 2013
Sicherheit von Maschinen – Sicherheitsbezogene Teile von Steuerungen - Teil1: Allgemeine Gestaltungsleitsätze; Teil2: Validierung

EN 62061: 2005 + Cor.:2010 + A1:2013 + A2:2015
Sicherheit von Maschinen – Funktionale Sicherheit sicherheitsbezogener elektrischer, elektronischer und programmierbarer elektronischer Steuerungssysteme.

EN 61508 Teile 1-7: 2010 ED II
Funktionale Sicherheit sicherheitsbezogener elektrischer, elektronischer, programmierbarer elektronischer Systeme Teil 1-7

EN 61326-3-1: 2008
Elektrische Mess-, Steuer-, Regel- und Laborgeräte- EMV-Anforderungen – Teil 3-1: Störfestigkeitsanfordrungen für sicherheitsbezogene Systeme und für Geräte, die für sicherheitsbezogene Funktionen vorgesehen sind (Funktionale Sicherheit) – Allgemeine Anwendungen,

Reihe SN 29500 Teil 1-14: 1998
Ausfallrate Bauelement, Erwartungswert für …, Zuverlässigkeit

EN 50178: 1998
Ausrüstung von Starkstromanlagen mit elektrischen Betriebsmitteln

BGIA-Papier: 2012
EMV und Funktionale Sicherheit für Leistungsantriebe mit integrierten Sicherheitsfunktionen

EN 60947-5-1: 2004 + Cor.:2005 + A1:2009
Niederspannungsschaltgeräte – Teil 5-1: Steuergeräte und Schaltelemente – Elektromechanische Steuergeräte

DIN EN 60664-4: 2006 +AC:2007
Isolationskoordination für elektrische Betriebsmittel in Niederspannungsanlagen - Teil 4: Berücksichtigung von hochfrequenten Spannungsbeanspruchungen