SIGMATEK

DIAS-Drive 2000

Power/Axes & Axes Modules

Instruction Manual

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Translation of the Original Instructions

Power/Axes & Axes Modules DIAS-Drive 2000

The DIAS-Drive 2000 series contains the power/axis modules and axis modules for a power input voltage of 400/480 V AC. The system is currently available in 2 different sizes. In the following document, the MDP/MDD 21XX series are referred to as “size 1”, devices of the MDP/MDD 22XX series as “size 2”.

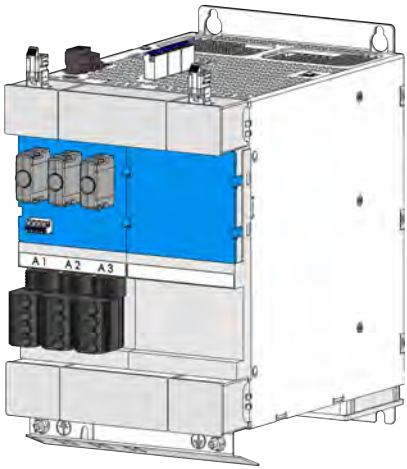
In the power/axis modules (MDP), as well as the axis modules (MDD), up to 3 servo amplifiers are integrated. With a power/axis module, several axis modules can be powered.

The DIAS-Drive 2000 is a complete servo drive system for the low to mid power range, which can also be used for applications high control performance. It is completely integrated into the LASAL design environment.

The power/axis module and axis modules are mounted directly onto the control cabinet wall. No mounting plate is required.

The current, speed and position control operates with a cycle time of 62.5 µs. DIAS-Drive 2000 is highly flexible when it comes to the connection to various feedback systems. VARAN connects the drive systems with the machine control.

Size 1



Size 2

Table of Contents

1 Introduction

1.1 Target Group/Purpose of this Operating Manual

This operating manual contains all information required for the operation of the product.

This operating manual is intended for:

- Project planners
- Technicians
- Commissioning engineers
- Machine operators
- Maintenance/test technicians

General knowledge of automation technology is required.

Further help and training information, as well as the appropriate accessories can be found on our website www.sigmatek-automation.com.

Our support team is happily available to answer your questions.
Please see our website for our hotline number and business hours.

1.2 Important Reference Documentation

- Safety System Handbook
- Setup Manual
- Helps: LASAL SAFETYDesigner, LASAL CLASS, LASAL MOTION, Hardware Classes

This and additional documents can be downloaded from our website or obtained through SIGMATEK Support.

1.3 Contents of Delivery

1x DIAS-Drive 2000 Component

Power/Axis Module MDP:

- 2x VARAN Mini-I/O-Block (VARAN IN/VARAN OUT)
- 2x DC-link covers
- Universal encoder module (optional)

Axis Module MDD:

- 1x Bus Connection Block
- 1x DC Connection Block
- Universal encoder module (optional)

All required opposing connectors except motor connection and optional encoder connectors (X1-X3, X11-X13): order numbers see 9.3 Connector Layout

The required cables are not included with delivery (see chapter 17.1 Cable Type Key).

2 General Instructions

2.1 Abbreviations

AWG	American Wire Gauge
BCB	Bus Connection Block
Cat.	Safety category according to ISO 13849-1
CE	Communauté Européenne (Symbol for conformity with EU directives (manufacturer's self-declaration))
CLOCK	Clock signal
DCB	DC Connection Block
EMC	Electromagnetic Compatibility
EN	European Norm
ESD	Electrostatic Discharge
IEC	International Electrotechnical Commission
IGBT	Insulated Gate Bipolar Transistor
ISO	International Organization for Standardization
LED	Light emitting diode
PDS	Power Drive System
PE	Protective Earth
PELV	Protective Extra Low Voltage
PL	Safety performance level according to EN ISO 13849-1
Rx	Receive
SELV	Safety Extra Low Voltage
SIL	Safety Integrity Level (safety integrity level according to IEC 62061)
STO	Safe Torque Off
Size	Construction
Tx	Transmit

V AC	Alternating current
V DC	Direct current

2.2 Brief Descriptions Used

Power/Axis Module	MDP 210X, MDP 2200
Axis Module	MDD 210X, MDD 2200
Axis	Combination of control and power electronics for a motor within a module.

2.3 Available Models

Short Description	Type	Safety	Universal Encoder	Article Number
MDP2102-DDD-00	Power/axis module with 3 x 5/15 A (230 V)	yes	yes	in preparation
MDP2100-DDD-03	Power/axis module with 3 x 5/15 A	yes	yes	09-83-100-DDD-03
MDD2100-DDD-03	Axis module with 3 x 5/15 A	yes	yes	09-84-100-DDD-03
MDP2200-HHH-03	Power/axis module with 3 x 10/30 A	yes	yes	09-83-200-HHH-03
MDD2200-HHH-03	Axis module with 3 x 10/30 A	yes	yes	09-84-200-HHH-03
MDP2100-DDD-00	Power/axis module with 3 x 5/15 A	yes	no	09-83-100-DDD-00
MDP2200-HHH-00	Power/axis module with 3 x 10/30 A	yes	no	09-83-200-HHH-00
MDD2100-DDD-00	Axis module with 3 x 5/15 A	yes	no	09-84-100-DDD-00

2.3.1 Upon Request

Short Description	Type	Safety	Universal Encoder	Article Number
MDD2200-HHH-00	Axis module with 3 x 10/30 A	yes	no	09-84-200-HHH-00

3 Basic Safety Directives

3.1 Symbols Used

The following symbols are used in the operator documentation for warning and danger messages, as well as informational notes.

DANGER

Danger indicates that death or serious injury **will occur**, if the specified measures are not taken.

→ To avoid death or serious injuries, observe all guidelines.

Danger indique une situation dangereuse qui, faute de prendre les mesures adéquates, **entraînera** des blessures graves, voire mortelles.

→ Respectez toutes les consignes pour éviter des blessures graves, voire mortelles.

WARNING

Warning indicates that death or serious injury **can** occur, if the specified measures are not taken.

→ To avoid death or serious injuries, observe all guidelines.

Avertissement d'une situation dangereuse qui, faute de prendre les mesures adéquates, **entraînera** des blessures graves, voire mortelles.

→ Respectez toutes les consignes pour éviter des blessures graves, voire mortelles.

CAUTION

Caution indicates that moderate to slight injury **can** occur, if the specified measures are not taken.

→ To avoid moderate to slight injuries, observe all guidelines.

Attention indique une situation dangereuse qui, faute de prendre les mesures adéquates, **peut** entraîner des blessures assez graves ou légères.

→ Respectez toutes les consignes pour éviter des blessures graves, voire mortelles.

DANGER

Electrical voltage

Tension électrique

DANGER

Danger for persons with pacemakers, implanted defibrillators or other active implants.

Danger pour les personnes portant un stimulateur cardiaque, un défibrillateur implanté ou d'autres implants actifs.

WARNING

Hot Surfaces

Surfaces chaudes

WARNING

Magnetic field warning

Alerte au champ magnétique

CAUTION

Danger for ESD-sensitive components.

Les signes de danger pour les composants sensibles aux décharges électrostatiques.

INFORMATION

INFORMATION

→ Provides important information on the product, handling or relevant sections of the documentation, which require particular attention.

3.2 Disclaimer

INFORMATION

The contents of this operating manual were prepared with the greatest care. However, deviations cannot be ruled out. This operating manual is regularly checked and required corrections are included in the subsequent versions. The machine manufacturer is responsible for the proper assembly, as well as device configuration. The machine operator is responsible for safe handling, as well as proper operation.

The current operating manual can be found on our website. If necessary, contact our support.

Subject to technical changes, which improve the performance of the devices. The following operating manual is purely a product description. It does not guarantee properties under the warranty.

Please thoroughly read the corresponding documents and this operating manual before handling a product.

SIGMATEK GmbH & Co KG is not liable for damages caused through, non-compliance with these instructions or applicable regulations.

3.3 General Safety Directives

The Safety Directives in the other sections of this operating manual must be observed. These instructions are visually emphasized by symbols.

INFORMATION

According to EU Directives, the operating manual is a component of a product.
This operating manual must therefore be accessible in the vicinity of the machine since it contains important instructions.
This operating manual should be included in the sale, rental or transfer of the product, or its online availability indicated.

Regarding the requirements for Safety and health connected to the use of machines, the manufacturer must perform a risk assessment in accordance with machine directives 2006/42/EG before introducing a machine to the market.

Operate the unit with devices and accessories approved by SIGMATEK only.

CAUTION

Handle the device with care and do not drop or let fall.
Prevent foreign bodies and fluids from entering the device.
The device must not be opened!

Manipulez l'appareil avec précaution et ne le laissez pas tomber.
Empêchez les corps étrangers et les liquides de pénétrer dans l'appareil.
L'appareil ne doit pas être ouvert!

If the device does not function as intended or has damage that could pose a danger, it must be replaced!

En cas de fonctionnement non conforme ou de dommages pouvant entraîner des risques, l'appareil doit être remplacé !

The module complies with EN 61800-5-1.
In combination with a facility, the system integrator must comply with EN 60204-1 standards.
For your own safety and that of others, compliance with the environmental conditions is essential.

Le module est conforme à la norme EN 61800-5-1.
En combinaison avec une équipement, l'intégrateur de système doit respecter la norme EN 60204-1.
Pour votre propre sécurité et celle des autres, le respect des conditions environnementales est essential.

3.4 Designated Use

The PDS of the DIAS-Drive 2000 series are designed exclusively for use in the control cabinet with the supply /axis modules, of the same series. They are combined and installed as components in electrical equipment and machines and can only be operated such machines and equipment.

The Safety functions are designed for use with safety applications (functional safety) and meet the required conditions for safe operation in compliance with EN 62061, EN ISO 13849-1/2 and EN 61800-5-2. The Safety Integrity level (SIL), Performance level (PL) achieved differs depending on the type of encoder used, the use of safe inputs with/without clock signal output to cross-circuit detection, whether single- or double-channel etc.
For details of the safety figures achieved, see chapter 4.4 Safety-Relevant Parameters.

CAUTION

The instructions contained in this operating manual must be followed. Installation, mounting, programming, initial start-up, operation, maintenance and decommissioning can only be performed by qualified personnel.
Qualified personnel in this context are people, who have completed training or have trained under supervision of qualified personnel and have been authorized to operate and maintain safety-related equipment, systems and facilities in compliance with the strict directives and standards of safety technology (Functional Safety).

Les instructions contenues dans ce manuel technique doivent être suivies. Pour un fonctionnement sans erreur, le transport et le stockage appropriés sont essentiels.
L'installation, le montage, la programmation, la mise en service initiale, l'exploitation, la maintenance et la mise hors service ne peuvent être effectués que par une personne qualifiée.
Dans ce contexte, on entend par personnel qualifié les personnes qui ont suivi une formation ou qui ont été formées sous la supervision d'un personnel qualifié et qui ont été autorisées à utiliser et à entretenir l'équipement, les systèmes et les installations de sécurité conformément aux directives et aux normes strictes de la technique de sécurité (Sécurité fonctionnelle).

For your own safety and that of others, the safety modules should be used for their designated purpose only.
Correct EMC installation is also included under designated use.

Pour votre propre sécurité et celle des autres, les modules de sécurité ne doivent être utilisés qu'à des fins prévues.
Une installation CEM correcte est également incluse dans l'utilisation prévue.

Non-designated use includes:

- any changes made to the device or the use of damaged devices
- use of the module inconsistent with the technical margins described in this Operating Manual or the speciation's defined in the technical data.

3.5 Danger Electrical Shock

DANGER

During installation and operation, an especially high risk of electric shock exists. Conductive components cannot be handled.

Il existe un risque de choc électrique pendant l'installation et l'utilisation. Les pièces sous tension ne doivent pas être touchées.

After shutting down the device or disconnecting from the mains voltage and following the 5 safety rules, a **wait time of 7 minutes** is required before voltage conducting components can be touched or connectors removed.

For safety purposes, measure the voltage in the intermediate circuit and wait until the voltage has dropped below 40 V.

DANGER

If the ballast connector is not plugged in, the DC link voltage contacts are exposed! Coming into physical contact with them may result in electrical shock!

Si la fiche ballast n'est pas branchée, la tension du circuit intermédiaire peut être touchée ! Cela peut entraîner un choc électrique !

3.5.1 5 Safety Rules

WARNING

Before and during all work on electrical machines and equipment, all safety-relevant guidelines and the five safety rules must be observed and followed in the specified order!

Avant et pendant tous les travaux sur les machines et installations électriques, toutes les consignes relatives à la sécurité et les cinq règles de sécurité doivent être observées et respectées dans l'ordre indiqué:

1. Disconnect electrical circuits from voltage supply (including electronics and auxiliary circuits)
2. secure against restarting.
3. Verify voltage-free condition
4. Ground and short circuit
5. cover or cordon off any neighboring voltage-carrying components

After competing the work, the safety measures taken must be removed in reverse order.

3.6 Hot Surface Warning

WARNING

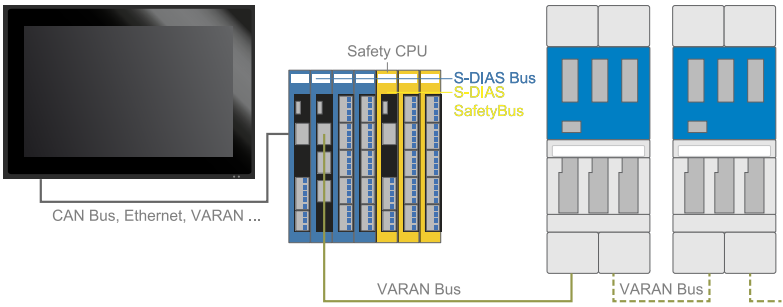
During installation and operation, high temperatures can be generated on thermally conductive components (heat sinks) of the device. Before touching these components, the temperature must be checked. When required, the operator must wait until the temperature has dropped below 40 °C.
Failure to follow the above safety measures can lead to severe injuries.

Pendant l'installation et l'utilisation, les pièces thermoconductrices (radiateurs) des appareils peuvent atteindre des températures élevées. Avant tout contact, il convient donc de vérifier la température de ces pièces ; le cas échéant, il faut attendre que la température soit descendue en dessous de 40 °C.
Le non-respect de ces mesures de précaution peut entraîner des blessures graves.

3.7 Operation Modes

In standalone operation, the DIAS-Drive 2000 can also be operated without FSoE safety control. In this case, the desired safety functions are controlled via the safe inputs of the DIAS-Drive 2000. Which safety functions are to be used for the application is defined via a configuration file.

The complete safety functions of the DIAS-Drive 2000 can be used in a system with a SIGMATEK FSoE safety controller (e.g. SCP 111). In addition to the safety PLC, the complete system consists of a functional PLC (e.g. a CP 112), which has the VARAN interface to be able to communicate with the DIAS-Drive 2000.



Example complete system

INFORMATION

The DIAS-Drive 2000 can only be operated with a functional PLC (e.g. CP 112) with an operating system Salamander.

WARNUNG

In standalone operation, the integrator must ensure that the release of an axis (axes) after an error must be confirmed by the user.

En fonctionnement autonome, l'intégrateur doit s'assurer que la libération d'un ou plusieurs axes après une erreur doit être confirmée par l'utilisateur.

3.8 Safe State

The safe state of the DIAS-Drive 2000 is defined by STO. The motor supply is switched off on two channels. Thus, no motor torque is generated.

This state can be triggered by the application or by configurable inputs. The safety functions can also trigger STO if their limits are violated, among other things. Any serious internal error detected by the DIAS-Drive 2000 also leads to this state. Optionally, the holding brake is also active in this state.

3.9 Safe Position Evaluation

The DIAS-Drive 2000 provides the safety application in the safety controller with a safe position, which can be used in the application for position monitoring. As with STO, the position is transferred using the FSoE protocol.

In addition to transmission to the safety controller, the safe position evaluation is also used in the DIAS-Drive 2000 to implement safety functions.

Hiperface DSL encoders are supported as encoders for safe position evaluation.

3.10 Current Evaluation

In addition to the safe position, the DIAS-Drive 2000 also provides the current in the safety application as an input. The current is transmitted together with the safe position and the other signals via FSoE protocol from the DIAS-Drive 2000 to the safety controller.

3.11 Safe Inputs and Outputs

The DIAS-Drive 2000 provides 6 safe inputs, which can optionally be used as capture inputs for recording the current actual position of the axes. The first 4 inputs can alternatively be used to activate the safety functions. A link to 2 two-channel inputs with cross-circuit detection is also possible. The clock outputs Clock A and Clock B are generated once internally in the module and output at SI7 (Clock A) and SI8 (Clock B).

When using several two-channel safe inputs with cross-circuit detection, ensure that parallel lines are assigned different clock pulses. Where this is not possible, other measures must be taken to prevent errors, such as separate cable routing.

Note the discrepancy time when using the inputs on two channels. If one input goes low while the other remains high, the safe state is not assumed until the set discrepancy time has elapsed. There are 2 safe outputs available, which can optionally be used as clock outputs for cross-circuit detection.

INFORMATION

Default delivery: SS1 for all axes (500 ms ramp time)

→ With cross-circuit detection - output 1 (clock A) must be connected to input 1 and output 2 (clock B) to input 2. See 6.3 Wiring Examples Safety.

→ Without cross-circuit detection - use input 3 and input 4

3.12 Software/Training

The application is created with the software LASAL CLASS 2 and LASAL SCREEN Editor, the Safety application is created using the SAFETYDesigner. Basic information on Safety (Functional Safety) can be found in the Safety System Handbook.

Training for the LASAL development environment, with which the product can be configured, is provided. Information on our training schedule can be found on our website.

4 Standards and Directives

4.1 Residual Risks

CAUTION

The following residual risks for the product must be included in the system integrator's risk assessment:

- Release of non-environmentally safe substances, emissions and unusual temperatures
- Hazardous contact voltages
- Effects of operational electrical, magnetic and electromagnetic fields
- Possible effects of information technology devices

Les risques résiduels suivants pour le produit doivent être inclus dans l'évaluation des risques de l'intégrateur de système :

- Libération de substances non respectueuses de l'environnement, émissions et températures inhabituelles
- Tensions de contact dangereuses
- Effets des champs électriques, magnétiques et électromagnétiques opérationnels
- Effets possibles des dispositifs de technologie de l'information

WARNING

If the system integrator has to consider unexpected start-up in his risk assessment, the manual reset function or the automatic restart must be transferred to the drive in a safety-oriented manner.

Si l'intégrateur de système doit considérer un démarrage inattendu dans son évaluation des risques, la fonction de réarmement manuel ou de redémarrage automatique doit être transmise au drive en fonction de la sécurité.

4.2 Safety of the Machine or Equipment

INFORMATION

Observe all on-site rules and regulations for accident prevention and occupational safety.

4.3 Directives

The product was constructed in compliance with the following European Union directives and tested for conformity.

4.3.1 Norms

Norms	Description
EN 61800-3	Electrical Drives with Adjustable Speed Part 3: EMC requirements, including specific test methods
EN 61800-5-1	Electrical Power Drive Systems with Adjustable Speed Part 5-1: Safety Requirements – Electrical, Thermal and Energy Requirements
EN 61800-5-2	Electrical Drives with Adjustable Speed Part 5-2: Functional Safety Requirements
EN 60204-1	Safety of Machines - Electrical Equipment of Machines Part 1: General Requirements
EN ISO 13849-1	Safety of Machines - Safety-related Components of Control Systems Part 1: General Design Directives
EN ISO 13849-2	Safety of Machines - Safety-related Components of Control Systems Part 2: Validation
EN IEC 62061	Machine Safety – Functional Safety of Safety-related Control Systems

4.3.2 EU Conformity Declaration

EU Declaration of Conformity

The product DIAS-Drive 2000 conforms to the following European directives:

- → **2006/42/EG** Machine Directive
- → **2014/30/EU** Electromagnetic Compatibility (EMC Directive)
- → **2011/65/EU** "Restricted use of certain hazardous substances in electrical and electronic equipment" (RoHS Directive)

The EU Conformity Declarations are provided on the SIGMATEK website. See Products/Downloads or use the search function and the keyword "EU Declaration of Conformity".

4.4 Safety-Relevant Parameters

Parameter	Safety Parameter
	STO
according to EN 62061	SIL 3, HFT 1
PL category according to EN ISO 13849-1	PL e / Cat. 4
SFF	99 %
PFH_D	5.4E-09 (1/h)
$MTTF_D$	454 years
DC	99 %

Parameter	Safety Parameter
	Safe inputs SI1-SI4 (without cross-circuit detection)
according to EN 62061	SIL 3, HFT 1
PL category according to EN ISO 13849-1	PL e / Cat. 4
SFF	99 %

PFH_D	4.7E-09 (1/h)
$MTTF_D$	453 years
DC	99 %

Parameter	**Safety Function**
	SOS, SLS, SS1, SS2, SMS, SLP, SLA, SLI, SDI, SMP, SMA, SSM, SCA
gemäß EN 62061	SIL 3, HFT 1
PL-Kategorie gemäß EN ISO 13849-1	PL e / Cat. 4
SFF	99 %
PFH_D	6,39E-9 (1/h)
$MTTF_D$	262 Jahre
DC	99 %

CAUTION

During the risk analysis and design of your machine, the MDD 2000's maximum response time of 12 ms - between generating a low signal at one of the safe inputs to the STO - must be taken into account.

Lors de l'analyse du risque et de la conception de votre machine, veuillez tenir compte du temps de réaction maximum du MDD 2000 de 12 ms, qui peut s'écouler entre l'application d'un signal bas sur l'une des entrées de sécurité et le STO.

INFORMATION

For the calculation of the STO safety function according to EN ISO 13849-1, only the PFH_D value of the STO is to be used for safety-related control via VARAN bus. Control via safe inputs requires an addition of the PFH_D values.

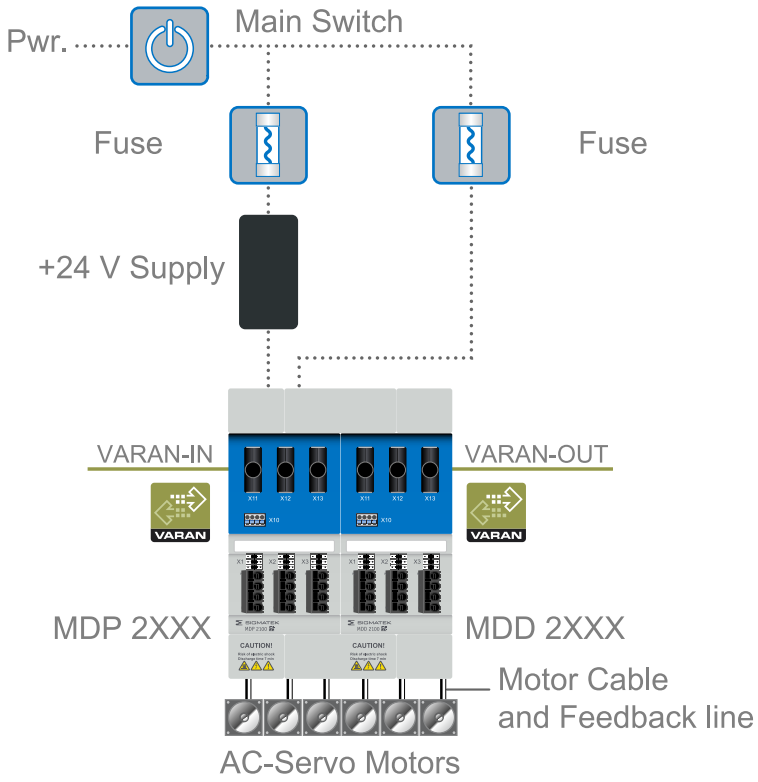
5 Description of Multi-Converter Systems

The DIAS-Drive 2000 series is a multi-converter system for synchronous motors. The device configuration can consist of several power/axis modules (MDP 2XXX) and up to 10 axis modules (MDD 2XXX).

The maximum number of axis modules depends on the cable length, brake configuration and motor size. It must be noted that the DC connection blocks can conduct a maximum of 40 A.

Furthermore, the maximum number of axis modules (MDD) that can be connected to a supply module (MDP) depends on the maximum chargeable DC link capacitance. This means that a maximum DC link capacitance of 3500 µF can also be connected to a supply module (MDP) see 7.1 DC-link Circuit.

5.1 System Components



5.2 Concept

The servo drive systems of the DIAS-Drive 2000 series consist of:

- Power/axis module with integrated IGBT power outputs for up to three axes
- Axis modules with IGBT power outputs for up to three axes
- power input of the power/axis module with integrated power filter for EN 61800 C3, rectifier and inrush current limiting.
- Plug connections via which the DC link voltage (DC connection block) is routed to the next axis module.
- Ballast switch and ballast resistor are integrated into the power/axis module. If the power of the internal brake resistor is insufficient, an external resistor can be added.
- Hiperface DSL as standard feedback system. Additional encoder systems are available via universal encoder option.
- +24 V help voltage input for supplying the internal electronics and the externally connected holding brake.
- Outputs for controlling the hold brake.
- Lowering function for the holding brake voltage.
- +24 V auxiliary voltage and VARAN are fed to the power/axis modules and distributed to other devices via the Bus Connection Block.
- Safety functions STO, SS1, SS2, SOS, SLS, SBC, SMS, SLP, SLA, SLI, SDI, SMP, SMA, SSM, SCA with performance level "e" in accordance with ISO 13849 and SIL 3 in accordance with EN 62061.
- 4 safe inputs.
- 2 capture inputs for recording the current actual position of the axes.
- 2 clock outputs for cross-circuit detection, which can be used as safe output.
- All shielding connections on housing.

- Protective functions against:
  - DC-link circuit Under/overvoltage
  - Several short circuit conditions
  - Phase error in the main voltage supply
  - Ballast resistor over heating
  - Over temperature (heat sink, ambient and motor)

INFORMATION

For USA:
The integrated contactless short-circuit detector does not serve as branch circuit protection Branch circuit protection must be installed according to manufacturer instructions as well as NEC (National Electric Code) and additional local directives.

5.3 Function Power/Axis Module

In the power/axis modules, the supply voltage is rectified. The resulting DC current is applied to the DC-link circuit and is therefore referred to as DC-link voltage.

The DC-link voltage is rectified by the axis IGBTs for the motor controls. If the DC-link circuit is charged over a certain voltage by braking of the motor, for example, the ballast resistor is connected to reduce the voltage.

the DC-link voltage can be provided to an axis via the DC Connection Block. The +24 V supply, as well as the VARAN connection are also provided from the power/axis module and relayed to the axis modules via the Bus Connection Block.

5.4 Function Axis Module

The axis modules do not have a power connection, instead, they are powered by the DC Connection Block. The DC-link capacitors are thereby charged. The individual axis IGBTs rectify the voltage for the control.

The axis modules can be powered with +24 V via the Bus Connection Block, as well as connected to VARAN. If the load of the devices and brakes is more than 20 A (maximum current in the Bus Connection Block), an additional power/axis module must be installed.

5.5 Software Function

- Field-oriented current controller (Cycle time 62.5 µs)
- Feedback detection and speed controller (access time 62.5 µs)
- Spline interpolation and position controller (cyclic time 62.5 µs)
- full synchronization up to the output stage to the control frequency with cycle times of 250 µs, 500 µs and 1 ms to 8 ms
- Log data are stored on a nonvolatile storage medium

6 Safety Functions

6.1 Overview

The devices of the series DIAS-Drive 2000 have the following safety features:

STO	Safe Torque Off (does not require safe position detection)
SS1	Safe Stop 1 (does not require safe position detection if SS1 with time control)
SS2	Safe Stop 2
SOS	Safe Operating Stop
SLA	Safely Limited Acceleration
SLS	Safely Limited Speed
SLP	Safely Limited Position (referencing of the absolute position necessary)
SDI	Safe Direction
SBC	Safe Brake Control
SSM	Safe Speed Monitor
SBT	Safe Brake Test
SMS	Safe Maximum Speed
SLI	Safely Limited Increment
SMA	Safe Maximum Acceleration
SCA	Safe Cam

INFORMATION

Settings and Configuration

→ For detailed information as well as configuration settings of the individual parameters, please refer to the SAFETY System Handbook and SAFETYDesigner help.

Safety functions such as Safe Limited Speed require safe position detection. In order to be able to implement the requirement according to EN ISO 13849, category 4, it must be possible to represent a continuous 2-channel structure.

Mechanical faults, such as axle breakage, must be excluded by the design, e.g. by overdimensioning. This is the task of the machine builder and is not considered here.

WARNING

Safety functions are only available if the basic conditions specified in the standards (with regard to encoders, etc.) are fulfilled!

Les fonctions de sécurité ne sont disponibles que si les conditions cadres spécifiées dans les normes (concernant les codeurs, etc.) sont remplies !

Safety functions are only available in combination with Hiperface DSL Safety encoders (EKS36, EKM36).

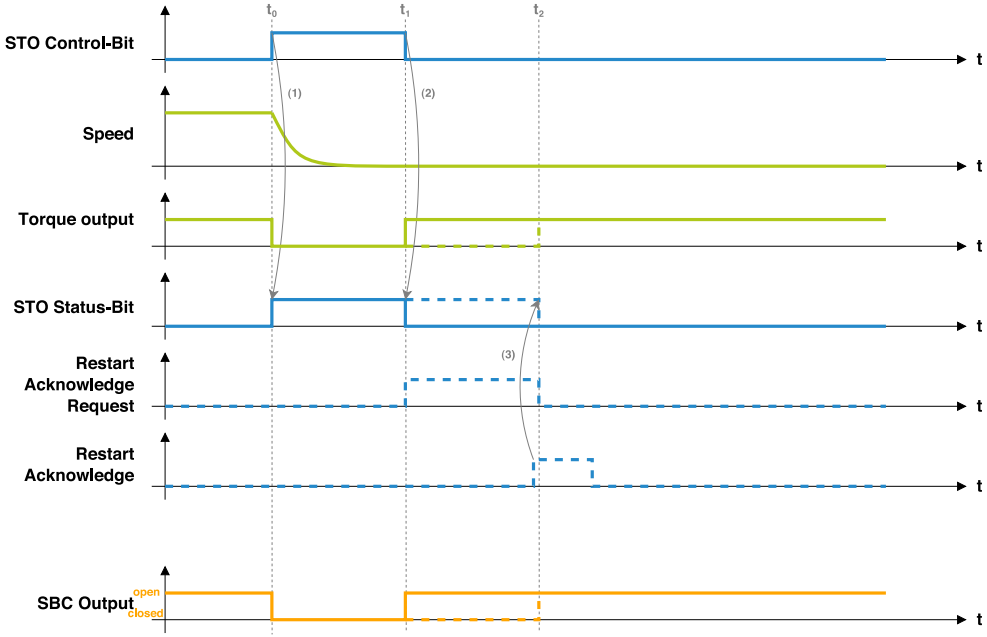
6.2 Description of the Safety Functions

6.2.1 Stop Functions

The different stop functions are explained below.

6.2.1.1 STO - Safe Torque Off

With the STO safety function the drive can be safely switched momentlessly and the axis can thus be brought to a standstill without being controlled. As soon as the function is executed, no more torque can be built up.



The signals shown in blue in the figure are control or status signals, which can only assume the HIGH or LOW states. The values marked in green correspond to measured values, that can take on more values accordingly.

Functional Description

By activating the STO control bit, the drive is switched momentlessly and the axis is brought to an uncontrolled standstill (1). From this point on, the axis can no longer be controlled and will coast to a stop, if it was previously in motion. The status bit signals, that no more torque can be built up.

The behavior when deactivating the control bit (2) depends on the restart behavior setting:

- Automatic restart: In this case, the function is terminated immediately and torque can be built up again.
- Manual restart: In this case, the function is not terminated, but continues to be executed, until a rising edge is triggered at the "Restart Acknowledge" (3). The function signals the need for a "Restart Acknowledge" by setting the "Restart Acknowledge Request" signal. The behavior is shown in the timing diagram with the dashed lines.

Optionally, with the activation of STO, an SBC safety function can also be executed to close the holding brake, while the axis is switched momentless.

Error Reaction

No error reactions are possible with the STO safety function.

Parameters	
Restart Acknowledge	Manual: Manual: Restart Acknowledge function is needed for this Automatic: Automatic restart
Activate SBC	Optional: Function for service brake is started when activated Possible entries: None, SBC_1,…,SBC_8

6.2.1.2 SS1 – Safe Stop 1

With the SS1 safety function the drive can be switched momentless with a time delay and the axis can thus be brought to a controlled standstill. The function related part can brake the axis appropriately during the execution of SS1 to prevent it from spinning out. STO is triggered at the end of the safety function.

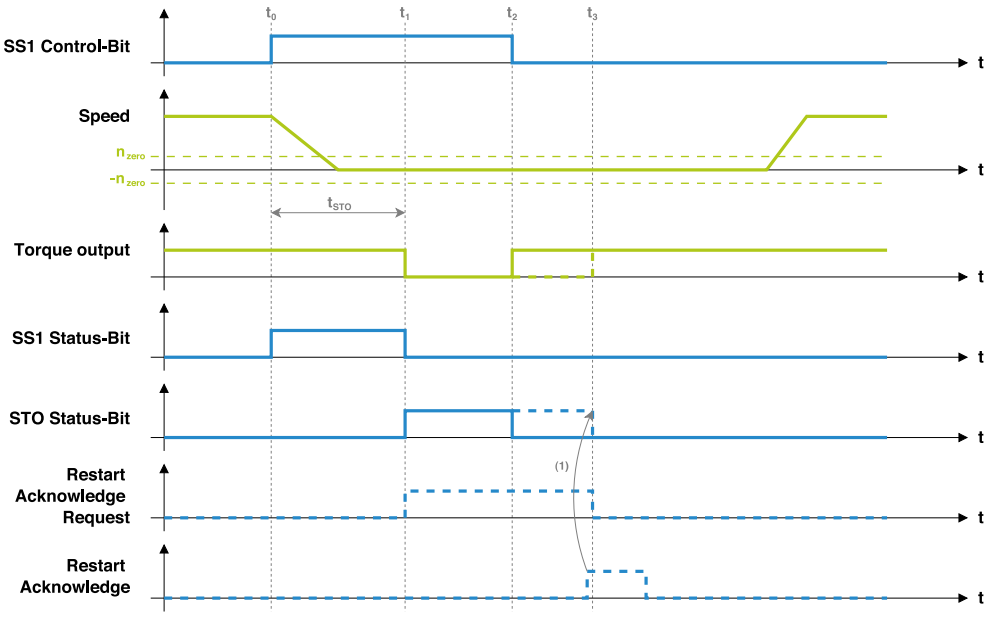
With SS1 different variants are possible depending on the configuration, whereby the variants are not mutually exclusive, but can be used in combination.

Regardless of the variant, SS1 always results in the STO safety function. Therefore, the restart behavior of STO also comes into play when triggered by SS1.

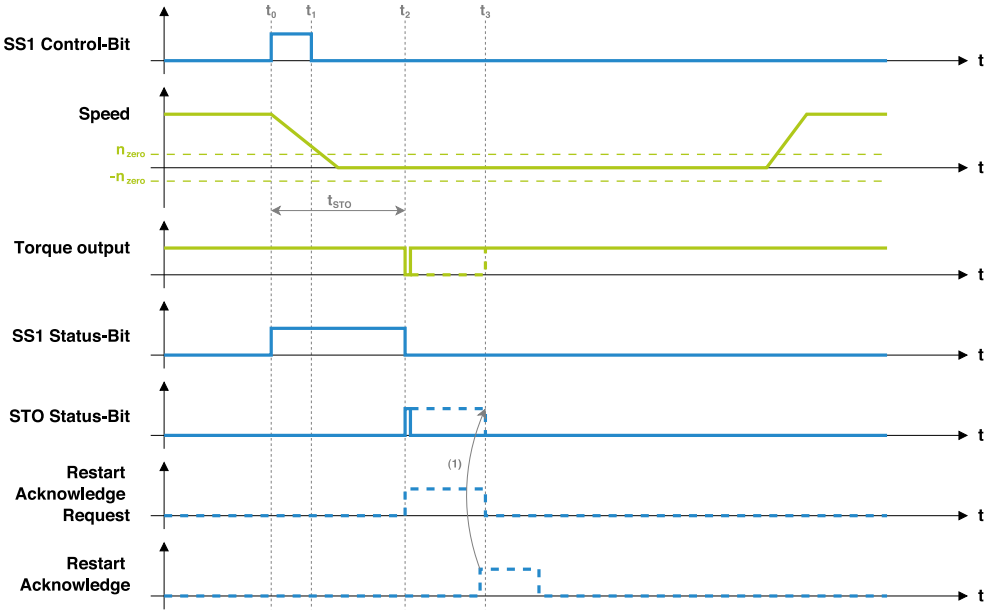
6.2.1.3 SS1 with Constant Time Delay

The standard and at the same time minimal variant of SS1 is that with time-delayed STO. After execution of SS1, STO is triggered after a set waiting time (t_{STO}).

Timing



The sequence shown in the figure shows the standard variant of SS1, where the SS1 trigger (control bit) is active for longer than t_{STO}. In the sequence shown in the following figure, in comparison, the trigger is activated only for a short moment. Regardless of this duration, SS1 is finalized after triggering in any case.



Functional Description

By activating SS1 (t_0) the timer starts counting, which leads to the execution of the safety function STO, after t_{STO} has expired. The activation of SS1 is communicated to the function related part and signaled via the status bit, so that the brakes can be applied accordingly.

Optionally a zero window (n_{zero}) can be configured. If this is included in the configuration, a check is made, when t_{STO} runs to see, whether the speed is within this window. If an overrun is detected, this leads to STO as an error reaction.

While the checks in the course of SS1 are still active and STO is not yet executed, the SS1 status bit is set. As soon as one of the conditions leads to the execution of STO, the SS1 status bit is reset and STO is executed (STO status bit set).

Regardless of whether the SS1 control bit is set long enough, SS1 is always executed until STO is triggered in sequence.

If the SS1 control bit is not removed until after STO has been triggered (see t_2 in "SS1 with Constant Time Delay" 1st figure), STO remains active until this point in time. After that the SS1 function and thereby also STO is terminated. For STO, the restart behavior configured at STO is used (solid line = automatic restart; dashed line = manual restart).

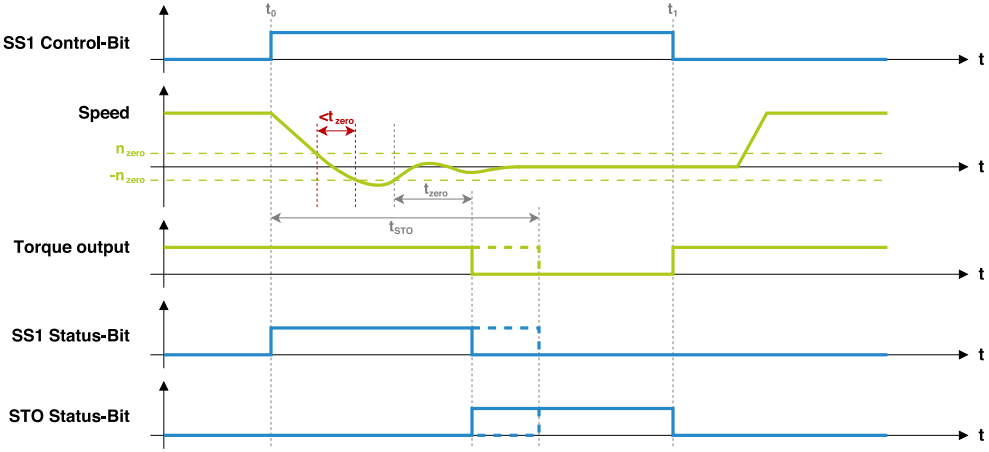
However, if the SS1 trigger is taken away prematurely (see t_1 in "SS1 with Constant Time Delay" 2nd figure), the function is still finalized and STO is executed at the end for only one cycle (if STO is configured with automatic restart).

For manual restart, a Restart Acknowledge is necessary (see arrow (1)).

6.2.1.4 SS1 with Speed Monitoring

In addition to the standard variant, the speed can be monitored to trigger STO prematurely, if the speed is in the zero window (n_{zero}) long enough (t_{zero}).

Timing



The SS1 sequence shown in this timing diagram includes a further configurable time (t_{zero}) that enables premature triggering of STO. Additionally, the standard variant is shown in dashed lines, which is used, if the t_{zero} time is not configured.

Functional Description

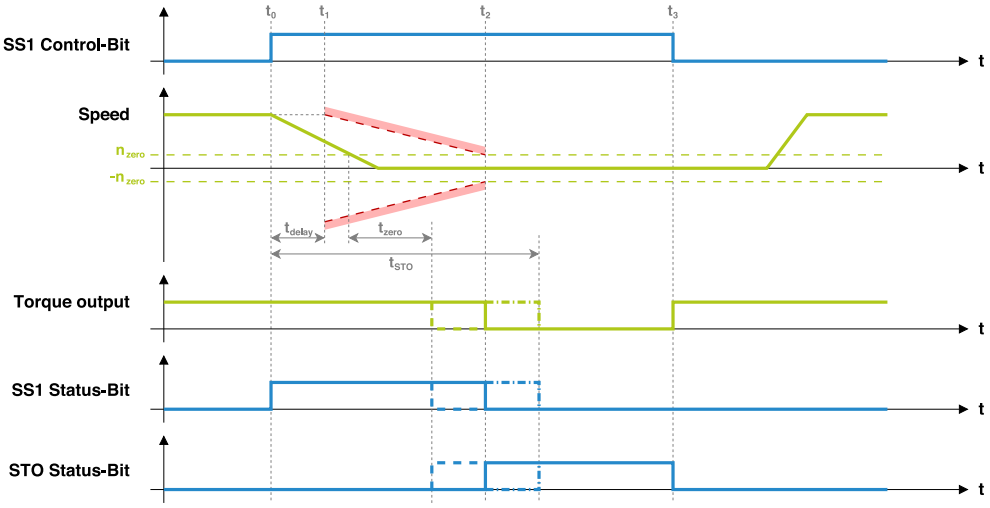
In order to be able to trigger STO before the time t_{STO} has elapsed in the event of a faster deceleration, speed monitoring can also be activated. This speed monitoring checks, if the speed is in the zero window (between $-n_{zero}$ and n_{zero}) long enough and is activated by configuring t_{zero} not equal to zero.

The speed must be within the zero window for at least t_{zero} at a time. If the speed reaches the window but then leaves it too quickly (see red marking in the above figure), the process is aborted and the timer is restarted the next time, it enters the zero window. As soon as the condition is fulfilled, SS1 is finalized prematurely and STO is triggered.

6.2.1.5 SS1 with Deceleration Monitoring

In addition to the monitoring already mentioned, the deceleration can also be monitored with SS1. This monitors, whether the speed is within the configured ramp during the braking process. This means, that it can be detected at an early stage, whether braking is working and STO can be triggered earlier in the event of an error.

Timing



Compared to temporal monitoring, the speed must be within the red mark during deceleration with active deceleration monitoring.

Functional Description

The temporal behavior of SS1 remains unchanged. In addition, the delay of the speed is monitored.

Since the function related part cannot start braking immediately, a delay (t_{delay}) is waited for from time t_0 onwards. Only when this delay has expired (t_1) the speed is monitored. However, it is not expected that deceleration is continuous, but that the maximum permitted speed is reduced millisecond by millisecond with the set delay.

Initially, the value that was measured, when SS1 was triggered, is used as the maximum permitted speed. The permitted speed is then reduced, until it reaches the zero window (t_2). If the speed remains within the permitted limits during this time, the SS1 function is finalized and STO is triggered at the moment, when the ramp (shown in red) reaches the zero window (t_2).

The point in time, when STO is triggered, depends on the delay time (t_{delay}) and the minimum delay ($a_{deceleration}$), i.e. also on the output speed. The higher the speed, the longer it takes for the ramp to reach the zero window. The maximum duration, until STO is triggered, is limited by t_{STO} (dash-dotted representation in above figure). Premature STO triggering by the zero window (dashed representation in the above figure) is also possible in combination.

If the maximum permitted speed is violated during monitoring, STO is triggered as an error reaction and the SS1 function is finalized.

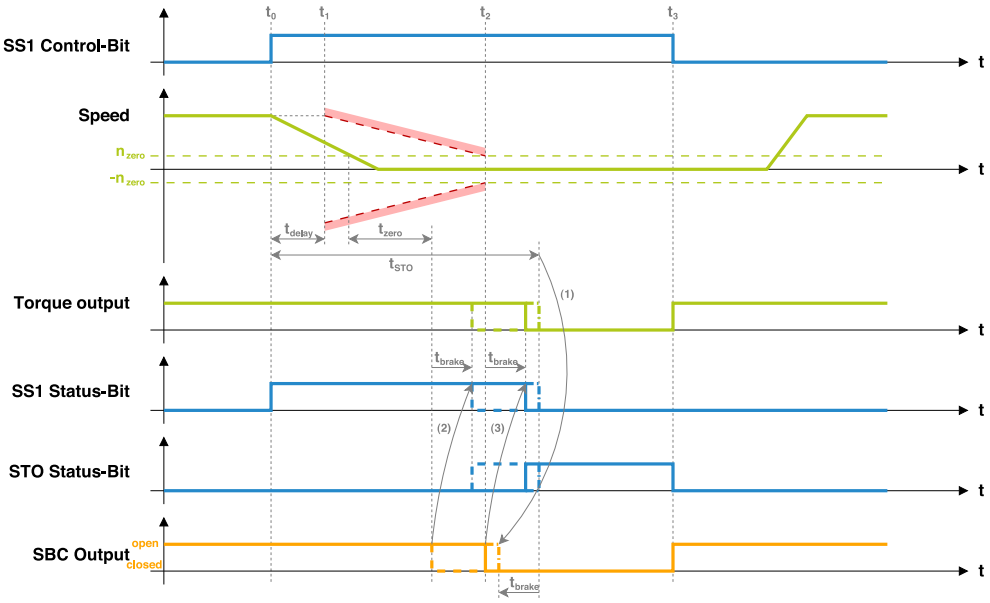
6.2.1.6 SS1 with SBC

With SS1 the holding brake can also be triggered as with STO. However, with SS1 there is the option of closing the holding brake correspondingly earlier, since this still requires a certain amount of time after being triggered, until the brake is actually closed.

Depending on the SS1 configuration, the brake can be closed prematurely in the following cases:

- Before expiration of t_{STO}: To ensure that STO is triggered after t_{STO} in any case, the brake is closed earlier in this case by the brake closing time configured at SBC (at time t_{STO}-tbrake).
- After premature triggering by zero window: If the speed has remained in the zero window long enough, SS1 is not directly finalized and STO is triggered at this point, if the SBC option is configured, but SBC is triggered first and STO is only triggered after t_{brake}.
- After premature triggering by deceleration monitoring: In this case the same logic is used as for the zero window. SBC is triggered first and STO only after t_{brake}.

Timing



The figure shows the same example as in the last figure but with additional SBC option. Therefore, the respective SS1 checks do not directly lead to SS1 finalization followed by STO, but as previously described first to the triggering of SBC. Only the case marked with arrow (1) does not delay the STO execution backwards, but executes SBC correspondingly earlier.

Functional Description

To configure SS1 so that the brake is also released accordingly, the SBC option must be activated at SS1. The time, the brake needs to close (t_{brake}), is not configured at SS1, but is part of the SBC configuration.

The brake is always executed at the time t_{brake} before STO, when the SBC option is active. The possible cases are shown with the arrows (1), (2) and (3) accordingly. This ensures, that the brake is already safely closed, before no more torque can be built up.

Error Reaction

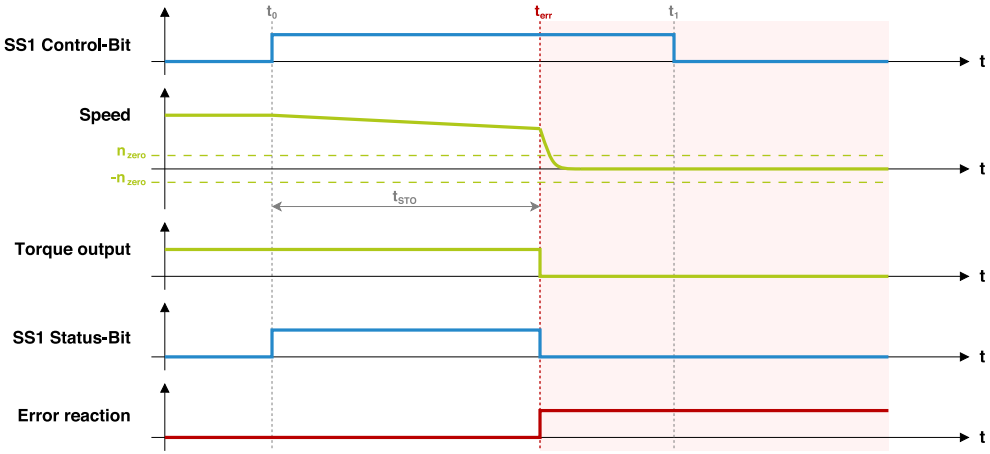
With SS1 2 different types of errors can occur:

Speed at the end not within the zero window: If the zero window is configured, the speed must be within the zero window (between $-n_{zero}$ and n_{zero}) when running t_{STO}.

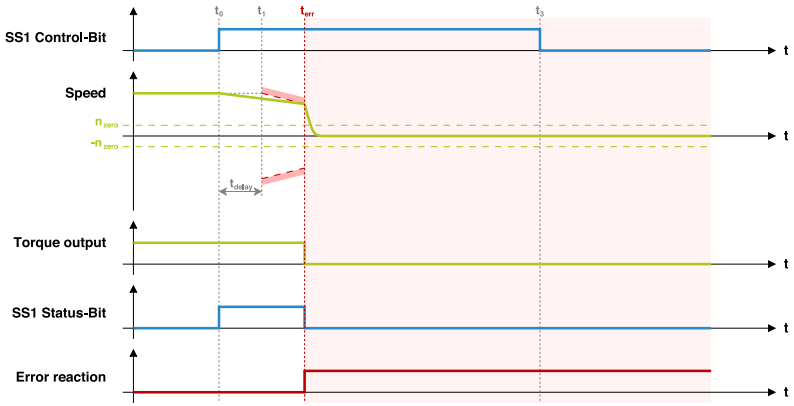
Maximum speed exceeded during deceleration monitoring: When deceleration monitoring is active, the speed must be within the deceleration ramp.

If an error is detected during one of the two checks, SS1 is immediately finalized and STO is triggered as an error reaction.

The two error cases are shown below with the help of timing diagrams. The time of the error is marked with t_{err}:



The error case shown in the figure shows the behavior of SS1, when the speed is outside the zero window, after t_{STO} has elapsed. The following diagram shows the error case for delay monitoring.



Parameters	
Time STO (t_{STO})	Timespan until STO is started
Velocity (n_{zero})	Optional velocity monitoring: if not 0, the velocity must be in this range after "Time STO" has expired
Time Velocity (t_{zero})	Optional: if not equal to 0, STO is activated immediately if the velocity "Time Velocity"-long is within the value of "Velocity".
Deceleration Limit ($a_{deceleration}$)	Optional for velocity monitoring: Limit value of the deceleration
Time Deceleration (t_{delay})	Optional: Time until deceleration monitoring is activated
Activate SBC	Function for service brake is activated Possible entries: None, SBC_1,...,SBC_8

INFORMATION

When using the service brake, note that it is started by "Brake Time" (from SBC) before "Time STO" has elapsed, or that after "Time Velocity" (for speed monitoring) SBC is started but only after "Brake Time" has elapsed is the status of STO set and the status of SS1 reset

6.2.1.7 SS2 – Safe Stop 2

With the SS2 safety function the drive can be stopped in a controlled manner without the axis being switched momentless. As a result, the SOS safety function is executed to hold the axis at the current position.

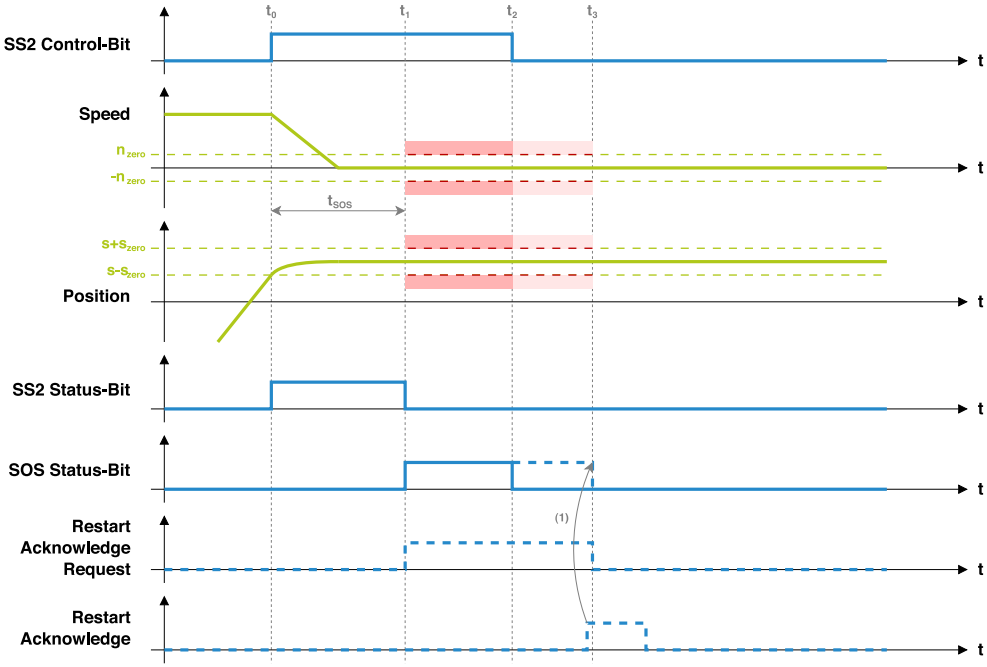
With SS2 different variants are possible depending on the configuration, whereby the variants are not mutually exclusive, but can be used in combination.

Regardless of the variant, SS2 always results in the associated SOS safety function. If SOS is triggered by SS2, the restart behavior of SOS can be configured as for SS1.

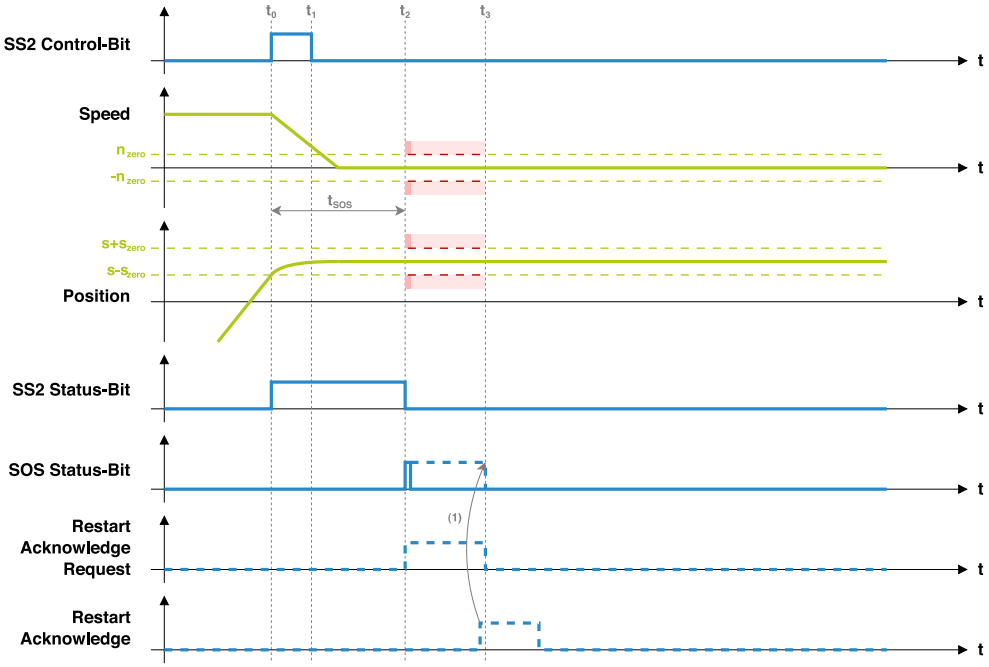
6.2.1.8 SS2 with Constant Time Delay

The standard and at the same time minimum variant of SS2 is the one with time-delayed SOS. In this case, SOS is triggered after execution of SS2 after a set waiting time (t_{SOS}).

Timing



The above sequence shows the standard variant of SS2, where the SS2 trigger (control bit) is active longer than t_{SOS}. In the sequence shown in the following figure, in comparison, the trigger is activated only for a short moment. Regardless of this duration, SS2 is finalized after triggering in any case.



By activating SS2 (t_0), the timer starts counting, which leads to the execution of the associated safety function SOS, after t_{SOS} has elapsed. By "associated" is meant, that for the 4th instance of SS2 (SS2_4) also the 4th instance of SOS (SOS_4) is used as a subsequent function.

The activation of SS2 is communicated to the function related part and signaled via the status bit, so that the brakes can be applied accordingly.

While the checks in the course of SS2 are still active and SOS is not yet executed, the SS2 status bit is set. As soon as one of the conditions leads to the execution of SOS, the SS2 status bit is reset and SOS is executed (SOS status bit set).

Regardless of whether the SS2 control bit is set long enough, SS2 is always executed until SOS is triggered in sequence.

If the SS2 control bit is not removed until after SOS has been triggered (see t_2 in "SS2 with Constant Time Delay" figure 1), SOS remains active until this time. After that the SS2 function and thereby also SOS is terminated. For SOS, the restart behavior configured at SS2 is used (solid line = automatic restart; dashed line = manual restart).

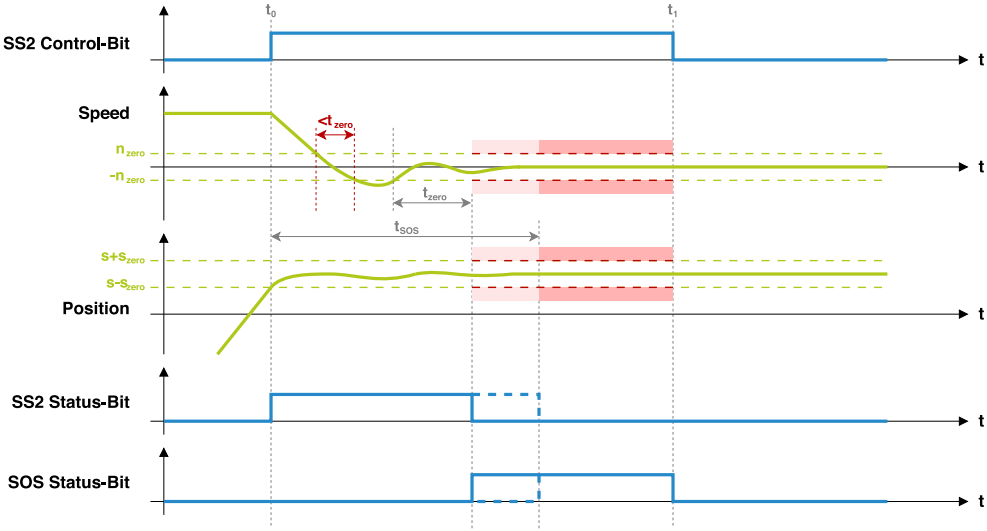
However, if SS2 triggering is removed prematurely (see t_1 in "SS2 with Constant Time Delay" figure 2), the function is still finalized and SOS is executed at the end for only one cycle (if automatic restart is configured).

For manual restart, a Restart Acknowledge is necessary (see arrow (1)).

6.2.1.9 SS2 with Speed Monitoring

In addition to the standard variant, the speed can be monitored to trigger SOS prematurely, if the speed is in the zero window of SOS (n_{zero}) long enough (t_{zero}).

Timing



The SS2 sequence shown in this timing diagram includes a further configurable time (t_{zero}), which enables premature triggering of SOS. Additionally, the standard variant is shown in dashed lines, which is used, if the t_{zero} time is not configured.

Functional Description

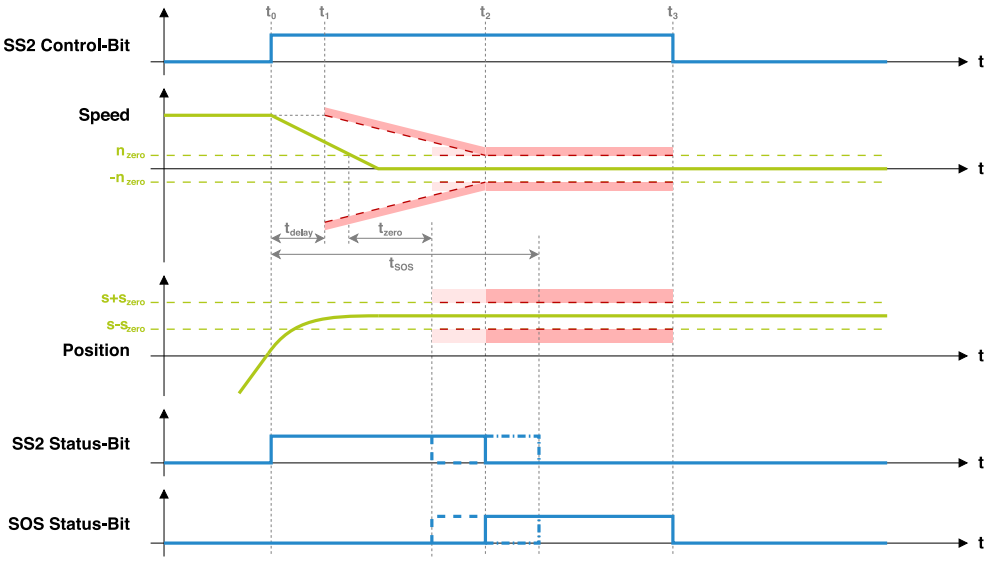
In order to be able to trigger SOS before the time t_{SOS} has elapsed in the event of a faster deceleration, speed monitoring can also be activated. This speed monitoring checks, if the speed is in the zero window of SOS (between $-n_{zero}$ and n_{zero}, configured at SOS) for a long enough time and is activated by configuring t_{zero} not equal to zero.

The speed must be within the zero window for at least t_{zero} at a time. If the speed reaches the window but then leaves it too quickly (see red mark in the figure), the process is aborted and the timer is restarted the next time it enters the zero window. As soon as the condition is fulfilled, SS2 is finalized prematurely and SOS is triggered.

6.2.1.10 SS2 with Deceleration Monitoring

In addition to the monitoring already mentioned, the deceleration can also be monitored with SS2. This monitors, whether the speed is within the configured ramp during the braking process. This makes it possible to detect at an early stage, whether braking is working and to trigger the configured error reaction in the event of an error.

Timing



Compared to temporal monitoring, the speed must be within the red mark during deceleration with active deceleration monitoring.

Functional Description

The temporal behavior of SS2 remains unchanged. In addition, the delay of the speed is monitored.

Since the function related part cannot start braking immediately, a delay (t_{delay}) is waited for from time t_0 onwards. Only when this delay has expired (t_1) the speed is monitored. However, it is not expected that deceleration is continuous, but that the maximum permitted speed is reduced millisecond by millisecond with the set delay.

Initially, the value that was measured, when SS2 was triggered, is used as the maximum permitted speed. The permitted speed is then reduced, until it reaches the zero window (t_2). If the speed remains within the allowed limits during this time, the SS2 function is finalized and SOS is started at the moment, when the ramp (shown in red) reaches the zero window (t_2).

The point in time, when SOS becomes active, depends on the delay time (t_{delay}) and the minimum delay (adeceleration), i.e. also on the output speed. The higher the speed, the longer it takes for the ramp to reach the zero window. The maximum duration, until SOS is activated, is limited by t_{SOS} (dash-dotted representation in the figure). The premature SOS activation by the zero window (dashed representation in the figure) is also possible in combination.

If the maximum allowed speed is violated during monitoring, the configured error reaction is triggered and the SS2 function is finalized.

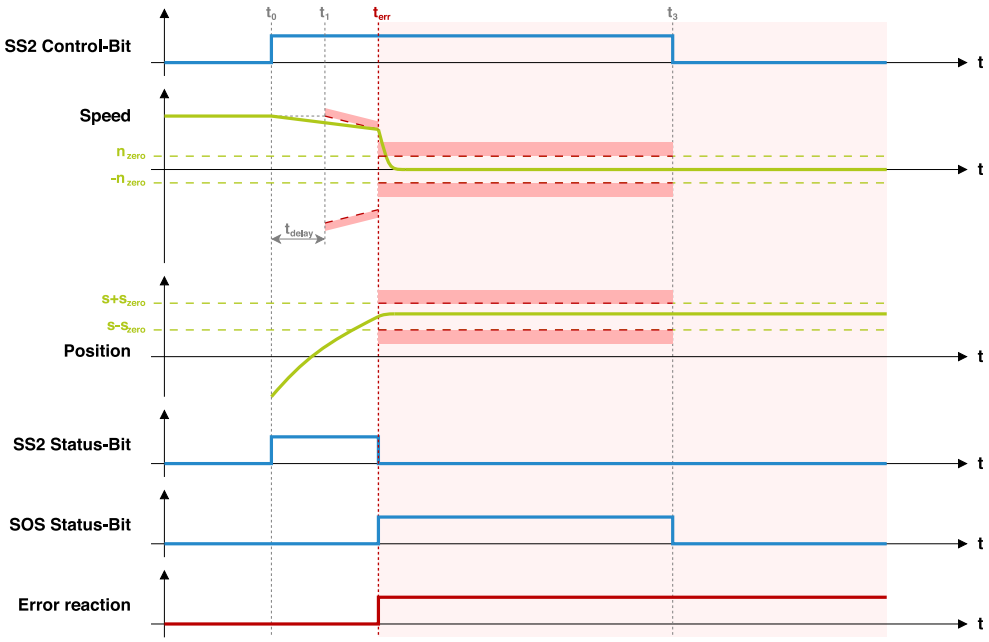
Error Reaction

Only one error can occur with SS2:

- Maximum speed exceeded during deceleration monitoring: When deceleration monitoring is active, the speed must be within the deceleration ramp. If an overrun is detected, SS2 is immediately finalized and the configured error reaction is triggered.

As soon as SS2 has been finalized and SOS is active, speed and position monitoring by SOS takes place. These can also cause corresponding error reactions and are described in the SOS chapter.

The described error case is shown below with the help of a timing diagram. The time of the error is marked with t_{err}:



Parameters	
Time SOS (t_{sos})	Timespan until SOS is activated. This activates the same instance of SOS (e.g. SS2_3 starts SOS_3).
Time Velocity (t_{zero})	Optional: if not 0, SOS is activated immediately if the velocity in time is within the value of "Velocity" (from the function SOS)
Deceleration Limit ($a_{deceleration}$)	Optional: Limit value of the deceleration
Time Deceleration (t_{delay})	Optional: Time until deceleration monitoring is activated.
Restart Acknowledge	Manual: Manual restart for SOS Automatic: Automatic restart for SOS
Error Reaction	Function started in case of an error Possible entries: STO, SS1_1,…SS1_8

6.2.2 Monitoring Functions

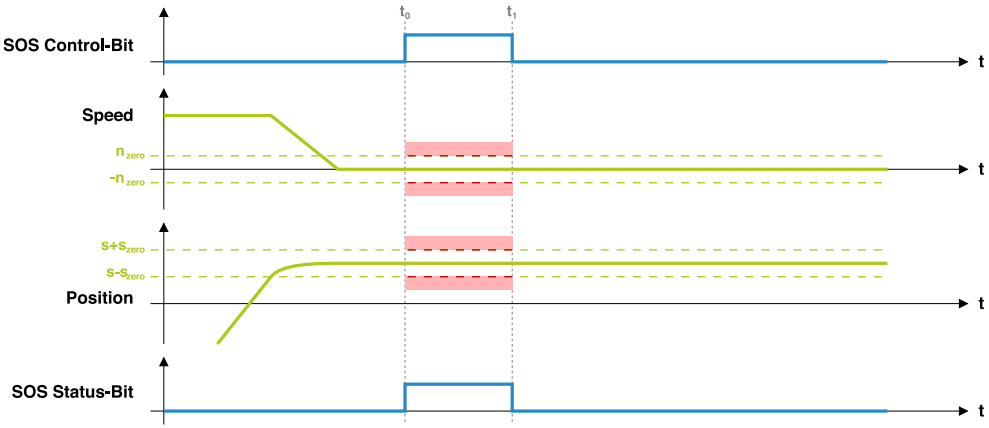
The different monitoring functions are explained below.

6.2.2.1 SOS – Safe Operation Stop

This function prevents the motor from deviating from the stop position by more than a specified amount. The drive is supplied with energy that enables it to withstand being attacked by external forces. The control to keep the drive in position is active.

The SOS safety function can be used to monitor, whether the position does not change or only changes minimally during execution.

Timing



The displayed timing diagram shows the behavior of the safety function SOS. If SOS is executed directly and not activated via SS2, monitoring is immediately inactive, when the SOS control bit is deactivated, which is why the manual restart behavior (only configurable when triggered via SS2) is not shown in this diagram.

Functional Description

With the activation of SOS by the control bit (t_0) the monitoring of the position is started. First the position measured at time t_0 is stored as the initial position. Then it is checked, whether the position remains within the zero window (between $s-s_{zero}$ and $s+s_{zero}$). If an overrun is detected here, the configured error reaction is triggered.

With the deactivation of SOS (t_1) the monitoring is stopped again. An active monitoring is signaled by the SOS status bit.

In addition to the position, the speed can optionally be monitored. For this purpose, a zero window must also be configured for the speed. A non-zero value activates this additional monitoring. However, compared to position monitoring, the zero window is not applied based on the speed measured at activation, but on the speed 0. It is therefore checked, that the speed remains between $-n_{zero}$ and n_{zero}. Exceeding this value also triggers the configured error reaction.

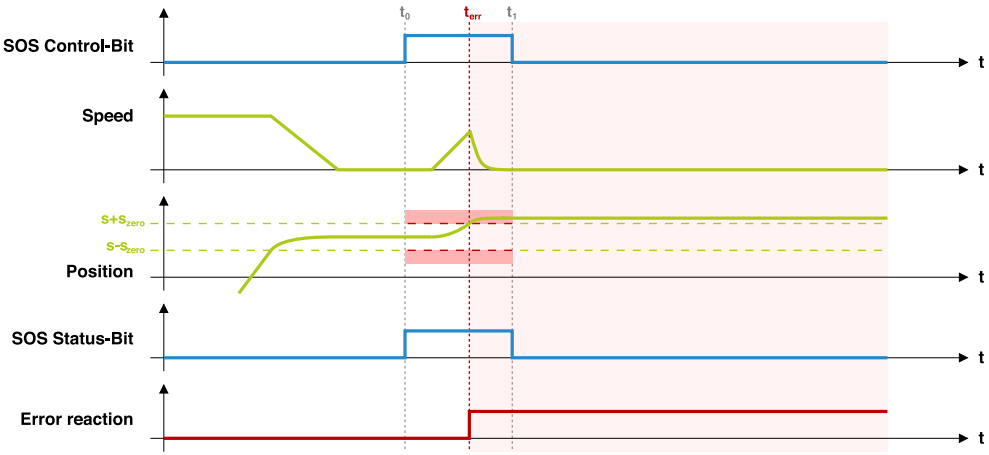
Error Reaction

With SOS 2 different types of errors can occur:

- Position outside the zero window: While SOS is active, the position must not leave the zero window (between $s-s_{zero}$ and $s+s_{zero}$).
- Speed is too high: If the zero window is configured for the speed, the speed must be within the zero window (between $-n_{zero}$ and n_{zero}), while SOS is active.

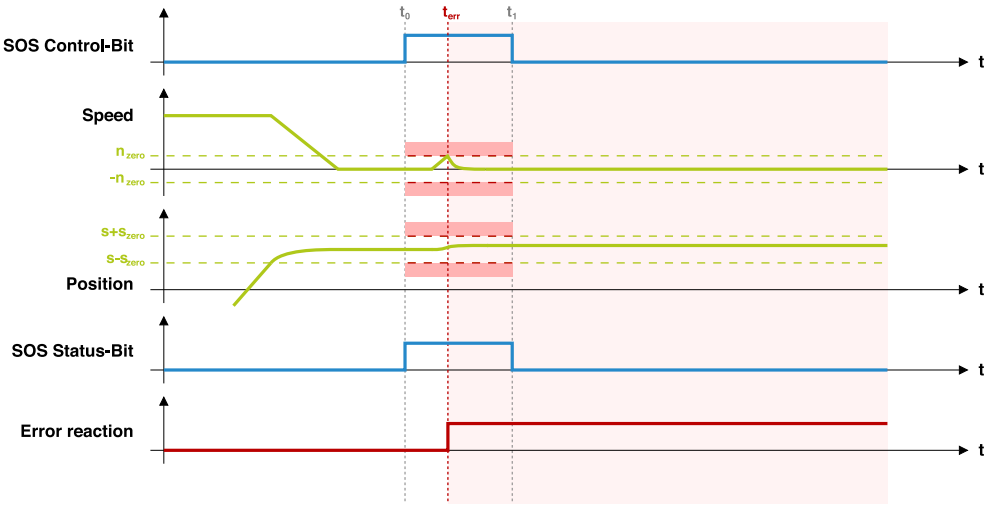
If an error is detected during one of the two checks, the safety function configured as error reaction is triggered.

The two error cases are shown below with the help of timing diagrams. The time of the error is marked with t_{err}:



In the error case shown, it can be seen, that after the error has been detected (t_{err}), SOS remains active, until the control bit is deactivated (t_1). If the error would be acknowledged between t_{err} and t_1, SOS would immediately return an error, because the position is still outside the zero window.

The error case with activated speed monitoring is shown below:



Parameters	
Position Tolerance (s_{zero})	Tolerance for position 0
Velocity Zero-Window (n_{zero})	Optional: Tolerance for velocity 0
Error Reaction	Function started in case of an error Possible entries: STO, SS1_1,…SS1_8

6.2.2.2 SLA (Safely limited Acceleration)

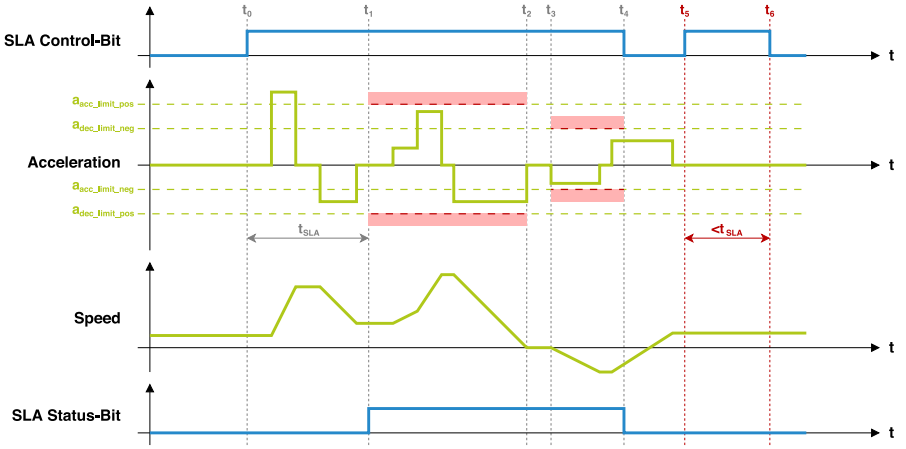
If the same acceleration or deceleration limits are to be used for both directions of rotation, the following applies:

$a_{acc\_limit\_pos} = -a_{acc\_limit\_neg}$

$a_{dec\_limit\_pos} = -a_{dec\_limit\_neg}$

The SLA safety function can be used to restrict the acceleration of the drive to a configurable range. While the function is active, it monitors, whether the acceleration does not exceed the configured limits.

Timing



The example shows the acceleration monitoring in the course of SLA, where different limit values are used depending on the direction of rotation (positive or negative speed).

Functional Description

With the activation of SLA by the control bit (t_0) a timer is started, which starts the monitoring of the acceleration/deceleration, after the time t_{SLA} has elapsed. Until it has expired (t_1), the configured limit values may still be exceeded.

As soon as the timer has expired, the acceleration/deceleration may only move within the set limits (for positive direction of rotation between $a_{dec\_limit\_pos}$ and $a_{acc\_limit\_pos}$, for negative speed between $a_{acc\_limit\_neg}$ and $a_{dec\_limit\_neg}$). This limitation is shown in red and is active, until SLA is deactivated again (t_4). If the allowed range is left, the configured error reaction is triggered.

If the time t_{SLA} is configured with 0, monitoring is started immediately after activation of the control bit. Should SLA be activated only for such a short time, that the total execution time is less than t_{SLA} (between t_5 and t_6), no monitoring takes place.

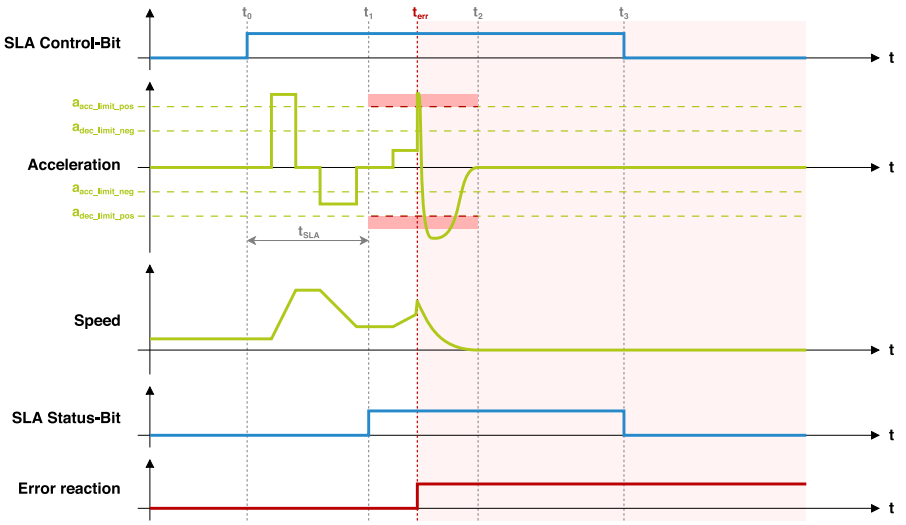
Whether acceleration or deceleration monitoring is currently taking place due to SLA, is signaled by the SLA status bit.

Error Reaction

Only one error can occur with SLA:

- Permitted acceleration/deceleration exceeded: If monitoring is active, the acceleration/deceleration must be within the set limit values depending on the direction of rotation. Should an overrun be detected, the configured error reaction is triggered.

The described error case is shown below with the help of a timing diagram. The time of the error is marked with t_{err}:



The error case shown indicates, that when the acceleration limit is exceeded (depending on the direction of rotation), the configured error reaction is triggered immediately. This example shows the behavior with STO as error reaction.

As soon as the speed reaches the value 0 (t_2), no further monitoring takes place. If the error is acknowledged before SLA is deactivated (t_3) or the speed changes for another reason, monitoring takes place again while SLA is still activated by means of the control bit.

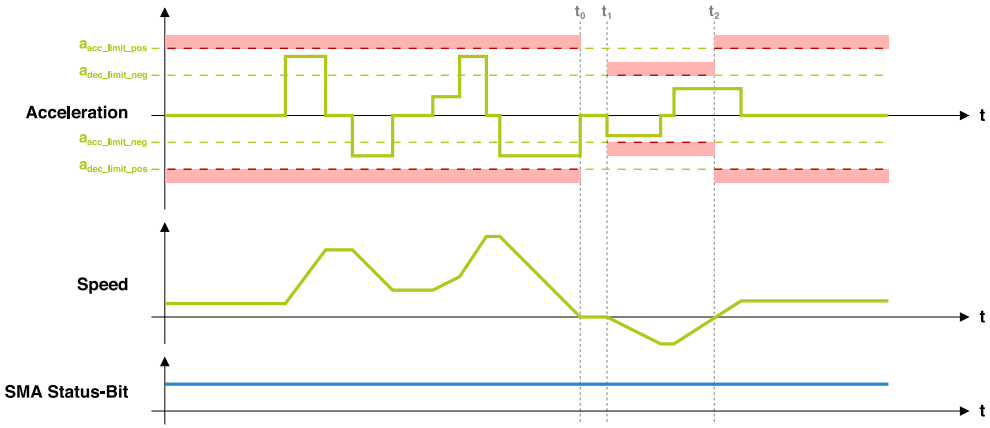
Parameters	
Time (t_{SLA})	Time until the start of monitoring
Acceleration Positive Limit ($a_{acc\_limit\_pos}$)	Limit for acceleration in positive direction of motion
Deceleration Positive Limit ($a_{dec\_limit\_pos}$)	Limit for deceleration in negative direction of movement
Acceleration Negative Limit ($a_{acc\_limit\_neg}$)	Limit for acceleration in negative direction of motion
Deceleration Negative Limit ($a_{dec\_limit\_neg}$)	Limit for deceleration in negative direction of movement

Parameters	
Error Reaction	Function started in case of an error Possible entries: STO, SS1_1,…SS1_8

6.2.2.3 SMA – Safe Maximum Acceleration

The SMA safety function can be used to limit the maximum acceleration or deceleration of the drive. The function is active by parameterization and executes the configured error reaction, when the set limit values are exceeded.

Timing



Functional Description

The function is permanently active, if at least one of the acceleration ($a_{acc\_limit\_pos}$ or $a_{acc\_limit\_neg}$) or deceleration ($a_{dec\_limit\_pos}$ or $a_{dec\_limit\_neg}$) limits is configured. Depending on the direction of rotation, different limit values for the permissible acceleration or deceleration can be set.

The following checks take place when the function is parameterized:

- Acceleration in positive direction of rotation may reach maximum $a_{acc\_limit\_pos}$
- Acceleration in negative direction of rotation may reach maximum $a_{acc\_limit\_neg}$
- Deceleration in positive direction of rotation may reach maximum $a_{dec\_limit\_pos}$
- Deceleration in negative direction of rotation may reach maximum $a_{dec\_limit\_neg}$

Exceeding the limit leads to the triggering of the configured error reaction. However, if the drive does not move in either the positive or negative direction (standstill) and thus the acceleration corresponds to the value 0, no check takes place at this time (period t_0 to t_1).

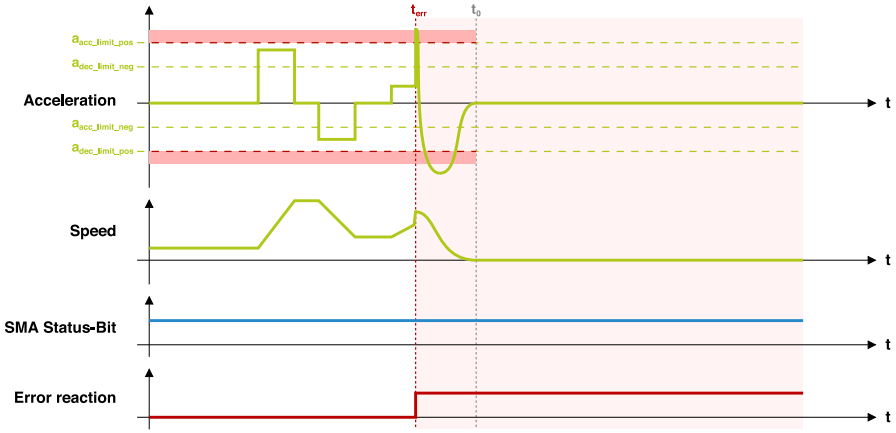
The SMA status bit indicates, whether the function is active.

Error Reaction

Only one error can occur with SMA:

- Permitted acceleration/deceleration exceeded: If SMA is parameterized, the acceleration/deceleration must be within the set limit values depending on the direction of rotation. Should an overrun be detected, the configured error reaction is triggered.

The described error case is shown below with the help of a timing diagram. The time of the error is marked with t_{err}:



Parameters	
Acceleration Positive Limit ($a_{acc\_limit\_pos}$)	Limit for acceleration in positive direction of motion
Deceleration Positive Limit ($a_{dec\_limit\_pos}$)	Limit for deceleration in negative direction of movement
Acceleration Negative Limit ($a_{acc\_limit\_neg}$)	Limit for acceleration in negative direction of motion
Deceleration Negative Limit ($a_{dec\_limit\_neg}$)	Limit for deceleration in negative direction of movement
Error Reaction	Function started in case of an error Possible entries: STO, SS1_1,…SS1_8

6.2.2.4 SLS - Safely Limited Speed

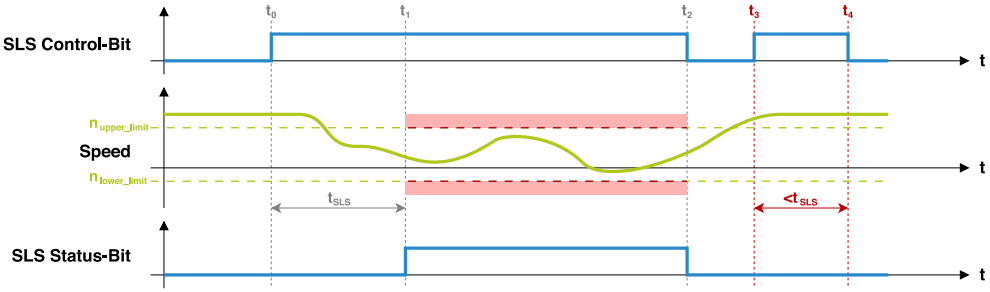
The SLS safety function can be used to limit the speed of the drive. While the function is active, the speed is monitored for compliance with the configured limit values.

If necessary, the monitoring can be started with a time delay, so that the speed does not have to be in the configured range immediately after activation, but there is still time available for braking. Different variants are possible with this delay, whereby the variants are not mutually exclusive, but can be used in combination.

6.2.2.5 SLS with Activation by Delay Time

The standard and at the same time minimal variant of SLS is the one with adjustable delay time. In this case, speed monitoring is started after the set waiting time (t_{SLS}) after activation of SLS.

Timing



The shown sequence shows a SLS configuration with set delay time.

Functional Description

With the activation of SLS by the control bit (t_0) a timer is started, which starts the monitoring of the speed after the time t_{SLS} has elapsed. Until this has expired (t_1), the speed may still exceed the configured limits.

Once the timer has expired, the speed may only move within the set limits (between n_{lower_limit} and n_{upper_limit}). This limitation is shown in red in the figure and is active until SLS is deactivated again (t_2). If the speed leaves the permitted range, the configured error reaction is triggered.

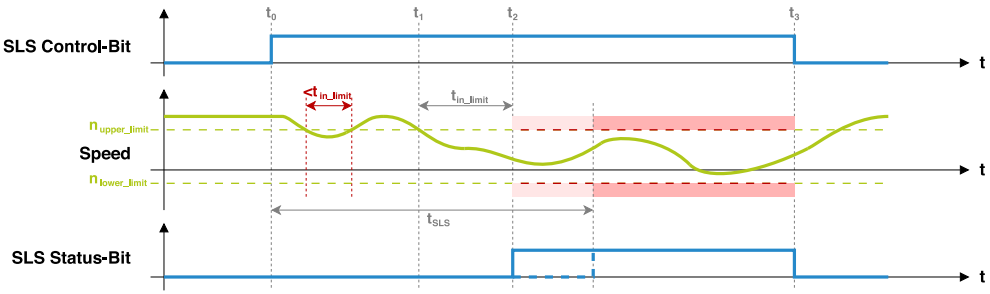
If the time t_{SLS} is configured with 0, monitoring is started immediately after activation of the control bit. If SLS is activated only for such a short time, that the total execution time is less than t_{SLS} (in the figure between t_3 and t_4), no speed monitoring takes place.

Whether speed monitoring is currently taking place due to SLS, is signaled by the SLS status bit.

6.2.2.6 SLS with Activation by Low Speed

In addition to the standard variant, speed monitoring can be activated prematurely, if the speed is within the set limits (between n_{lower_limit} and n_{upper_limit}) long enough (for at least t_{in_limit}).

Timing



Functional Description

Similar to SS1 and SS2, in addition to the time delay, the speed can be checked to start speed monitoring ahead of time. For this the time t_{in_limit} must be configured with a value unequal 0.

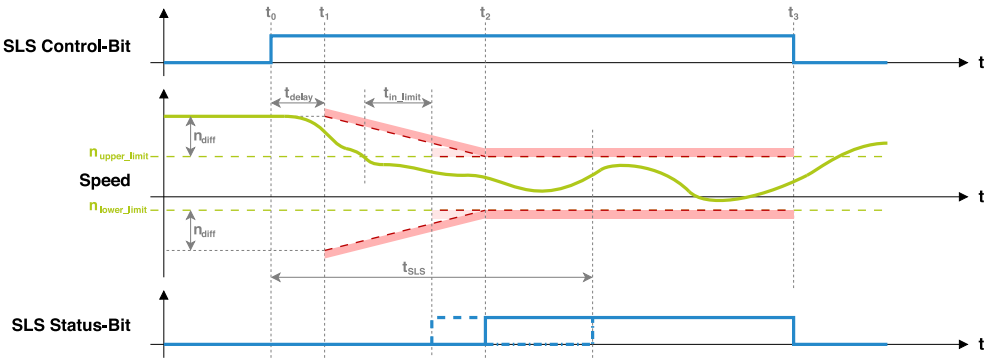
If this value is configured, it is checked from time t_0, whether the speed is between n_{lower_limit} and n_{upper_limit} long enough (for at least t_{in_limit} in a row). As soon as this is the case (in the example shown at time t_2), the check is completed and the speed monitoring is activated. From this point on, the speed must no longer exceed the configured limit values. Otherwise the configured error reaction is triggered.

Speed monitoring is activated at the latest, after the time t_{SLS} has elapsed.

6.2.2.7 SLS with Delay Monitoring

In addition to the monitoring already mentioned, the delay can also be monitored with SLS, before the speed monitoring becomes active. This monitors, whether the speed is within the configured ramp during the braking process. This makes it possible to detect at an early stage, whether braking is working and to trigger the configured error reaction in the event of an error.

Timing



Functional Description

The temporal behavior of SLS remains unchanged. In addition, the delay of the speed is monitored.

Since the function related part cannot start braking immediately, a delay (t_{delay}) is waited for from time t_0 onwards. Only when this delay has expired (t_1) the speed is monitored. However, it is not expected that deceleration is continuous, but that the maximum permitted speed is reduced millisecond by millisecond with the set delay.

For the subsequent deceleration monitoring, two output speeds are determined. To do this, the value n_{diff} is first calculated. This corresponds to the difference between the speed measured when SLS was triggered and the closer speed limit (in this example n_{upper_limit}).

For the upper ramp the value $n_{upper\_limit}+n_{diff}$ is used as output speed, while the lower ramp starts with the speed $n_{lower\_limit}-n_{diff}$. As a result, both ramps reach the permitted speed range (n_{lower_limit} to n_{upper_limit}) at the same time.

Subsequently, the permitted speed is reduced, until it reaches the permitted speed range (t_2). If the speed remains within the permitted limits during this time, at the moment when the ramp (shown in red) reaches the permitted speed range (t_2), the check is terminated and the speed monitoring is activated. If the maximum permitted speed is violated during monitoring, the configured error reaction is triggered.

For delay monitoring, the time t_2 also depends on the set delay time (t_{delay}) and the minimum delay ($a_{deceleration}$), i.e. also on the output speed. The higher the speed, the longer it takes for the ramp to reach the permitted speed range. The maximum duration, until the speed monitoring is activated, is limited by t_{SLS} (dash-dotted representation in the figure). Premature activation by low speed (dashed representation in the figure) is also possible in combination.

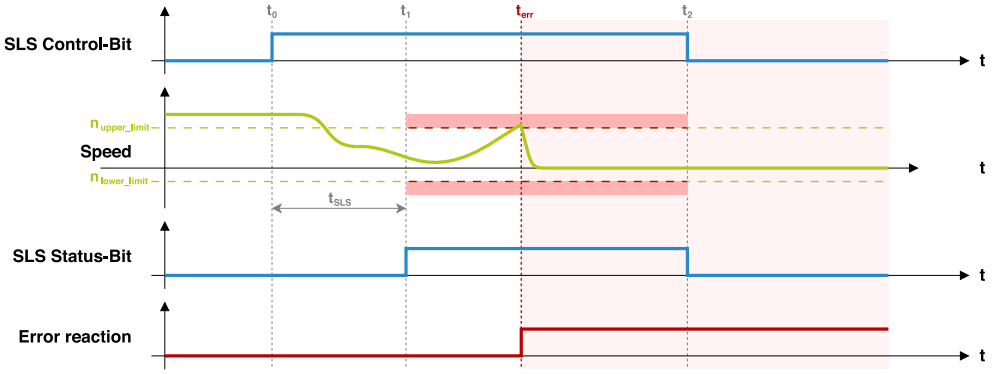
Error Reaction

With SLS 2 different types of errors can occur:

- Speed leaves the permitted speed range: As soon as the speed monitoring is active, the speed must not leave the permitted speed range (between n_{lower_limit} and n_{upper_limit}).
- Maximum speed exceeded during deceleration monitoring: When deceleration monitoring is active, the speed must be within the deceleration ramp.

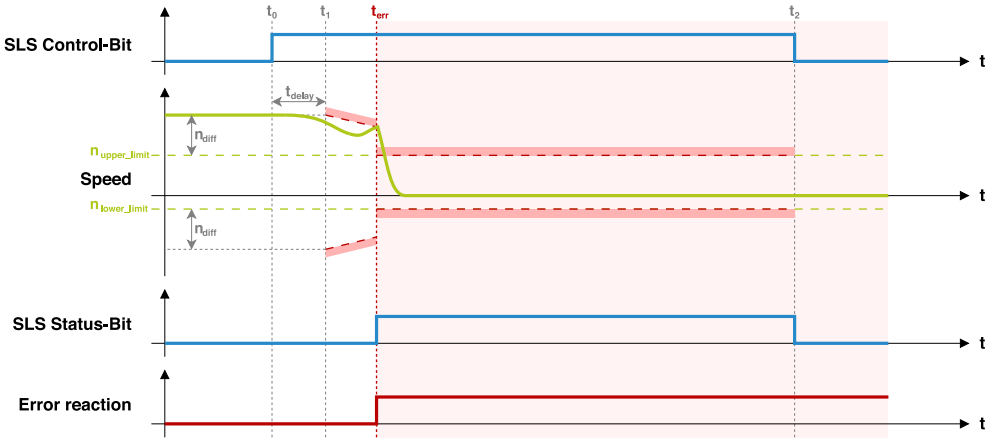
If an error is detected during one of the two checks, the speed monitoring becomes active (if not already) and the configured error reaction is triggered.

The two error cases are shown below with the help of timing diagrams. The time of the error is marked with t_{err}:



The figure shows the behavior of SLS, when the speed leaves the permitted range, while speed monitoring is already active (the behavior of STO is shown as the error reaction). In this case, monitoring is already active at the time of the error and continues, until SLS is deactivated (t_2).

The following diagram shows the error case for delay monitoring. Here you can see, that with detection of the error (t_{err}) also the speed monitoring becomes active at the same time (SLS status bit):

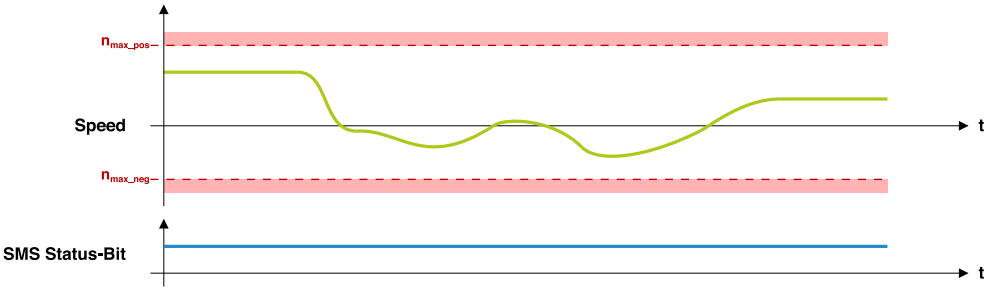


Parameters	
Time Velocity (t_{SLS})	Maximum time to reach the limit values
Upper Limit (n_{upper_limit})	Maximum value for velocity
Lower Limit (n_{lower_limit})	Minimum value for velocity
Time Velocity Limit (t_{in_limit})	Optional: Time until velocity monitoring is activated after limit values are reached (before Time Velocity expires)
Time Deceleration (t_{delay})	Optional: Time until deceleration monitoring is activated

6.2.2.8 SMS – Safe Maximum Speed

With the SMS safety function, the maximum speed of the drive can be restricted. The function is active by parameterization and executes the configured error reaction, when the set limit values are exceeded.

Timing



Functional Description

The function is permanently active, if at least one of the two speed limits (n_{max_pos} or n_{max_neg}) is configured. It is checked, whether the speed does not exceed n_{max_pos} in positive direction of rotation or n_{max_neg} in negative direction of rotation. Exceeding the limit leads to the triggering of the configured error reaction.

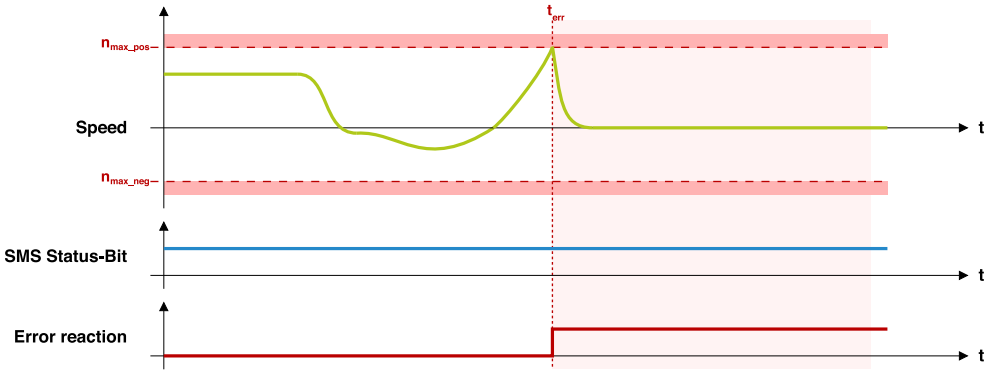
The SMS status bit indicates, whether the function is active.

Error Reaction

Only one error can occur with SMS:

- Permitted speed exceeded: If SMS is parameterized, the speed must be within the configured maximum values, depending on the direction of rotation. Should an overrun be detected, the configured error reaction is triggered.

The described error case is shown below with the help of a timing diagram. The time of the error is marked with t_{err}:



The example above shows an error case with STO as error reaction. Speed monitoring remains active despite an error, but STO causes the speed to drop to 0, which means that the system is immediately ready for use again in the event of a subsequent error acknowledgment.

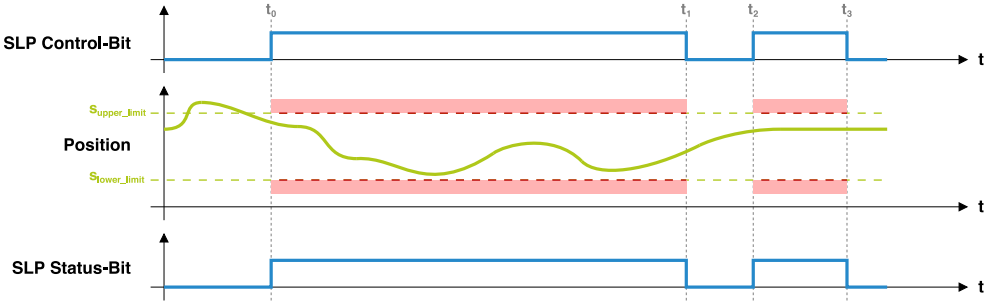
Parameters	
Positive Limit (n_{max_pos})	Maximum value for positive velocity
Negative Limit (n_{max_neg})	Maximum value for negative velocity
Error Reaction	Function started in case of an error Possible entries: STO, SS1_1,…SS1_8 STO, SS1_1,…SS1_8

6.2.2.9 SLP - Safely Limited Position

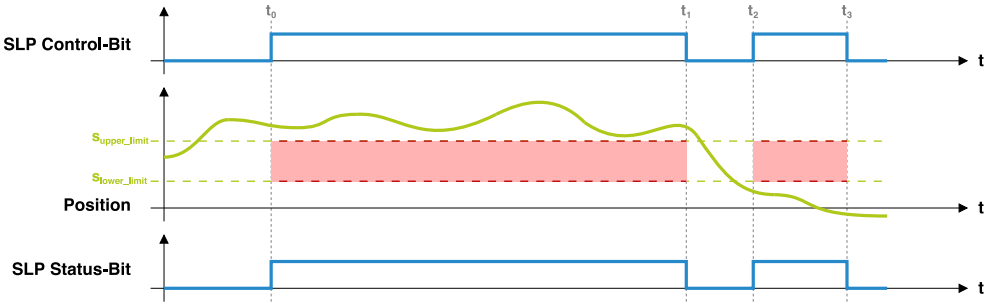
With the SLP safety function the position of the drive can be restricted to a configurable range. While the function is active, the position is monitored for compliance with the configured limit values.

This monitoring is only possible, if the encoder used can resolve a sufficient number of revolutions absolutely and this range is not left during operation. Since the position of the encoder can assume any value within the value range when installed in a machine, an absolute position referencing must first be performed. Only when this referencing is completed, SLP is available.

Timing



The above example shows the use of SLP with "inside window" configuration. This checks, whether the position is within the set limit values. With "outside window" configuration the position must remain outside:



Functional Description

With the activation of SLP by the control bit (t_0) the monitoring of the position is started immediately. It remains active, until SLP (t_1) is deactivated.

If the function is configured with the setting "Region = inside window", the position may only move within the set limits (between s_{lower_limit} and s_{upper_limit}) during the execution of SLP (see above figure 1).

If, on the other hand, it is configured with "Region = outside window", the position may only move outside the set limits (above s_{upper_limit} or below s_{lower_limit}) during the execution of SLP (see above figure 2).

If the position leaves the permitted range during active position monitoring, the configured error reaction is triggered.

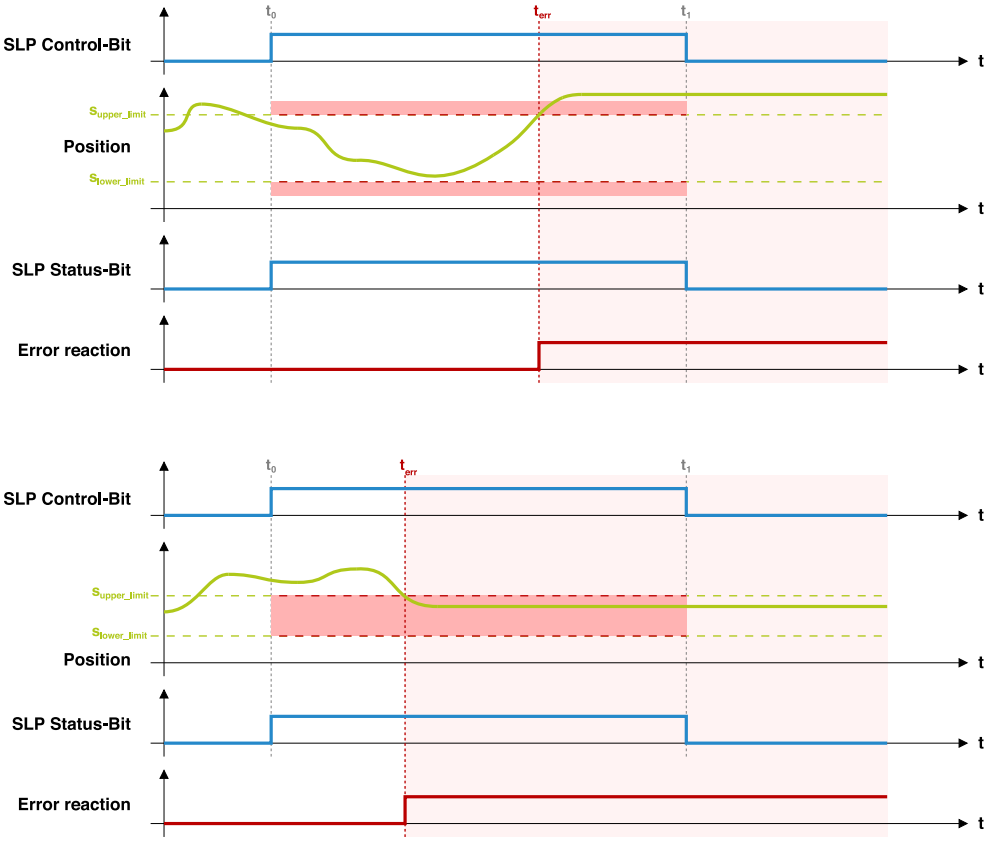
Whether a position monitoring due to SLP is currently taking place, is signaled by the SLP status bit.

Error Reaction

Only one error can occur with SLP:

- Allowed position window left: If position monitoring is active, the position must be either within or outside the set limits, depending on the setting. Should an overrun be detected, the configured error reaction is triggered.

The described error case is shown below with the help of two timing diagrams. The time of the error is marked with t_{err}:



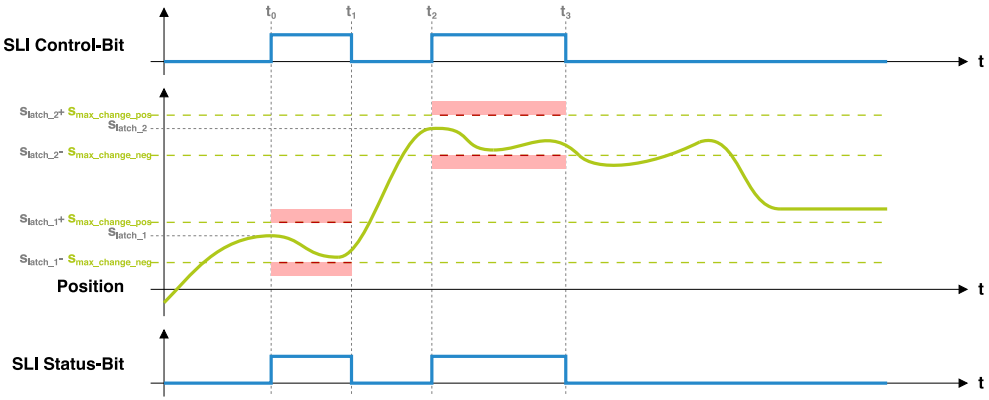
In both error cases shown, position monitoring is continued, so that in the event of an error acknowledgment and SLP remaining active, an error is immediately detected again. Since the position is likely to remain outside the allowed range after an error is acknowledged (in the example, the behavior with STO is shown as an error reaction, there is no possibility to actively move the position back into the window), SLP must be deactivated before the error acknowledgment and the position must be back in the allowed range before reactivation.

Parameters	
Upper Limit (s_{upper_limit})	Upper limit for position
Lower Limit (s_{lower_limit})	Lower limit for position
Error Reaction	Function started in case of an error Possible entries: STO, SS1_1,…SS1_8
Region	Position must be inside or outside the limits Possible entries: Inside, outside

6.2.2.10 SLI - Safely Limited Increment

The SLI safety function can be used to restrict the movement of the drive. As soon as the function is active, the position may only change upwards or downwards by the set values. The position determined, at the time the function was activated, is used as the basis. We therefore speak of incremental position monitoring.

Timing



Functional Description

With the activation of SLI by the control bit (t_0) the incremental monitoring of the position is started. The position measured at time t_0 is stored as the initial position (s_{latch_1} for the first activation or s_{latch_2} for the second activation).

Then it is checked, whether during SLI is active, the position remains within the allowed position window. The upper limit of the window corresponds to the latched position value plus the position change allowed in positive direction of rotation ($s_{latch}+s_{max\_change\_pos}$), while the lower limit corresponds to the latched position value minus the position change allowed in negative direction of rotation ($s_{latch}- s_{max\_change\_neg}$).

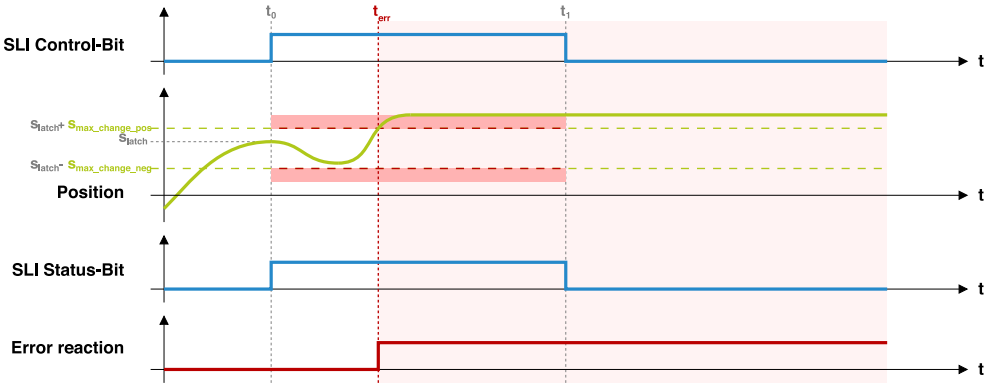
With the deactivation of SLI (t_1) the monitoring is stopped again. An active monitoring is signaled by the SLI status bit.

Error Reaction

Only one error can occur with SLI:

- Permitted position change exceeded: When monitoring is active, the position, starting from the initial position determined when the safety function was activated, may only change by the set values. Should an overrun be detected, the configured error reaction is triggered.

The described error case is shown below with the help of a timing diagram. The time of the error is marked with t_{err}:

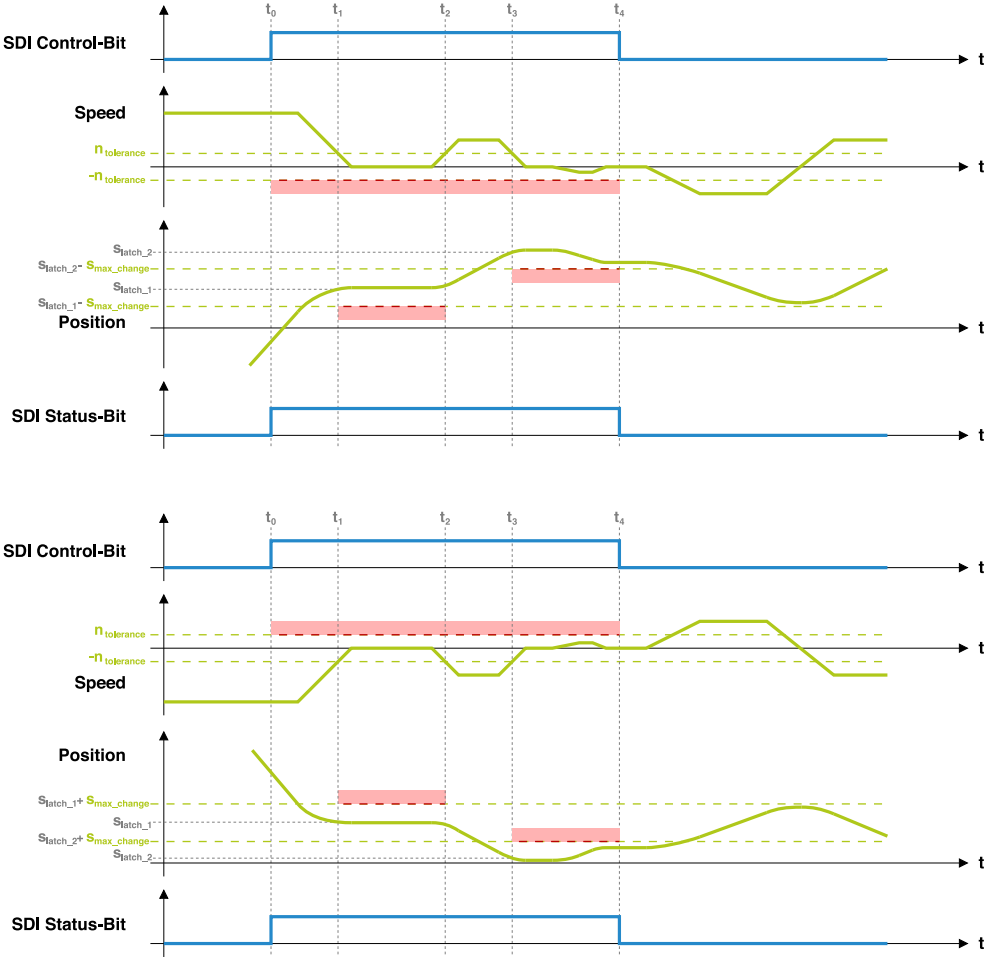


Parameters	
Positive Limit ($s_{max\_change\_pos}$)	Maximum value for position change in positive direction of rotation
Negative Limit ($s_{max\_change\_neg}$)	Maximum value for position change in negative direction of rotation
Error Reaction	Function started in case of an error Possible entries: STO, SS1_1,…SS1_8

6.2.2.11 SDI – Safe Direction

With the SDI safety function, the direction of rotation of the drive can be restricted. Once the function is active, only the positive or negative direction of rotation is allowed, depending on the configuration.

Timing



Functional Description

With SDI configuration parameters can be used to set, whether only the positive or only the negative direction of rotation should be allowed, while SDI is active. The restriction to "only positive direction of rotation allowed" is exemplified in the first figure, while the variant "only negative direction of rotation allowed" is shown in the second figure.

The allowed direction of rotation cannot be changed at runtime, therefore 2 SDI instances must be created, if partly the positive and partly the negative direction of rotation shall be restricted.

With the activation of SDI by the control bit (t_0) the monitoring of the direction of rotation is started. While SDI is active, the speed must not fall below the value $-n_{tolerance}$ with positive permitted direction of rotation. With negative permitted direction of rotation, the value $n_{tolerance}$ must not be exceeded.

As soon as the speed is in the zero window (between $-n_{tolerance}$ and $n_{tolerance}$), the position is additionally monitored. At the time, when the zero window is reached (t_1), the measured position is stored as initial position (s_{latch_1} at the first reaching at time t_1 or s_{latch_2} at the second reaching at time t_2).

While the speed is within the zero window (in the two examples between t_1 and t_2 or between t_3 and t_4), the position must not fall below or exceed the value $s_{latch}-s_{max\_change}$, if the direction of rotation is allowed to be positive, or the value $s_{latch}+s_{max\_change}$, if the direction of rotation is allowed to be negative. This ensures, that the axis cannot move too far in the non-permitted direction of rotation at low speed (within zero window), while the axis is in non-permitted direction of rotation.

As soon as SDI is deactivated again by the control bit (t_4), the direction of rotation monitoring is cancelled and both directions of rotation are permitted again.

An active direction of rotation monitoring is signaled by the SDI status bit.

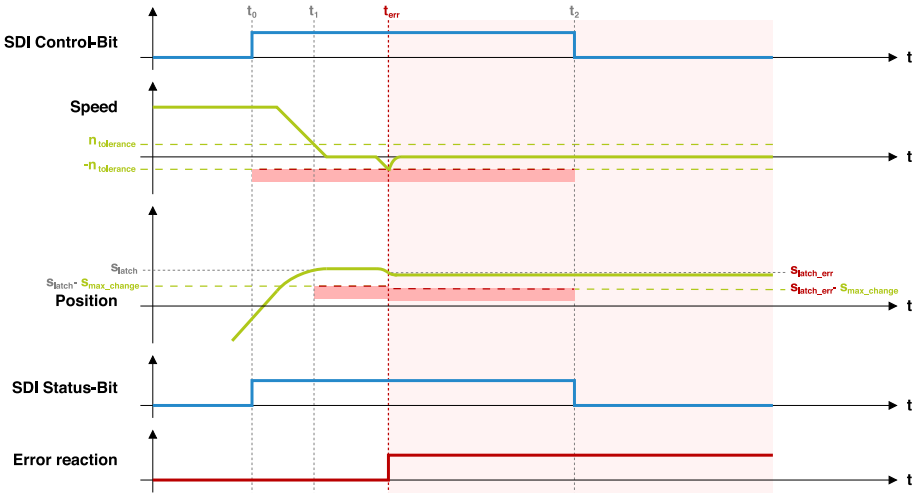
Error Reaction

With SDI 2 different types of errors can occur:

- Speed in non-permitted direction of rotation too high: While monitoring is active, the speed must not fall below the value $-n_{tolerance}$, if the direction of rotation is only permitted to be positive, or must not exceed the value $n_{tolerance}$, if the direction of rotation is only permitted to be negative.
- Too large change of position in non-permitted direction of rotation: While the speed is in the zero window (between $-n_{tolerance}$ and $n_{tolerance}$), the position in the not allowed direction of rotation may only change by the maximum allowed position tolerance (s_{max_change}).

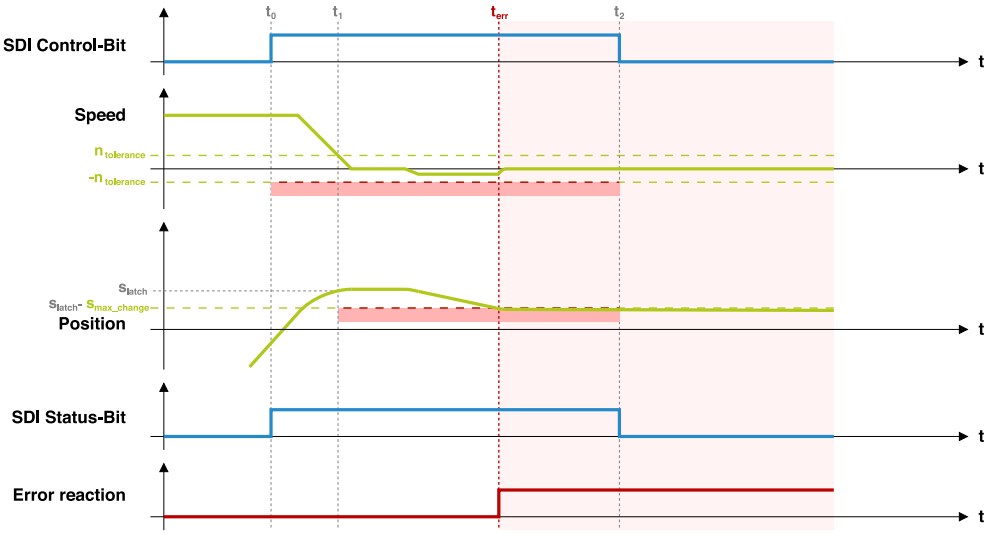
If an error is detected during one of the two checks, the safety function configured as error reaction is triggered.

The two error cases are shown below with the help of timing diagrams. The time of the error is marked with t_{err}:



In the error case shown above, the position is re-latched at time t_{err} in addition to triggering the error reaction, since the zero window is briefly exited.

The following shows the error case with low speed but position violation:



Parameters	
Direction	This direction is allowed for movement, opposite direction is monitored (limited), possible entries: positive, negative
Position Zero-Window (s_{max_change})	Tolerance for position
Velocity Zero-Window ($n_{tolerance}$)	Tolerance for velocity
Error Reaction	Function started in case of an error Possible entries: STO, SS1_1,…SS1_8

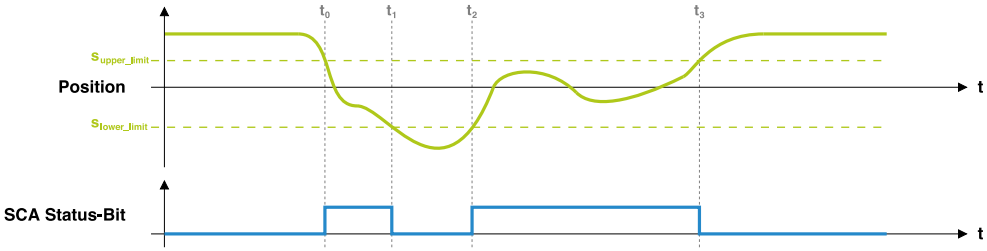
6.2.2.12 SCA - Safe CAM

The position of the drive can be monitored with the SCA safety function. The function is active by parameterization and signals with the status bit, whether the set limits are currently being observed or have been exceeded.

Since the function is only for signaling and not for limiting, no error reaction can be configured. If an error reaction is required, the SMP or SLP safety functions can be used instead.

The function is executed independently of the absolute position referencing, if configured.

Timing



Functional Description

The function is permanently active, if at least one of the two position limits (s_{upper_limit} or s_{lower_limit}) is configured. It is checked, whether the position is inside or outside this window.

If the position is within (between s_{lower_limit} and s_{upper_limit}), this is signaled by an active status bit (in the example between t_0 and t_1 or between t_2 and t_3). If the position is outside, the status bit becomes inactive.

Error Reaction

No error reactions are possible with the SCA safety function. Exceeding or falling below the set limit values is signaled via the status bit.

Parameters	
Upper Limit (s_{upper_limit})	Upper limit for the position
Lower Limit (s_{lower_limit})	Lower limit for the position

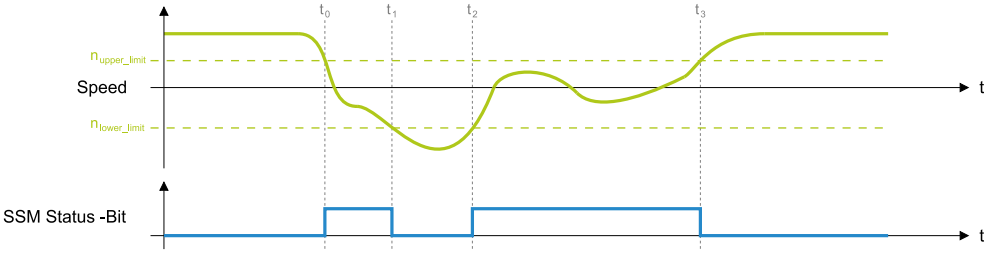
6.2.2.13 SSM - Safe Speed Monitor

This function provides a safe output signal to indicate whether the motor speed is within a defined limit value.

With the SSM safety function the speed of the drive can be monitored. The function is active by parameterization and signals with the status bit, whether the set limits are currently being observed or have been exceeded.

Since the function is only for signaling and not for limiting, no error reaction can be configured. If an error reaction is required, the SMS or SLS safety functions can be used instead.

Timing



Functional Description

The function is permanently active, if at least one of the two speed limits (n_{upper_limit} or n_{lower_limit}) is configured. It is checked, whether the speed is inside or outside this window.

If the speed is within (between n_{lower_limit} and n_{upper_limit}), this is signaled by an active status bit (in the example between t_0 and t_1 or between t_2 and t_3). If the speed is outside, the status bit becomes inactive.

No error reactions are possible with the SSM safety function. Exceeding or falling below the set limit values is signaled via the status bit.

Parameters	
Upper Limit (n_{upper_limit})	Maximum value for velocity
Lower Limit (n_{lower_limit})	Minimum value for velocity

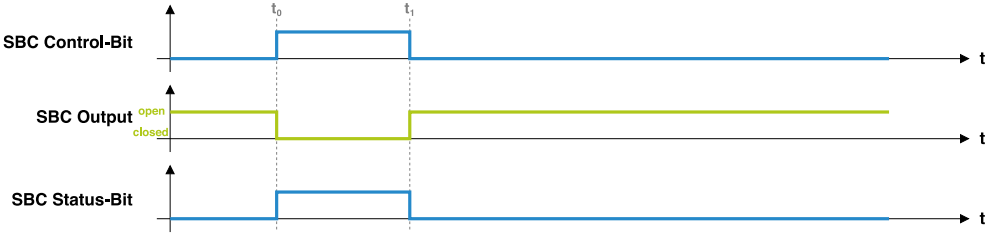
6.2.3 Output Functions per Axis

The different output functions are explained below.

6.2.3.1 SBC - Safe Brake Control

With the SBC safety function the holding brake (if present) of the drive can be safely closed. The function can be used independently, but also together with STO and SS1. The independent use is described below.

Timing



Functional Description

By activating the SBC control bit (t_0), the holding brake of the affected axis is closed by no voltage being output at the "SBC output" anymore. The status bit signals, that the brake is closed. When deactivating the control bit (t_1), the holding brake is opened again.

Error Reaction

No error reactions are possible with the SBC safety function.

Parameters	
Brake Close Time (t_{brake})	Time that the brake needs after activation, until it engages. The value is only used when SBC is triggered by SS1.

6.2.3.2 SBT – Safe Brake Test

The SBT function is not a safety function in the conventional sense, but a diagnostic function for the service brake. With SBT, the brake is tested with a defined torque. In this process, current is injected into the drive for the duration "Test Duration Time". If a slip of the brake is detected, the optionally adjustable error reaction is triggered. Thus, wear of the brake can be detected at an early stage.

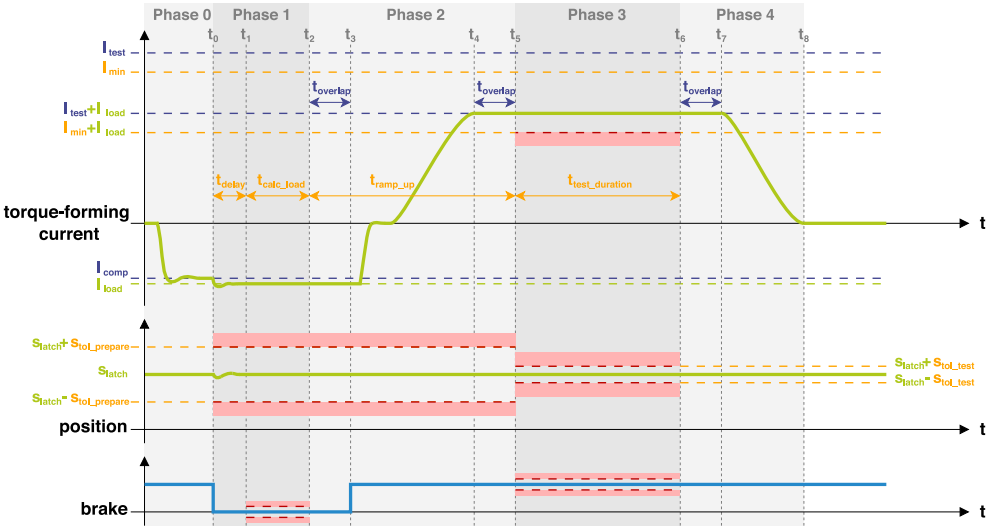
In addition to monitoring during the test execution, the test frequency is checked.

The time "Test Interval Start" is the maximum allowed time between the power-on of the MDD and the first SBT execution. The specification of this time is only relevant, if the first test must take place faster than the interval for the time between 2 tests.

The time window "Test Interval Cyclic" represents the maximum allowed time between 2 SBT executions. If no separate time is specified for the first test after switch-on, this time is also used for it.

Timing

In order to better describe the temporal relationships during test execution, an exemplary sequence is shown in the following figure:



The presented process consists of 5 phases, of which the first and last phase concern only the function related part. The 5 phases are each described individually below:

Phase 0 – Test Preparation

When the brake test is started by the application, the function related firmware starts preparing the test. First the controller is set to the position controller mode in order to hold the current position during the following steps. Subsequently, with the brake closed, the compensation current I_{comp} (adjustable via A-ICOMP parameter) is applied. The compensation current should correspond to the current required to hold a suspended load, so that the subsequent opening of the brake does not lead to an excessive drop in position.

As soon as the compensation current is reached (t_0), the brake is opened, so that the suspended load can be measured in the subsequent phase.

Phase 1 – Load Determination

When preparation is complete, the function related part triggers the brake test in the safety related part. From this point in time (t_0), the brake test thus runs both function related and safety related.

Function related, the phase begins with the re-adjustment of the compensation current to maintain the position with the brake open. This must be done within t_{delay}, because with the expiration of this time (t_1) the determination of the holding current for a possible suspended load begins. The torque-forming current is measured for the duration t_{calc_load} and the mean value I_{load} is formed.

Safety-related, the position is monitored during the entire phase, which may change by a maximum of $\pm_{stol\_prepare}$. For this purpose, the current position is latched (s_{latch}) at time t_0 and used as the target position for the entire duration of the test.

After t_{delay} has elapsed, the holding current I_{load} is also determined on the safety related side in order to be able to take into account the force effect of a possible suspended load, when the brake is tested later on. In addition to this, a check is made during this time as to whether the brake is actually open.

Phase 2 – Apply Test Current

When both firmware parts have determined the holding torque (t_2), the function related part can start to close the brake and apply the I_{test} test current (adjustable via A-BTC parameter) in a high-ramp phase.

However, the phase for the function related part starts delayed by $t_{overlap}$ (thus only at time t_3) to ensure, that the tasks of the safety related firmware from phase 1 are not distorted, as these could overlap with phase 2 of the function related firmware. The $t_{overlap}$ time is also one of the parameters, that can be set from the application via the A-BTT parameters.

After this time has elapsed (at time t_3), the function related part closes the brake and then reduces the applied current to 0. The configured test current is then applied in a ramp-up phase (duration depends on t_{ramp_up}, so that the test current is fully applied at time t_4). The holding current determined in phase 1 is taken into account accordingly, whereby the current to be reached corresponds to the value $I_{test}+I_{load}$.

Since overlaps to the next phase are also to be expected at the end of the phase, the time $t_{overlap}$ is waited for again from t_4 to t_5, before the next phase begins.

During the entire phase (from t_2 to t_5), the safety related firmware only checks, whether the position is still within the tolerance (between $s_{latch-stol\_prepare}$ and $s_{latch+stol\_prepare}$).

Phase 3 – Check Brake

In this phase, the previously applied test current $I_{test}+I_{load}$ is held for the duration $t_{test\_duration}$, while the brake remains closed. The position must not change in the process, which is why a narrower tolerance window is used for position monitoring in this phase (s_{tol_test}).

In addition, it is checked, whether the applied torque or the torque-forming current is high enough to meet the test specifications. It must be above the $I_{min}+I_{load}$ value during the entire phase, so that the test is considered to be passed at the end (t_6).

Phase 4 – Complete Brake Test

After the actual test is completed, the function related part waits a third time for the $t_{overlap}$ time to ensure, that ramping down is not started too early and then (from t_7 to t_8) reduces the torque-forming current back to 0. The duration of ramping down is identical to the duration of ramping up in phase 2, which is why no time needs to be set here.

At the end of this phase, the regulator mode set before the test (G-MODE) is restored and the axis is made available to the application again.

Parameters	
Time to SBT (t_{delay})	Time that the brake needs after activation until it engages
Torque Rise Time (t_{ramp_up})	Time needed to build up the torque
Test Duration Time ($t_{test\_duration}$)	Time period for torque application
Direction	Direction of movement for test Possible entries: Any, positive, negative
Load Torque Calculation Time	Time in which the static applied load is determined with the brake open
Minimum Torque (I_{min})	Minimum size of the torque with which is tested
Position Limit Preparation ($s_{tol\_preparation}$)	Limit value for position change during preparation
Position Limit Tes (t_{stol_test})	Limit value for position change during test phase
Test Interval Start ($t_{interval\_start}$)	Maximum time span in which the first test after start must be performed (can be 0, then Test Interval Cyclic applies)
Test Interval Cyclic ($t_{interval\_cyclic}$)	Maximum time between tests (can be 0 if no monitoring is desired)
Error Reaction	Function started in case of an error Possible entries: None, STO, SS1_1,…SS1_8

SBT Error	
During the preparation time the position changes by more than "Position Limit Preparation"	After parameter “Error Reaction”
During the test phase the position changes by more than "Position Limit Test"	After parameter “Error Reaction”
Brake not open during "Load Torque Calculation Time" or not closed during "Test Duration Time"	After parameter “Error Reaction”
Minimum torque "Minimum Torque" not reached during "Test Duration Time" or torque built up in wrong direction	After parameter “Error Reaction”

6.3 Wiring Examples Safety

To be able to execute the configured safety functions, they must be controlled via safe digital inputs. Dual channel mapping is used here.

6.3.1 Dual Channel Input Mapping

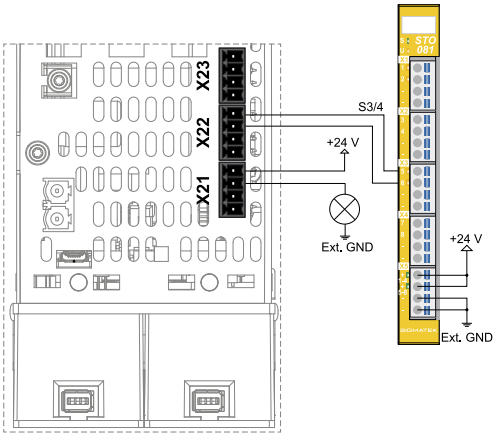
4 inputs are available. For dual channel mapping, 2 inputs must always be considered in combination:

- both input pairs (all inputs) actuated
- only input pair 1 (input 1 & 2) actuated
- only input pair 2 (input 3 & 4) actuated
- no input pair actuated

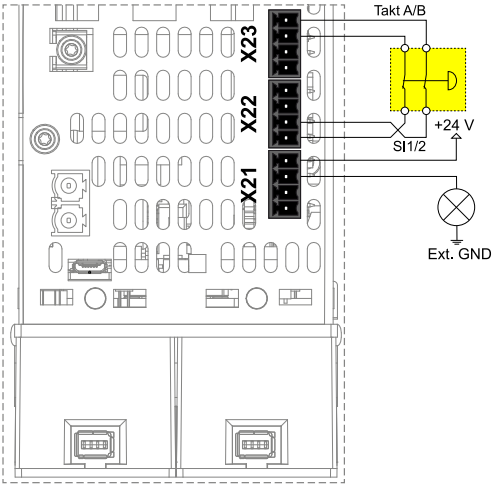
An input pair is considered to be actuated when at least one of the two inputs assumes the LOW state. If the two inputs of an input pair have different states for too long, this is considered an error and leads to the error state.

With delivery condition, the following 2 variants can be selected.

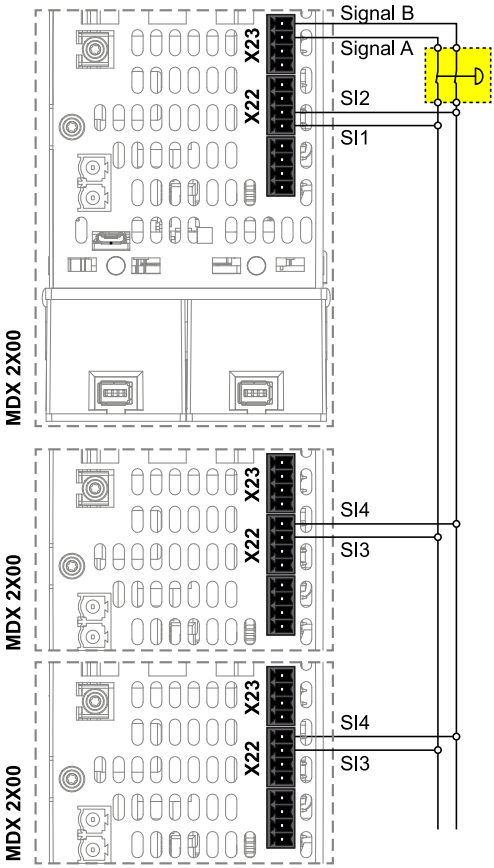
Without cross-connection check: here, the safe inputs SI3&4 are used.



An MDD 2000 with cross-connection testing: here, the clock output signals A & B are connected with the safe inputs SI1&2.



Multiple MDD 2000 with cross-circuit testing:



6.4 Preconditions for Safety Functions

6.4.1 Referencing the Position

For the use of safety functions with absolute position, referencing of the position is required for all axes. The safety functions concerned are SLP (Safely Limited Position) and SMP (Safe Maximum Position). The referencing is executed via the functional application and requires a predefined sequence.

CAUTION

An incorrectly referenced system can lead to accidents as well as destruction of the machine.

INFORMATION

The value range of the encoder must not be exceeded.

6.4.2 Encoder Verification

The use of safe Hiperface DSL encoders requires verification of the encoders. The verification process is executed from the functional application and is done using a predefined flow. The DIAS-Drive 2000 runs in a restricted functional mode until the verification is completed.

7 Technical Data

7.1 DC-link Circuit

Module	MDP/MDD 2102		MDP/MDD 2100		MDP/MDD 2200	
Effective nominal power	1.3 kW	2.6 kW for 10 s	4 kW	8 kW for 10 s	9 kW	18 kW for 10 s
Intermediate circuit nominal voltage	325 V		565 V		565 V	
Maximum DC-link voltage	430 V		850 V		850 V	
DC-link capacitance	1320 µF (MDP)	1980 µF (MDD)	330 µF (MDP)	495 µF (MDD)	660 µF	
Maximum current via DCB	40 A		40 A		40 A	

7.2 +24 V Auxiliary Voltage

Module	MDP/MDD 210X	MDP/MDD 2200
Rated input voltage	+24 V	
Input voltage range	+22-30 V SELV/PELV	
Current consumption per module	1 A + brake current	
Input capacitance	1 mF	
Maximum current via BCB	20 A	
Maximum cable length	30 m	

7.3 Axis/Motor Connection

Module	MDP/MDD 210X	MDP/MDD 2200
Maximum number of drives	3	
Switching frequency	8 kHz	
Derating	2.5 %/°C over 45 °C (axis current and DC-link power are affected)	
Continuous current/peak current for 1 s per axis	5/15 A	10/30 A
Maximum total current	15 A	30 A
Maximum output frequency	599 Hz	
Maximum cable length	30 m	

7.4 Safe/Capture Inputs

Type	Safe input (input 1-4)	Capture input (input 5-6)
Number	6	
Rated input voltage	+24 V	
Input voltage range	+18-30 V	
Signal level	low: ≤ +5 V	low: ≤ +5 V, high ≥ +15 V
Switching threshold	typically +11 V	
Input current	typically 3.6 mA at 24 V	
Input delay	typically 0.5 ms at +24 V	typically 3 µs at +24 V

7.5 Signal Output for Cross-Circuit Detection

Module	MDP/MDD 210X	MDP/MDD 2200
Number	1x signal A per module 1x signal B per module	
Rated output voltage	+24 V	
Output voltage range	+22-30 V	
Output current	maximum 100 mA	
Short-circuit proof	yes	

CAUTION

Cross-Circuit Detection
It is important to keep in mind that the cross-circuit detection only functions correctly when it is configured and wired correctly. It must also be considered that the cross-circuit detection only works between adjacent inputs. The machine installer must take constructive measures to prevent cross-circuit connections between non-adjacent inputs (e.g. separate cable routing, insulated cables).

Détection des courts-circuits transversaux
Il faut absolument tenir compte du fait que la détection des courts-circuits transversaux ne fonctionne correctement en matière de sécurité que si elle a été câblée et configurée correctement. En outre, il faut tenir compte du fait que la détection des courts-circuits transversaux ne fonctionne qu'entre des entrées voisines. Les courts-circuits transversaux entre des entrées non voisines doivent être empêchés par des mesures constructives (par ex. pose de câbles séparés, câbles isolés) prises par l'installateur de la machine.

7.6 Encoder Interface

Module		MDP/MDD 210X	MDP/MDD 2200
Internal	Maximum amount	3	
	Type	Hiperface DSL	
	Connection type	Single cable solution	
	Power supply	12 V	
Optional	Maximum amount	3	
	Type	Resolver/Sin-Cos/TTL/Hiperface/EnDAT 2.1/Tamagawa/BiSS-C	
	Voltages	5 V (with Remote Sensing)/9 V	
	Maximum cable length	30 m	

7.7 Expanded MDP 2XXX Specifications

7.7.1 Power Supply

Module	MDP 2102	MDP 2100	MDP 2200
Rated supply voltage	1x 230 V AC	3x 400 V AC	
Supply voltage range	1x 230 V AC ±10 %	3x 380-480 V AC ±10 %	
Over voltage category	III	III	
Power supply frequency	45-65 Hz	45-65 Hz	
Rated connection load	2.8 kVA	8.5 kVA	17.25 kVA
Supply input current	12 A	12 A	25 A
Inrush current	maximum 15 A	maximum 35 A	
Neutral point	grounded	grounded	
Maximum permissible short-circuit current	5 kA	5 kA	
Net	TN-S, TN-C-S (with grounded neutral point)	TN-S, TN-C-S (with grounded neutral point)	
	IT (by request)	IT (by request)	
Maximum fuse	yes	yes	
Module	Line protection: 13 A Type C	Line protection: 13 A Type C	Line protection: 25 A Type C
	Operating class gG (gL): 13 A	Operating class gG (gL): 13 A	Operating class gG (gL): 25 A

7.7.2 Ballast Resistance

Module	MDP 2102	MDP 2100	MDP 2200
Internal brake resistor available	yes (25 Ω)	yes (25 Ω)	yes (25 Ω)
Peak power int./ext.	7.4 kW/12.3 kW	28.9 kW/28.9 kW	28.9 kW/36.1 kW
Continuous power int./ext.	50 W/500 W	50 W/500 W	200 W/1000 W
Minimum permissible brake resistance (ext.)	15 Ω	25 Ω	20 Ω
Overload protection	yes	yes	yes
Short circuit protection	yes	yes	yes
Ground fault protection	no	no	no
Maximum cable length	3 m	3 m	3 m

WARNING

The surface of the ballast resistor can reach temperatures far above 85 °C. Since contact can lead to serious injury the temperature should be checked before touching.

La surface de la résistance de ballast peut atteindre des températures bien supérieures à 85 °C. Comme le contact peut entraîner des blessures graves, la température doit être vérifiée avant de toucher.

7.8 Communication

Module	MDP/MDD 210X	MDP/MDD 2200
Bus	VARAN	

7.9 Motor Holding Brake

Module	MDP/MDD 210X	MDP/MDD 2200
Maximum continuous current	1.5 A	

Overload and short-circuit protection	yes
Under voltage monitor	yes
Cable break monitor	yes
Brake voltage reduction	yes (12-24 V)

7.10 Mechanics

Module	**MDP/MDD 210X**	**MDP/MDD 2200**
Cooling	Air, Cold-Plate in preparation	
Backplane	not required	
Mounting position	vertically hanging	
Clearance above and below	at least 3 cm	
Fan	yes, exchangeable (life span ca. 70,000 h)	
Dimensions (W / H / D)	75 x 242 x 219 mm	150 x 242 x 219 mm
Weight	3 kg	5.2 kg

7.11 Environmental Conditions

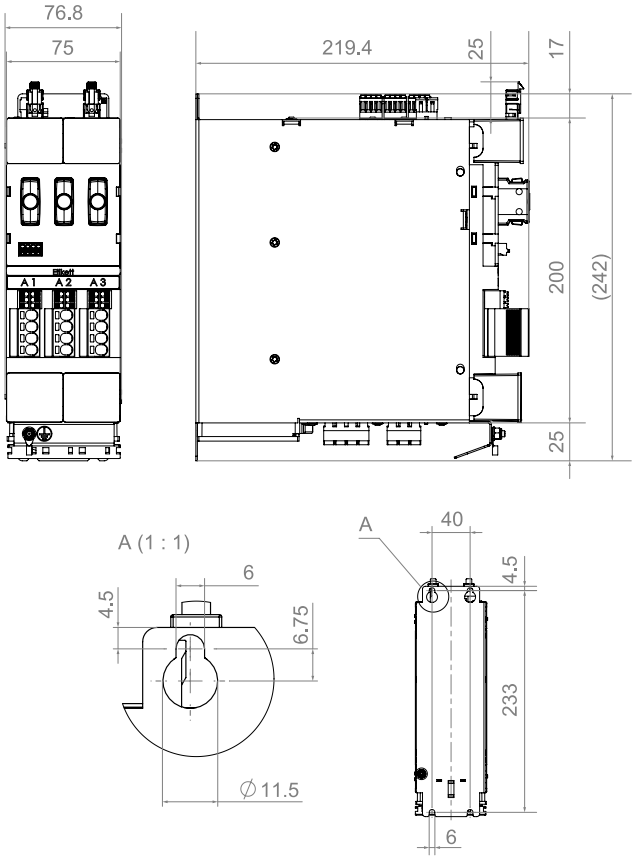
Module	MDP/MDD 210X	MDP/MDD 2200
Storage temperature	-25 ... +70 °C	
Nominal environmental temperature	0 ... +45 °C	
Environmental temperature max.	0 ... +55 °C (with derating 2.5 %/°C above 45 °C)	
Humidity	maximum relative humidity 85 %, non-condensing	
Altitude	up to 1000 m above NN at rated values 1000-3000 m above NN with reduction by 1.5 % / 100 m (rated output current and rated input power affected)	
Operating conditions	pollution degree 2	
Noise emissions	≤ 70 dB	
Vibration resistance	frequency: 5-150 Hz acceleration: 1 g amplitude: 0.075 mm (0.15 mm pp)	
Shock resistance	acceleration: 15 g	
Protection type	IP20	

7.12 Miscellaneous

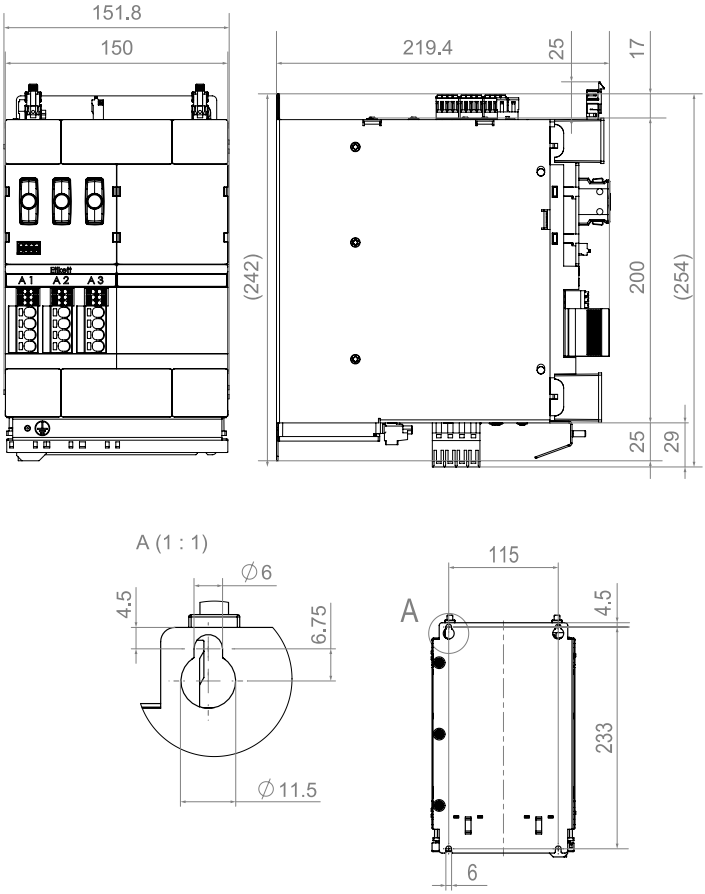
Module	MDP/MDD 210X	MDP/MDD 2200
Standard	designed according to UL	
Approvals	CE, TÜV-Austria EG-type-examined	

8 Mechanical Dimensions

8.1 Size 1



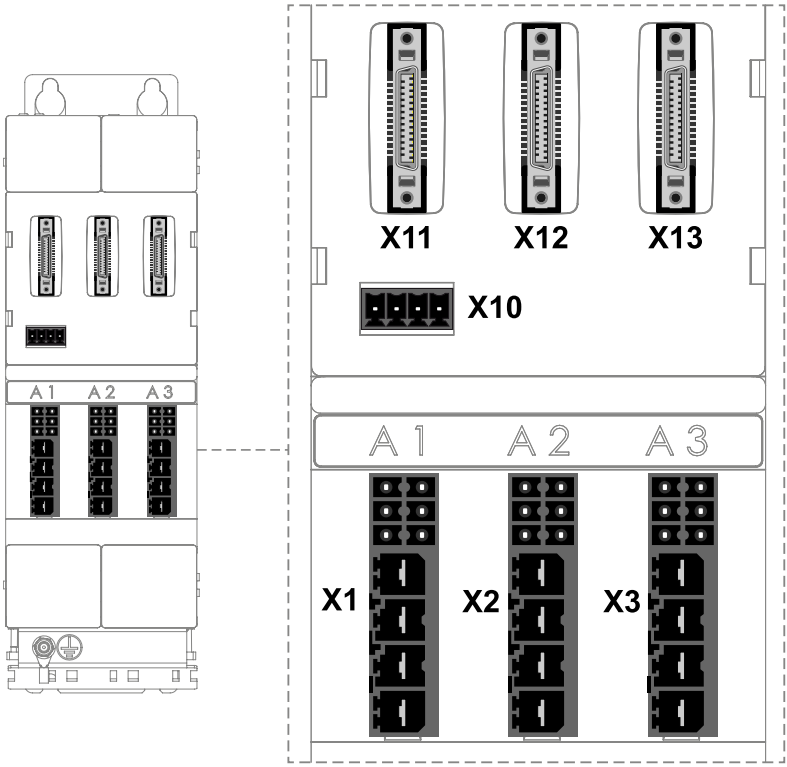
8.2 Size 2


151.8
150
219.4
25
17
(242)
200
(254)
25
29
A1
A2
A3
A (1 : 1)
∅6
4.5
6.75
∅11.5
115
A
4.5
233
6

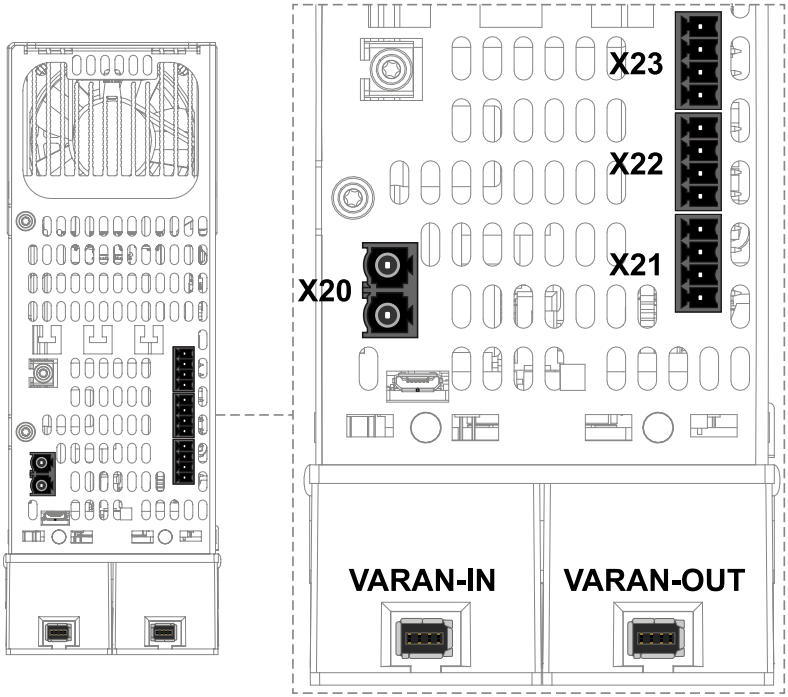
9 Connectors and Cables

9.1 Size 1 Overview

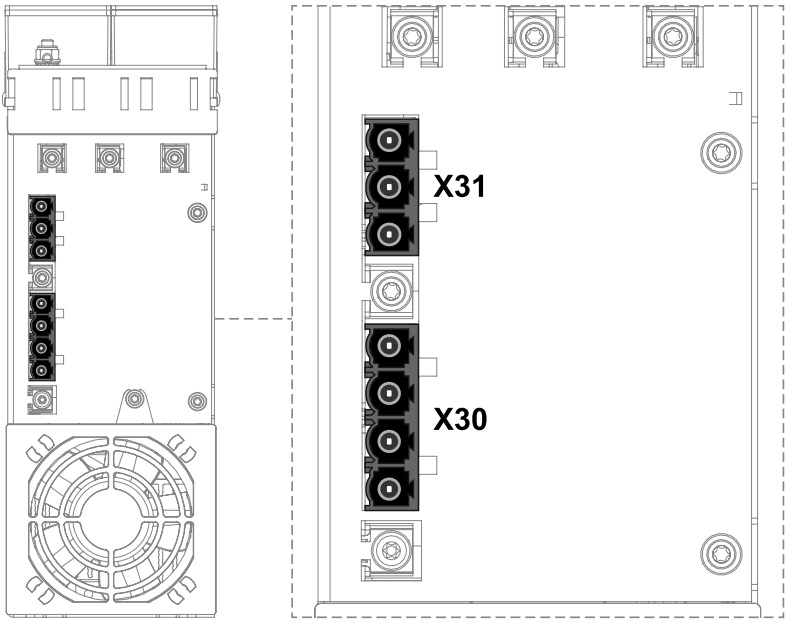
9.1.1 Size 1 Front Interfaces



9.1.2 Size 1 Top Interfaces

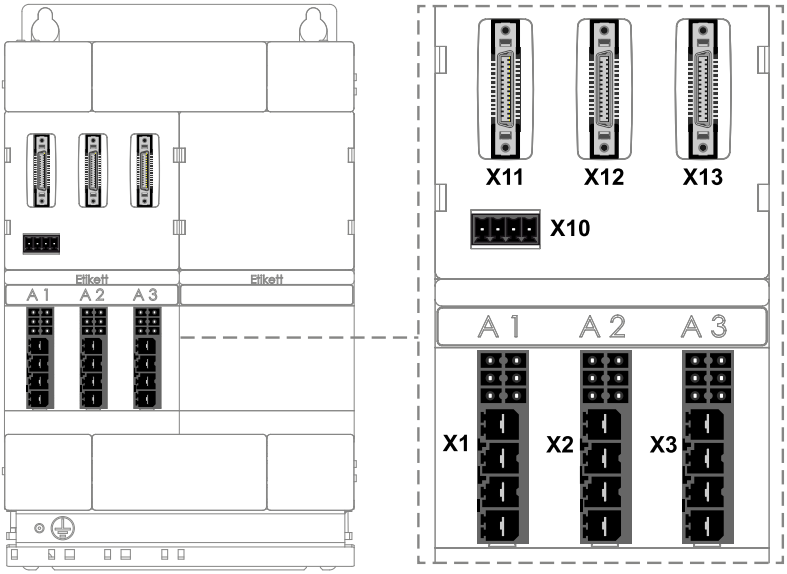


9.1.3 Size 1 Bottom interfaces (Power/Axis Module)

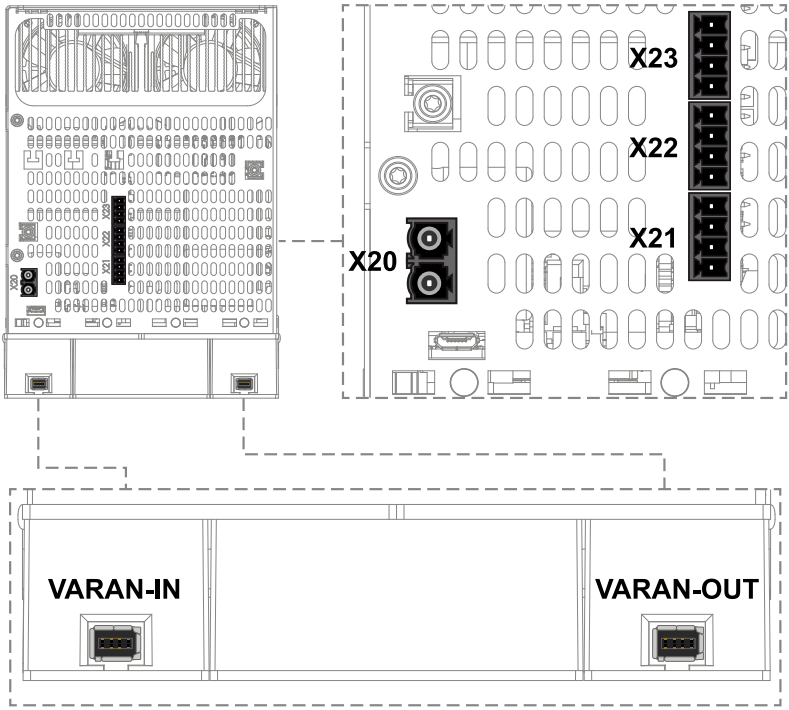


9.2 Size 2 Overview

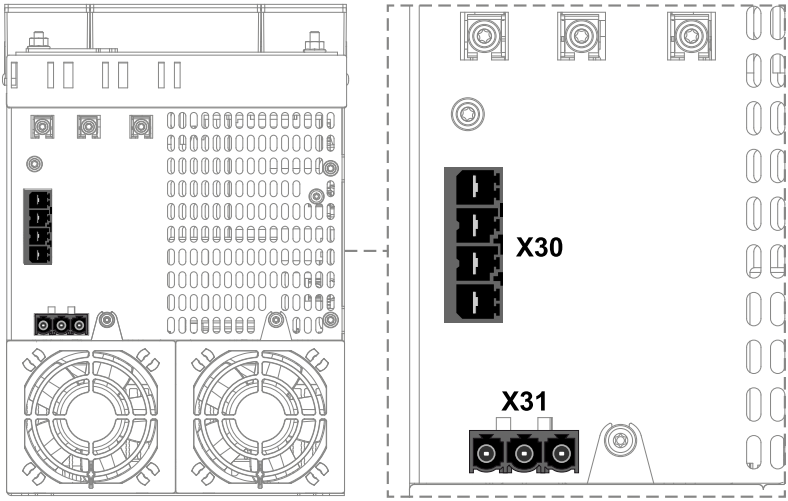
9.2.1 Size 2 Front Interfaces



9.2.2 Size 2 Top Interfaces



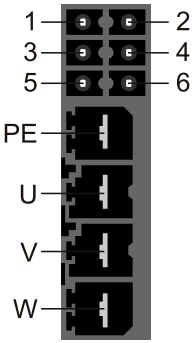
9.2.3 Size 2 Bottom interfaces (Power/Axis Module)



9.3 Connector Layout

9.3.1 X1, X2, X3: Motor Connection

not included in delivery
Weidmüller (1080440000) BVF 7.62HP/04/180 BCF/06R SN BK BX
Article number: 4080221212



Pin	Function
1	Hiperface DSL+
2	Hiperface DSL-
3	Motor temperature+
4	Motor temperature-
5	Holding brake+
6	Holding brake-
PE	Ground wire
U	Motor phase 1
V	Motor phase 2
W	Motor phase 3

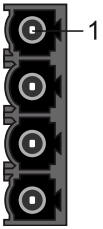
9.3.1.1 Pin Assignment Hiperface DSL Cable

Connector Layout Variant 1 (Hiperface DSL)			
BVF 7.62HP/04/180...	**Function**	**Color**	**Epic LS1 D6 3+PE+4 K 10.5-15.5**
1	Hiperface DSL+	Not defined	E
2	Hiperface DSL-	Not defined	C
5	Motor brake+	Not defined	A
6	Motor brake-	Not defined	B
PE	Neutral	green/yellow	PE
And	Phase 1	black	And
V	Phase 2	black	V
W	Phase 3	black	W

9.3.1.2 Motor Temperature Cable Pin Assignment

Connector Layout Variant 1 (Motor Temperature)			
BVF 7.62HP/04/180...	**Function**	**Color**	**Epic LS1 D6 3+PE+4 K 10.5-15.5**
3	Motor temperature+	Not defined	C
4	Motor temperature-	Not defined	E
5	Motor brake+	Not defined	A
6	Motor brake-	Not defined	B
PE	Neutral	green/yellow	PE
And	Phase 1	black	And
V	Phase 2	black	V
W	Phase 3	black	W

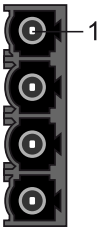
9.3.2 X30 BG1: Power Supply (MDP 2102)



Pin	Function
1	Ground wire
2	n.c.[1)]
3	Power phase L1
4	Neutral conductor

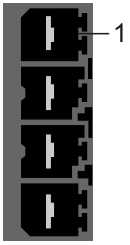
[1)] n.c. = do not use

9.3.3 X30 BG1: Power Supply (MDP 2100)



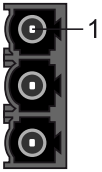
Pin	Function
1	Ground wire
2	Power phase L1
3	Power phase L2
4	Power phase L3

9.3.4 X30 BG2: Power Supply (MDP 2200)



Pin	Function
1	Ground wire
2	Power phase L1
3	Power phase L2
4	Power phase L3

9.3.5 X31: Ballast Resistance (MDP 210X, MDP 2200)



Pin	Function
1	PDC
2	Rtr
3	Rint

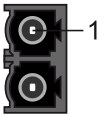
X31 does not have a fuse on the device side! When the external brake resistor does not have a fuse, the device can be destroyed. The user must install the fuse protection on the system side. An intrinsically safe brake resistor must be used.

INFORMATION

When using the internal ballast resistor, Rtr and Rint must be connected (in delivery condition, these are already connected).
This connection must be removed when an external ballast resistor is used. The external ballast resistor must be connected between PDC and Rtr.

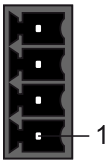
The I^2t fuse of the external brake resistor must be parametrized accordingly, otherwise the brake resistor can be destroyed.

9.3.6 X20: +24 V Supply



Pin	Function
1	+24 V
2	GND

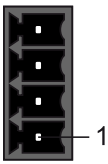
9.3.7 X21: STO Diagnostic Relays



Pin	Function
1	STO DIAG RELAIS NC1
2	STO DIAG RELAIS NC2
3	STO DIAG RELAIS NO1
4	STO DIAG RELAIS NO2

9.3.8 X22: Safe Inputs/Capture Inputs

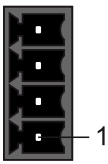
Configuration see following chapter "Wiring Examples Safety" on page 94.



Pin	Function
1	Safe input/capture input 1
2	Safe input/capture input 2
3	Safe input/capture input 3
4	Safe input/capture input 4

9.3.9 X23: Safe Inputs/Capture Inputs/Clock Signal Outputs

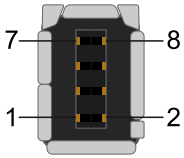
Configuration see following chapter "Wiring Examples Safety" on page 94.



Pin	Function
1	Capture input 5
2	Capture input 6
3	Signal output A/safe output 1
4	Signal output B/safe output 2

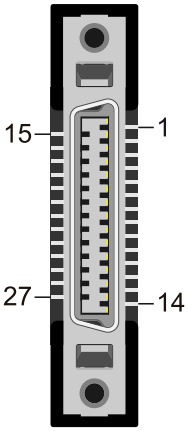
9.3.10 VARAN Bus (Industrial Mini I/O)

The VARAN connection is located on the VARAN interface, which is plugged into the device. It is also possible to connect multiple devices in a row using the Bus Connection Block.



Pin	Function
1	Tx+/Rx+
2	Tx-/Rx-
3	Rx+/Tx+
4	n.c.
5	n.c.
6	Rx-/Tx-
7	n.c.
8	n.c.

9.3.11 X11, X12 X13: Optional Encoder Module



Pin	Function
1	GND
2	+9 V
3	GND
4	+5 V
5	Encoder B+
6	Encoder B-
7	Encoder A+
8	Encoder A-
9	Z-
10	Z+
11	Clock-/B-
12	Clock+/B+
13	Data-/A-
14	Data+/A+
15	n.c.
16	Resolver Cosinus-
17	Resolver Cosinus+
18	Resolver Sinus-
19	Resolver Sinus+
20	Resolver excitation-
21	Resolver excitation+
22	Motor temperature
23	Motor temperature
24	5 V Sense-

Pin	Function
25	5 V Sense+
26	Battery
27	Battery+

Manufacturer	Article Number	Description	Specification
Hirose	4080225722 DH-27-CT1B	plug cover case	metal button type
Hirose	4080225723 DH40-27S	plug unit - solder contact type	solder contacts
Hirose	4080225725 DH-27-CMB(6.9) 244-0036-9 00	metal clamp	cable outer diameter 6.9 ±0.3 mm
Hirose	DH-27-CMB(7.3) / 244-0032-8 00	metal clamp	cable outer diameter 7.3 ±0.5 mm

9.3.11.1 EnDat Cable Pin Assignment

Connector Layout Variant 1 (EnDat)				
Drive	**Function**	**Color**	**Twisted Pair**	**Motor**
3	GND	white	Pair 1	2
4	+5 V	grey	Pair 1	4
5	Encoder B+	green	Pair 2	9
6	Encoder B-	yellow	Pair 2	1
7	Encoder A+	red	Pair 3	11
8	Encoder A-	orange	Pair 3	3
11	Clock-/B-	orange/white	Pair 4	15
12	Clock+/B+	red/white	Pair 4	8
13	Data-/A-	violet	Pair 5	13
14	Data+/A+	blue	Pair 5	5
22	Temp-	brown	Pair 6	7
23	Temp+	black	Pair 6	14
24	5V_Sens-	yellow/white	Pair 7	10
25	5V_Sens+	green/white	Pair 7	12

9.3.11.2 Resolver Cable Pin Assignment

Connector Layout Variant 2 (Resolver)				
Drive	**Function**	**Color**	**Twisted Pair**	**Motor**
16	Resolver Cosinus-	red	Pair 1	7
17	Resolver Cosinus+	orange	Pair 1	3
18	Resolver Sinus-	green	Pair 2	8
19	Resolver Sinus+	yellow	Pair 2	4
20	Resolver exciter-	blue	Pair 3	9
21	Resolver exciter+	violet	Pair 3	5
22	Temp-	brown	Pair 4	6
23	Temp+	black	Pair 4	2

9.3.11.3 Hiperface Cable Pin Assignment

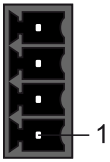
Connector Layout Variant 2 (Hiperface)				
Drive	**Function**	**Color**	**Twisted Pair**	**Motor**
1	GND	white	Pair 1	2
2	+9 V	grey	Pair 1	4
5	Encoder B+	green	Pair 2	9
6	Encoder B-	yellow	Pair 2	1
7	Encoder A+	red	Pair 3	11
8	Encoder A-	orange	Pair 3	3
13	Data-/A-	violet	Pair 4	13
14	Data+/A+	blue	Pair 4	5
22	Temp-	brown	Pair 5	7
23	Temp+	black	Pair 5	14

9.3.11.4 BiSS-C Cable Pin Assignment

Connector Layout Variant 1 (BiSS-C)				
Drive	**Function**	**Color**	**Twisted Pair**	**Motor**
3	GND	white	Pair 1	2
4	5 V	grey	Pair 1	4
11	Clock-/B-	orange/white	Pair 2	15
12	Clock+/B+	red/white	Pair 2	8
13	Data-/A-	violet	Pair 3	13
14	Data+/A+	blue	Pair 3	5
22	Temp-	brown	Pair 4	7
23	Temp+	black	Pair 4	14

9.3.12 X10: Battery Terminal

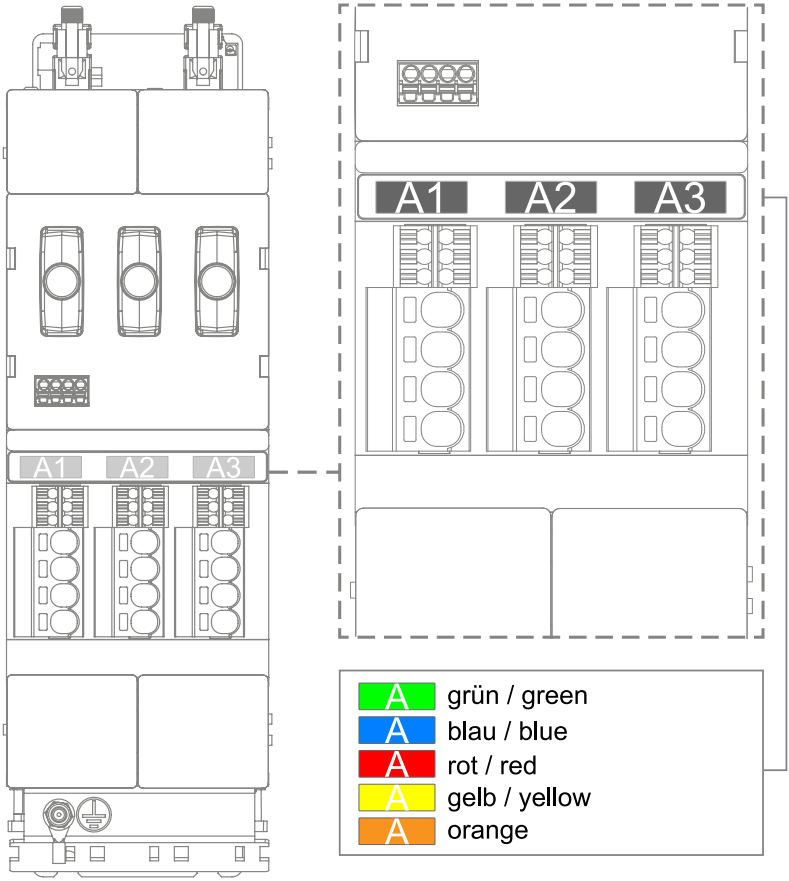
Several encoders also then require a supply if the device is not powered. A battery terminal for an external battery is therefore implemented.



Pin	Function
1	Battery+
2	Battery
3	Battery+
4	Battery

9.4 Status LEDs

3 status LEDs are located on the front panel of the DIAS-Drive 2000 series, which are used to read the drive states. The LEDs are labeled A1-A3 (Axis 1, Axis 2, Axis 3)



Color	Status	Frequency	Definition
Red	blinks	2x blink - Pause - 2x blink ...	Error in the Start-up phase
Yellow	blinks	Slow blink	Start-up phase
Blue	blinks	Slow blink	Firmware update
Red	blinks	Fast blinking frequency:	Safety error
Red	blinks	Slow blink	General error
Green	blinks	Axis-specific slow blinking frequency	Axis deactivated, no warnings triggered and VARAN is not synchronized
Green	blinks	Axis-specific fast blinking frequency	Axis deactivated, no warnings triggered and VARAN is synchronized
Green	on	Axis-specific	Axis activated and no warnings triggered
Orange	blinks	Axis-specific slow blinking frequency	Axis deactivated, warnings triggered and VARAN is not synchronized
Orange	blinks	Axis-specific fast blinking frequency	Axis deactivated, warnings triggered and VARAN is synchronized
Orange	on	Axis-specific	Axis activated and warnings triggered

9.5 Cable Cross Sections

The machine builder is responsible for ensuring that the cables are designed according to their capacity. The applicable norms and laws must be observed.

Due to the versatile application possibilities, a standard cross section cannot be specified in most cases.

9.5.1 X1, X2, X3 (motor connection)

Connector type:

- Weidmüller (1080440000) BVF 7.62HP/04/180 BCF/06R SN BK BX

Terminal range, connector dimension (power)	0.5-10 mm^2
Terminal range, connector dimension (signal)	0.2-1.5 mm^2
Conductor cross-section AWG, (power)	AWG 24-AWG 8
Conductor cross-section AWG, (signal)	AWG 26-AWG 16
Single-wire, H05(07) V-U (power)	0.5-10 mm^2
Single-wire, H05(07) V-U (signal)	0.14-1.5 mm^2
Fine-stranded wire, H05(07) V-K (power)	0.5-6 mm^2

Fine-stranded wire, H05(07) V-K (signal)	0.14-1.5 mm^2
with AEH with collar DIN 46 228/4, (power)	0.5-6 mm^2
with AEH with collar DIN 46 228/4, (signal)	0.25-1.5 mm^2
with ferrule according to DIN 46 228/1, (power)	0.5-6 mm^2
with ferrule according to DIN 46 228/1, (signal	0.25-1.5 mm^2

9.5.2 X30 BG1 (power supply), X31 (ballast resistor), X20 (+24 V supply)

Connector type:

- X30, BG1: Weidmüller (1059600000) BLZ 7.62HP/04/180 SN BK BX
- X31: Weidmüller (1059590000) BLZ 7.62HP/03/180 SN BK BX
- X20: Weidmüller (1059580000) BLZ 7.62HP/02/180 SN BK BX

Terminal range, min.	0.08 mm^2
Terminal range, max.	4 mm^2
Conductor cross-section AWG, min.	AWG 28
Conductor cross-section AWG, max.	AWG 12
Single-wire, min. H05(07) V-U	0.2 mm^2
Single-wire, max. H05(07) V-U	4 mm^2
Fine-stranded wire, min. H05(07) V-K	0.2 mm^2
Fine-stranded wire, max. H05(07) V-K	4 mm^2
with AEH with collar DIN 46 228/4, min.	0.2 mm^2
with AEH with collar DIN 46 228/4, max.	2.5 mm^2
with ferrule according to DIN 46 228/1, min.	0.2 mm^2
with ferrule according to DIN 46 228/1, max.	2.5 mm^2
Plug gage according to EN 60999 a x b; ø	2.8 x 2.4 mm

9.5.3 X30 BG2 (power supply)

Connector type:

- Weidmüller (1060410000) BVFL 7.62HP/04/180 SN BK BX

Terminal range, min.	0.5 mm^2
Terminal range, max.	10 mm^2
Single-wire, min. H05(07) V-U	0.5 mm^2
Single-wire, max. H05(07) V-U	10 mm^2
Multi-strand max. H07V-R	10 mm^2
Fine-stranded wire, min. H05(07) V-K	0.5 mm^2
Fine-stranded wire, max. H05(07) V-K	10 mm^2
with AEH with collar DIN 46 228/4, min.	0.5 mm^2
with AEH with collar DIN 46 228/4, max.	6 mm^2
with ferrule according to DIN 46 228/1, min.	0.5 mm^2
with ferrule according to DIN 46 228/1, max.	10 mm^2

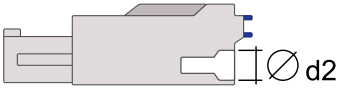
9.5.4 X21 (STO diagnostic relay), X22 (inputs), X23 (signal output), X10 (battery connector)

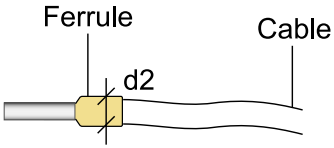
Connector type:

- Phoenix FMC1.5/ 4-ST-3.5

Stripping length/sleeve length:	10 mm
Mating direction:	parallel to the conductor axis or circuit board
Conductor cross section rigid:	0.2-1.5 mm^2
Conductor cross section flexible:	0.2-1.5 mm^2
Conductor cross-section strands ultrasonically compacted:	0.2-1.5 mm^2
Conductor cross section AWG/kcmil:	24-16
Conductor cross section flexible with ferrule without plastic sleeve:	0.25-1.5 mm^2

Conductor cross section flexible with ferrule with plastic sleeve:	0.25-0.75 mm^2 (reason for reduction d2 of the ferrule)





d2 = max. 2.8 mm

9.6 Cable Lengths

The cross sections of the cable depends on the configuration used and must be selected so that the nominal requirements are met.

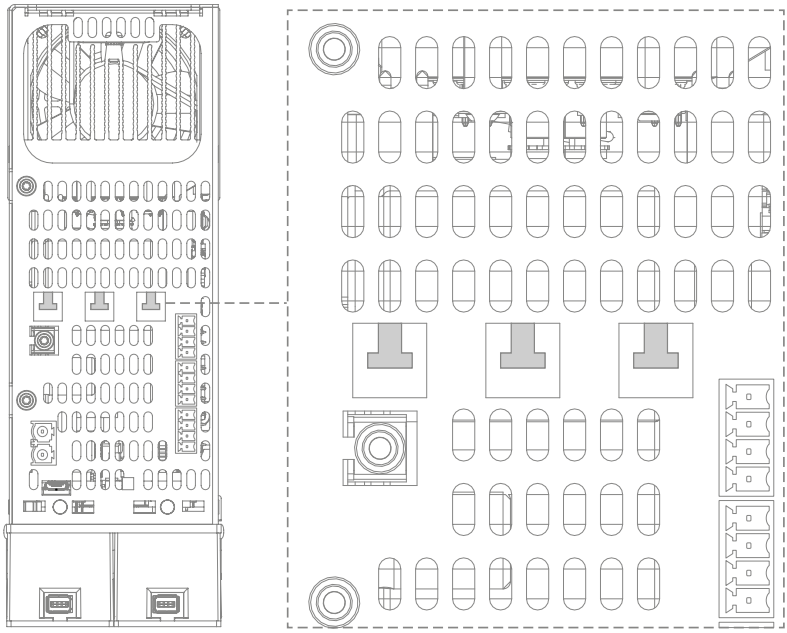
The specified cross sections are based on the standard connectors included with delivery, which must be properly assembled.

Cable	Connection	Maximum length
Power connector	X30	-
Motor cable	X1 X2 X3	30 m
Ballast cable	X31	3 m
I/O cable	X21 X22 X23	30 m
Encoder cables	X11 X12 X13	30 m
Battery cable	X10	3 m
+24 V power supply	X20	30 m
Varan cable	VARAN-In/Out	100 m
Protective earth	PE	-

9.7 Cable Strain Relief

In order to avoid unnecessary strain on the connected plugs, and also as a safeguard, a strain relief can be used to affix the cable to the housing. As an alternative, the cable can be places in a cable channel over the shortest distance possible.

For the encoder and VARAN plugs, as well as the plugs X20-X23, straps are provided on the top top panel of the device. This can be accomplished with cable ties. For the power and ballast plugs, provisions for strain relief must be made in the control cabinet.



9.8 Applicable Cable Types

The cable must be designed for the individual application and be able to withstand the demands of the operating environment. The applicable norms and laws must be thereby observed.

WARNING

Fire Risk

→ Incorrect cable dimensioning can cause a cable fire.

Risque d'incendie

→ Un dimensionnement incorrect du câble peut provoquer un incendie du câble.

9.8.1 +24 V Power Supply

For the +24 V supply, an insulated double-wire cable can be used, which does not have to be shielded. The cross section per wire must be dimensioned for the appropriate current and heat resistant. They must also be assembled with the appropriate connectors. The cable length must be kept as short as possible (maximum length is 30 m).

9.8.2 VARAN

For the VARAN connection, an S-FTP CAT5e network cable must be used that is equipped with the appropriate connectors. The maximum cable length from the first device to the primary bus participants is 100 m. The contacts must be made in compliance with TIA-568A/B. The appropriate cable configurations can be found on the SIGMATEK homepage.

9.8.3 DC-link Circuit

For the DC-link connection, the DC connection blocks (included with delivery) from SIGMATEK GmbH & Co KG must be used exclusively.

DANGER

The voltage of the DC connection block can be up to 850 V!

La tension du bloc de connexion DC peut atteindre 850 V !

9.8.4 Motor Cable

The motors must be connected with an appropriate cable in accordance with EN 60204-1, Installation Type C, environmental temperature ≤ 40 °C. The cable must be shielded. The cable length cannot exceed 30 m.

9.8.5 Encoder Cables

Endat/Hiperface	Lapp 00277101
Resolver	Lapp 00277151

Equivalent cables s are also authorized.

INFORMATION

The appropriate motor and encoder cables can be ordered from SIGMATEK, see chapter 17.1 Cable Type Key

10 Configuration and Setting

The modules of the DIAS-Drive 2000 series are integrated into the design environment LASAL. There, the devices can be configured and linked with control programs. In addition, LASAL has numerous debugging functions the simplify trouble shooting on the machine are available.

CAUTION

Errors in the device configuration, such as incorrect motor parameters, can result in damage to the device as well as the machine into which the device is installed. The configuration can therefore only be performed by trained personnel.

Des erreurs dans la configuration de l'appareil, comme par exemple des paramètres moteur erronés, peuvent provoquer des dommages sur l'appareil ainsi que sur la machine dans laquelle l'appareil est monté ! La configuration doit donc être effectuée par un personnel spécialisé et formé.

10.1 Training Opportunities

A LASAL Motion course is recommended for correctly configuring the DIAS-Drive 2000 series. Training courses are offered by SIGMATEK GmbH & Co KG. Schedules and registration options can be found on our website.

11 Electrical Configuration

11.1 Motor Selection

With the DIAS-Drive 2000 series, synchronous servo motors can be controlled. The motors must meet the requirements specified in the technical data.

INFORMATION

During the initial start-up, ensure that the motor parameters are set correctly. In particular, an incorrect M-ROFF value can lead to motor spin-through. Not every device supports storing or reading motor data in the encoder (Hiperface DSL starting from FW version 1.20).

The following encoder types are supported:

11.1.1 Internal

- Hiperface DSL

11.1.2 With Encoder Interface

- Resolver
- Sin/Cos
- TTL
- Hiperface
- EnDAT 2.1
- Tamagawa
- BiSS-C

11.1.3 Supplementary Specifications Encoder

Type	Specification		
Resolver	Excitation frequency of 8 kHz or higher		
Endat 2.1	Maximum frequency of incremental signals 1 MHz		
Hiperface[1)]	Identifier	Encoder designation example	
	0x02	SCS60	
	0x07	SCM60	
	0x12	SNS50	
	0x22	SRS50	
	0x27	SRM50	
	0x32	SKS36	
	0x37	SKM36	
	0x42	SEK36	
	0x47	SEL52	
	0xFF	Encoder with electronic nameplate. Currently only rotary encoders with electronic nameplate are supported, no linear encoders!	
SinCos	Encoder frequency up to 1 MHz with 1 Vpp (112 Ω terminating resistor)		
TTL	Encoder frequency up to 1 MHz, balanced (RS422) ±0.5 V to ±3.3 V (112 Ω terminating resistor)		
BissC	Maximum 32 bit singleturn and maximum 32 bit multiturn position		
Tamagawa	ID	Encoder designation example	Resolution
	0x11	TS5669N124	17 bit singleturn 16 bit multiturn
	0x17	TS5700N8500	23 bit singleturn 16 bit multiturn
Hiperface DSL	Maximum 32 bit singleturn and maximum 32 bit multiturn position (EKS36, EKM36)		

1) Encoders with different designations can have the same identification. The identification is noted in the respective encoder documentation.

11.2 Electrical Installation

The following sections describe the electrical installation and wiring of the converter system and are generally based on the modules of the DIAS-Drive 2000 series.

11.2.1 Fuse

The supply line of the devices must be protected with a fuse. The dimensioning of the fuse depends on the application, however, the “Maximum Fuse Protection” specified in the technical data (see chapter 7.7 Expanded MDP 2XXX Specifications)!

11.2.2 Guidelines for Installation and Wiring

Modules with IP20 protection must be installed and operated in a closed control cabinet. The manufacturer of the machine is obligated to use the required cables with the standard wire cross sections for the connector cables; this especially applies for all power conducting connections.

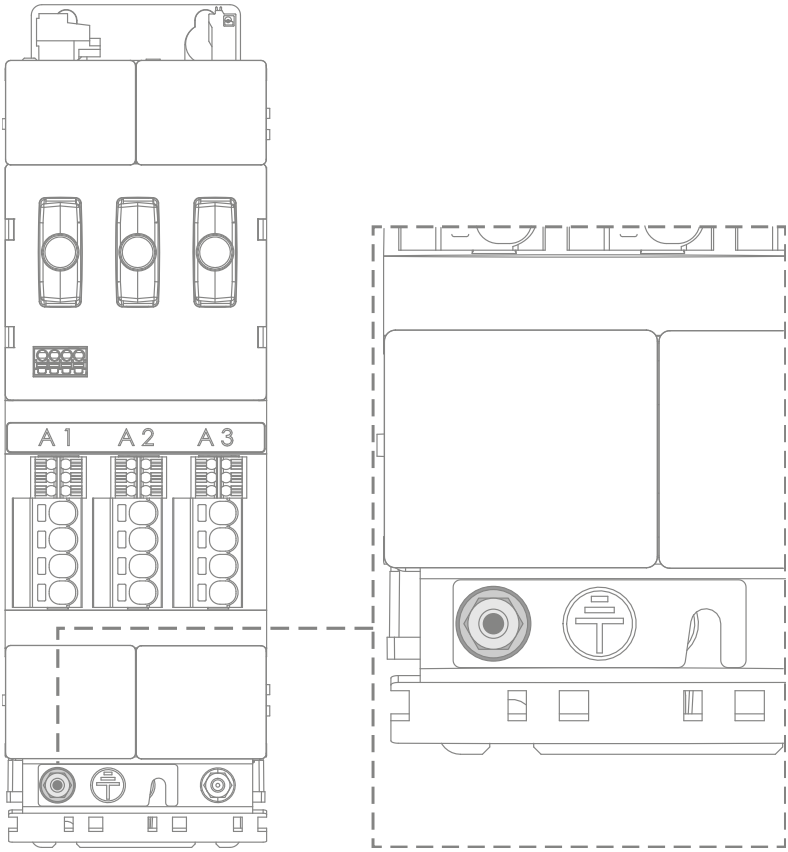
This especially applies to all power conducting connections such as power connections, ballast and motor connections etc. The wiring of the devices to peripheral devices must be implemented with the appropriate cable types. The length of the motor and encoder cables is limited to 30 m.

The motor cables must be run downward from the module, the feedback and data cables upward.

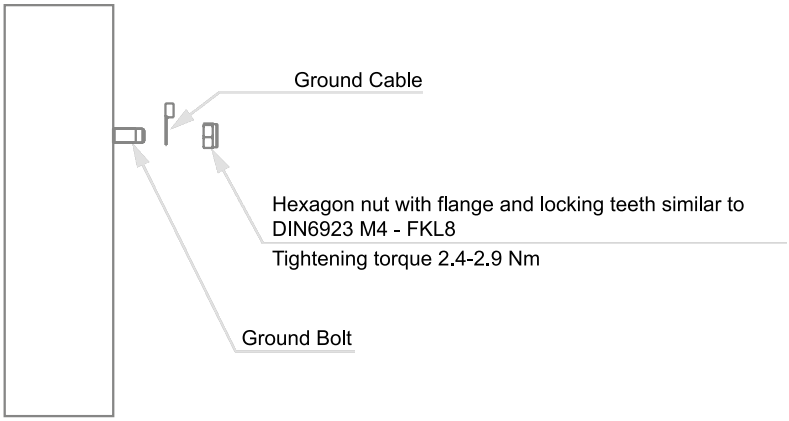
WARNING

To maintain the protective earth connection, the protective earth line must comply with applicable norms and regulations.

11.2.3 Protective Earth Connection



The connection of the protective earth must be made as follows:

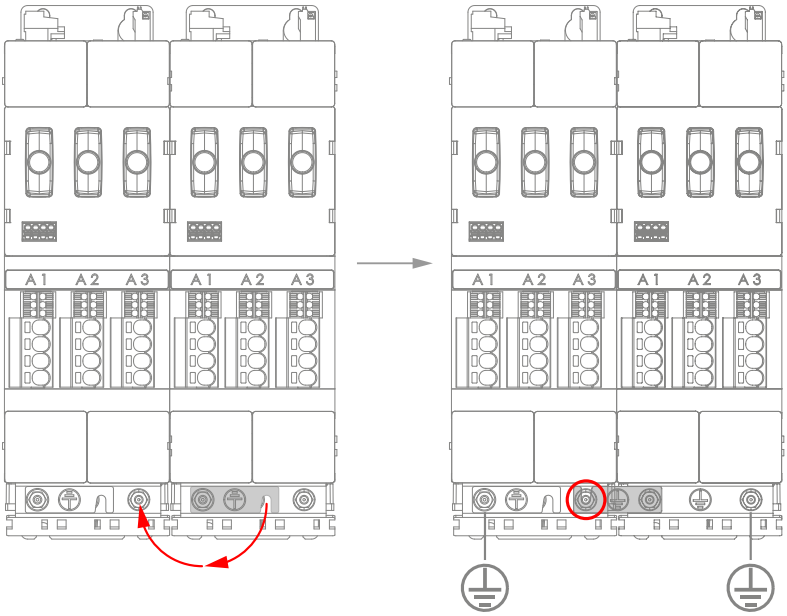


The protective earth must have a minimum cross section according to the table. Each protective earth that is not a component of the cable must have a minimum cross section of 4 mm^2.

Cross-sectional Area of the Phase Conductor A [mm^2]	Minimum Cross Section of the Protective Earth Terminal A_{PE} [mm^2]
A ≤ 16	A_{PE} = A
16 < A ≤ 35	A_{PE} = 16
35 < A	A_{PE} = A / 2

11.2.4 Protective Earth Connection between Multiple Modules

Provide the MDP with a protective earth cable at the connection terminal. The following modules can then be connected using a protective earth bar. No separate protective earth line is therefore required for the connected components. A protective earth is then connected to the last device using a cable.



INFORMATION

On the 1st and last module, 1 protective earth line is always connected by via cable.

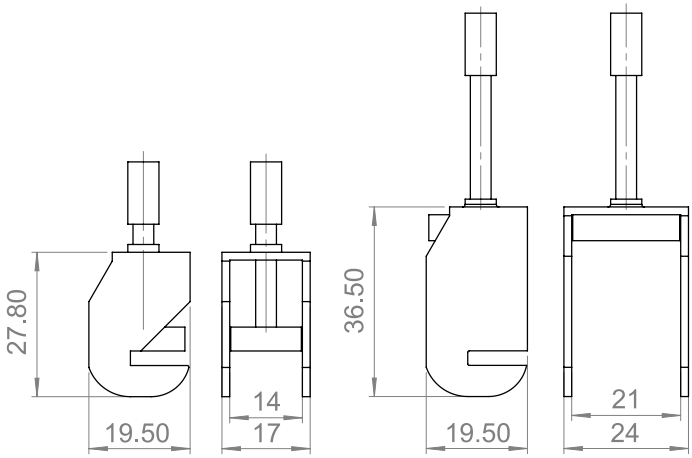
11.2.5 Ground Fault Interrupter

INFORMATION

This product can cause a DC current in the protective ground conductor. Where a residual current device (RCD) or residual current monitor (RCM) is used for protection in the event of direct or indirect contact, only an RCD or RCM of Type B (all-current sensitive according to IEC 60755) is allowed on the current supply side of this product.

11.2.6 Shield Connector Clamps

The shielding was designed especially for the shielding clamps of type Phoenix SK 14-D and SK 20-D. It is essential that the connection of the motor line shielding to the shield support be made over a broad surface and have good electrical conductivity.



11.3 Guidelines for Correct EMC Control Cabinet Construction

The converters of the DIAS-Drive 2000 series are designed for operation in an industrial environment, in which high electromagnetic noise is expected. Only correct installation ensures safe and disruption-free operation.

WARNING

The machine builder must ensure that their machine can comply with the required EMC guidelines. Since the EMC response depends on the cables, motors, installation type etc., SIGMATEK GmbH und Co. KG has no influence on the EMC response of the machine. The responsibility and liability lies with the machine builder.

In a domestic environment this product may cause high frequency interference in which case interference suppression measures may be required.

11.3.1 Configuration of the Control Cabinet

- All metal components of the control cabinet (side panels, back walls, top and bottom panels) must have an electrically conductive connection – as flat as possible or over a large number of point-formed screw terminals – with the control cabinet frame.
- The devices must be connected to protective earth at their PE screw on the front in a well-conducting manner.
- All metallic housings of the modules installed in the cabinet, as well as additional components such as converters or power components, must have highly conductive, wide-area connections to the cabinet frames. The power/axis module and axis modules are mounted directly onto the control cabinet wall. No mounting plate is required.
- All connections must be made permanent. Screw connections to lacquered or anodized metallic components must be made with either special contact discs, which penetrate the insulated surface and therewith create a metallic conductive connection or the insulation must be removed at the point of contact.

11.3.2 Wiring

- The lines from the mains supply to the power/axis module must be separated by unfiltered power lines with high noise levels (connection lines between the ballast switch and corresponding ballast resistor, as well as motor lines).
- Signal and data lines, as well as filtered power lines can only cross unfiltered power lines at a right angle.
- The length of all conductors must be kept as short as possible.
- Signal and data lines, and corresponding potential compensation lines are always parallel and with the smallest possible clearance.
- Motor cable shielding must be connected on both sides, over a large surface and highly conductive with the grounded housing.
- For the power cable, the shield support on the lower front edges of the module should be used.
- The Shielding clamps must be connected with the shield support over a large, low-inductivity surface.
- Conductor shielding should not be interrupted.

11.4 Using Cooling Devices

The Servo amplifier functions up to an environmental temperature of 45 °C (55 °C with reduced power). Under some circumstances, a cooling device is required.

WARNING

Cooling units produce condensation water The important points must therefore be observed!

Les unités de refroidissement produisent de l'eau de condensation Les points importants doivent donc être respectés !

- Cooling units must be mounted in such a way that no condensation water can drip into the control cabinet.
- Cooling units must be mounted so that condensation water is not distributed over electrical or electronic components.

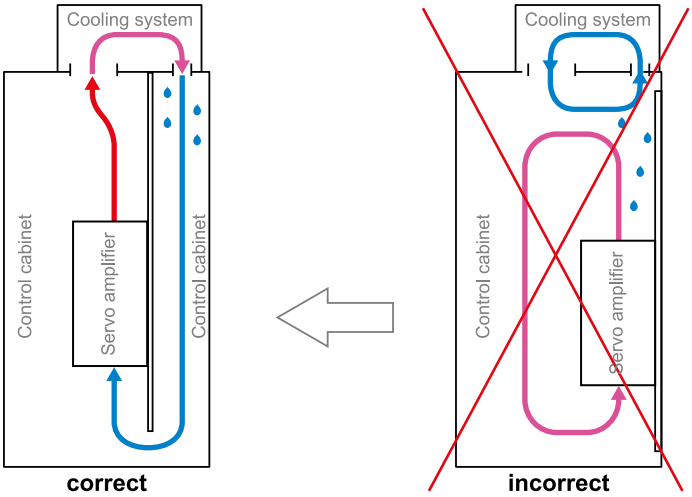
DANGER

Condensation water can cause hazards due to electric shock.

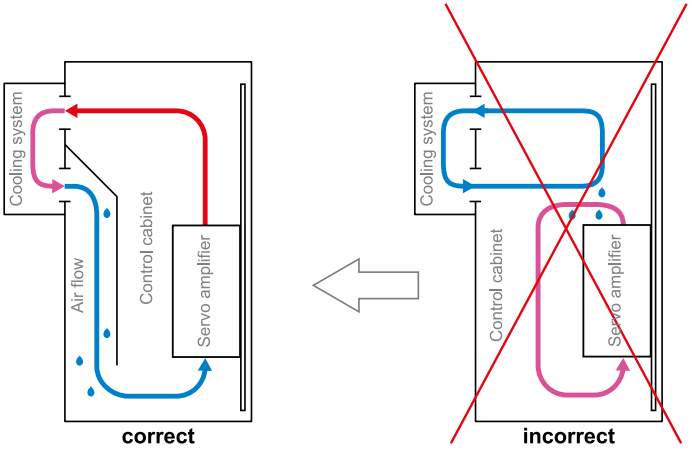
L'eau de condensation peut présenter un risque de choc électrique.

Condensation water can also be avoided as follows:

- The switch point of the temperature regulator should be a little below the building temperature.
- In damp environments, the proper seals should be used in the control cabinet.
- If electronic components are colder than the air in the control cabinet, condensation water can be generated; especially when the cabinet door is opened during servicing. After closing the control cabinet doors, ensure that the humidity is not too high and that no condensation has formed on the electronics before the initial start-up.



Cooling device mounted in the top of the control cabinet



Cooling device mounted in the cabinet door

11.5 Pre-Start Check List

The initial start-up must be designed for the machine in which the device is installed. This is the responsibility of the machine builder.

- ☐ All cables connected correctly?
- ☐ Devices secure and tightly screwed down?
- ☐ Proper connection to PE?
- ☐ Appropriate ballast resistor or ballast jumper connected?
- ☐ VARAN connection made with the right connectors and forwarded?
- ☐ Motors connected correctly?
- ☐ Motor feedback, brake and temperature lines connected?
- ☐ Motor cable shielding placed and secured to the shield support with the appropriate shield clamp?
- ☐ All tools and unnecessary material removed from the danger zone?
- ☐ All required and optional safety measures taken?

11.5.1 Safety

- Encoder must be tested
- Machine must be tested
- Safety parameterization must be done
- Safety functions used must be tested
- encoders must be verified on the drive
- reference position must be inserted at the Drive (if absolute position is needed)
- Safety CPU must be validated (if used)
- Steps must be logged (at least name of the person performing the work, date and steps performed)

WARNING

Incorrect motor parameter files can lead to serious damage to the motor and connected machine components.

12 Assembly/Installation

This chapter describes the assembly of the multi-converter system and is generally based on the modules of the DIAS-Drive 2000 series.

12.1 Check Contents of Delivery

Ensure that the contents of the delivery are complete and intact. See chapter 1.3 Contents of Delivery.

INFORMATION

On receipt and before initial use, check the device for damage. If the device is damaged, contact our customer service and do not install the device in your system.

Damaged components can disrupt or damage the system.

12.2 Safety Guideline

1. Personnel involved with the installation must be trained specialists as described in the chapter regarding designated use. The installation site must be inaccessible for all other personnel; if necessary, warning notices must be placed where they are clearly visible.
2. The installation site has to be ESD-compliant; personnel performing the installation must be familiar with ESD guidelines.
3. The modules must be in delivery condition and may only be removed from the original packaging directly before installation.
4. Possible cable connections to the modules and the control cabinet must be removed.
5. During installation, voltage cannot be supplied to any part of control cabinet and modules.
6. The operating manual, with its safety guidelines and the specifications for designated use, as well as the mounting instructions must be available at the installation site.

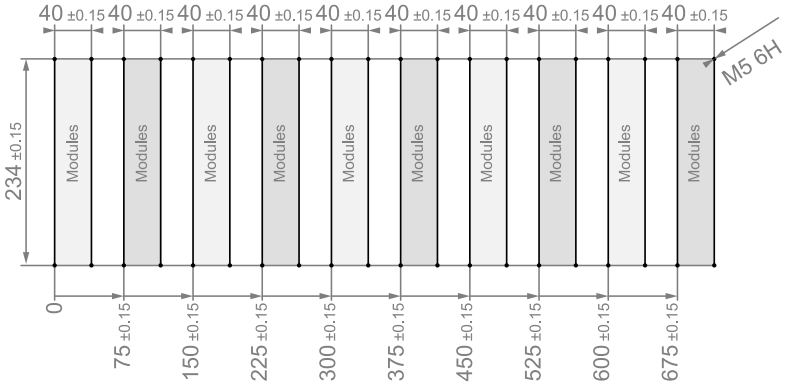
INFORMATION

Mounting

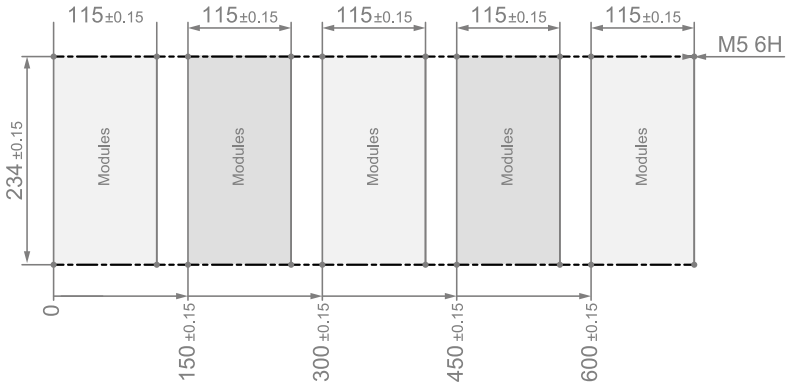
→ The machine manufacturer must ensure that the drive is installed using the appropriate tools according to the applicable regulations and in compliance with the safety guidelines, as well as according to the conditions and requirements (e.g. protective earth connection, clearance between components and housing, cooling measures, tightening torque of the screw, type of screws and spacer bolts etc.).

12.3 Position of the Mounting Holes

12.3.1 Size 1

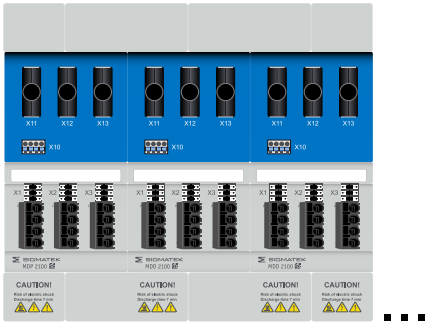


12.3.2 Size 2


115 ±0.15
115 ±0.15
115 ±0.15
115 ±0.15
115 ±0.15
M5 6H
234 ±0.15
Modules
Modules
Modules
Modules
Modules
0
150 ±0.15
300 ±0.15
450 ±0.15
600 ±0.15

12.4 Mounting and Connecting the MDP and MDD Modules

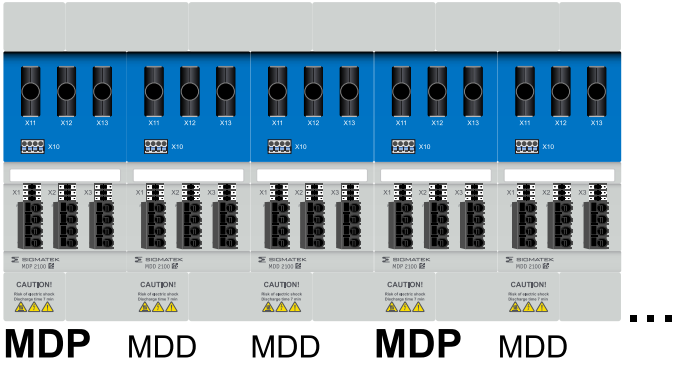
Installation begins with the MDP on the left side. The individual modules are mounted on the back wall of the control cabinet with the appropriate screws.



INFORMATION

Only An external ballast resistor may be connected to one MDP. The shunt resistor must be disabled on each additional MDP. The parameters are defined via the G-RBAL parameter (see parameter description DIAS-Drive).

If the DC-link output is insufficient, an additional MDP of the same size can be inserted. More Dc-link capacity can thereby be used and more regenerative braking energy stored.



12.4.1 Connecting DC-Link and VARAN

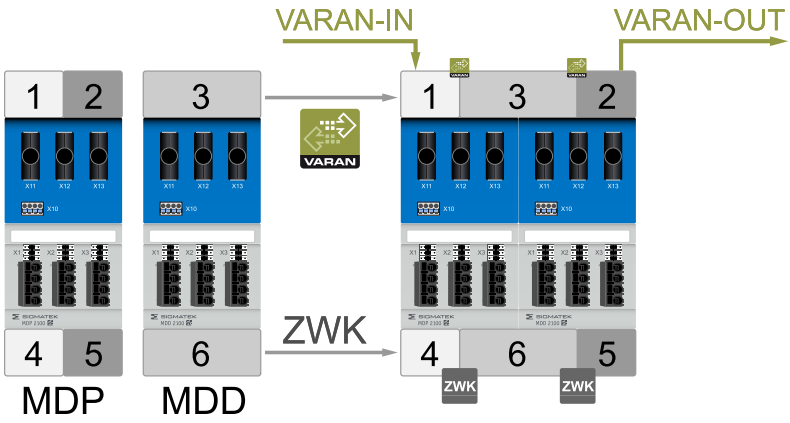
The VARAN connection with the MDP (VARAN In) is made via cable. VARAN signals are transmitted via the VARAN connectors to the additional MDDs. The DC-link is transmitted according to the same principle. On the MDP, remove the right single DC-link/VARAN connection Remove the double DC-link/VARAN connection from the MDD and use it as a bridge between MDP and MDD. Repeat this process until all modules are connected with one another. On the last device, plug the single DC-link/VARAN connection of the MDP into the remaining interface.

It is possible that several MDD 2000 blocks are connected to each other.

INFORMATION

It is absolutely essential to ensure that the DC-linke circuit is completely discharged when connecting. Otherwise, the device can be destroyed!

If MDPs of different sizes are used in the system, the DC-link between this sizes (MDP) must be separate.

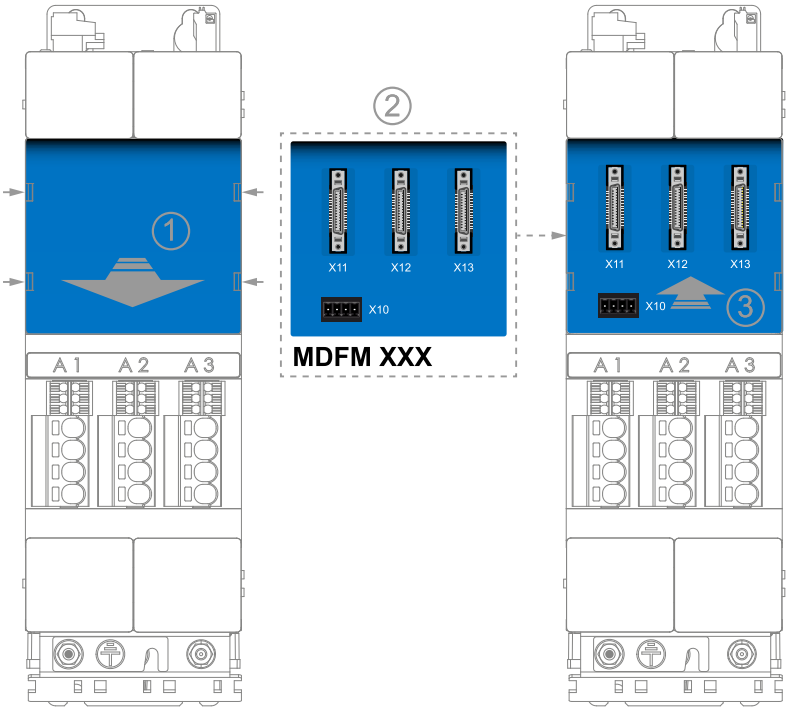


12.5 Installing Universal Encoder Modules

CAUTION

The exchange or installation of the universal encoder mode is only permitted with appropriate ESD safety equipment.

1. With the appropriate screwdriver, release the 4 latches by pressing them in and holding them so that the latch does not reengage. After all 4 latches are released, pull the MDFM forward.
2. Place the MDFM straight on until it is latched in.



13 Monitoring and Warning Functions

13.1 Error Configuration

Many errors can be deactivated for debugging and setting purposes. However, it is highly recommended that they be reactivated before restarting normal operation.

For the safety of the device and personnel, errors that serve to protect the modules are not turned off. An example of this is the temperature monitor for the heat sink.

The machine manufacture is responsible for the correct and safe configuration of the errors and their reactions.

13.2 Over Temperature Protection

To protect the power semiconductors, the converters of the DIAS-Drive 2000series have an I^2t temperature model that calculates the actual temperature of the semiconductor via the heat sink temperature and the load.

Warning and error limits are defined. When the error limit is reached, the machine is brought to a controlled standstill.

13.3 Motor Overload Protection

The motor temperatures can be determined using an I^2t temperature model or a temperature sensor built into the motor.

The triggering characteristics of the protective function can be individually configured in LASAL.

14 Decommissioning and Maintenance

14.1 Repairing Individual Devices

INFORMATION

Exchange of individual devices

→ The manufacturer can exchange the modules.

Observe the requirements of the Machinery Directive and the regionally applicable standards. Depending on the machine, this may result in requirements for commissioning, such as checking all safety functions of the machine.

CAUTION

Repairs on the modules can only be performed by SIGMATEK GmbH & Co KG.
Exception: exchanging a defective fan.

Les réparations sur les appareils ne peuvent être effectuées que par SIGMATEK GmbH & Co KG, à l'exception du remplacement d'un ventilateur défectueux.

14.2 Maintenance

INFORMATION

Except for forming, the DIAS-Drive 2000 series devices are maintenance-free. The devices that implement safety functions must be exchanged, at the latest, after 20 years. The DIAS-Drive 2000 must be restarted at least once a year for diagnostic purposes once a year. To do this, interrupt the power supply.

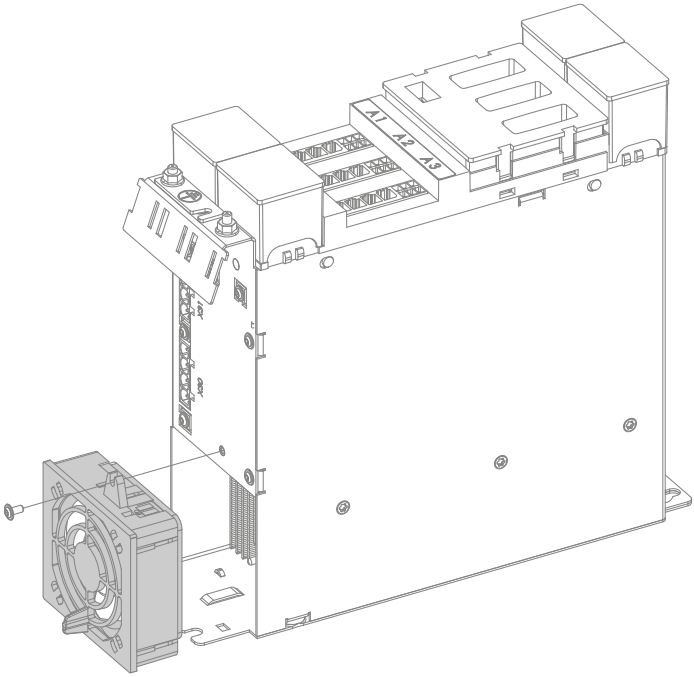
14.3 Exchanging the Fan

The DIAS-Drive 2000 series fan is exchangeable. The fan can be removed and exchanged or cleaned by loosening the locking screw (TX10) on the bottom panel.

WARNING

Before removing the fan, the device must be turned off for at least 7 minutes.
To ensure that the DC-link circuit is discharged, the voltage at the DC link socket must be measured.

Avant de retirer le ventilateur, l'appareil doit être éteint pendant au moins 7 minutes.Pour s'assurer que le circuit intermédiaire est déchargé, il faut mesurer la tension aux prises DC-Link.



14.4 Encoder Exchange

INFORMATION

Verification

→ Encoders must be re-verified after replacement. Replacing an encoder means that all encoders must be re-verified to prevent manipulation or confusion.

When an encoder is replaced, the drive must be commissioned.

The following points must be observed:

- ☐ Reset verification of all encoders
- ☐ Resetting the referencing of all exchanged encoders
- ☐ Encoders must be tested
- ☐ Machine must be tested
- ☐ Safety functions used must be tested
- ☐ All encoders must be verified on the drive
- ☐ Reference position must be inserted for exchanged encoders on the drive (if position is required)
- ☐ Steps must be logged (at least name of the person performing the work, date and steps performed)

14.5 Forming

The DC-link circuit of the DIAS-Drive 2000 series is based on electrolytic capacitors With longer storage times, the oxide layer of the capacitors can be damaged If the device is out of operation or in storage for longer than one year, the DC-link capacitors must be formed. For storage times less than a year, forming is unnecessary.

CAUTION

If the PDS is put into operation after a long storage time without forming the DC-link capacitors, an short-circuit can occur within the device.

Si un PDS est mis en service après une longue période de stockage sans que les condensateurs du circuit intermédiaire aient été formés, un court-circuit peut se produire à l'intérieur de l'appareil !

14.5.1 Forming of Capacitors

Shelf life	Solution
< 1 year	keine
1-2 years	Before the Initial Startup, the device must be supplied with nominal voltage for one hour. An external 10 kΩ power resistors must be installed at the ballast connection. Procedure: 1)internal ballast resistor = remove bridge 2) install 10 kΩ as external ballast 3) connect supply voltage for 1 hour 4) reassemble device for operation
2-3 years	Before the Initial Startup, the device must be powered with a regulatable voltage source. Additional measures required, see point 1-2 years. The voltage is increased incrementally (0.1V increment). 1. 30 minutes with 25 % nominal voltage 2. 30 minutes with 50 % nominal voltage 3. 30 minutes with 75 % nominal voltage 4. 30 minutes with 100 % nominal voltage
> 3 Years	Before the Initial Startup, the device must be powered with a regulatable voltage source. Additional measures required, see point 1-2 years. The voltage is increased incrementally (0.1V increment). 1. 2 hours with 25 % nominal voltage 2. 2 hours with 50 % nominal voltage 3. 2 hours with 75 % nominal voltage 4. 2 hours with 100 % nominal voltage

INFORMATION

Lifespan

→ If the PDS of the DIAS-Drive 2000 series are in storage longer than 5 years, they should no longer be operated.

14.6 Exchange of MDD

INFORMATION

All points of the initial commissioning (chapter 11.5) must be performed, if a communication with a safety CPU takes place (FSoE).

14.7 Restarting

WARNING

After triggering a safety function, a user action is normally required. As long as a primary (e.g. application-controlled) automatic reaction occurs, the operator must perform an additional risk analysis. The machine manufacturer must ensure compliance with the requirement in EN 60204-1:2019 chapter 7.5. There, it states: "When voltage returns or when the power supply is switched on, the machine must be prevented from restarting automatically or unexpectedly. If such a restart could be hazardous."

Après le déclenchement d'une fonction de sécurité, une action de l'utilisateur est normalement requise. Si une réaction automatique de niveau supérieur (par exemple, commandée par une application) a lieu, une analyse de risque supplémentaire doit toujours être effectuée par l'utilisateur!Le fabricant de la machine doit s'assurer que l'exigence de la norme EN 60204-1:2019 Chapitre 7.5 est respectée. Elle stipule: "Lors du rétablissement de la tension ou de la mise sous tension, un redémarrage automatique ou inattendu de la machine doit être empêché si ce redémarrage peut provoquer une situation dangereuse."

15 Transport/Storage

INFORMATION

This device contains sensitive electronics. During transport and storage, high mechanical stress must therefore be avoided.

For storage and transport, the same values for humidity and vibration as for operation must be maintained!

Temperature and humidity fluctuations may occur during transport. Ensure that no moisture condenses in or on the device, by allowing the device to acclimate to the room temperature while turned off.

When sent, the device should be transported in the original packaging if possible. Otherwise, packaging should be selected that sufficiently protects the product from external mechanical influences. Such as cardboard filled with air cushioning.

15.1 Packaging, Transport and Storage Specifications

INFORMATION

Error-free operation can only be guaranteed through proper and careful handling! The packaging, transport and storage guidelines must therefore be followed.

Packaging	Packaging consists of carton (corrugated board) with inboard conductive upholstery. The modules additionally are enclosed in conductive foil. The packaging can be disposed in accordance with local regulations. Before unpacking, the packaging must be checked for damage and if necessary, the transport company informed. After unpacking, the component must be checked that it is complete and intact. Only complete and intact products can be installed and operated. If damaged, the transport company and the manufacturer must be informed. It is expressly emphasized that incomplete and/or damaged modules cannot be installed and operated!
Transport	The environmental temperature must be within -25 ... +70 °C (-13 ... +158 °F). Max. change 20 K/h. Falls and vibration must be avoided.

Storage	The environmental temperature must be within -25 ... +70 °C (-13 ... +158 °F). Max. change 20 °C/h. Maximum relative humidity 85 % (non-condensing). The modules must be stored clean and dry in the original packaging, as well as protected from weather affects. The modules must also be protected against saline mist, industrial gasses, corrosive fluids, rodents and mold. The storage period should not exceed 1 year under storage conditions defined in EN 61800-2. If the product is stored for a longer period, the DC-link capacitors must be reformed (see chapter 14.5).

16 Maintenance

INFORMATION

During maintenance as well as servicing, observe the safety instructions from chapter 3 Basic Safety Directives.

Lors de l'entretien et de la maintenance, respectez les consignes de sécurité du chapitre 3 Basic Safety Directives.

16.1 Repair

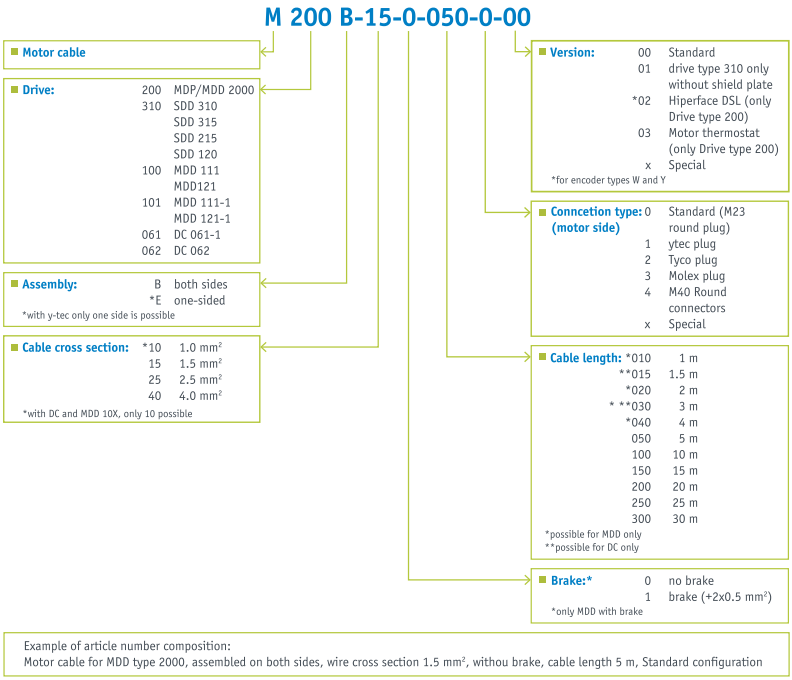
INFORMATION

In the event of a defect/repair, send the device with a detailed error description to the address listed at the beginning of this document.
For transport conditions, see chapter 15 Transport/Storage.

17 Accessories

17.1 Cable Type Key

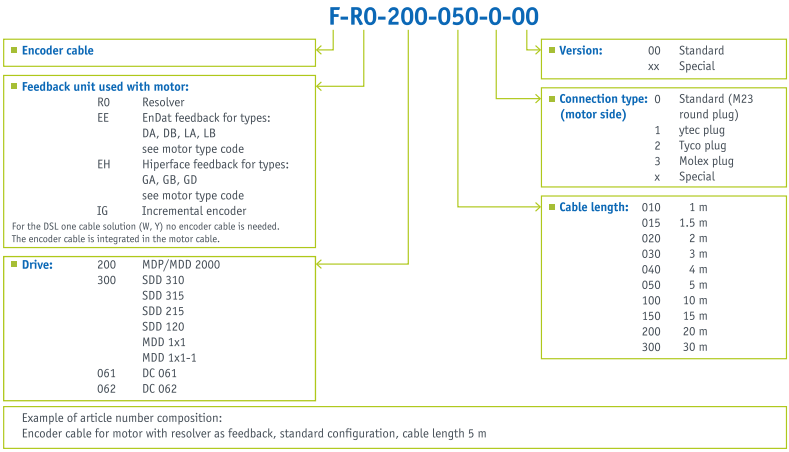
17.1.1 Motor Cables



Article Number	Cable Diameter	Outer Ø	Brake	Connector
Motor cable without Hiperface DSL				
M200B-15-1-XXX-0-00	4x1.5 mm² + 2x0.5 mm²	12 mm	X	M23
M200B-15-1-XXX-1-00	4x1.5 mm² + 2x0.5 mm²	12 mm	X	ytec
Motor cable with Hiperface DSL (single cable solution)				
M200B-15-0-XXX-0-02	4x1.5 mm² + 2x22 AWG	11.2 mm	-	M23
M200B-15-1-XXX-0-02	4x1.5 mm² + 2x1 mm² + 2x22 AWG	13.2 mm	X	M23

Standard Cable Lengths XXX	Length
010	1 Meter
030	3 Meters
050	5 Meters
100	10 Meters
150	15 Meters
200	20 Meters
250	25 Meters
300	30 Meters

17.1.2 Encoder Cables



Article Number	Encoder Type	Outer Ø	Connector
F-R0-200-XXX-0-00	Resolver	ca. 6.4 mm	M23
F-R0-200-XXX-1-00	Resolver	ca. 6.4 mm	ytec
F-EE-200-XXX-0-00	EnDat	ca. 7.8 mm	M23
F-EH-200-XXX-0-00	Hipferface	ca. 7.8 mm	M23

Standard cable lengths XXX	Length
010	1 Meter
030	3 Meters
050	5 Meters
100	10 Meters
150	15 Meters
200	20 Meters
250	25 Meters
300	30 Meters

other cable versions on request

17.2 Encoder Modules

Description	Order Number
MDFM 031 MD feedback module with 3 encoder connections	09-83-021

17.3 Replacement Fan

Description	Order Number
Replacement fan for SZ1/2	01-270-2144-E3

18 Disposal

INFORMATION

Should you need to dispose of the device, the national regulations for disposal must be followed.

The device appliance must not be disposed of as household waste.

Changes Chart

Change date	Affected page(s)	Chapter	Note
24.09.2021	14	2.3 Available Models	changed
	20	3.4 Designated Use	changed
		Warning against electromagnetic fields	deleted
		Operation Modes	changed
	25	3.8 Safe State	changed
		Safe position evaluation	deleted
		Safe current evaluation	deleted
	25	3.11 Safe Inputs and Outputs	changed
	26	3.12 Software/Training	changed
	29	4.4 Safety-Relevant Parameters	Value changed, removed unsupported functions
	32	5.2 Concept	changed
	35	6.1 Overview	changed
	38	6.2.1.1 STO - Safe Torque Off	changed
	40	6.2.1.2 SS1 – Safe Stop 1	changed
		Safe stop 2	deleted
		Monitoring functions	deleted
		Output functions per axis	deleted
	113	9.3 Connector Layout	X22, X23 changed
	130	11.1 Motor Selection	changed
	136	11.3 Guidelines for Correct EMC Control Cabinet Construction	changed
14.01.2022	14	2.3 Available Models	Models available without encoder module

Change date	Affected page(s)	Chapter	Note
03.02.2022	104	7.10 Mechanics	Life span fan added
26.08.2022	29	4.4 Safety-Relevant Parameters	Safety-Relevant Parameters input added
	40	6.2.1.2 SS1 – Safe Stop 1	SS1 => SS1-t
18.10.2022	12	1.3 Contents of Delivery	required opposing connector modified
	113	9.3 Connector Layout	added article number to order the opposing connectors which are not included in delivery
20.02.2023	22	3.5 Danger Electrical Shock	Added hazard warning
	23	3.6 Hot Surface Warning	Symbols adjusted
	25	3.11 Safe Inputs and Outputs	Text rewritten
	28	4.3.1 Norms	Annual figures added
	102	7.7 Expanded MDP 2XXX Specifications	Warning added
	126	9.8 Applicable Cable Types	Note fire hazard added
	138	11.4 Using Cooling Devices	Warning information changed
13.03.2023	29	4.4 Safety-Relevant Parameters	Information added
03.07.2023	28	4.3.1 Norms	Annual figures deleted

Change date	Affected page(s)	Chapter	Note
18.08.2023		Document	Size 3 removed
	20	3.4 Designated Use	Chapter extended
	24	3.7 Operation Modes	Chapter added
	25	3.8 Safe State	Chapter extended
	25	3.9 Safe Position Evaluation	Chapter added
	25	3.10 Current Evaluation	changed
	25	3.11 Safe Inputs and Outputs	Chapter extended
	26	3.12 Software/Training	changed
	27	4.1 Residual Risks	Warning added
	29	4.4 Safety-Relevant Parameters	Chapter extended
	32	5.2 Concept	changed
	35	6.1 Overview	Safety functions extended with SLP, SLA, SLI, SDI, SMP, SMA, SSM, SCA Diagrams changed (STO, SS1)
		Safe Referencing	changed
		Safe Position	changed
	94	6.3 Wiring Examples Safety	Chapter extended
	97	6.4 Preconditions for Safety Functions	Chapter added
	140	11.5 Pre-Start Check List	Chapter extended
	151	14.4 Encoder Exchange	Chapter extended
	153	14.6 Exchange of MDD	Chapter added
01.10.2023	113	9.3 Connector Layout	BiSS-C added
	130	11.1 Motor Selection	
03.10.2023	11	1.2 Important Reference Documentation	Chapter expanded
	13	2.1 Abbreviations	SBC added

Change date	Affected page(s)	Chapter	Note
	35	6.1 Overview	Additional Informations
	37	6.2 Description of the Safety Functions	Graphics new
	40	6.2.1.2 SS1 – Safe Stop 1	Activate SBC: optional
	49	6.2.1.7 SS2 – Safe Stop 2	Information added
	67	6.2.2.4 SLS - Safely Limited Speed	Information added
		SMP	Chapter deleted
		Safe Referencing	Chapter deleted
	79	6.2.2.10 SLI - Safely Limited Increment	Information added
	86	6.2.2.13 SSM - Safe Speed Monitor	Text corrected
		Safe Position	Chapter deleted
	140	11.5 Pre-Start Check List	Chapter expanded
	151	14.4 Encoder Exchange	Chapter expanded
12.10.2023	97	6.4 Preconditions for Safety Functions	Information added
08.01.2024	98	7.1 DC-link Circuit	MDD value capacitance added
09.02.2024	31	5 Description of Multi-Converter Systems	DC-link circuit added
01.03.2024	126	9.8 Applicable Cable Types	Danger warning: wording corrected
12.03.2024	37	6.2 Description of the Safety Functions	Adaptation to SafetyDesigner, detailed descriptions of the functions