



# Product manual

## smartServo BL 4000-C

**Important!**  
**Read thoroughly before use!**  
**Retain for future reference!**

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## Original Product manual

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# 1 About this Product manual

The purpose of this Product manual is to ensure the safe use of the servo drives of the BL 4000-C series and of the Kuhnke ServoCommander® parameterisation software (abbreviated "MSC").

The safety instructions and warnings in this Product manual must always be followed.

## 1.1 Explanations and notation

### 1.1.1 Structure of the warning notes

Warning notes have the following structure:

- Signal word
- Type of hazard
- Measures to prevent the hazard

#### > Signal words

**⚠ DANGER** Indicates an imminent hazard.

If the situation is not avoided, extremely serious and possibly fatal injuries will result.

**⚠ WARNING** Indicates a potentially hazardous situation.



If the situation is not avoided, extremely serious and possibly fatal injuries may result.

**⚠ CAUTION** Indicates a potentially hazardous situation.

If the situation is not avoided, slight or minor injuries may result.

**NOTICE** Warns against damage to property.

#### > Warning signs as per ISO 7010

Warning sign	Explanation
	Warning against fatal electric voltage.
	Warning against hot surfaces.

## 1.1.2 Notation in this product manual

### › Structure of notes

The notes in this Product manual have the following structure:

- Signal word "NOTE"
- Introductory phrase
- Explanations and special tips

### › Operating elements, menus

Operating elements, menus and menu paths are written in orange.

**Example:** Double-clicking the desired device or clicking the button **Establish connection** will establish an online connection.

### › Quick-start symbol

The quick-start symbols in the main window of Kuhnke ServoCommander® are explained as follows:



Parameter / IOs / Digital Outputs

## 1.2 Additional documents

Further information can be found in the following manuals:

- EtherCAT and CANopen manual BL 4000-C:  
This manual describes the commissioning procedure for the servo drives ARS 2000 FS or BL 4000-C with a CANopen or EtherCAT control system.
- PROFIBUS/PROFINET manual ARS 2000 FS / smartServo BL 4000-C: This manual describes the commissioning procedure for the servo drives ARS 2000 FS or BL 4000-C with a PROFINET control system.

You can find all of these documents on our homepage for download. Certificates and declarations of conformity for the products described in this manual can also be found at our homepage.

## 1.3 Order numbers

Order number	Description
9200-4102-1000	BL 4102-C
9200-4104-1000	BL 4104-C
9200-4210-00	BL 4100-C connector set

Order number	Description
9200-4304-1000	BL 4304-C
9200-4308-1000	BL 4308-C
9200-4312-1000	BL 4312-C
9200-4310-00	BL 4300-C connector set

## 1.4 Applicable standards

Standard	Description
EN 13849-1:2015	Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design
EN 50581	Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances
EN 60204-1	Safety of machinery - Electrical equipment of machines - Part 1: General requirements
EN 61800-3	Adjustable speed electrical power drive systems - Part 3: EMC requirements and specific test methods
EN 61800-5-1	Adjustable speed electrical power drive systems - Part 5-1: Safety requirements - Electrical, thermal and energy
EN 61800-5-2	Adjustable speed electrical power drive systems - Part 5-2: Safety requirements - Functional
EN 62061	Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems
EN ISO 12100	Safety of machinery - General principles for design - Risk assessment and risk reduction
IEC 61508 Teil 1-7	Functional safety of electrical/electronic/programmable electronic safety-related systems
IEC 82079-1	Preparation of instructions for use - Structuring, content and presentation - Part 1: General principles and detailed requirements
UL 61800-5-1	Standard for Adjustable Speed Electrical Power Drive Systems - Part 5-1: Safety Requirements - Electrical, Thermal and Energy
CSA C22.2 No. 274	Adjustable speed drives

## 2 For your own safety

### 2.1 General information

Servo drives of the BL 4000-C series can only be used safely if you read and comply with this document.

The servo drive has a safe design. However, certain hazards exist in the context of certain activities. These hazards can be avoided by following the correct procedures. The correct procedures for avoiding these hazards are described in this document.

In addition to the instructions described in this document, there may be additional health and safety instructions as well as general safety instructions that you must comply with. Keep informed about all of these aspects.

Professional project planning is a prerequisite for the correct and trouble-free operation of the servo drive.

The following requirements must be fulfilled to ensure the trouble-free and safe operation of the servo drive.

- Proper and correct transport
- Proper storage
- Proper installation
- Proper project planning taking in consideration all of the potential risks, necessary protective and emergency measures and the installation
- Careful operation and proper maintenance.

Only trained and qualified personnel in accordance with section 2.3 *Target group* on page 17 are authorised to work with or on the electrical systems. The following instructions must be read and understood prior to the initial operation of the system in order to prevent injuries and/or damage to property. The following safety instructions must be complied with at all times:

- Do not attempt to install or start the servo drive without having read all of the safety instructions in this document concerning the electrical drives and controllers. These safety instructions and all other user notes must be read prior to performing any work with the servo drive.
- If the servo drive is sold, rented out or otherwise distributed to third parties, these safety instructions must be included.
- The user must not open the servo drive for safety and warranty reasons.

## 2.2 Intended use

The electronic drive control unit (servo drive) is intended for operation in combination with electric motors in an industrial environment. The handling of the servo drive requires qualified personnel that have been trained in terms of general and, in particular, electrical safety. The intended use also includes compliance with the information and instructions in this manual.

Any use going beyond or deviating from the intended use will be considered as misuse.

### **⚠ WARNING Hazards caused by misuse**

Misuse of the servo drive will lead to dangerous situations.

- Use the servo drive only under the ambient conditions that are specified in section 12.
- Do not use the servo drive outdoors or in explosive atmospheres.
- Use suitable and qualified specialist personnel for any type of work on the servo drive.
- Always comply with the voltage ranges that are specified in section 12 *Technical data* on page 215.
- Follow all of the instructions in this manual concerning the safe use of the servo drive.

## 2.3 Target group

Over its entire service life, work on the servo drive, with the exception of its operation, may only be performed by specialist personnel and/or instructed persons who have been trained for the required tasks. The servo drive is to be operated by the user.

### **› Trained and qualified personnel**

Qualified personnel in the sense of this product manual are persons who are sufficiently familiar with the project, set-up, installation, commissioning and operation of the servo drive as well as with all of the warnings and precautions and who are sufficiently qualified in their field of expertise:

- They have been trained, instructed and authorised to perform the switching and earthing (grounding) of the devices/systems in line with the applicable safety standards and to label them accordingly as per the job requirements.
- The service and maintenance personnel have undergone special training in the context of ESD protection measures.
- They have been trained and instructed in line with the applicable safety standards in terms of the maintenance and use of adequate safety equipment.
- They have completed first aid training.

## 2.4 General safety instructions

### **⚠ DANGER** Danger to life due to electric shock! ⚠

Non-compliance with the safety instructions will lead to a potentially fatal electric shock.

The general set-up and safety rules and regulations concerning the work on power installations (e.g. DIN, VDE, EN, IEC or any other national or international rules and regulations) must be complied with.

- Safety-critical applications of the servo drive are not allowed unless specifically approved by the manufacturer.
- For information about the EMC-compliant installation, see section 13.1 *Notes concerning the safe and EMC-compliant installation* on page 240. The manufacturer of the machine or system is responsible for ensuring compliance with the limits that are specified by the applicable national rules and regulations.
- The ambient conditions that are specified in the product manual must be strictly observed.
- The technical data as well as the connection and installation conditions of the servo drive are stated in this document and must be complied with at all times.
- The servo drive has an IP20 protection rating and a pollution degree rating of 2. Ensure that the environment corresponds to this protection rating and pollution degree rating.
- Use only original accessories and original spare parts that have been approved by the manufacturer.
- The servo drives must be connected to the mains power supply in accordance with the country-specific regulations (EN standards, VDE rules) so that they can be disconnected from the mains power supply by way of suitable disconnectors (e.g. main switches, contactors, circuit breakers).
- Use gold contacts or contacts with a high contact pressure for switching the control contacts.
- You can protect the servo drive with an AC/DC-sensitive residual-current device (RCD) with 300 mA minimum.
- Preventive interference suppression measures should be taken for the switchgear. This can be done, for example, by connecting RC circuits or diodes to the contactors and relays.

## 2.5 Personal protective equipment

Always use personal protective equipment during the transport, installation, start-up, cleaning, maintenance and removal of the servo drive, for example:

- **Protective gloves**  
To prevent superficial hand injuries.
- **ESD safety shoes**  
To prevent foot injuries caused by falling parts.  
To prevent electrostatic charging.
- **Protective work clothes**  
To prevent superficial injuries and soiling.
- **Protective goggles**  
To prevent eye injuries caused by dust or shards/splinters.
- **Light respiratory protection**  
To prevent the inhalation of harmful substances.

## 2.6 Safety notes for installation and maintenance

### **⚠ DANGER** Dangerous electrical voltage! ⚠

Prior to performing any maintenance tasks, you need to ensure that the power supply and the external power supply of the servo drive have been disconnected and secured against reconnection and that the DC bus has discharged.

During the operation of the servo drive and up to 10 minutes thereafter, the corresponding connections and an external braking resistor carry dangerous DC bus voltages. Contact with these voltages may result in serious or even fatal injuries.

Wait 10 minutes prior to performing any work on the connections. Always measure the voltage with a suitable instrument.

### **⚠ WARNING** Risk of burns due to hot surfaces! ⚠

The servo drive and, in particular, the (external or internal) braking resistor may become hot during operation. Always wait a sufficient amount of time prior to touching these parts.

Always use suitable personal protective equipment to avoid severe burns.

### **⚠ CAUTION** Risk of injury for unqualified personnel!

Only personnel who are trained and qualified for working on or with electrical devices are authorised to install, maintain and repair the servo drive.

### ➤ To prevent accidents, injuries and damage to prop

Perform a risk assessment and follow all of the statutory and local safety instructions and accident prevention regulations when installing or maintaining the system.

Ensure that the AC or DC power supplies are switched off and locked prior to performing any work in the area of the machine. The deactivation of the output stages or servo drive enable signals is not a suitable means of locking. In the case of a malfunction, the drive may accidentally be put into action. This does not apply to drives with the special "Safe Torque Off" feature in accordance with EN 61800-5-2.

Electronic devices are never completely fail-safe. It is the user's responsibility to ensure that the system is brought to a safe state if the electrical device fails.

Disconnect the electric equipment from the power supply via the main switch and secure it against reconnection. Wait until the DC bus has discharged in the following cases:

- maintenance and repairs
- cleaning
- long downtimes

The standard motor holding brake that is included in the scope of supply or any other external motor holding brake that is actuated by the servo drive is not suitable for the protection of the operators if used alone!

Be particularly careful during the installation process. During the installation and also later on during the operation of the drive, ensure that no drilling chips, metal dust or installation parts (screws, nuts, cable sections) can fall into the servo drive.

Use suitable personal protective equipment during the installation.

Vertical axes must be additionally secured against falling down or lowering after the motor has been switched off, for example by way of the following:

- mechanical locking of the vertical axis,
- external braking, catching or clamping devices, or
- sufficient weight counterbalance of the axis.

Perform the start-up process with idling motors. This is to avoid mechanical damage, e.g. due to an incorrect direction of rotation.



## 2.7 Protection against contact with electrical parts

### **⚠ DANGER** Dangerous electrical voltage! ⚠

In certain device constellations, the rapid discharge of the DC bus voltage of the servo drive may be rendered ineffective. In these cases, the servo drives may still carry dangerous voltage levels up to 10 minutes after they have been switched off (residual capacitor charge).

Wait 10 minutes prior to performing any work on the connections. Always measure the voltage with a suitable instrument.

### ➤ To prevent accidents, injuries and damage to property:

Follow the national accident prevention regulations (for Germany, this is DGUV regulation 3 (formerly BGV A3)).

Do not touch the electrical connections of the components when they are switched on.

Prior to accessing electrical parts carrying voltages above 50 V, disconnect the device from the mains power supply or voltage source. Secure it against reconnection.

Install the respective covers and guards against accidental contact prior to switching the device/system on. Rack-mounted devices must be protected against accidental contact by way of an enclosure, e.g. a switch cabinet.

Prior to start-up and even for brief measurements or tests, connect the protective earth conductor (ground conductor) of all of the electrical devices in accordance with the circuit diagram (see section 13 *Electrical installation* on page 240) in a fixed manner (hardwiring) to the supply network or to the earthing system on site.

Comply with the minimum copper cross-section for the protective earth conductor (ground conductor) over its entire length (see EN 61800-5-1). Otherwise, the housing may carry high voltages which can cause electric shock.

Due to the integrated line filters, the leakage current exceeds 3.5 mA. This is why two connection points must be hard-wired

The magnitude of the DC bus voltage must be taken into consideration during the installation process in order to ensure proper insulation and protection. Ensure proper earthing (grounding), conductor rating and protection against short circuits.

## 2.8 Protection against electric shock by way of protective extra-low voltage (PELV)

### **⚠ DANGER** Dangerous electrical voltage! ⚠

There is a risk of high electrical voltage due to incorrect electrical connections.

Always follow the safety instructions stated hereinbelow.

All of the connections and terminals with voltages up to 50 V of the servo drive have protective extra-low voltage. They are protected against contact in accordance with IEC 61800-5-1 and EN 61800-5-1.

Only devices, electrical components and wires or cables with protective extra-low voltage (PELV) may be connected to connectors and terminals with voltages from 0 to 50 V.

When connecting voltages and circuits, ensure that they are securely isolated from any dangerous voltages. This isolation can be realised by way of isolation transformers, safe optocouplers or battery operation without mains power.

## 2.9 Protection against dangerous movements

### **⚠ WARNING** Risk of injury due to dangerous movements

Always follow the safety instructions stated hereinbelow.

Dangerous movements can be caused by the faulty actuation of the connected motors. Causes may be as follows:

- improper or faulty wiring or cabling
- errors during the operation of the components
- errors of the sensors and transducers
- defective or non-EMC-compliant components
- software errors in the superordinate control system.

These errors can occur directly after the activation of the device or after some time during the operation.

The monitoring systems in the drive components exclude any malfunction in the connected drives to the greatest possible extent. However, in view of the protection of the operators, particularly in terms of the risk of injuries and damage to property, relying solely on this measure is not recommended. Until the built-in monitoring systems become effective, faulty drive movements should always be anticipated. The extent of these faulty drive movements depends on the type of control and on the operating state.

For the reasons mentioned above, protection must be ensured by monitoring or by superordinate measures. This must be implemented by the system manufacturer based on the specific system situation and on a hazard and fault analysis. This also includes the

safety rules and regulations that apply to the system. Random movements of the machine or other malfunctions may be caused by deactivating, bypassing or failing to activate the safety devices.

## 2.10 Protection against contact with hot parts

### **⚠ WARNING** Risk of burns due to hot surfaces.

The servo drive and, in particular, the (external or internal) braking resistor may become hot during operation. Always wait a sufficient amount of time prior to touching these parts.

Always use suitable personal protective equipment to avoid severe burns.

## 2.11 Protection during the handling and installation of the devices

### **⚠ CAUTION** Risk of injury caused by crushing, shearing, cutting or impacts

Improper handling and installation of certain parts will cause injuries.

Always follow the safety instructions stated hereinbelow.

- When installing the servo drive, ensure that it can be installed, operated and removed without any danger.
- Appropriate installation clearances must also be defined.
- Comply with the intended use of the servo drive.
- When transporting the servo drive, pay particular attention to the edges and corners of housings and other components. Use suitable personal protective equipment.
- If you install the components of the system on a wall or on the floor, dust may be created by drilling. Use suitable personal protective equipment.
- Use only suitable installation and transport equipment.
- Prevent trapping and crushing by suitable protective measures.
- Use only suitable tools. If specified, use special tools.
- Use lifting equipment and tools in a proper manner.
- Do not step under suspended loads.
- Liquid spills on the floor must be removed immediately.

## 3 Product description

The servo drives of the smartServo BL 4000-C series are smart AC servo drives for controlling three-phase synchronous motors, torque motors and linear motors. The servo drives can be used in a universal manner, since they can be combined with a wide range of encoder systems and motors. Due to their extensive parameterisation options, they can be adapted to a variety of different applications. Servo drives of the BL 4000-C series are intended for use as devices installed in control cabinets.

The connection to a superordinate control system can be realised by way of the integrated EtherCAT/Profinet or CAN interface.

Parameter sets that have been created for the ARS 2000 FS series can be used for the BL 4000-C, BL 4000-M and BL 4000-D series and vice versa.

### 3.1 Type designation

Type key using the example of a BL 4104-C.



Figure 1: Nomenclature

Pos.	Description
1	Type designation: Basic Line
2	4th Kuhnke servo drive product family
3	Mains power connection: 1 = single-phase / 3 = three-phase
4	Nominal current in [A <sub>eff</sub> ]
5	Cabinet (control cabinet device)

Based on this, the following type designations are used in this product manual:

Designation	Description
BL 4000-C	All control cabinet servo drives of the Basic Line series, both single-phase as well as three-phase
BL 4100-C	All single-phase control cabinet servo drives of the Basic Line series
BL 4300-C	All three-phase control cabinet servo drives of the Basic Line series
BL 4104-C	A single-phase control cabinet servo drive with 4 A <sub>eff</sub> rated current

## 3.2 Device view

### > Front view

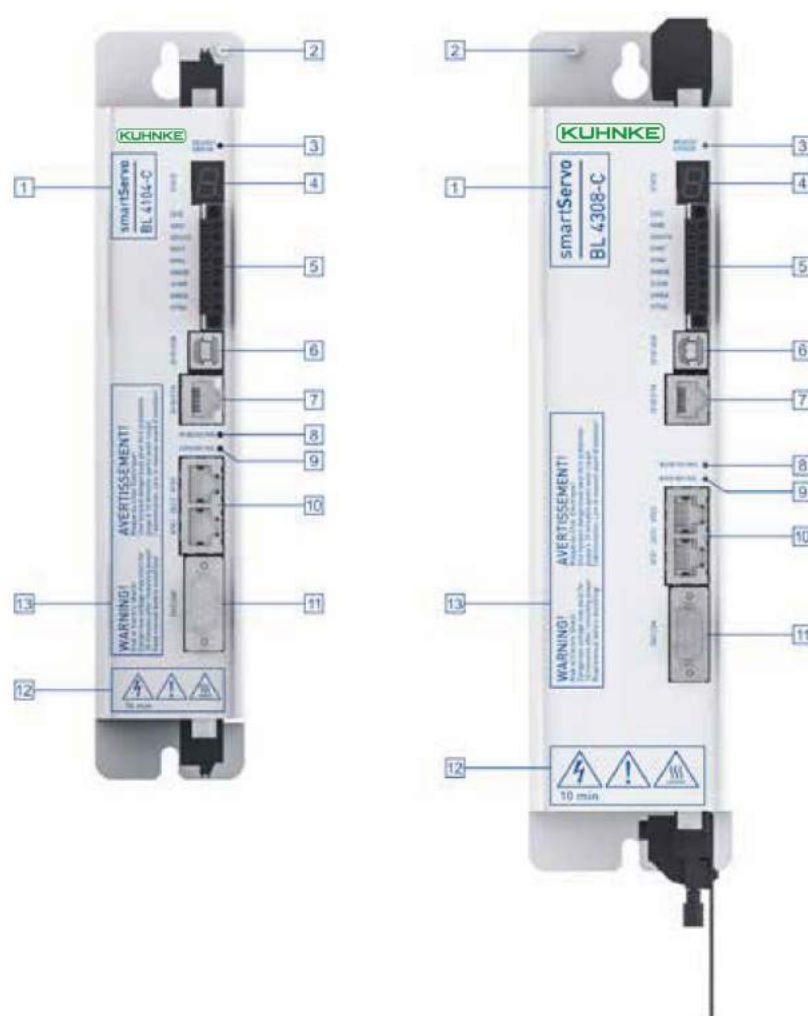


Figure 2: Front view of a BL 4100-C (left) and a BL 4300-C (right)

01	Product name	08	LED (RUN/SF/MS)
02	Earthing screw	09	LED (ERR/BF/MS)
03	Status indicator LED (READY, ERROR, ENABLE)	10	[X21] Real-time Ethernet interface
04	Seven-segment status indicator	11	[X4] CANopen interface
05	[X3] STO interface (STOA, STOB), Limit switch (DIN6, DIN7), Dig. output (DOUT0)	12	Safety Symbols as per ISO 7000
06	[X19] USB interface	13	Warnings
07	[X18] Ethernet interface		

### › Top view

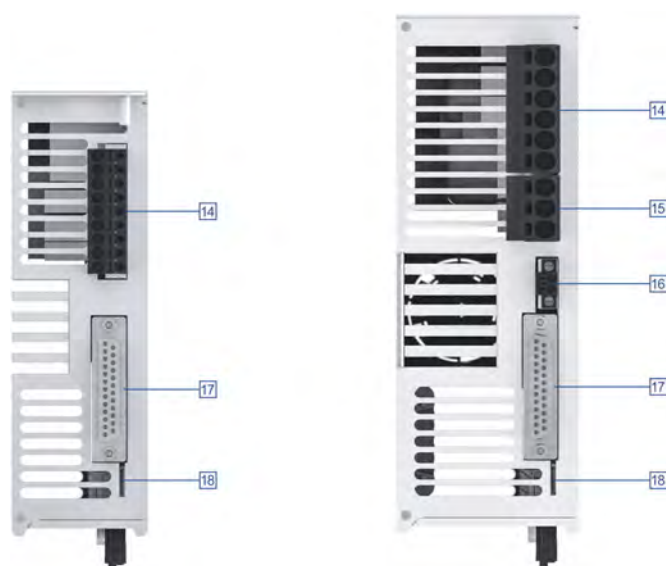


Figure 3: Top view of a BL 4100-C (left) and a BL 4300-C (right)

14	[X9] Power supply	17	[X1] I/O communication
15	[X9A] Braking resistor (BL 4300-C)	18	Slot for microSD cards
16	[X9B] 24 V supply (BL 4300-C)		

### › Bottom view

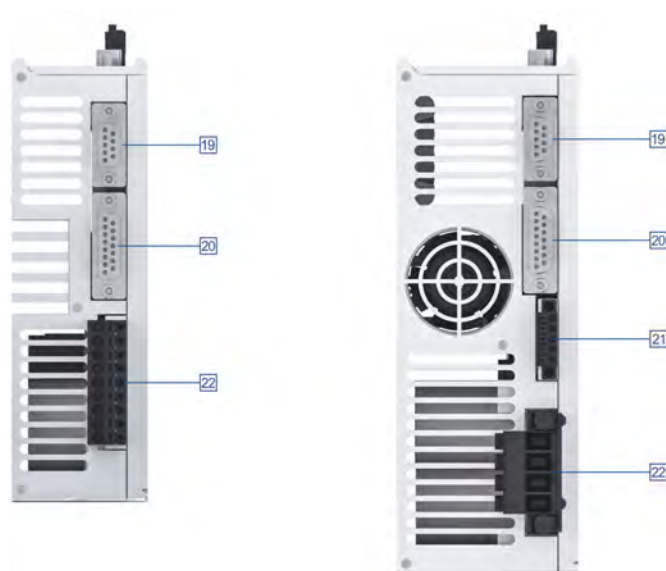


Figure 4: Bottom view of a BL 4100-C (left) and a BL 4300-C (right)

19	[X2A] Resolver/ analogue Hall sensors	21	[X6A] Motor brake / HIPERFACE DSL® (BL 4300-C)
20	[X2B] Multi-encoder	22	[X6] Motor connection

## 3.3 Features

All of the servo drives of this series have the following features:

### › Integrated fieldbus interfaces

- CANopen interface for the integration in automation systems
- EtherCAT interface (CoE)
- ProfiNet interface (Kuhnke standard telegrams, based on PROFIdrive)

### › Integrated universal shaft encoder evaluation for the following encoder types:

- Resolvers
- Analogue and digital incremental encoders with and without commutation signals
- High-resolution Stegmann incremental encoders with HIPERFACE®
- High-resolution Sick incremental encoders with HIPERFACE DSL® (single-cable variant)
- High-resolution Heidenhain incremental encoders with EnDat 2.2 (ENDAT22)
- Master frequency input/output and pulse direction interface

### › Suitable motors

- Permanent-magnet synchronous machines with sinusoidal EMF
- Torque motors
- Linear motors
  - Air-core and iron-core linear motors with a low motor inductance (0.5 ... 4 mH)
  - Automatic determination of the motor parameters

### › User-friendly parameterisation with the Kuhnke ServoCommander® software

- Adjustment of all of the parameters via a PC and online representation of operating parameters and diagnostic messages
- User-guided initial start-up, loading and saving of parameter sets as well as offline parameterisation are possible
- Oscilloscope function for optimising the drive and for analysing the PLC I/O coupling
- Supported languages: German, English
- Automatic motor identification and procedures for the automatic determination of the commutation position in the case of encoders without a commutation track
- Automatic adjustment of the control circuits for current, speed and position control

#### › Integrated functional safety

- "Safe Torque Off (STO)" safety function integrated in the device
- SS1 functionality possible

#### › Homing and positioning

- Integrated positioning control with a wide range of functions as per "CAN in Automation (CiA) DSP402" plus numerous additional application-specific functions.
- Jerk-free or time-optimal positioning, relative or absolute with regard to a reference point. Point-to-point positioning with and without smooth position transitions.
- High-speed sample inputs for triggering the storage of position marks
- Numerous homing methods
- Rotor and position triggers

#### › Brake control and automatic brake

- Direct control of a holding brake in the motor with high current. As a result, an external relay is not necessary. In addition, variable delays can be used.
- "Automatic brake" for deactivating the power section during longer breaks to save energy

#### › Electrical characteristics

- Wide-range supply input (AC)
- "Soft switch-on" features for the soft precharging and quick charging of the DC bus
- DC bus coupling between devices with the same mains power supply for buffering the brake energy
- Improved monitoring and analysis of the mains power supply by a direct measurement of the mains voltage



#### › Applications

- Speed- and angle-synchronous operation with an electronic gear, incremental encoder input or fieldbus. Extensive modes of operation, e.g. "flying saw"
- Jog mode, teach-in mode, motion programs, torque-limited set more

#### › Special control features

- High control quality due to high-quality sensors, far superior to conventional market standards, and above-average processor resources
- Short cycle times, bandwidth in the current control circuit approx. 2 kHz (with  $t_i = 32 \mu s$ ), in the speed control circuit approx. 500 Hz (with  $t_n = 64 \mu s$ )
- Parameterisable band-stop filters for suppressing the natural frequency of the controlled system
- Load torque compensation for vertical axes
- Synchronisable internal clock system for the synchronisation with external clock sources for CANopen and EtherCAT fieldbus systems by way of an internal PLL

#### › Certification and qualification

- Compliance with the current CE and EN standards without any additional external measures
- UL certification
- Completely closed, EMC-optimised housing for mounting on conventional switch cabinet mounting plates. The devices have an IP20 degree of protection.
- Integration of all of the required filters, e.g. line filters, filters for the 24 V supply and filters for the inputs and outputs, into the device in order to ensure compliance with the EMC regulations during operation (industrial environment)

## 4 Quick-start guide

This chapter describes the fundamental steps that are necessary for operating a motor with the servo drive for the first time.

The correct installation of the servo drive in the control cabinet is described in section 13 *Electrical installation* on page 240.

### **INFORMATION** Electromagnetic compatibility

Since the connecting cables have a strong influence on the electromagnetic compatibility (EMC) of the system, it is essential to follow the instructions in section 13.1.3 *Proper wiring* on page 241.

### › Tools/materials

The following tools and materials are necessary for the initial wiring of the device:

- Flat-bladed and cross-head screwdrivers of various sizes (1 to 3)
- Digital multimeter
- Motor with motor cable and encoder cable
- Power supply cable
- Emergency cut-out switch at [X3]
- Connector set (if required)
- USB cable or Ethernet cable (PC connection)

### › Connecting the motor

To connect the motor, proceed as follows:

1. Plug the connector of the motor cable into the corresponding socket of the motor and tighten the connection.
2. The motor connector [X6], including the shield, must be connected depending on the device type as described in the following sections. Ensure proper earthing.  
section 13.5 *BL 4100-C: Connector: motor [X6]* on page 249  
section 13.6 *BL 4300-C: Connector: motor [X6], [X6A]* on page 252.
3. Plug the connector of the encoder cable into the encoder output socket of the motor and tighten the connection.
4. Plug the D-Sub connector into the resolver socket [X2A] or encoder socket [X2B] of the servo drive. Tighten the locking screws.
5. Check all of the connections once more.
6. Check the earth connection of the motor housing and servo drive housing by way of a multimeter. The resistance should be  $< 1 \Omega$ .

## › Connecting the power supply

### **NOTICE** Risk of destruction due to a connection with reverse polarity

If the polarity of the 24 V supply at [X9] or [X9B] is reversed, the servo drive and the PC will be destroyed. It is essential that you follow the correct connection instructions.

To connect the power supply, proceed as follows:

1. Ensure that the power supply is switched off.
2. The connector for the power supply [X9] must be connected depending on the device type as described in the following sections.  
section 13.3 *BL 4100-C: Connector: power supply [X9]* on page 244  
section 13.4 *BL 4300-C: Connector: power supply [X9], [X9A], [X9B]* on page 246
3. Connect the 24 V connectors to a suitable power supply unit.
4. Establish the mains power supply connections. Do not switch on the supply yet.
5. Check all of the connections once more.
6. Switch on the 24 V power supply.

### **⚠ WARNING** Risk of injury due to uncontrolled motor movements

Do not switch on the mains power supply until you want to let the motor turn! The mains power supply is not necessary for the simple testing of the communication or angle encoders, nor for the parameterisation.

7. Switch on the mains power supply.

## › Connecting the PC (USB/Ethernet)

### **INFORMATION** USB: wiring and adapter

Follow the USB adapter wiring instructions in the section 13.9 *Connector: USB [X19]* on page 261.

To connect the PC, proceed as follows:

1. Connect the male connector B of the USB interface cable to the female connector for the USB interface of the PC.
2. Connect the male connector A of the USB interface cable to the female connector [X19] USB of the servo drive.

### **Alternative:**

1. Connect the servo drive to the PC via the Ethernet interface [X18] ETH (upper female Ethernet connector).

Now, you can communicate with the servo drive by way of the Kuhnke ServoCommander® parameterisation software.

## 4.1 Using the parameterisation program

### **⚠ WARNING Risk of injury due to uncontrolled motor movements**

Data that is transferred online may cause unwanted reactions and dangerous movements of the drive.

Ensure that no one is within the danger area of the drive. Perform a test with a drive that can rotate freely.

Kuhnke ServoCommander® ("MSC") is a PC program for the parameterisation and operation of the servo drive. The program will be provided by your sales partner.

Usually, any changes made in MSC will be transferred immediately to the servo drive. As a result, changes can be implemented without delay and the servo drive can be put into operation in an interactive manner.

### 4.1.1 The user interface

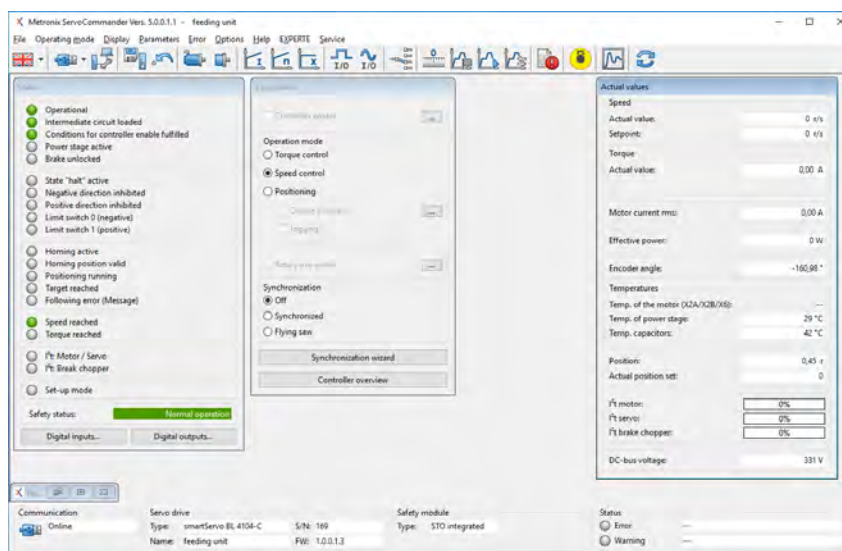


Figure 5: Main window of Kuhnke ServoCommander®

The upper area of the MSC main window includes a **menu bar** and a **toolbar**.

All of the functions of the program can be activated via the **menu bar**.

Alternatively, numerous functions can also be accessed via the **toolbar**.

## 4.1.2 Setting up the communication

When the program is started, it tries to set up a communication connection to a servo drive via the last interface used. If this fails, the following will be displayed by Kuhnke ServoCommander®:

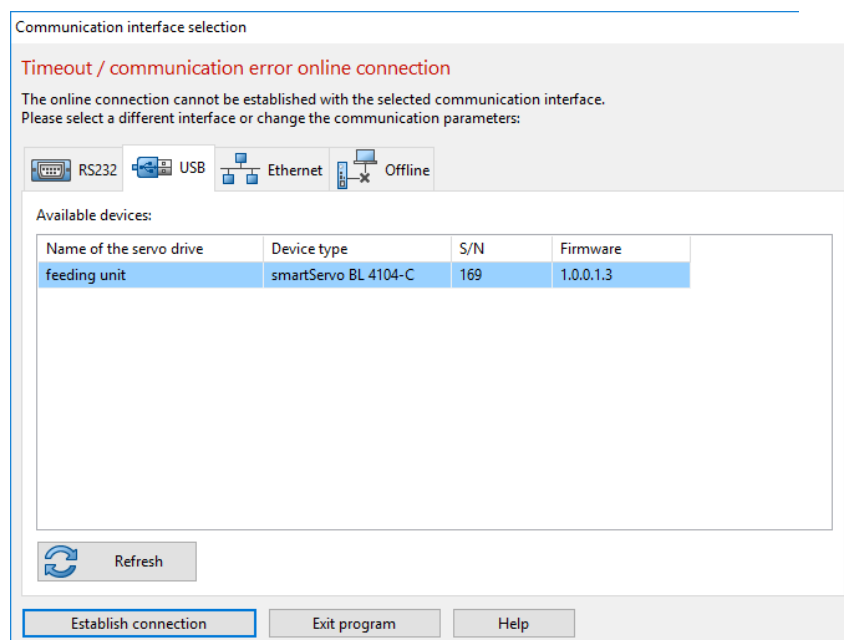


Figure 6: "Communication interface selection" window

Select the interface (USB or Ethernet) via which you would like to parameterise the device. In general, all of the available devices will be displayed automatically. Alternatively, you can also look for new devices by way of the **Refresh** button.

Double-click the desired device or click the button **Establish connection** to establish an online connection.

### 4.1.2.1 Communication via USB

If you connect the device to a PC for the first time, the installation of the USB driver by the Windows operating system may take a few minutes. It is only after this has been completed that the device will be displayed.

In case of problems, you can use the Windows Device Manager to check whether the system has recognised the hardware and whether the driver has been loaded correctly.

If the system does not recognise the servo drive, disconnect the USB connector briefly from the servo drive or PC and then reconnect it. As a result, the connection setup process will be restarted.

### 4.1.2.2 Communication via Ethernet

**NOTICE** Damage to the servo drive due to an Internet connection

Do not connect the Ethernet interface directly to the Internet.

The Ethernet interface provides full access to all of the parameters and functions of the servo drive. The servo drive itself does not have any safety function to protect it against unauthorised access.

Use the servo drive only within a closed network with state-of-the-art safety features to protect the access to the network.

If you have selected "Ethernet" as the interface, the operating system may show you a large number of servo drives. You can identify the selected servo drive by right-clicking. The seven-segment display of the selected servo drive displays the message "HELLO".

**NOTICE** Risk of damage to the servo drive due to an incorrect device

The Ethernet connection may show numerous devices. Be particularly careful when selecting the desired device.

If, for example, the default parameter set is loaded on a running machine, damage may result. This is why you should check carefully whether the device with which you are currently connected via Ethernet is actually the correct device.

When closing the "Communication interface selection" window, some Windows systems may freeze the Kuhnke ServoCommander® window for approximately 3 minutes before actually closing it.

This is caused by a faulty Windows API function and can be avoided by opening an input prompt and entering the following command: "netsh interface ipv4 set global multicastforwarding=disabled".

## › Manual assignment of the network address

In their delivery state, the servo drives receive their IP addresses automatically. This is realised either via a DHCP server on your network or via Auto-IP if you have set up a 1-to-1 connection, e.g. with a laptop.

However, you can also configure the servo drive so that it uses a fixed IP address. You can find the necessary settings in the menu under:

Options / Communication / Communication parameters UPD (Ethernet) / Configuration (servo drive).

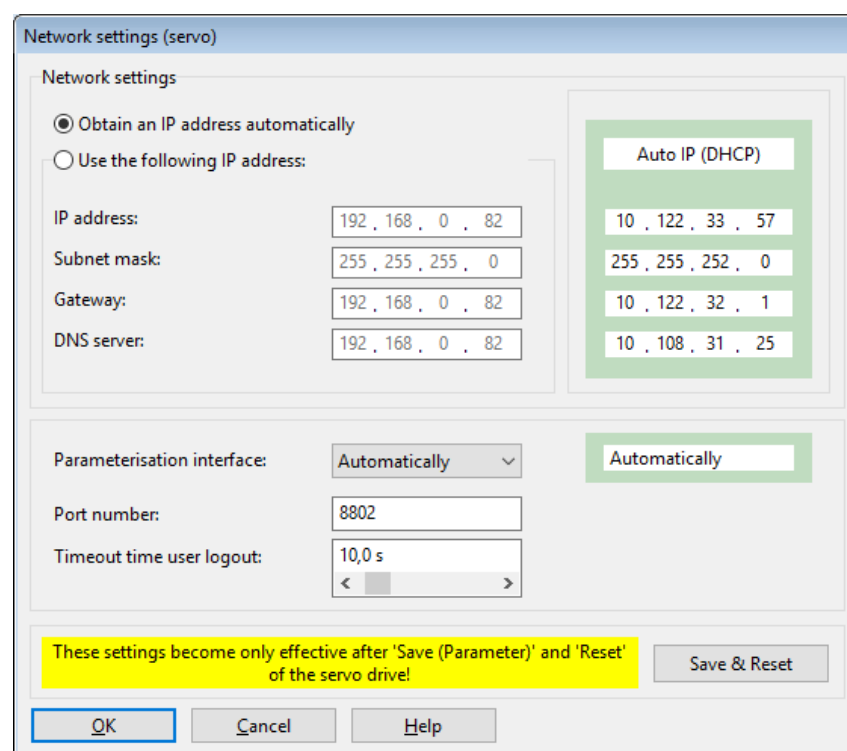


Figure 7: "Network settings (servo)" window

To use a fixed IP address, the option **Use the following IP address** must be selected. Then, the following parameters can be entered:

Parameter	Description
IP address	IP address for the Ethernet communication. This address must be unique in the network segment of the servo drive.
Subnet mask	The subnet mask is used to divide a network into subnets connected to routers/gateways.
Gateway	IP of the gateway on the subnet of the servo drive.
DNS server	IP of the DNS server that is used for resolving the name.
Port number	Number of the port of the Ethernet communication via UDP. You have to select a free port between 5000 and 65535.

To configure the Ethernet access, consult your network administrator to decide about the network parameters to be used.

### 4.1.2.3 Changing the communication interface

If you want to change the communication interface, simply open the **Communication interface selection** window:



Options / Communication

Select the desired communication interface and device.

### 4.1.2.4 Communication errors

Cause	Measure
There are sporadic servo drive communication errors	<ol style="list-style-type: none"> <li>1. Click <b>Establish connection</b></li> <li>2. Perform a RESET of the servo drive</li> <li>3. Click <b>Establish connection</b></li> <li>4. Change the communication cable</li> <li>5. Change the communication interface (e.g. Ethernet instead of USB)</li> <li>6. If necessary, disable the servo drive and check whether the communication can be restored. In this case, faults concerning the output stage cause the problems. Check whether the machine, servo drive and motor are properly connected to earth. Deactivate parts of the system one after the other to isolate the error source</li> </ol>
Another parameterisation program communicates with the device	Close the other parameterisation program or select another interface
The communication remains impossible	<p>Check the following:</p> <ul style="list-style-type: none"> <li>• Is the servo drive switched on?</li> <li>• Is the connecting cable properly connected?</li> <li>• Is the connecting cable broken?</li> </ul> <p>Eliminate the error. Then, click <b>Establish connection</b></p>



#### 4.1.2.5 Numeric input fields for changing parameters online



Figure 8: Numeric input field for changing parameters online

The windows of the Kuhnke ServoCommander® parameterisation program include fields for numeric inputs. Entries can be made in the following ways:










- Directly by way of the keyboard: Enter the value directly into the entry line. As long as the entry is not complete, the text will be shown in thin print and will not be transferred to the servo drive yet.
- The ENTER key can be used to confirm the input and to apply the change immediately. If the TAB key is used to select another input field, the changed parameter will also be applied. The numerical value will then be shown in bold print.
- Clicking the arrow buttons: The value changes in small steps (fine adjustment).
- Clicking the areas between the grey boxes and the arrow buttons: The value changes in large steps (rough adjustment).
- Clicking the grey box and moving the mouse with the left mouse button pressed: The value can easily be preset quickly over the entire value range.

The input field shows the desired value that needs to be set. The value shown on a green background is the currently active value of the servo drive. Deviations from the desired value may have several reasons:

- The changed parameter has to be saved and a RESET has to be performed in order to make the parameter effective.
- Temporary value range overshoots, e.g. rated current > maximum current
- Incorrect value ranges, e.g. when loading a parameter set of a servo drive of a higher power class (rated current > rated device current). In this case, the firmware accepts only the permissible values, thereby limiting the internal values to the maximum permissible values for the device class.

## 4.2 Operating mode and error indication

The seven-segment display of the servo drive indicates the operating state and any errors that may be present.

Indication	Meaning
	<b>Torque-controlled mode</b>
 	<b>Speed-controlled mode</b> In this mode, the outer segments "rotate". The indication depends on the current position or speed. If the servo drive is enabled, the center segment is active in addition.
	<b>Positioning mode</b>
	<b>Homing</b> The number stands for the currently active phase of the homing run: 0 : Search phase 1 : Crawling phase 2 : Movement to home position The numbers are successively displayed.
	<b>Delivery status</b> When delivered, the servo drive must be parameterised.
	<b>Error message</b> Error messages always start with the letter E. The first two numbers after the letter E are the index and the last number is the subindex. In this example here, error 12-3 is indicated.
	<b>Warning</b> The first two numbers after the hyphen are the index and the last number is the subindex. In this example here, warning 27-0 is indicated.
	<b>"Safe torque off" active</b> Permanent, see also section 8.5.7 <i>Additional diagnostics functions</i> on page 199.

## 4.3 Operability check

To check whether the servo driver is ready for operation, proceed as follows:

1. Ensure that the STO input is deactivated.
2. Switch on the 24 V power supply. The READY LED on the front panel of the servo drive lights up **green**. In the event of a fault, the READY-LED lights up **red**.

The seven-segment display shows a series of numbers in the event of a fault. This is the number of an error message. You need to eliminate the cause of the indicated error. To do so, read section 9 *Fault messages* on page 208.

If the device displays nothing at all, follow these steps:

1. Switch the power supply off.
2. Wait for 10 minutes so that the DC bus can discharge.
3. Check all of the connecting cables.
4. Check whether the 24 V supply is ready for operation (current limitation, polarity).
5. Disconnect all of the connectors with the exception of the connectors of the 24 V supply to localise any potential overload due to faulty external wiring.
6. Switch the power supply back on.

## 4.4 Software-guided commissioning

### **NOTICE** Risk of damage to the servo drive and motor

Perform the fundamental adjustment steps in the proper sequence as described in the manual. This is to prevent the motor and/or servo drive from being damaged beyond repair.

The commissioning process is a feature to help non-expert users with the initial start-up of the motor/drive. The user is guided through several dialogue-based menus. Some of these menus use automatic identification mechanisms of the servo drive.

The commissioning of the servo drive can be performed after the correct installation of the Kuhnke ServoCommander® parameterisation program and the setup of a communication connection to the servo drive. In addition, the servo drive should be completely connected and the supply with mains power should be possible. Follow the instructions concerning the correct installation of the servo drive in section 13.1 *Notes concerning the safe and EMC-compliant installation* on page 240.

You can also start the commissioning process for a servo drive that is already in use. To do so, select the menu item **File/Commissioning**. It is also possible to load a suitable preset parameter set.

### **INFORMATION** Status "not commissioned"

When it is delivered, the servo drive has the status "not commissioned". In this case, the 7-segment display shows the letter "A". As soon as one of the windows relevant for the commissioning process (e.g. the menu **Angle encoder settings**) is opened and a value is changed, the letter "A" will disappear.

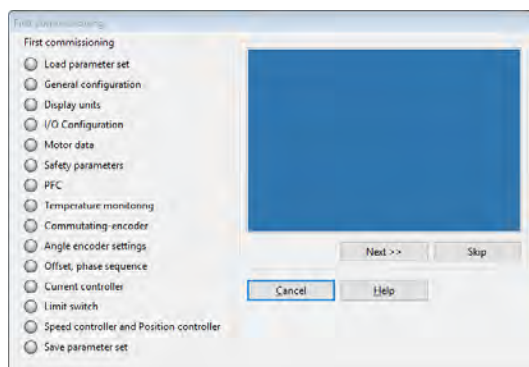


Figure 9: "Commissioning" windows

### **INFORMATION** Complete performance of the commissioning process

Even if a parameter set has been loaded, perform the entire commissioning process to verify the settings.

Take your time. Ensure that you have properly understood and configured everything.

The following sections describe the individual windows of the commissioning process in detail.

### 4.4.1 General configuration

From the outside of the commissioning process, the window can be opened via the menu **Parameters/Application parameters/General configuration**.

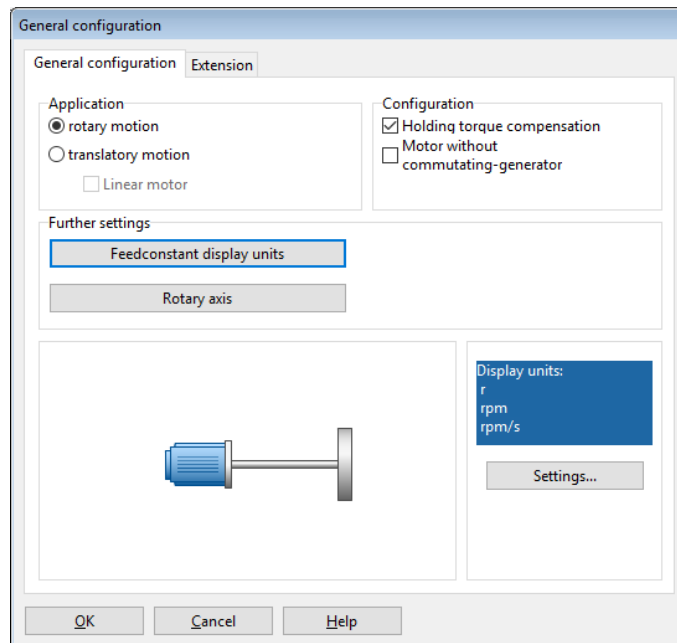


Figure 10: "General configuration" window - "General configuration" tab

In the **Application** field, you can choose between a rotatory (indication of values in revolutions, degrees or radian) and translatory application (indication of values in units of length). The checkbox **Linear motor** can be optionally ticked. As a result, the picture in the lower window pane changes. When using linear motors, ensure to tick the checkbox **Motor without commutating generator**.

The checkbox **Holding torque compensation** must be ticked if the application is subject to stress due to permanent torque in one direction (e.g. weight in the case of a vertical axis). In this case, the holding torque of a servo drive will be used as a feedforward value when the holding brake is released in speed control or position control mode or during a positioning run in order to minimise the sagging of the axis due to its own weight. The servo drive automatically updates the required holding torque when it is enabled. As a result, possible load changes are continuously tracked. If the servo drive is enabled after the first activation of the holding torque compensation function, the feedforward-controlled holding torque is still zero. If the holding torque compensation is not activated, the feedforward control is automatically set to zero.

The checkbox **Motor without commutating generator** must be ticked for all drives in which the connected angle encoder does not supply any commutation signals, e.g. in the case of linear motors. For a correct commutation of the motor, there must be a valid commutation position after the servo is switched on and before it is enabled for the first time. For this purpose, the encoder angle referred to 1 revolution must be known. This is not the case for incremental angle encoder systems, for example. They require additional measures for determining the commutation position. The checkbox must also be ticked if the motor includes a rotary encoder that does not supply any commutation signals.

The selection field **Further settings** depends on the type of application:

- Rotatory** The button **Gearbox display units** opens the menu **Display units** where you can enter values for your gear (see section 4.4.2 *Configuration of the display unit* on page 45).  
The button **Rotary axis** allows you to set a positioning range and to specify the behavior of the interpolator when positioning in this range.
- Translatory** The button **Feed constant display units** opens the menu **Display units** where you can enter values for your gear (see section 4.4.2 *Configuration of the display unit* on page 45).

The field displayed in light blue shows the display units that are currently used. The button **Settings** can also be used to access the **Display units** menu (see section 7.3 *Display units* on page 126).

The tab **Extension** is where special settings for motors without commutation signals can be performed.

**NOTICE Risk of damage to the servo drive**

If the settings are not ideal, a successful automatic determination of the commutation position may no longer be possible.  
This is why only experts should perform these settings. If this is not possible, they should only be performed after consultation!

In general, the following types of angle encoders do not require a determination of the commutation position:

- Resolvers
- EnDat
- HIPERFACE®/HIPERFACE DSL®
- Analogue encoders with a Z1 track (e.g. ERN1387)
- Angle encoders with Hall support (block commutation)

In the case of the encoders mentioned hereinabove, it is only necessary to adjust the offset angle during the commissioning process.

If you do not have a motor with commutation signals, the commutation position must be determined. This will be done whenever the servo drive is started. There are different methods to choose from. They differ from one another by the specific required movement and by the specific boundary conditions, e.g. the physical characteristics of the drive.

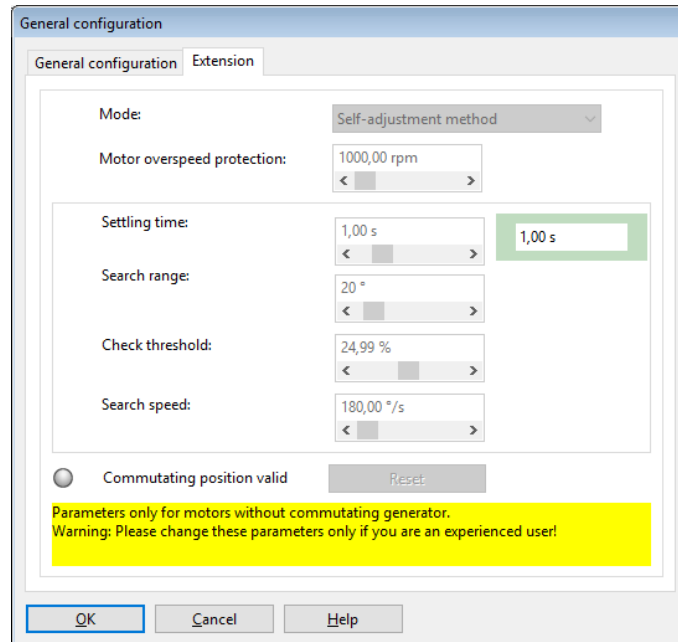


Figure 11: "General configuration" window - "Extension" tab

#### Self-adjustment method

With this method, the drive moves over the double search range in a controlled manner. Depending on the initial position, the drive may jerk. This method is not suitable for vertical axes.

#### Reaction method (recommended)

This method is suitable for all types of drives without a braking system. It is suitable for horizontal and vertical applications. Only minimal mobility (the system is more or less motionless) is sufficient for determining the commutation position.

#### Saturation method

This method is not suitable for air-core drives. It requires a braked drive as the drive must be absolutely motionless during the determination of the commutation position. It is suitable for horizontal and vertical applications.

#### Commutation position valid LED

It indicates that the determination of the commutation position has been successful. This status will be reset, e.g. if an angle encoder error occurs.

It is only relevant for motors with angle encoders without any commutation signal.

### Motor overspeed protection

The motor overspeed protection function is a mechanism to react to counting errors in the case of pure incremental encoders. The function monitors the drive for "uncontrolled movements".

Depending on the operating mode, the motor overspeed protection function is realised by way of different mechanisms:

Operating mode	Mechanism
Torque control	Comparison with the current actual speed value, as no reasonable speed setpoint has been provided.
Speed control Positioning	Comparison with the difference between the set speed value and actual speed value.

#### **INFORMATION** Mix-up of parameter

The parameter is not identical with the motor overspeed protection function that can be accessed via the menu [Parameters/Safety parameters...](#)



## 4.4.2 Configuration of the display unit

By adapting the display units, physical variables such as the position, speed and acceleration can be displayed in the Kuhnke ServoCommander® program as required by your specific application. If you use a linear axis, for example, you can select translatable display units so that the position will be indicated in mm, the speed in mm/s and the acceleration in mm/s<sup>2</sup>.

As the configuration of the display units is highly complex, only the basic principles will be discussed in this section. You can find a detailed description in section 7.3 *Display units* on page 126.

The field **Display mode** offers a range of default settings to choose from. The mode **Standard values** covers a wide range of applications.

### 4.4.2.1 Rotatory operation

The following is possible for rotatory systems:

- Position values in revolutions, degree or radian
- Speed values in revolutions/s or degrees/s or rad/s
- Acceleration values in revolutions/s<sup>2</sup> or degrees/s<sup>2</sup> or rad/s<sup>2</sup>

In rotatory mode, you can enter a gear ratio if you want to adjust your application to the unit at the output. To do so, tick the checkbox **with gear**.

### 4.4.2.2 Translatory operation

The following is possible for translatory systems:

- Position values in units of length: m, mm or µm
- Speed values in m/s, mm/s or µm/s
- Acceleration values in m/s<sup>2</sup>, mm/s<sup>2</sup> or µm/s<sup>2</sup>

In translatory mode, you need to define the unit of length corresponding to one motor revolution. Enter this value into the field **Feed constant**.

### 4.4.2.3 Other setting options

The area **Display units** enables the selection of various units (for rotatory or translatory operation). You can define whether you want torque values to be displayed in A or Nm. For the latter, tick the checkbox **Torque in Nm**. A prerequisite is a correct conversion constant (A→Nm) (button **Factor**).

In addition, the number of decimals for the position, speed and acceleration values can be modified.

The selection of display units (including a transmission and feed constant) only affect the indication of the values in the Kuhnke ServoCommander® program.

The settings inside the servo drive will not be changed.

### 4.4.3 Adjusting the input limits

Via the menu **Options/Input limits**, the following window can be accessed:

**Input limits**

**Torque values**

Maximum torque value to be set: 12,80 A

Maximum torque slope to be set: 100000,00 A/s

**Speed values**

Maximum velocity to set: 3000,000 rpm

Maximum acceleration to set: 200000 rpm/s

**Caution!** These input limits only refer to the input windows of the parameterization program! Already entered parameters are not limited automatically!

OK Cancel Help

Figure 12: Input limits

Enter the maximum speed and acceleration values that you are expecting for your application. The Kuhnke ServoCommander® program uses these values for limiting the entries into the program. Any values that are already present in the servo drive will not be limited by this process.

### 4.4.4 Configuration of the motor data



Parameters/Device parameters/Motor data

During the commissioning process, the following menu appears. You can enter the maximum and nominal current values of the motor into this menu.

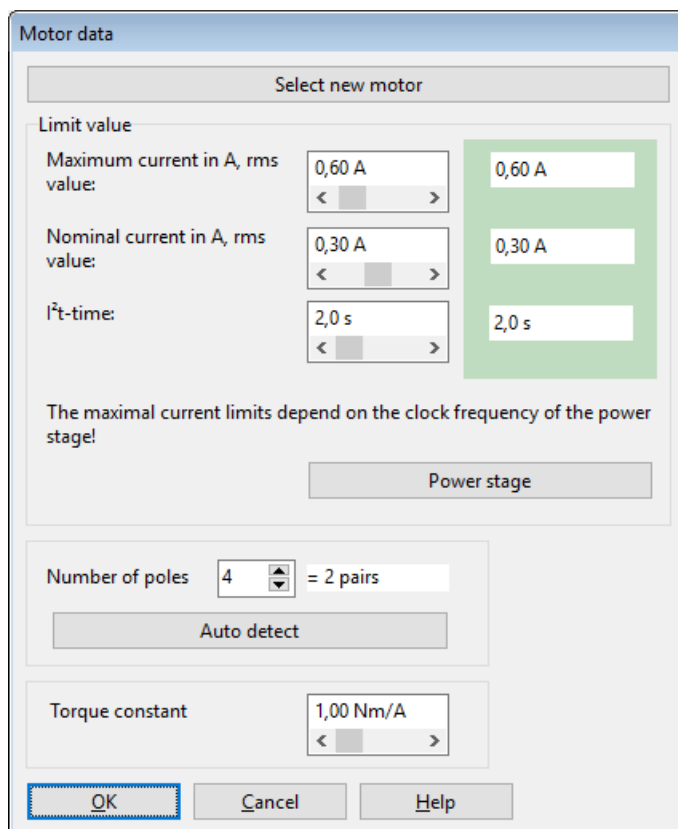


Figure 13: "Motor data" window

Enter the current values based on the data on the type plate.

#### **NOTICE** Risk of damage to the motor

Please note that the values to be entered for the maximum current and rated current are effective values! If the current values are too high, the motor will be destroyed as the permanent magnets inside the motor will be demagnetised.

The current limits stated by the manufacturer must not be exceeded. If in doubt, use smaller current values initially.

The maximum current limits may depend on the clock frequency of the output stage. To parameterise the clock frequency, click the **Power stage** button.

The **I<sup>2</sup>t time** is the time interval in which the I<sup>2</sup>t value increases to 100%. The I<sup>2</sup>t value describes the current load of the motor. The I<sup>2</sup>t value increases when the actual current value is higher than the nominal current. The value decreases when the actual current value is lower than the nominal current. When the I<sup>2</sup>t value reaches 100%, the current setpoint will be limited to the nominal current value. This limitation remains active until the I<sup>2</sup>t integral has reached 0% once.

#### **INFORMATION** I<sup>2</sup>t value

When the I<sup>2</sup>t value reaches 100%, the motor current will be limited to the nominal current value. In positioning applications, this may cause a following error as the drive cannot perform the motion profile as intended.

In critical cases, perform a test under full load to see whether the I<sup>2</sup>t value reaches 100%.

In addition, you can enter the number of poles (**Number of poles**) of your specific motor. There is also an automatic identification function which determines the number of poles and the offset angle of the angle encoder automatically. To use this function, simply click the **Auto detect** button. The **Torque constant** is used to specify the torque in Nm. You can calculate it as the quotient of rated torque/rated current.

### 4.4.5 Safety parameters

This menu is used to parameterise the limitations and monitoring functions of the drive. They are not functions in the sense of functional safety.

Fields that are irrelevant for the commissioning process are greyed out. Outside of the commissioning process, the menu can be activated via **Parameters/Safety parameters**.

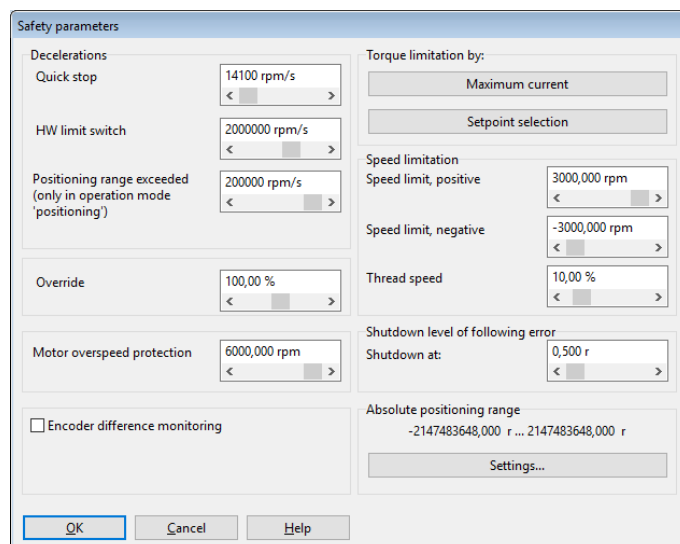


Figure 14: "Safety parameters" window

The **Decelerations** group can be used to define the deceleration of the drive under various conditions.

**Override:** In **Positioning** mode, the current, preset speed of movement of an active positioning run is additionally determined by a specific factor (override). As a result, the speed of movement stored in the position set multiplied by the override factor is taken into consideration during the cyclic calculation. The override applies to all of the position sets and is also used during the homing run. If it has a value of 100%, it has practically no effect.

The override is mainly used by fieldbus systems which set this value cyclically. It is also useful during a commissioning process. It can be used for the temporary reduction of the speed of motion of all of the position sets without having to change this parameter individually in the various position sets.

The override will not be saved. After a reset, the value is always 100%.

**Motor overspeed protection:** If the current speed exceeds the value stated in this field, error number 10-0 "Overspeed (motor overspeed protection)" will be issued.

**Encoder difference monitoring:** This option is useful if the encoder used for determining the actual position is a different encoder than the one that is used for determining the commutation position/actual speed. The parameter **Actual position value - commutation position** can be used to define an interval in which both positions may differ from one another. In the event of a stronger difference, an error will be issued.

**Torque limitation by:** The maximum torque (or the maximum current) of the application can be limited by

- The setting of the motor currents: Click the button **Maximum current** to access the menu for configuring the motor data (see section 4.4.4 *Configuration of the motor data* on page 47).
- An explicit setpoint limitation. Click the button **Setpoint selection** to access the corresponding menu (see section 5.2 *Operating modes* on page 65).

### ➤ Speed limitation

**Speed limit, positive:** Here, you can enter the maximum positive speed of your application. However, the effective speed limit depends on the settings for the override and thread speed (set-up speed) (see "Set-up mode").

**Speed limit, negative:** Here, you can enter the maximum negative speed of your application. However, the effective speed limit depends on the settings for the override and thread speed (set-up speed) (see "Set-up mode").

**Set-up mode:** Here, you can specify a speed limitation in per cent. It refers to the lower speed limit (see the right-hand box in the menu). In **Speed control** mode, the set speed value is limited to this set-up speed value. In the positioning mode, the set-up mode takes effect during the position control process. In this case, the profile speed is reduced to such an extent that an adjustment reserve (5%) remains for the speed controller.

#### Example:

Positive speed limit:	4900 U/min
Negative speed limit:	-4000 U/min
Set-up speed:	10 %

#### **Speed control** mode:

Maximum speed in set-up mode  
 = absolute value (-4000) rpm \* 10%  
 = 400 rpm

#### **Positioning** mode:

Maximum profile speed of a positioning run in set-up mode  
 = (4000 rpm \* 10%) – 5% (adjustment reserve)  
 = 400 rpm \* 0.95  
 = 380 rpm

The set-up mode must be activated via a digital input. See section 7.7 *Digital inputs* on page 168.

The **Shutdown level of following error** can deactivate the drive if the set and actual position differ from one another by an amount that is greater than the set threshold value. The reaction must be parameterised accordingly in the error management system (see section 9.1 *Error management* on page 210).

The button **Settings** in the field **Absolute positioning range** opens the menu **Global positioning settings** (see section 6.2.1 *Global positioning settings* on page 86).

## 4.4.6 Motor temperature monitoring

This menu is used to configure the motor temperature monitoring function. The menu can also be opened via [Parameters/Device parameters/Temperature monitoring](#).

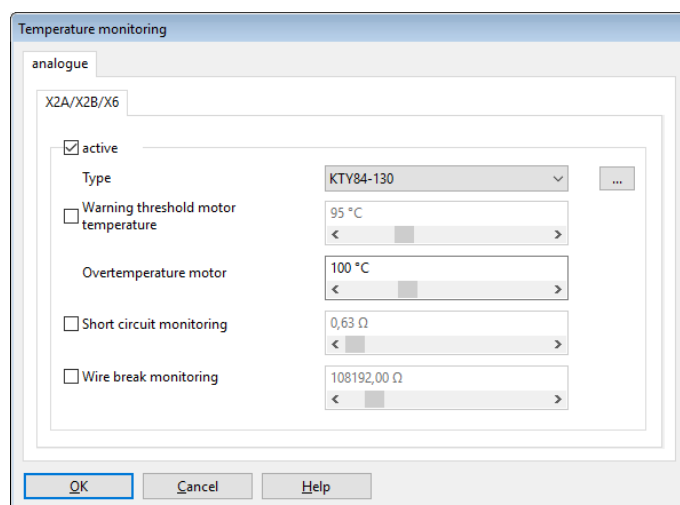


Figure 15: "Temperature monitoring" window

It is possible to directly select typical sensors for the analogue motor temperature sensor. In addition, non-linear characteristic curves with up to 10 interpolation points can be parameterised. The parameterisation of such a characteristic curve and of other monitoring functions (short circuit and wire break) are described in detail in section 7.16 *Motor temperature monitoring system* on page 190.

**⚠ DANGER Dangerous electrical voltage! ⚡**

The signals for the temperature sensor "MT-" and "MT+" at the motor connector [X6] must be connected to protective extra-low voltage (PELV) on the motor side and they must be insulated against the motor phases.



### 4.4.7 Commutation encoder

This menu is used to define the input through which the servo drive will receive its commutation information. The menu can also be opened via **Parameters/Device parameters/Actual value selection**.

State the connection through which the commutation information and the actual speed value will be provided.

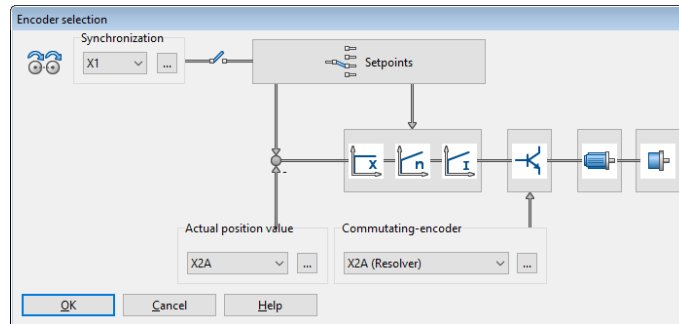


Figure 16: "Encoder selection" window

The actual value selection defines the encoder signal for feedback. The signals X2A, X2B and X1 are available. An angle encoder is assigned to these signals in the angle encoder menu (**Settings** button). You can define separate angle encoders for the acquisition of the actual position value (**Actual position value**), commutation (**Commutating encoder**) and synchronisation. See section 6.3 *Applications with several angle encoders* on page 104.

The selected configuration is shown in the form of an overview.

The setpoint selector and the controller overview are provided in the form of buttons used to activate the corresponding dialogues.

#### **INFORMATION** Buttons

You can use the buttons to quickly open the associated menus (e.g. setpoint selection). This option is disabled during the commissioning process.

## 4.4.8 Angle encoder settings



Parameters/Device parameters/Angle encoder settings/X2B

The menu is skipped during the commissioning process, if a resolver (X2A) is used as the commutation encoder.

If the commutation encoder is connected to X2B, additional information about the angle encoder must be provided. This can be done in this menu.

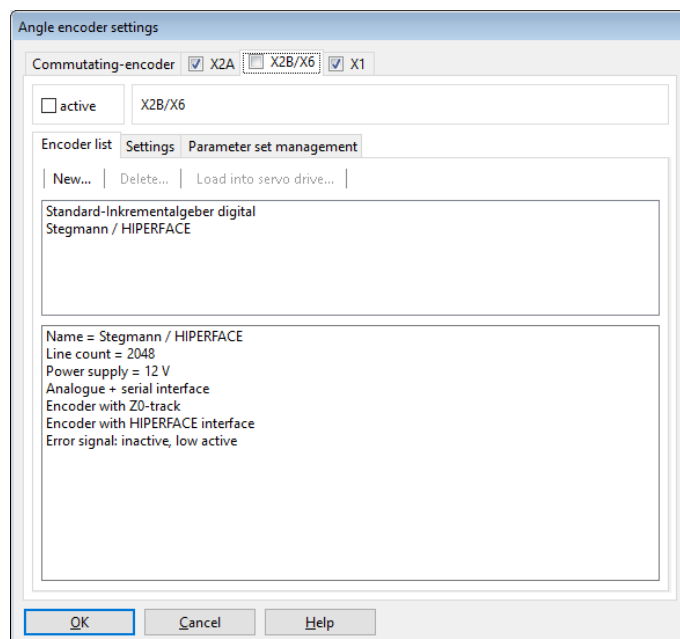


Figure 17: "Angle encoder settings" window - "X2B/X6" tab

First, you need to tick the checkbox **active** so that the servo drive will evaluate the encoder information of this connection.

You can use the tab **Encoder list** to select your specific encoder type or encoder series from a list of predefined encoders. In the case of encoders with serial connection for communication with the servo drive, all of the relevant information will then be read out of the encoder.

However, the encoder settings can also be defined manually on the **Settings** tab. All of the setting options are explained in detail in section 7.5 *Angle encoder settings* on page 134.

### 4.4.9 Angle encoder identification (automatic determination)

The angle encoder is automatically identified during the commissioning process. The following parameters are determined during the identification:

- Number of pairs of poles
- Angle encoder offset
- Phase sequence of the angle encoder (anti-clockwise, clockwise)

Outside of the commissioning process, the function can be accessed via the following menus:

- **Parameters/Device parameters/Motor data:** button **Auto detect**
- **Parameters/Device parameters/Angle encoder settings:** button **Auto detect**

The following conditions must be fulfilled for an automatic identification:

- The motor is completely wired and connected to earth
- The DC bus voltage is present
- The servo drive is free from errors
- The STO inputs are connected to the 24 V supply
- The shaft can move freely

**NOTICE** Damage to property caused by incorrect data

Incorrect angle encoder data may lead to uncontrolled movements of the drive. This may cause damage to the motor or to the entire system.

A failure of the automatic identification may be due to the following:

- The parameterised motor current is too low or the motor shaft cannot move
- If there are several servo drives in the same control cabinet, another encoder than the one belonging to the motor is connected to the servo drive
- Incorrect encoder configuration
- Defective motor (this must be analysed by measuring the winding resistance values)
- Not all of the phases are connected. This must be analysed by measuring the winding resistance values at the motor connector of the servo drive

### 4.4.10 Automatic identification of the current controller

#### **NOTICE** Damage to property caused by incorrect data

Incorrect data of the current controller gain and time constant may cause oscillations. This, in turn, may destroy the motor and the servo drive.

The current controller is automatically identified during the commissioning process. The following parameters are determined during the identification:

- Current controller gain
- Current controller time constant

Outside the commissioning process, the function can also be accessed as follows:



Parameters/Controller parameters/Current controller Button Auto detect

### 4.4.11 Configuring the polarity of the limit switches

This menu can also be accessed via **Parameters/Device parameters/Limit switches**.

Adjust your drive such that no limit switch is active. Ensure that no LED is active in the menu shown below. You can configure this by clicking **Normally closed** or **Normally open**. The switch symbols indicate the recognised state of the inputs.

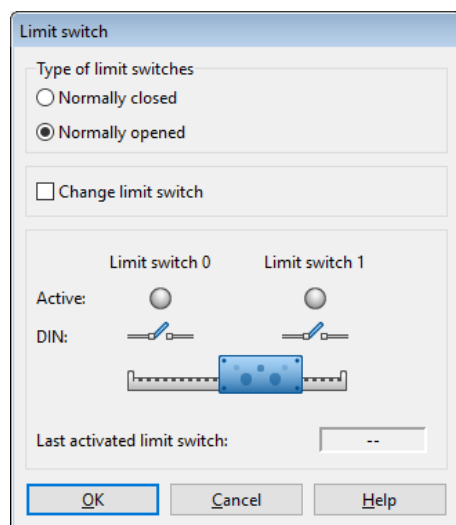


Figure 18: "Limit switches" window

The checkbox **Change limit switch** can be used to swap the assignment of the two digital inputs DIN6 and DIN7 to the limit switches E0 and E1. The physical limit switch that is connected to DIN6 adopts the mode of operation of the limit switch that is connected to DIN7 and vice versa. As a result, the functional assignment can be changed flexibly without having to change the wiring of the servo drive.

The little illustration in the middle shows a blue arrow when the drive moves towards one of the limit switches.

Limit switches are used to limit the range of movement of the application. For the optimum set-up of the limit switches, the following conditions must be fulfilled:

- In the case of movement at high speed, the necessary distance for braking must be taken into consideration. The installation of the limit switches must provide sufficient space for stopping until the stop is reached.
- To ensure the correct performance of homing runs and the correct disabling of the direction of rotation by the servo drive, the limit switches must be suitable for the direction of movement of the drive. This means that in the case of a positive movement (the position value in the actual value display increases), limit switch 1 (E1) will be actuated, thereby limiting the range of movement.

#### 4.4.12 Configuration of the speed controller (auto-tuning with FAST)

The Kuhnke ServoCommander® parameterisation program and the auto-tuning tool FAST (Flexible Advanced Servodrive Tuning) can be used for the automatic determination of the parameters for the speed and position controller with regard to the application.

##### **NOTICE** System damage caused by oscillations

Using this method for adjusting the speed and position controllers will briefly cause oscillations of the drive and mechanical components.

In extreme cases, the system may be damaged.

Do not use this method if the system is prone to oscillate as damage may result.

The auto-tuning tool FAST is suitable for the following types of systems:

Rigid systems:

- Rotatory synchronous motor with a direct load connection
- Linear motor with a direct load connection

Partially elastic systems:

- Rotatory synchronous motor with a transmission and load connection
- Rotatory synchronous motor with or without a transmission and a translatory ball screw axis with a direct load connection

The auto-tuning tool FAST is not suitable for elastic systems (e.g. a motor with a toothed belt axis). However, these systems can also be optimised rather well.

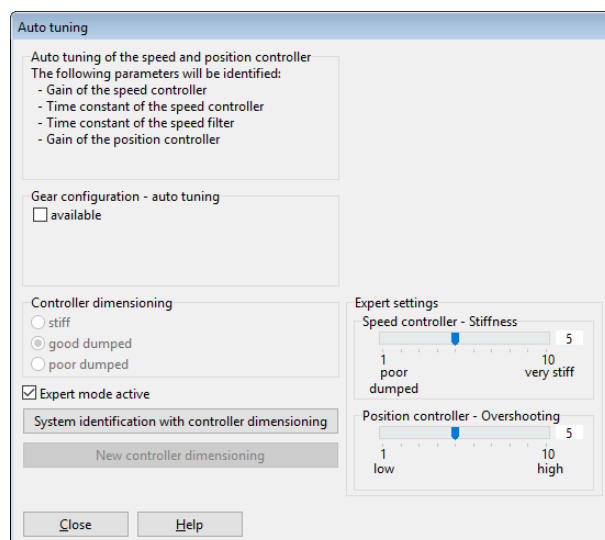


Figure 19: "Auto tuning" window

For the system identification, it is important to enter the values of a possibly existing gear. Then, the controller dimensioning can be selected, and the identification process of the auto-tuning tool FAST can be started by way of the button **System identification with controller dimensioning**. The data can be stored in an XML file for analysis.

After the system identification, the controller dimensioning can be changed anytime without requiring a new system identification. Simply click the button **New controller dimensioning**.

The expert mode can be used for the manual configuration of the stiffness of the speed controller (**Speed controller stiffness**) and the overshooting of the position controller (**Position controller overshooting**).

If the automatic controller dimensioning process fails, a brief change of the nominal current (e.g. a reduction in the case of small drives with a low mass) in the **Motor data** menu can lead to a successful identification.

If the automatic identification (FAST) has not been successful, the system suggests using the default parameters for the speed controller.

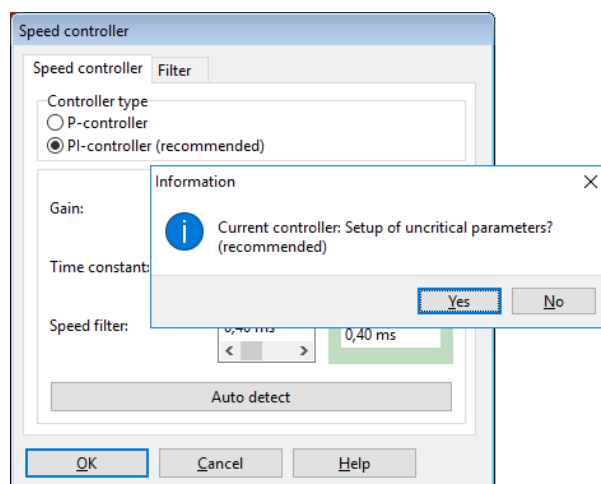


Figure 20: "Speed controller" window

### 4.4.13 Configuration of the position controller

If the automatic identification (FAST) has not been successful, the system suggests using the default parameters for the position controller.

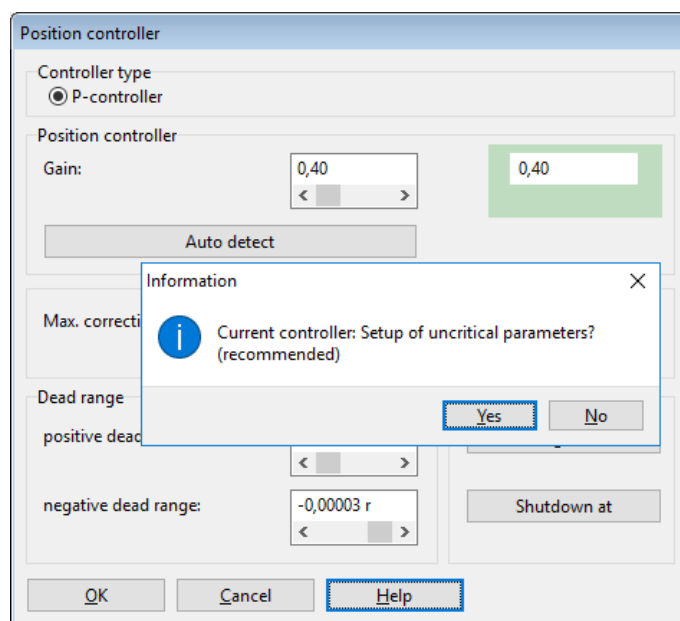


Figure 21: "Position controller" window

If the automatic identification of the controller parameters has not led to an optimum result, the drive can be optimised manually. This is described in section 7.6.4 *Manual optimisation of the controllers* on page 162.

The following values can be changed:

- **Gain:** Proportional gain of the position controller.
- **Max. correction speed:** Here, you can define the speed to be added to the speed of movement in the event of a following error.
- **Dead range:** negative and positive dead range: Here, you can specify a permissible distance between the setpoint value and the actual value within which the position controller will not become active.

In addition, the following settings can be made in the "Position controller" window (please note that they are not shown during the commissioning process).

Following error:

- **Message:** Parameterisation of a positive and negative following error and of a response delay. In the event of a greater deviation between the setpoint value and actual value, a message will be issued.
- **Shutdown at...:** Here, you can parameterise a second limit. If this limit is exceeded, the drive will be switched off. The reaction must be configured accordingly in the fault management system.

**NOTICE** Following error: suitable parameterisation

The following error should always be parameterised in a suitable manner to ensure that the drive will be switched off as quickly as possible in the event of overload.

The switch-off threshold can be determined, for example, by determining a maximum following error during a test run under load. The switch-off threshold is then set to a value that is 20% higher than the maximum following error that has been determined beforehand.



## 4.4.14 Permanent storage of the parameters



### File/Parameter set/Save parameter set (EEPROM)

For a successful completion of the parameterisation, the parameters must be stored permanently in the servo drive.

Click **Next >>**.

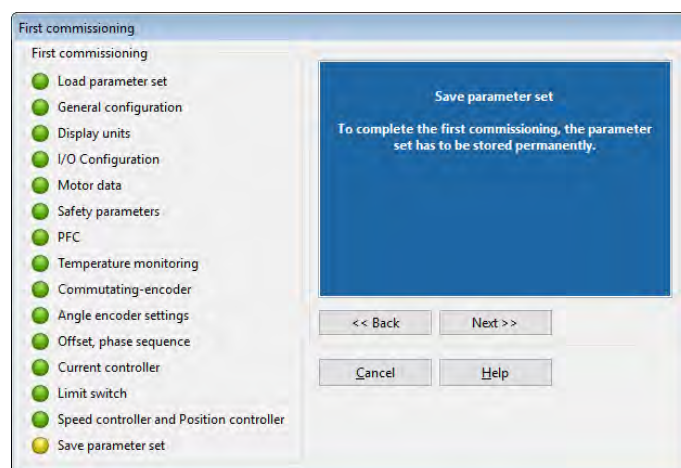


Figure 22: "First commissioning" window

### › Saving the data in a DCO file

The values determined during the commissioning process should be saved permanently in the servo drive and also in a file on the PC. As a result, other drive systems with the same servo drive/motor combination can be commissioned particularly quickly and easily. In addition, the parameters can be restored easily in the event of a fault or service.

All of the adjustable parameters combined are known as a parameter set (see section 7.4 *Parameter sets* on page 128). To save a parameter set as a DCO file on the PC, click **Next >>**

Enter a file name with the extension DCO into the **\*.DCO** field. In addition, enter the **Motor type** and a brief **Description**. To save the file, simply click **OK**.

If you do not want to save the parameter set, click **Skip**.

## 5 Enabling the servo drive and selecting the set values

After the commissioning process, the servo drive can be enabled, and the motor can perform a movement.

### 5.1 Configuring the enable logic

In order to be able to enable the servo drive, the enable logic must be configured. The enable logic determines the conditions that must be fulfilled to activate the power output stage so that the motor is supplied with current.

#### **INFORMATION** Servo drive enable logic

Please note that the servo drive enable logic will be automatically configured for the bus system after a reset when the bus system is activated. As a result, the servo drive can only be enabled via the bus system.

To enable the drive via MSC for test purposes, you need to deactivate the bus system and change the servo drive enable logic.

The default parameter set switches the operating mode to positioning. This is why it is recommended to use the drive in jog mode for testing.

To select the servo drive, either select **Parameters/Device parameters/Controller enable logic** or click the button "..." in the field **Controller enable** in the **Commands** window.

Select **Parameterisation interface only**.

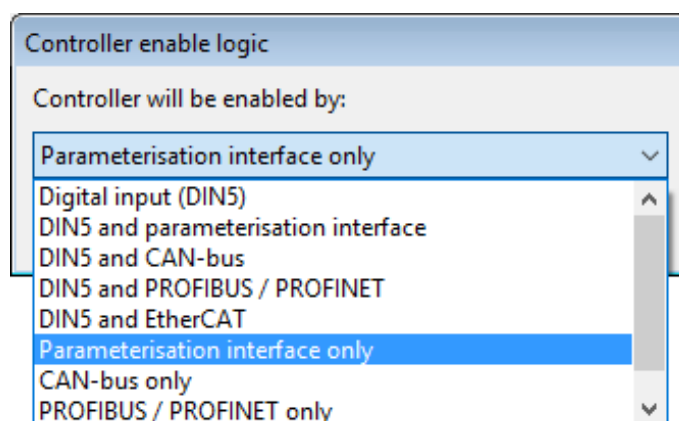


Figure 23: "Controller enable logic" window

After the servo drive has been successfully enabled, the following conditions must be fulfilled:

- No errors
- DC bus charged
- Encoder systems completely initialised (it may take some time to read the parameter sets out of the encoder)
- STO inactive (X3 correctly connected and emergency cut-out deactivated)

**NOTICE** Damage to the system due to unwanted movements

When the system is switched on for the first time, it may perform unwanted movements.

Ensure that the motor is correctly wired (encoders, all of the motor phases, PE) and connected to earth and that it can move freely. Release any couplings at the output or, in the case of linear slides, ensure that the slide does not touch any of the stops.

Do not switch on the mains power supply until the wiring is complete and the servo drive and motor are properly connected to earth!

**NOTICE** Damage to the system

Prior to switching on the drive, read the manual completely and thoroughly. Especially the settings concerning the current limits and operating mode must be complied with.

Incorrect settings may destroy the servo drive/motor and the mechanical drive.

**NOTICE** Damage to the system due to unwanted movements

Disable the servo drive after a test. Wait until the shaft has completely stopped. If the parameterisation of the servo drive is incorrect, you may stop the motor simply by switching off the power supply.

We strongly recommend using an emergency cut-out switch for the power supply and STO input. Use strongly reduced nominal and maximum current values to protect the drive system.

The STO inputs must be connected to the 24 V supply so that the drive can be enabled by clicking **Controller enable**. If you click again, the drive will be disabled.

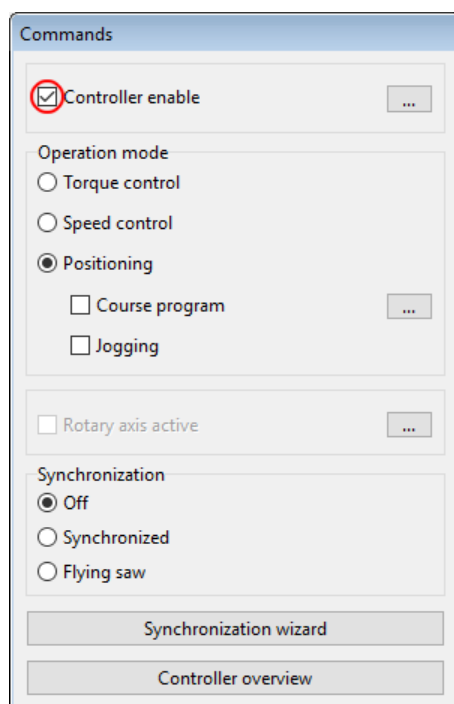


Figure 24: "Commands" window

The drive is in its selected operating mode. In positioning mode, for example, it remains in its actual position, i.e. in the position it was in when the servo drive was enabled.

## 5.2 Operating modes

The operating mode can be changed in the "Commands" window. This window is permanently displayed. To change the operating mode, select the corresponding button. However, this should not be done when the servo drive is enabled.

The various operating modes are described in detail in the next chapters.

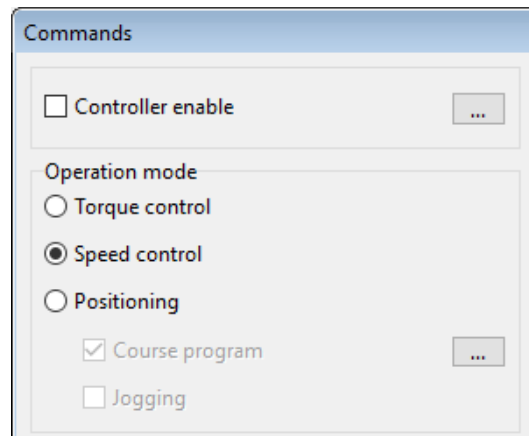


Figure 25: "Commands" window

### 5.2.1 Torque-controlled mode (torque control)

In torque-controlled mode, a target torque that the motor is to provide can be specified. If there is no counter-torque, the motor will accelerate up to its idling speed.

In this operating mode, only the current controller is active. In addition, a speed limitation can be activated in this operating mode.

The target torque can be specified in A or Nm. This can be selected under **Options/Display units**. The associated actual value and set value menus will then automatically adopt the selected unit.

If you want to use the unit Nm for the torque, you have to specify the torque constant, i.e. the conversion factor between the current and torque. The torque constant must be entered under **Parameters/Device parameters/Motor data**. In general, it can be calculated using the information stated on the type plate of the motor: To do so, divide the rated torque by the rated current.

#### **INFORMATION** Torque constant

A torque constant of 0 Nm/A is not permissible if "Torques in Nm" has been selected.

This operating mode is used if the servo drive is controlled by a superordinate control system, e.g. via an analogue input or via a fieldbus, so that positioning processes are calculated by the control system, and if a superordinate, external speed and position control circuit and an external positioning control system are present.

## 5.2.2 Speed-controlled mode (speed control)

In speed-controlled mode, a specific speed setpoint is specified. The servo drive determines the actual speed  $n_{\text{actual}}$  by evaluating the encoder data. To ensure compliance with the speed setpoint, the current setpoint  $i_{\text{set}}$  is determined. To activate the speed-controlled mode, "Speed control" must be selected in the "Commands" window.

The menu **Operating mode/Controller overview** provides a simplified control-related overview of this operating mode to help you with using the associated menus.

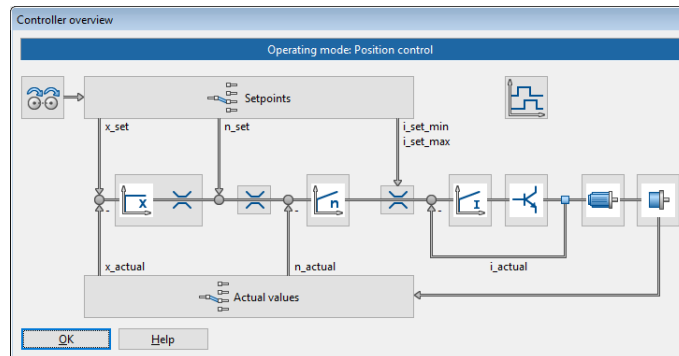


Figure 26: "Controller overview" window

This operating mode is used if the servo drive is controlled by a superordinate control system, e.g. via an analogue input or via a fieldbus, so that positioning processes are calculated by the control system, and if a superordinate, external position control circuit and an external positioning control system are present.

### 5.2.3 Position-controlled mode and positioning mode (positioning process)

In position-controlled mode/positioning mode, a superordinate position controller is active in addition to the speed control. This position controller processes the deviation of the actual position from the set position and converts it into the corresponding set values for the speed controller.

The position controller calculates a corrective speed based on the difference between the set position and actual position and transfers this speed value as a set value to the speed controller.

Usually, the position controller is only used in conjunction with a positioning control or the synchronisation control. It is a P-controller with parameterisable input and output limits.

#### **INFORMATION** Using the position controller without a positioning control

Using the position controller without a positioning control only makes sense in combination with a synchronisation via the master frequency input. In this case, the servo drive acts as a follow-up control system with the master frequency input being configured for the feedforward control of the speed setpoint.

The position controller is parameterised under **Parameters/Controller parameters/Position controller** (see section 4.4.13 *Configuration of the position controller* on page 59).

## 5.2.4 Using the servo drive in jog mode

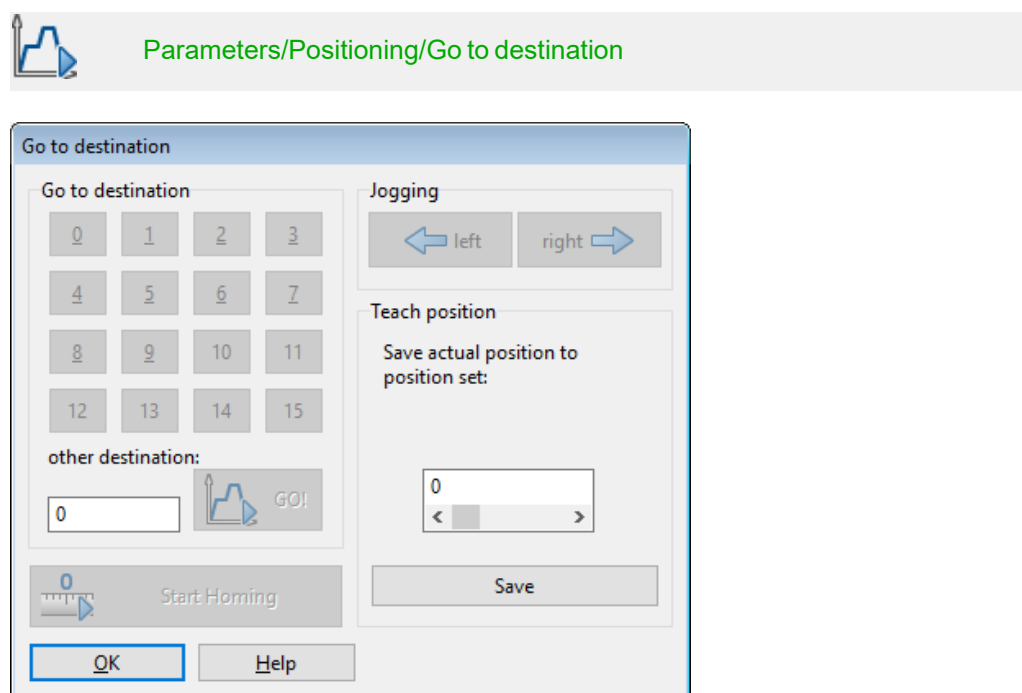


Figure 27: "Go to destination" window

If the servo drive is in **Positioning** mode, the drive can be moved manually by clicking and holding the arrow buttons. The speed and acceleration of the motion profile can be configured in the **Destination parameters** window (see section 6.2 *Positioning process* on page 86).



## 5.3 Selecting the setpoints



### Operating mode/Setpoint selectors

In the operating modes **Torque control** and **Speed control**, the setpoint source can be selected.

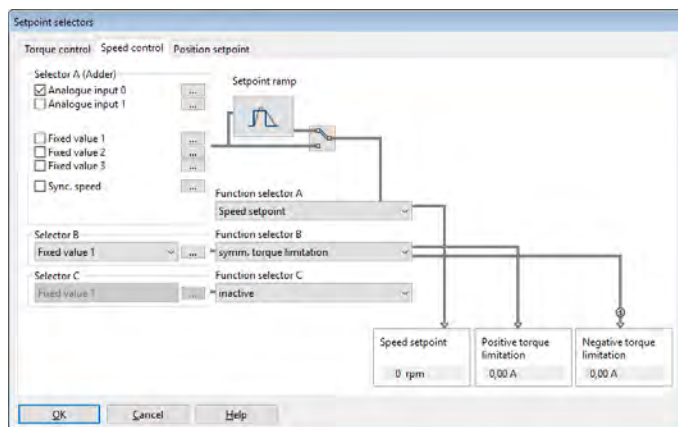


Figure 28: "Setpoint selectors" windows - "Speed control" tab

The following setpoint sources can be selected:

- Analog input
- Fixed value 1 (this is also used by fieldbus systems and can be labelled accordingly: CANopen/EtherCAT/PROFINET, etc.) (the setting depends on the enable logic)
- Fixed value 2 (the setting depends on the enable logic)
- Fixed value 3 (the setting depends on the enable logic)
- Synchronous speed
- Master frequency input as PWM input

If no setpoint source is activated, the setpoint is zero.

Two additional selectors (**Selector B** and **Selector C**) can be used to select additional sources as setpoints and/or limit values. These will not be fed through the ramp generator, however. The total setpoint is the sum of all of the values. The ramp can be parameterised as the acceleration or deceleration time depending on the direction.

In addition, the torque limitation can be activated in the **Setpoint selectors** menu for the speed setpoint selection. It can be asymmetric or symmetric and the limitation source can be selected as desired. In the example above, **Fixed value 1** has been selected as the source for a symmetric torque limitation.

### 5.3.1 Specifying the setpoints (speed and torque values)

In the **Setpoint selectors** window in **Selector A** for **Fixed value 1**, click "..." to specify the setpoints.

You can also access the menu via **Operating mode/Setpoint value (speed**

The screenshot shows a software window titled "Setpoint value - Speed values". It is divided into three horizontal sections, each for a "Fixed value" (1, 2, and 3). Each section contains two input fields: "Speed limit" and "Speed setpoint", both currently displaying "0 rpm" and featuring a horizontal slider bar. Below these fields in each section is a checked checkbox labeled "Transfer immediately" and a button with a circular arrow icon and the text "Transfer". At the bottom of the window, there is a large red octagonal "STOP" button in the center, and three smaller buttons on the left: "OK", "Cancel", and "Help".

Figure 29: "Setpoint value (speed)" window

Here, you can enter numerical values for the setpoints and limitation values. If you want to cancel incorrect inputs immediately, click the red **STOP** symbol. The setpoint will be set to 0 and transferred immediately.

### 5.3.2 Settings concerning the analogue input AIN

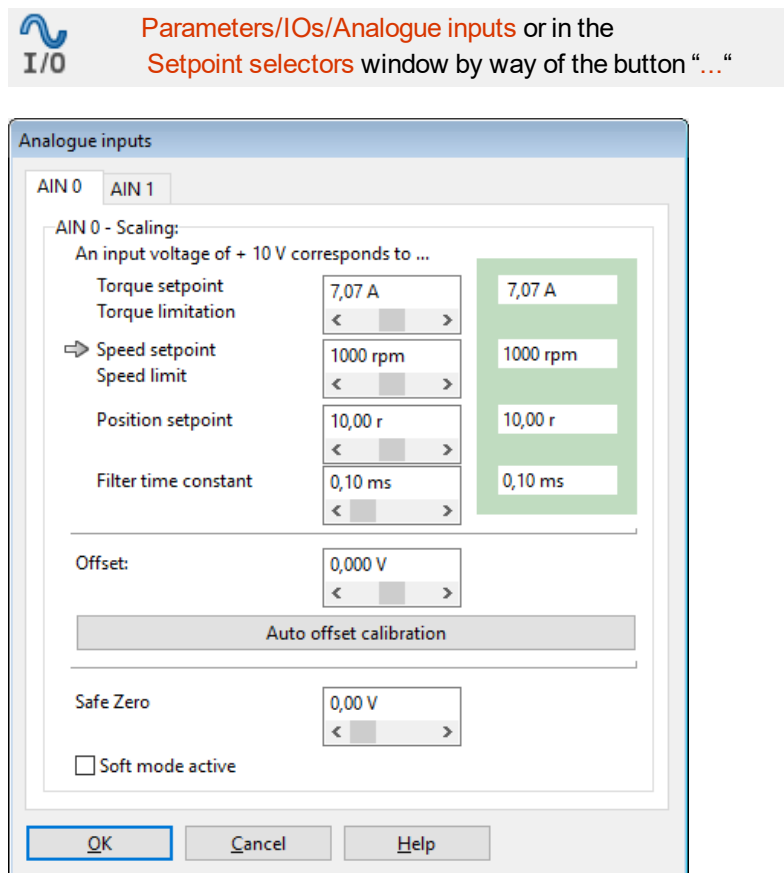


Figure 30: "Analogue inputs" window

The values that need to be set are used to specify the "conversion factor" for the conversion between the input voltage and setpoint.

The three fields **Torque setpoint/Torque limitation**, **Speed setpoint/Speed limit** and **Position setpoint** are used to specify the conversion of the input voltage into a torque, speed or position value. The small blue arrow indicates the parameter that is currently controlled by the analogue input.

In the field **Filter time constant**, noisy signals can be filtered more strongly by increasing the time constant.

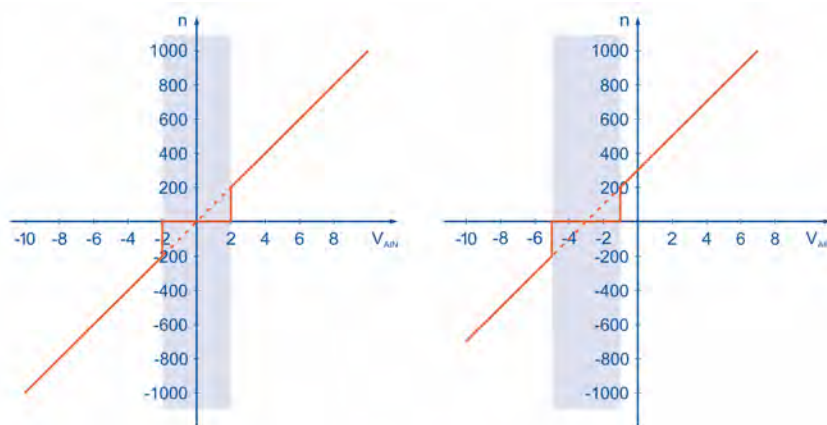
### 5.3.3 Offset calibration and "Safe zero"

In some cases, an external voltage of 0 V may still generate a very small setpoint because the upstream electronic system and the analogue input path have an offset. In this case, the offset can be calibrated.

This can be done manually by adjusting the offset value accordingly. However, we recommend performing an automatic offset calibration. For an automatic offset calibration, the input must be short-circuited or connected to the potential corresponding to the "zero" setpoint. Then, click **Auto offset calibration**.

In some cases, it would be good to achieve a defined setpoint value of 0 (**Safe zero** regardless of any offset fluctuations, noise, etc., e.g. to realise a defined standstill of the drive in **Speed control** mode.

The parameter **Safe zero** provides the (symmetric voltage threshold below which the input value will be considered zero. This is shown in the following illustrations. The scaling is 10 V = 1000 rpm. The characteristic without a **Safe zero** is shown as a dashed line.



Safe zero = 2 V

Safe zero (2 V) with an offset shift (-3 V)

Figure 31: Analogue input: Offset shift and Safe zero

Even if the safe zero is used, the parameterisable **Offset** will be taken into consideration. Figure 31 (*Analogue input: Offset shift and Safe zero*) shows the shift of the characteristic as a result of the offset. The "Safe zero" function can be used to suppress the noise of the setpoint source. The value for the **Safe zero** function should not be too high. In the upper example, it is unrealistically high to explain the concept.

#### **INFORMATION** The analogue input as control input

If the analogue input is to be used as a control input within a superimposed control circuit, neither an offset calibration nor the "Safe zero" function is required.

# 6 Applications

## 6.1 Homing process

Every positioning control requires a defined zero point (reference point) at start-up, which can be determined by way of a homing run (this is not required in the case of multi-turn encoders). The servo drive can perform this homing run automatically. It evaluates several inputs, e.g. the limit switch inputs or a stop, as the reference signal.

A homing run can be started via a fieldbus, Kuhnke ServoCommander® or a digital input. It can also be performed automatically when the servo drive is enabled. For homing, several different methods have been implemented following the DSP 402 CANopen protocol. Most methods consist of 3 parts: a search run (1), a crawl run (2) and the movement to the home position (3). First, the system tries to locate a reference signal (e.g. a switch) at search speed. During the crawl run, the system leaves the switch slowly to determine a more precise position. To increase the level of accuracy even more, an additional reference point (e.g. the zero signal of an angle encoder) can be used. In addition, the option **Go to zero position after homing** can be activated so that the system moves to the determined home position at the end of the homing run. If this option is not activated, this would not always be the case due to the deceleration process and the use of additional reference points. If a homing process is started via CANopen, there will be no follow-up positioning to the home position.

The ramps and speed values for the homing run can be parameterised and the homing run can be performed in a time-optimal and jerk-free manner. The successful completion of the homing run is indicated by a set status bit in the device. This can also be output via a digital output.

### › Homing methods – overview

The following table provides a rough classification of the homing methods based on the target and reference point. For a detailed description, see the next sections. The movement to the home position is always included in the schematic representations of the homing run. Not all of the included movements may actually be performed, e.g. if the position of the index pulse is already known.

Target	Reference point	Methods
Stop	Stop	-18, -17
Stop	Index pulse	-1, -2
Limit switch	Limit switch	17, 18
Limit switch	Index pulse	1, 2
Reference switch	Reference switch	23, 27
Reference switch (pos/neg)	Reference switch	-23, -27
Reference switch	Index pulse	7, 11

### 6.1.1 Methods -17 and -18: Stop

If this method is used, the drive moves in the positive direction (-18) or negative direction (-17) until it reaches the stop. Normally, a 50% increase of the  $i^2t$  value is used as the criterion for detecting the stop. Alternatively, a comparison torque value at which the stop will be considered as detected can be specified (see section 6.1.14 *Tab: Torques* on page 84). The mechanical design of the stop must be such that it cannot be damaged with the parameterised maximum current. The home position refers directly to the stop. Since, in this case, the home position would be located directly at the stop, the parameter **Offset start position** should be used to shift the home position in a suitable manner.

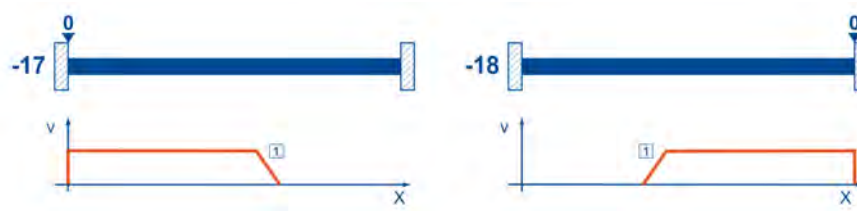


Figure 32: Homing run to the stop

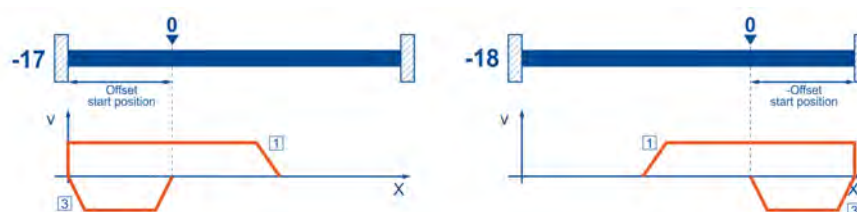


Figure 33: Use of "Offset start position"

### 6.1.2 Methods -1 and -2: stop with index pulse evaluation

These methods correspond to the methods -17 and -18. However, the home position also refers to the first index pulse of the angle encoder in the negative (-2) or positive (-1) direction as seen from the stop.

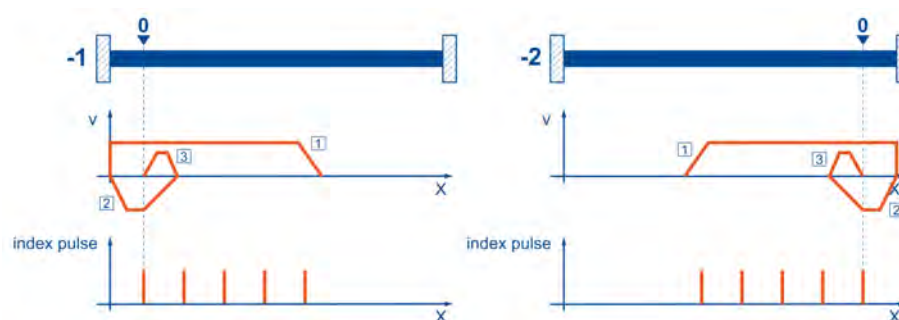


Figure 34: Homing run to the stop with index pulse evaluation

### 6.1.3 Methods 17 and 18: positive and negative limit switch

If these methods are used, the drive moves in the positive direction (18) or negative direction (17) at search speed until it reaches the limit switch. Then, the drive moves back at crawl speed and tries to find the exact position of the limit switch. The home position refers to the falling edge of the limit switch.

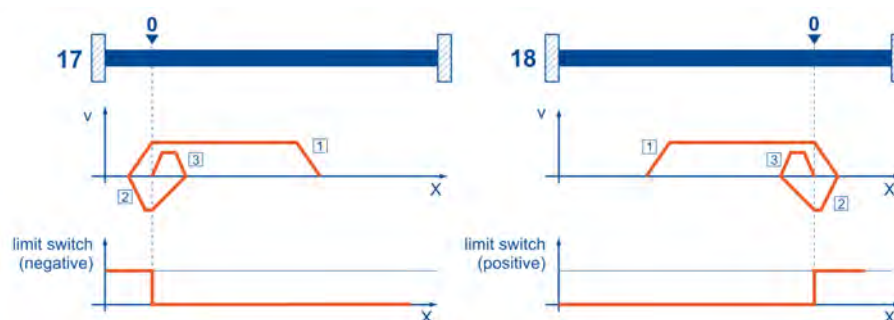


Figure 35: Homing run to the limit switch

### 6.1.4 Methods 1 and 2: positive and negative limit switch with index pulse evaluation

Like in the case of the previous method, the system tries to find the limit switch. However, in this case, the home position refers to the first index pulse of the angle encoder in the negative (1) or positive (2) direction as seen from the limit switch.

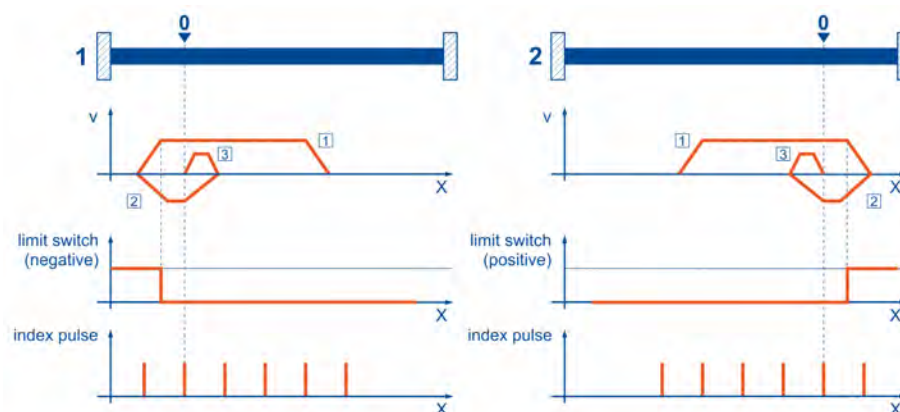


Figure 36: Homing run to the limit switch with index pulse evaluation

### 6.1.5 Methods 23 and 27: reference switch

These two methods use a reference switch which is active only over a certain part of the distance. This method is particularly suitable for rotary axis applications in which the reference switch is activated once during every rotation. If this method is used, the drive moves in the positive direction (23) or negative direction (27) at search speed until it reaches the reference switch. Then, the drive moves back at crawl speed and tries to find the exact position of the reference switch. The home position refers to the falling edge of the reference switch. If, at the beginning, the drive moves away from the reference switch, the associated limit switch causes a reversal of the direction of rotation so that the reference switch will be found.

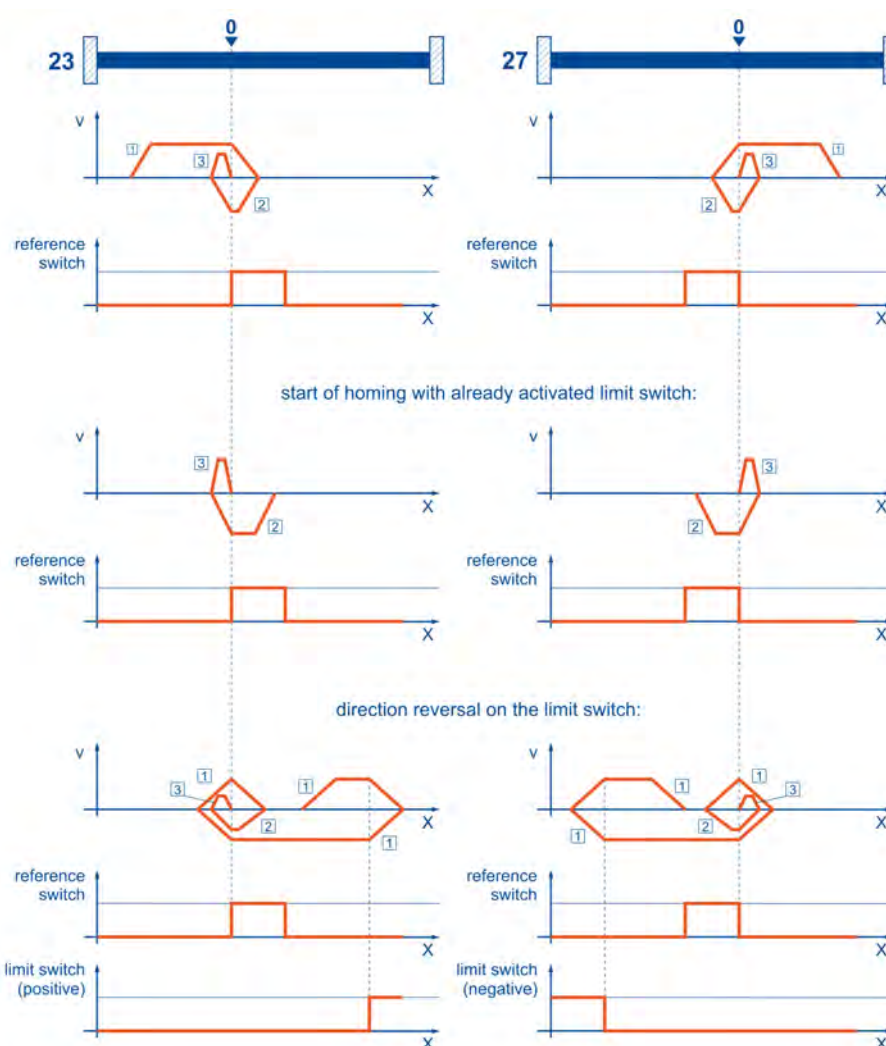


Figure 37: Homing run to the reference switch



## 6.1.6 Methods 7 and 11: reference switch and index pulse evaluation

Like methods 23 and 27, methods 7 and 11 use the reference switch. In addition, however, the home position refers to the first index pulse in the negative or positive direction as seen from the reference switch.

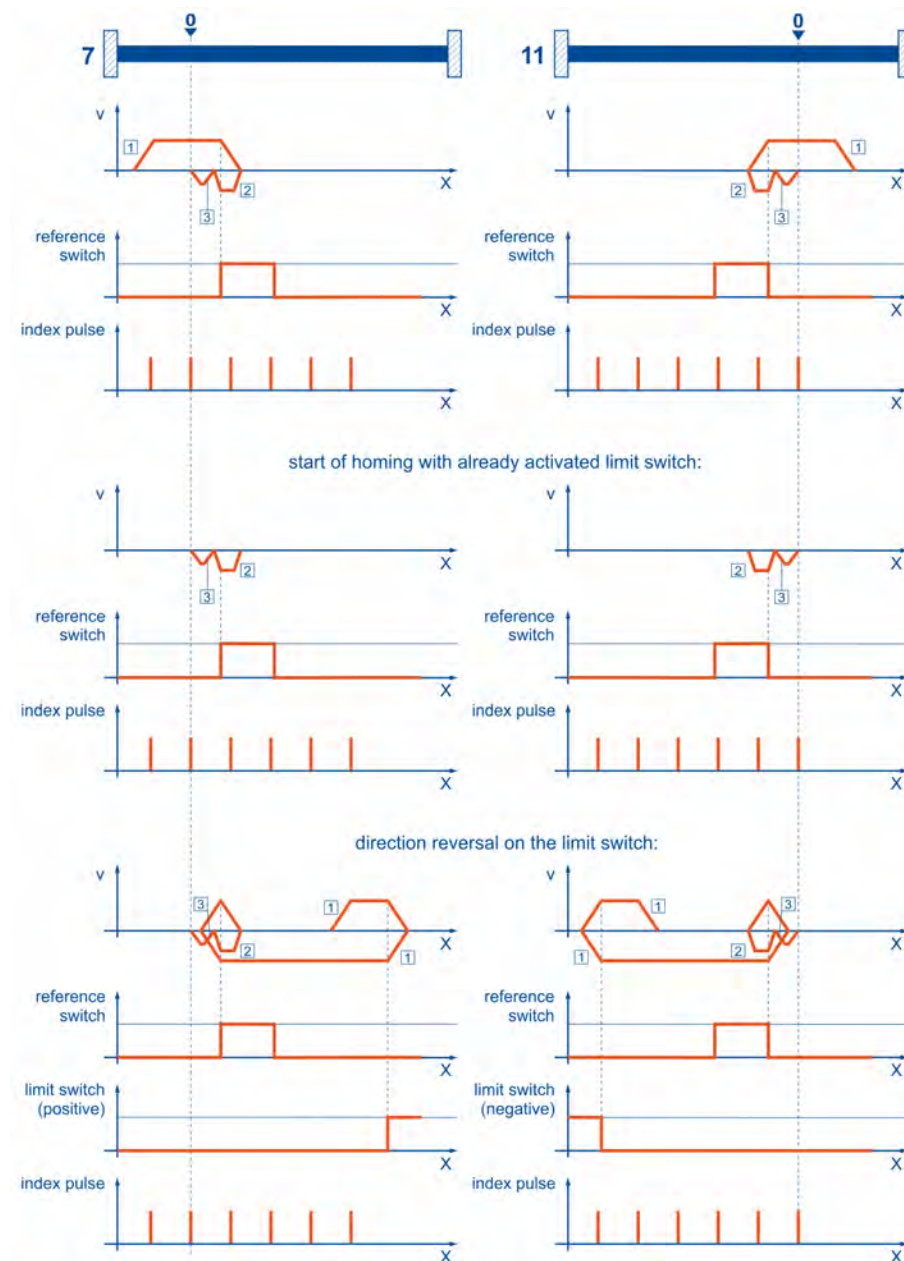


Figure 38: Homing run to the reference switch with index pulse evaluation

### 6.1.7 Methods -23 and -27: homing run (positive/negative) to the reference switch

These methods are similar to the methods 23 and 27. However, in this case, the system tries to locate the end of the range of movement, e.g. the stop or a limit switch, in a first step. It is only then that the system searches for the reference switch. As a result, several switches can be connected to the same input for the reference switch. During the homing run, the "last" switch in the search direction will be used as the reference switch. In the case of method -23, the drive moves in the positive direction first, and in the case of method -27, it moves in the negative direction first. The home position refers to the falling edge of the reference switch.

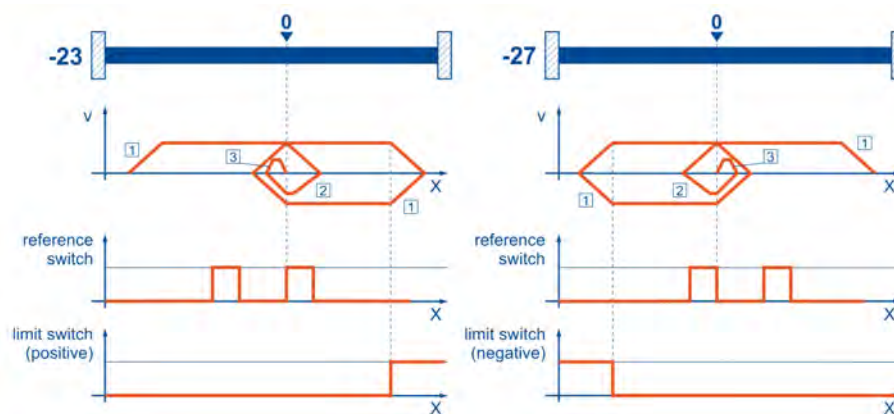


Figure 39: Reference switch with an initial movement in the positive and negative direction

### 6.1.8 Methods 32 and 33: homing to the index pulse

In the case of method 32 and method 33, the direction of the homing run is negative or positive. The home position refers to the first index pulse of the angle encoder in the search direction.

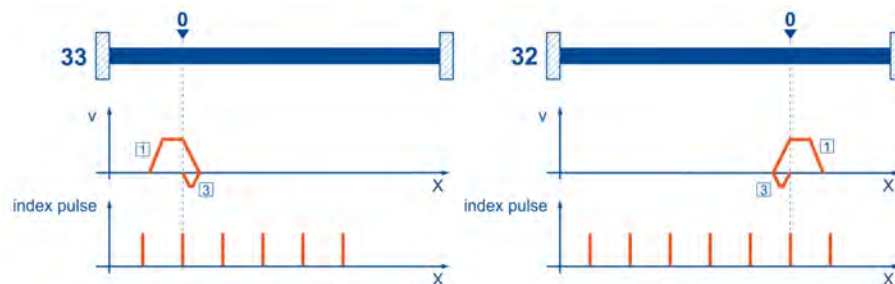


Figure 40: Index pulse with a negative (32) and positive (33) initial movement

### 6.1.9 Method 34: homing to the current position

In the case of method 34, the home position refers to the current position, i.e. the current position of the drive is set to zero.

### 6.1.10 Parameterisation of the homing method



The homing run can be parameterised in the **Homing position** menu.

This is where you can select your homing method. See also section 6.1 *Homing process* on page 73.

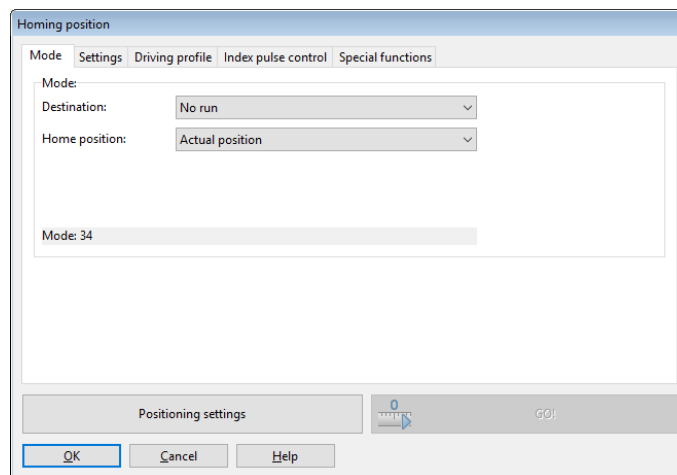


Figure 41: "Homing position" window - "Mode" tab

### 6.1.11 Parameterisation of the homing run: settings

Under the **Settings** tab, a window opens where the following settings can be made:

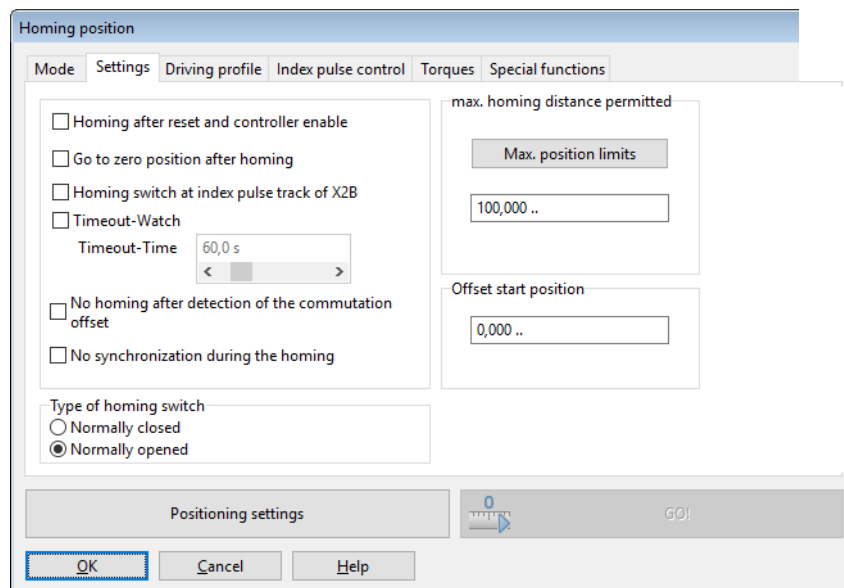


Figure 42: "Homing position" window - "Settings" tab

#### Homing after reset and controller enable

If this option is selected, the homing run will not be started until the servo drive is enabled for the first time after the 24 V supply has been activated.

#### Go to zero position after homing

If this option is selected, the drive will move to the home position at normal running speed after the target and reference point of the homing run have been reached.

#### Homing switch at index pulse track of X2B

If this option is active, an index pulse of X2B will be considered a reference pulse.

#### Timeout watch

If this option is active, the time will be monitored. If the homing run takes longer than the specified timeout time, an error will be generated. The time will be monitored at intervals of 10 ms.

#### No homing after detection of the commutation offset

This option does not become effective unless the drive is a drive without any commutation signals. In the default configuration, a homing run will be started automatically after the successful determination of the commutation position. If you want to suppress this, select this option.

#### No synchronisation during the homing run

In the case of synchronised applications, it may be useful to suppress the synchronisation during the homing run. In this case, select this option to deactivate the synchronisation during the homing run.

#### Type of homing switch

Please specify whether your reference switch (homing switch is a normally closed switch or a normally open switch).

#### Max. homing distance permitted

This option can be used to specify a maximum search distance. If the system cannot

detect any target signals (e.g. a limit switch) or the home position within this search distance, it will issue an error message.

#### Max. position limits

If this button is clicked, the search distance will be determined based on the maximum position limits.

#### Offset start position

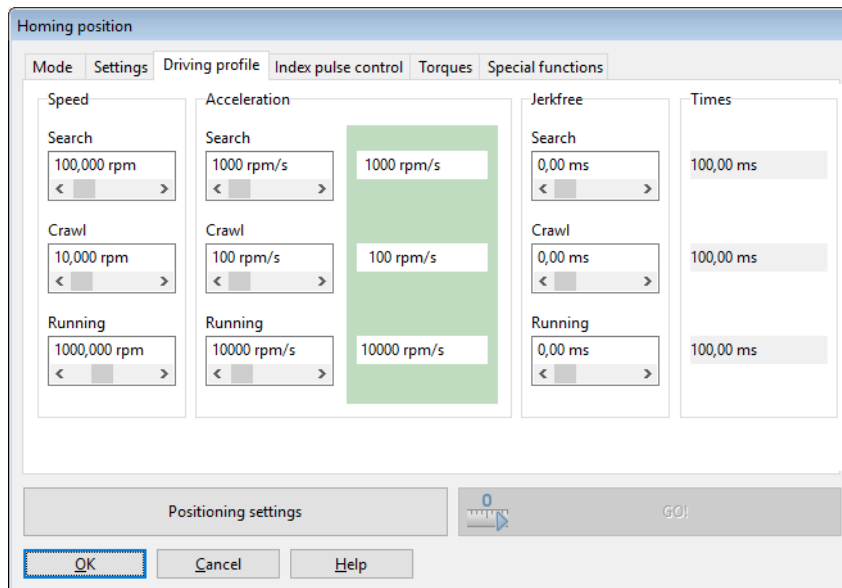
The actual home position, i.e. the mathematical zero point for the subsequent positioning runs, is slightly offset from the reference point of the homing run. This offset is stated under **Offset start position**. At first, this offset value leads to a shift of the actual position. To ensure that the drive actually moves to this position, **Go to zero position after homing** (see above) must be activated.

#### **INFORMATION** Actual position of multi-turn encoders

In the case of multi-turn encoders, the current actual position is preserved even if the supply voltage is switched off, provided that the multi-turn range is not exceeded. However, it is useful to shift this position, e.g. when setting up the machine.

The firmware includes an offset parameter for this case. It can be stored in the internal parameter set of the encoder. The offset parameter can be redetermined by way of a homing run and then stored in the encoder parameter set.

## 6.1.12 Parameterisation of the homing run: motion profile



Mode	Settings	Driving profile	Index pulse control	Torques	Special functions
Speed	Search: 100,000 rpm Crawl: 10,000 rpm Running: 1000,000 rpm	Search: 1000 rpm/s Crawl: 100 rpm/s Running: 10000 rpm/s	Search: 1000 rpm/s	Search: 0,00 ms Crawl: 0,00 ms Running: 0,00 ms	Times: 100,00 ms 100,00 ms 100,00 ms

Positioning settings: 0 GO!

OK Cancel Help

Figure 43: "Homing position" window - "Driving profile" tab

Here, you can enter speed and acceleration values as well as jerk-free parameters for the following processes:

- **Search**  
Movement of the drive until it reaches the target (limit switch, reference switch, stop)
- **Crawl**  
Reversal of the movement (at low speed) to determine the contact threshold
- **Running**  
Optional movement to the zero point (reference point) of the application

### 6.1.13 Tab: Index pulse control

Index pulse control (index pulse monitoring) is important if a target other than "index pulse" has been selected and the reference point is an "index pulse". If the target is located very close to the index pulse, slight changes in the mechanical system may cause a point slightly "before" or "after" the original index pulse to be used as the reference point (or home position) during the next homing run. The index pulse control (index pulse monitoring) function is used to indicate the distance between the target and the index pulse. The following window will be displayed:

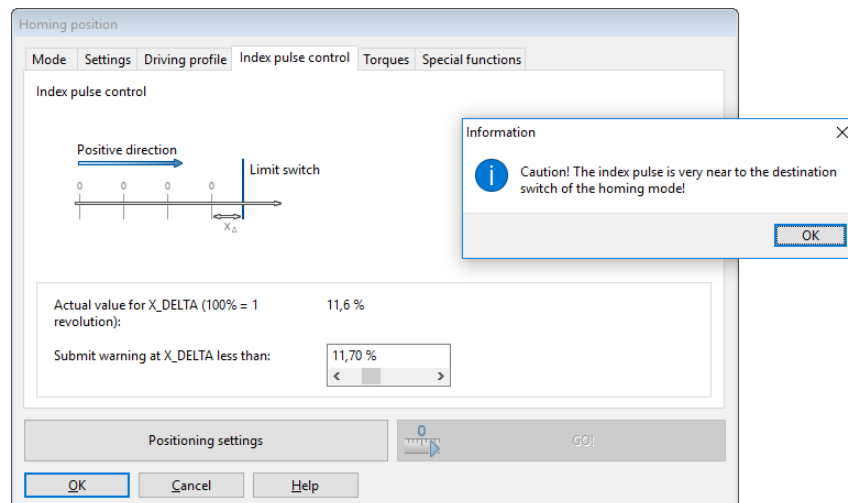


Figure 44: "Homing position" window - "Index pulse control" tab

You can indicate the current distance between the target and index pulse. In addition, you can configure a threshold. If the actual value falls below this threshold, a warning will be issued. 100% corresponds to one revolution.

### 6.1.14 Tab: Torques

The conventional homing method based on a stop can be optionally refined by way of a homing run to a comparison torque. As a result, the target of the homing run is reached when the specified comparison torque is reached. In this case, the system no longer uses the criterion "50% increase of the  $i^2t$  value".

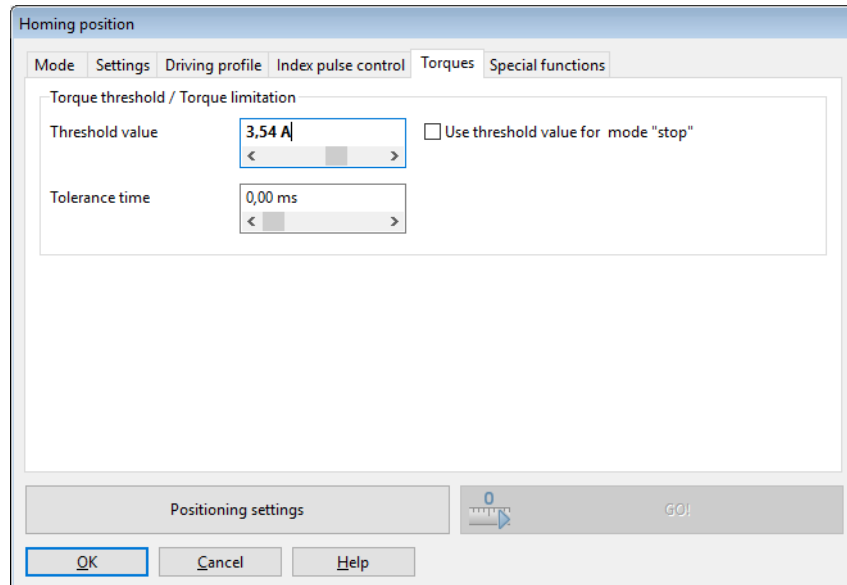


Figure 45: "Homing position" window - "Torques" tab

The reference value for the comparison torque that is monitored by the system must be specified in the field **Threshold value**. During the **Tolerance time**, the system ignores the fact that the reference torque is reached. The checkbox **Use threshold value for mode "stop"** is used to enable the homing method functionality.



### 6.1.15 Tab: Special functions

The checkbox **Flying referencing** activates a function that is similar to

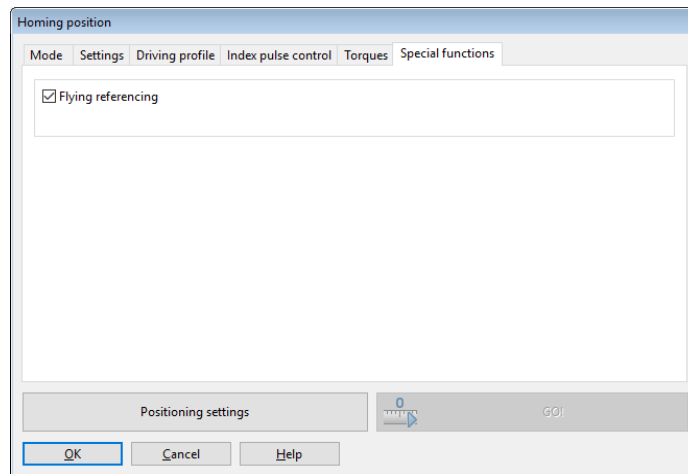


Figure 46: "Homing position" window - "Special functions" tab

The "flying referencing" function can be used to avoid accumulating errors in endless applications. For this purpose, the set and actual position are set to zero on a rising edge at the digital input SAMPLE (0/1). This function roughly corresponds to a rotary axis application. However, in this case, the rotary axis is triggered externally.

#### **INFORMATION** Configuration of the homing runs

When configuring the homing runs, the following must be taken into consideration:

- If multi-turn encoders are used, a homing run is not required after a reset, as the absolute position will always be read out of the encoder. When the application is set up for the first time, a homing run may be useful in order to set the absolute position to a specific value. In this case, an internal zero offset will be calculated. It can be stored in the EEPROM of the angle encoder so that it remains active after every reset. Alternatively, the motor shaft can be turned so that the current actual position has the desired value before the motor is connected to the driven component.
- The speed of movement during the homing run should be selected so that the reference marks can actually be detected by the servo drive. In some cases, very low speeds are necessary to ensure this.
- The deceleration values should be sufficiently high to ensure that the servo drive does not exceed the targets excessively when its direction of movement is reversed.
- When a homing run has been completed without any errors, the drive may not always be positioned precisely at the zero position. This depends on the selected method. A known difference with regard to the index pulse will be taken into consideration if the index pulse is the reference position for the homing run. It is only after a follow-up positioning run to home position that the drive is physically located at zero.

## 6.2 Positioning process

The servo drive has a table of 256 positions which can be used for the advance parameterisation of target positions. In addition, there are special position sets for the fieldbus and jog mode.

### 6.2.1 Global positioning settings

For applications in the position-controlled mode and in positioning mode, certain fundamental parameters must be configured. This is done in the menu **Parameters/Positioning/Global positioning settings**.

Global Positioning Settings

Positioning range

Maximum value 2147483648,000 r

Minimum value -2147483648,000 r

Course program

☒ Course program active

Digital inputs Conflict detection

Positioning set HOME 1

Positioning set START 2

Position rate action synchronous position

0,000 r

Homing

Destination parameters

OK Cancel Help

Figure 47: "Global positioning settings" window

In the case of absolute positioning runs, the new target position is checked to see whether it lies between the limits for the absolute positioning range. The parameters **Minimum** and **Maximum** in the field **Positioning range** indicate the absolute position limits for the position setpoint and actual position. The positioning range always refers to the home position of the drive (see also section 6.1 *Homing process* on page 73).

The options in the field **Course program** (motion program) are explained in section 6.2.7 *Motion program* on page 97. The buttons **Homing** and **Destination parameters** can be used to open the associated windows.

## 6.2.2 Destination parameters: general buttons

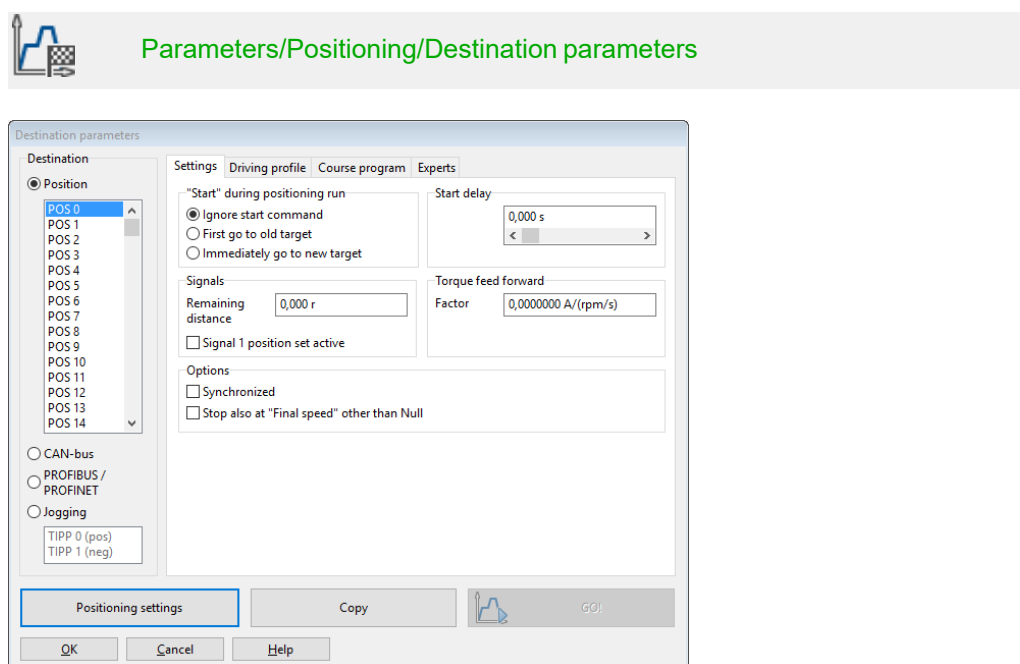


Figure 48: "Destination parameters" window - "Settings" tab

The button **Positioning settings** can be used to change the general positioning settings (e.g. the position limits (see section 6.2.1 *Global positioning settings* on page 86).

The button **GO!** can be used to start a positioning run with the position set that is currently displayed.

The button **Copy** can be used to copy all of the settings for a specific target position to another target position. The following window will be displayed:

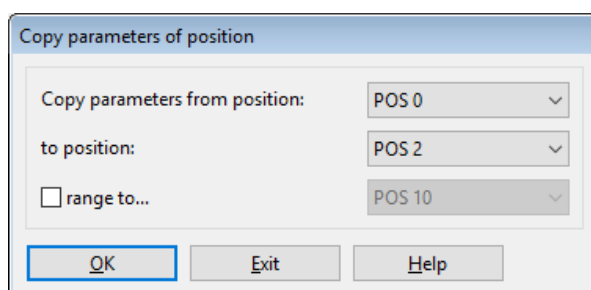


Figure 49: "Copy parameters of positions" window

You can copy a source position to a single target position. To do so, enter data into the two upper fields. If you want to copy a position to several positions, activate the checkbox **Range to....** Then, enter the last target position into the third field.

## 6.2.3 Destination parameters: Settings tab



### Parameters/Positioning/Destination parameters

The target positions are parameterised in the menu stated hereinabove. The window below will be displayed. It includes the tab **Settings**:

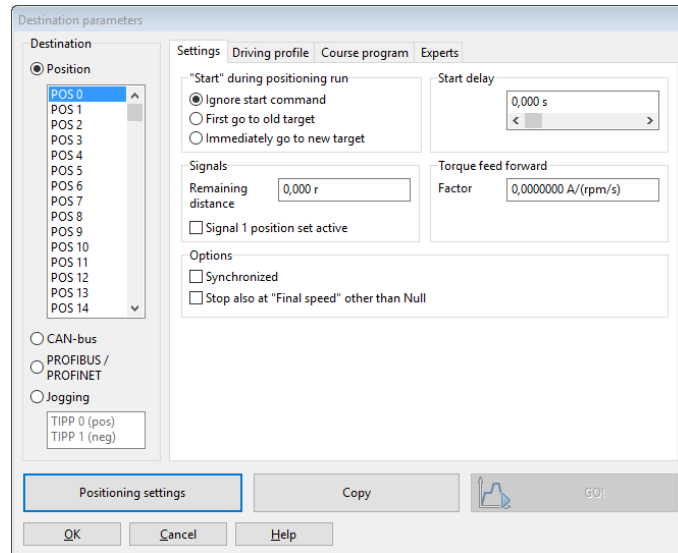


Figure 50: "Destination parameters" window - "Settings" tab

You can select the target position to be parameterised in the field on the left.

The field **Start during positioning run** defines the behaviour of the servo drive if the start command for a new target position is issued during a running positioning run. It has the following options:

- **Ignore start command**: The positioning command for the new position cannot be selected or started until the current positioning run is completed.
- **First go to old target**: The current positioning run will be completed before the new positioning process is started. The next positioning run can be selected prior to the running positioning run. The new positioning run will be started automatically when the current positioning run is completed. If a relative positioning run is started, the reference position for "relative" usually is the last target position.
- **Immediately go to new target**: The current positioning run will be interrupted, and the new position will be approached immediately. In the case of a "relative" positioning run, the reference position for the calculation of the new target position is the current position setpoint. However, in general, this is not a reasonable combination. In the case of the option **Relative to last destination**, on the other hand, the reference position is the (old) target position of the positioning run that has just been interrupted.

**INFORMATION** Bouncing switches

Please note that a bouncing switch at the digital start input may cause problems if **Immediately go to new target** is permitted during a relative positioning run. The drive may move just a little too far!

The input field **Start delay** is used to define a time interval that passes after the start command for a positioning run has been issued and before the desired position is approached.

The field **Messages** can be used to parameterise trigger messages that can be issued via the fieldbus or a digital output. These trigger messages indicate the remaining distance up to the end of a running positioning run. See also section 7.8 *Digital outputs* on page 172.

The field **Torque feed forward** can be used to increase the dynamic behaviour during the positioning runs. This variable must be determined experimentally for the present load case. The default setting is 0.

The checkbox **Synchronised** is used for the **Flying saw** function (see section 6.4 *Flying saw* on page 108). When the "Flying saw" mode is active, the synchronisation can be activated or deactivated by starting a position set. If the synchronisation is active, the position of the encoder (master) that has been selected for the synchronisation is added to the position setpoint. As a result the drive follows the position changes of the master drive.

In most cases, the option **Stop also at "Final speed" other than null** should only be used for position sequences. This means that the next position will be approached immediately after a position has been reached. If the function mentioned above is active and a final speed  $\neq 0$  has been parameterised, the drive will stop, provided that no follow-up positioning has been requested.

## 6.2.4 Destination parameters: Driving profile tab

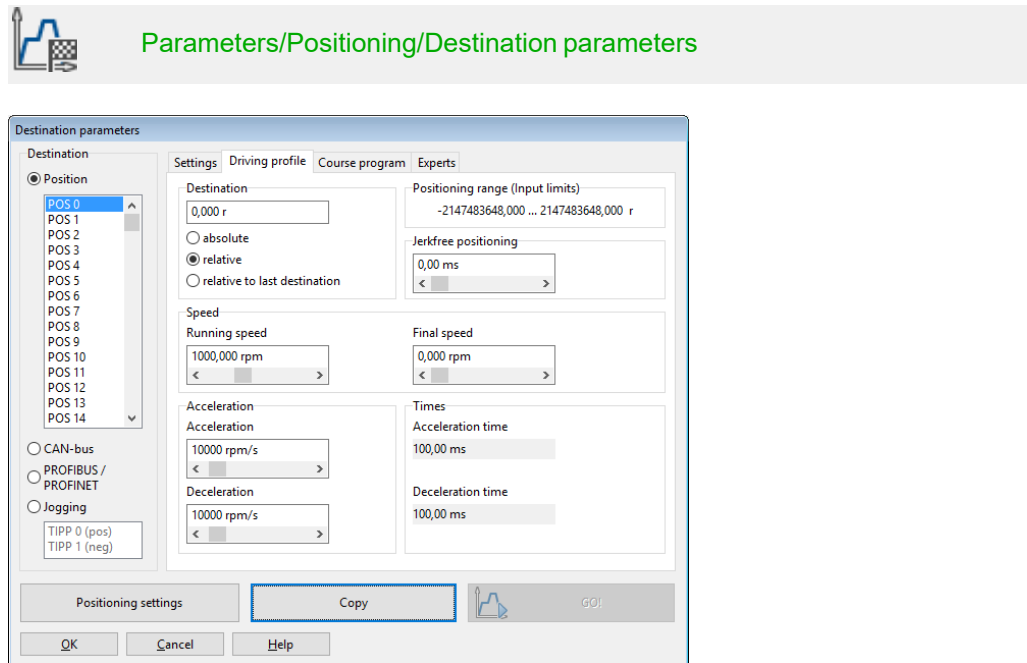


Figure 51: "Destination parameters" window - "Driving profile" tab

You can enter the target position into the field **Destination**. You can state whether the specified target should be interpreted as an **absolute** value (referred to the reference point) or as a relative value. **Relative** refers to the current position setpoint, e.g. during a running positioning run. The option **Relative to last destination**, on the other hand, calculates the new position based on the target position that has been or will be reached.

During a positioning run, the required acceleration can be optionally smoothed by way of a filter. This leads to a jerk-limited or jerk-free positioning run. The associated filter time can be defined in the field **Jerk-free positioning**. The acceleration or deceleration process will be extended by this period of time. The total duration of the positioning run will also be extended by this filter time. If the jerk-free time exceeds the acceleration or deceleration time, it may not be possible to reach the specified speed.

The field **Speed** can be used to specify the speed for approaching the target. The **Final speed** is the speed of the drive upon reaching the target. In most cases, it is zero.

A **Final speed** unequal zero is used to string two positioning runs together without decelerating the drive to zero. In this case, the **Final speed** of the first set is set to the **Speed** of the second set.

The illustration below shows a motion profile with 2 sets (P1 and P2). In the picture on the left, the drive decelerates to zero before the second positioning run is started. In the picture on the right, the final speed of the first set has been set to the profile speed  $v_2$  of the second set. As a result, the drive will not be decelerated to zero between the positioning runs.

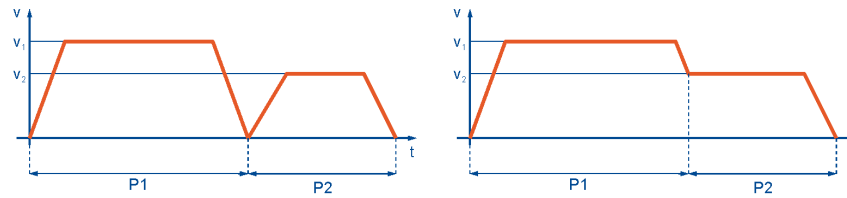


Figure 52: Positioning: motion profile

The fields **Acceleration** and **Deceleration** can be used to configure the acceleration and deceleration values for the drive. The area **Times** shows the resulting time values.

## 6.2.5 Destination parameters: Experts tab

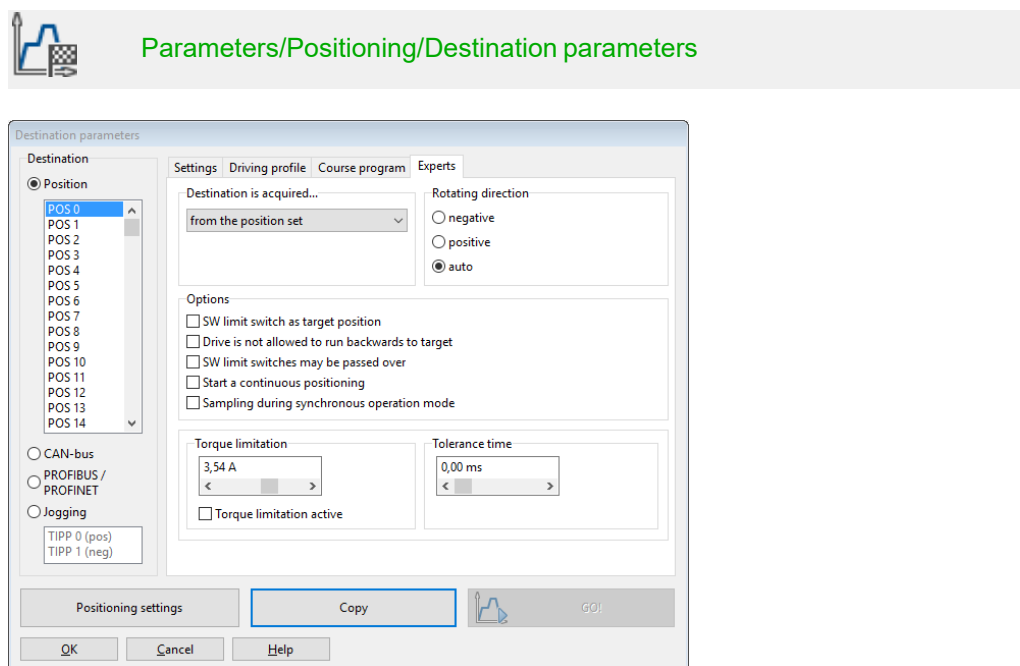


Figure 53: "Destination parameters" window - "Experts" tab

The list **Destination is acquired...** can be used to specify the source of the target position for the current positioning run:

- **From the positioning set**  
This is the default setting. The position specified on the **Driving profile** tab will be used as the target position.
- **From analogue input AIN**  
The current value of the analogue input will be converted into a target position. See also the menu **Analogue inputs**.

The input field **Rotating direction** can be used to specify a fixed direction for the positioning run. This option becomes effective in combination with other options, e.g. rotary axes or SW limit switches as the target position. During a normal relative or absolute positioning run, the positioning control determines the direction of rotation itself. The following options are available:

- **Positive**  
The drive always moves in the direction of the positive limit switch, regardless of the target position value. In general, this option only makes sense in combination with the option **SW-limit switch as target position** (jog mode)
- **Negative**  
The drive always moves in the direction of the negative limit switch, regardless of the target position value. In general, this option only makes sense in combination with the option **SW-limit switch as target position** (jog mode)
- **Automatic**  
This is the default setting. The direction of movement will be determined



automatically based on the current position, target position and any additional options (**absolute**, **relative**, **relative to last destination** etc.).

#### **INFORMATION** Priority of the options

The option **SW-limit switch as target position** is usually used only for position sets in the jog mode. Depending on the selected direction, the negative or positive end of the positioning range will be entered as the target position.

This option has a higher priority than the option **Destination is acquired... from analogue input AIN**.

In some cases, it might be useful to stop the drive as quickly as possible in the positioning mode. This is the case, for example, during the synchronisation deactivation phase of the "flying saw" application. The position set for the synchronisation deactivation can be configured as "relative positioning, destination 0", for example. If the drive is still moving when this position set is started, the drive travels beyond the target position and must then reach the target by moving backwards. The option **Drive is not allowed to run backwards to target** suppresses this behaviour.

If the checkbox **SW limit switches may be passed over** is ticked, the set SW position limits will be ignored. In this case, the user must ensure that this does not cause any damage.

In general, the option **Start a continuous positioning** is only useful if the option **from analogue input AIN0** has been selected for **Destination is acquired....** If this option is active, the target position will be continuously updated by the firmware. This means that the drive will follow any changes at analogue input AIN0. Otherwise, the position would be used only when the start command is issued. As a result of this option, the current positioning run will not be completed. The system will not issue any "Target reached" message. As a result, a new positioning run can only be started if the start option "Immediately go to new target" is activated.

If necessary, the torque for the position set can be limited in the area **Torque limitation**.

Alternatively, the value in the field **Torque limitation** can be configured as a comparison value for the "Target reached" message for this position set. In this case, the checkbox **Torque limitation active** must not be ticked. If the **Tolerance time** is set to a value greater than zero, the torque comparison process will not start until this time has passed. As a result, it is possible to accelerate with a greater torque during this time. When the torque comparison value is reached, or when the tolerance time has passed, the "Target reached" message will be issued. The drive will then stop the positioning process and adopt the current actual position as the new position setpoint. The "Target reached" message will also be issued when the target position that is stored in the position set is reached. Please contact the Technical Support team if you need more information about the parameterisation and torque-based positioning runs.

### ➤ Sampling in synchronous mode

This mode can be used for the "flying saw" function. It delays the start of the position set when a certain lead has been exceeded.

The fast digital input SAMPLE can be used to store the current actual position of a master system (trigger event). The digital input START can then be used to start the

synchronisation process. The current master position is stored by the master frequency input whenever a trigger event occurs.

A new synchronisation process requires a new start command. The target will be calculated based on the stored synchronous position. The advantage of this method is the higher level of precision when the synchronous target is determined as jitter during the start of the synchronisation process is reduced.

**INFORMATION** Start command

The start command can be issued prior to reaching the range of movement of the master position. In this case, the drive will not start the positioning run until the lead has been covered.

This may lead to unwanted positioning runs. If a start command is issued without a preceding trigger signal, error 41-0 will be issued.

## 6.2.6 Moving to specific positions

There are different ways to select target positions and to start the associated positioning runs:

- via digital inputs
- via the parameterisation interface (Kuhnke ServoCommander®)
- via a fieldbus (described in the respective fieldbus manual)

### 6.2.6.1 Positioning via digital inputs

The individual targets are selected via the digital inputs. A rising edge of the digital input that has been parameterised for the start of a positioning run leads to the adoption of the target and the start of the positioning run.

BL 4000-C servo drives have 4 digital inputs (DIN0...DIN3) for the target selection based on 16 positions. In addition, the assignment of functions to the digital inputs of the basic device can be changed (see section 7.7 *Digital inputs* on page 168).

### 6.2.6.2 Positioning via the parameterisation interface (USB/Ethernet)



#### Parameters/Positioning/Go to Destination

All of the 256 positions can be selected via this interface. In addition, one of the position sets is reserved for control via USB/Ethernet. The command syntax for the parameterisation of these positions and for starting is described in the Application Note 38 "RS232 commands for ARS 2000".

The movement to the target position and the homing run can be started by way of Kuhnke ServoCommander® :

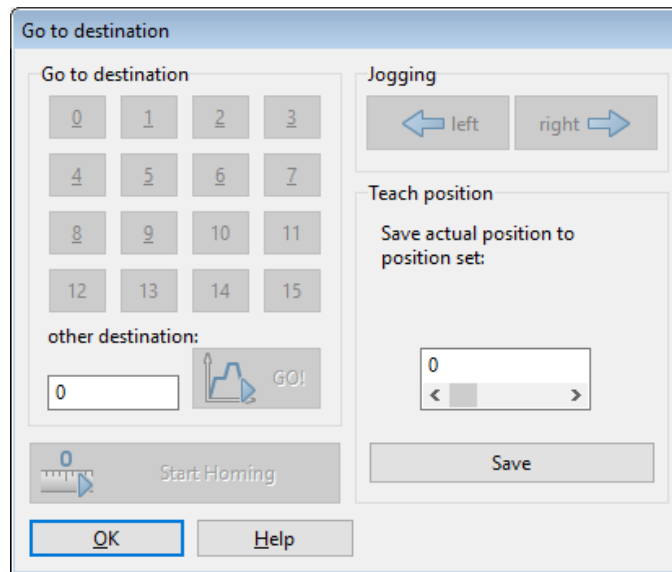


Figure 54: "Go to destination" window

### › Go to destination

- **Destination 0 to 15:** Click the button to move to the associated position.
- **Other destination:** Enter the position number and click the **GO!** button to move to the corresponding position.
- **Start homing:** Click the button to start the homing run.

### › Jog mode

These buttons (left and right) can be used to move the drive. The drive stops when the buttons are released. This function is useful during the start-up process when the drive needs to be moved manually in a position-controlled manner.

**Save actual position to position set:** Here, the current actual position can be stored in a position set as the position setpoint.

## 6.2.7 Motion program

A motion program can be used to link several position sets to form a sequence. These positions will be approached one after the other.

Based on its motion program options, a position set can become part of a motion program. The result is a linked list of positions:

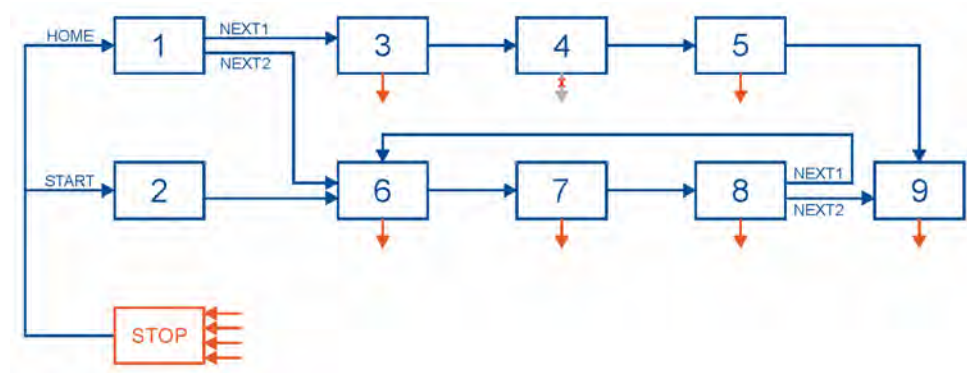


Figure 55: Motion program

### › Features:

- All of the positions can be linked together to form a motion program.
- Apart from linear sequences, which are terminated sooner or later, circular linking is also possible.
- Up to 2 following positions can be set for every step (position) of the motion program. As a result, branching is possible within a motion program. Branching occurs depending on the status of the digital inputs (NEXT1, NEXT2).
- The motion program can control two digital outputs. Three different messages (target reached, remaining distance message and position set active) are available for every step of the motion program.
- A motion program can be started via two default start points (HOME, START) or directly via the target selector (see section 6.2.6.1 *Positioning via digital inputs* on page 95). In addition, it can also be started directly via a fieldbus.
- The motion program can be stopped at any time via a digital input (stop input). This function can be suppressed for individual specific positions (position 4 in this example).
- The motion program can be created and monitored via the parameterisation interface. The application is saved in the parameter set and can be transferred to other servo drives.

### 6.2.7.1 Linking positions



#### Parameters/Positioning/Destination parameters

The following window is displayed under the **Course program** (motion program) tab.

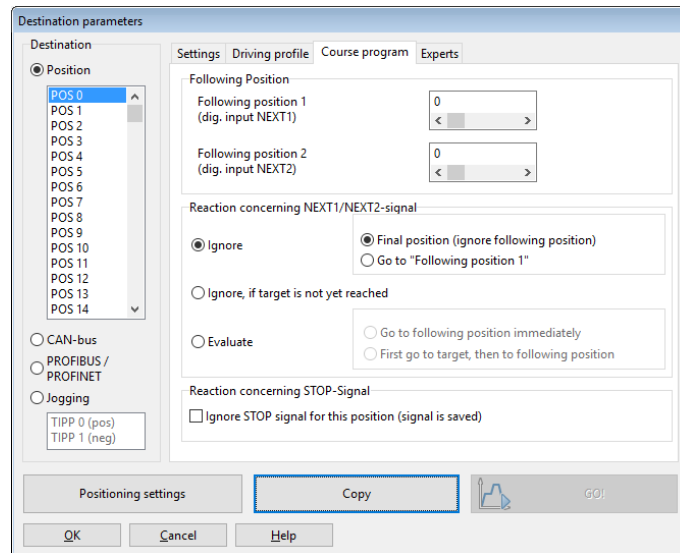


Figure 56: "Destination parameters" window - "Course program" tab

In the area **Following position**, the positions can be linked. Up to two following positions can be specified (field **Following position 1** and **Following position 2**). The following position that the system branches off to depends on the state of the digital inputs:

<b>Position 1:</b>	Following position 1	Digital Input DIN2
	(NEXT1) = 3	
	Folgeposition 2	Digital Input DIN3
	(NEXT2) = 6	

The assignment of the **NEXT1/NEXT2** signals to the digital inputs DIN2 and DIN3 is explained in section 7.7 *Digital inputs* on page 168.

The area **Reaction concerning NEXT1/NEXT2 signal** can be used to specify if and under which condition positions will be approached. This will be explained based on the example in Figure 55 (*Motion program*).

Pos.	Task	Parameterisation
1	If NEXT1 = 1, move to pos. 3 immediately. If NEXT2 = 1, move to pos. 6 immediately.	Following pos: Following position 1 = 3 Following position 2 = 6  Reaction to NEXT1/NEXT2: Evaluate, go to following position immediately
3	At the end of pos. 3, continue with pos. 4 (without any other condition).	Following position: Following position 1 = 4  Reaction to NEXT1/NEXT2: Ignore, go to following position
4	At the end of pos. 4, continue with pos. 5. Do not stop after this position.	Following position: Following position 1 = 5  Reaction to NEXT1/NEXT2: Ignore, go to following position  Reaction to STOP signal: Ignore STOP signal for this position
8	If NEXT1 = 1, first move to pos. 8, and then to pos. 6. If NEXT2 = 1, first move to pos. 8, and then to pos. 9.	Following position: Following position 1 = 6 Following position 2 = 9  Reaction to NEXT1/NEXT2: Ignore, if target is not yet reached
8	If NEXT1 = 1, first move to pos. 8, and then to pos. 6. If NEXT2 = 1, first move to pos. 8, and then to pos. 9. Changes concerning NEXT1/NEXT2 are saved during the movement to pos. 8. When pos. 8 is reached, the most recent signal flank at NEXT1/NEXT2 is evaluated.	Following position: Following position 1 = 6 Following position 2 = 9  Reaction to NEXT1/NEXT2: Evaluate, first go to target, then to following position
9	Final position, stop of the motion program.	Reaction to NEXT1/NEXT2: Final position (ignore following position).

The motion program stops when a final position is reached or when a STOP signal is detected. The assignment of the stop signal is explained in section 7.7 *Digital inputs* on page 168.

If the motion program should not be stopped at certain steps, the options **Ignore STOP signal for this position (signal is saved)** can be selected. In this case, the drive will move to the next position and then it will stop (provided this option has not been set for this position, too).

### 6.2.7.2 Global settings

The global settings for the motion program are made in the menu **Parameters/Positioning/Global positioning settings**. See also section 6.2.1 *Global positioning settings* on page 86. The window includes the following area which is relevant for the motion program:

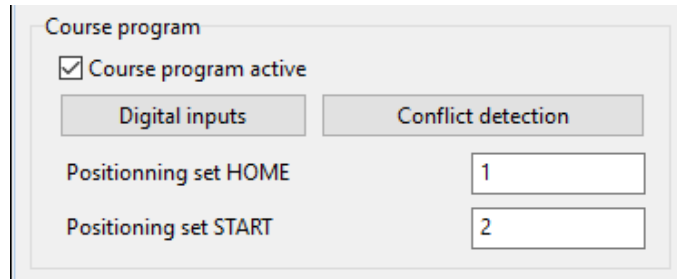


Figure 57: "Global positioning settings (course program)" window

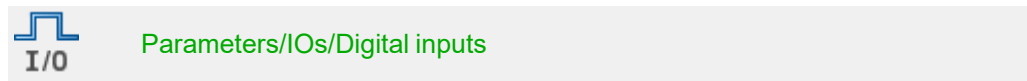
The checkbox **Course program active** determines whether positions will be linked or not. The element is the same as the checkbox "Course program" in the command window.

The inputs fields **Positioning set HOME** and **Positioning set START** can be used to define the entry points into the motion program. To link the position sets with the corresponding digital inputs, click **Digital inputs**, see section 6.2.7.3 *Digital inputs - Motion program* on page 101.

The button **Conflict detection** can be used to open the window **Digital inputs -Functional overview** where inputs that are used twice can be easily identified.



### 6.2.7.3 Digital inputs - Motion program



The following assignments can be defined via the **Course program** (motion program) tab.

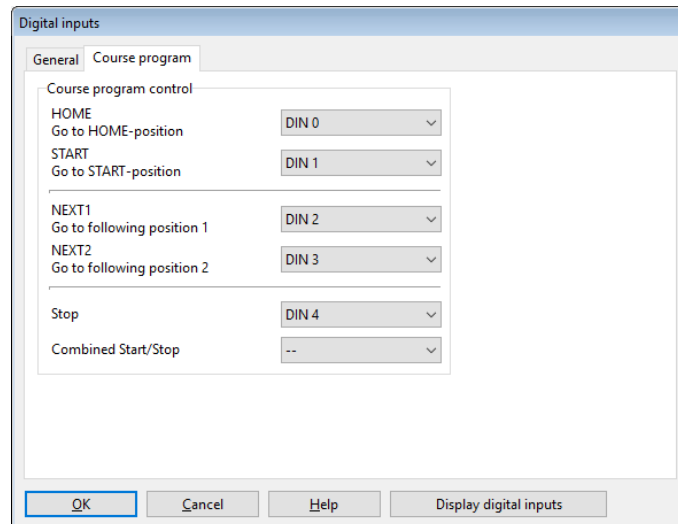


Figure 58: "Digital inputs" window - "Course program" tab

The fields **HOME** and **START** can be used to define the two digital inputs that trigger the entry into the motion program.

The fields **NEXT1** and **NEXT2** are used to define the two digital inputs that are responsible for branching.

Use the field **Stop** to specify the digital input for stopping the motion program.

Use the field **Combined start/stop** to specify the digital input for starting and stopping the motion program.

#### **INFORMATION** Motion program

A motion program can also be started directly by starting a position set. With the aid of the 1 of N assignment of the available DINs, motion programs can be configured more freely. This is the case, in particular, if the STOP and NEXT functions are used as well.

## 6.2.8 Jog mode

Jogging is the controlled movement of a drive to a specific position. The drive continues to move as long as a specific input signal is active.

The servo drive supports jogging in a positive and negative direction. A separate speed of movement and separate acceleration values can be specified for every direction. In addition, it is possible to specify one input for jogging in the positive direction and one input for jogging in the negative direction.

The jog mode must be activated in the command window.

The speed of movement and the acceleration values in the positive and negative direction are parameterised in the position window: ([Parameters/Positioning/Destination parameters](#))

The digital inputs are assigned in the window [Parameters/IOs/Digital inputs](#) on the [Jogging](#) tab (see the section 7.7.1 *Configuration of the digital inputs* on page 169):

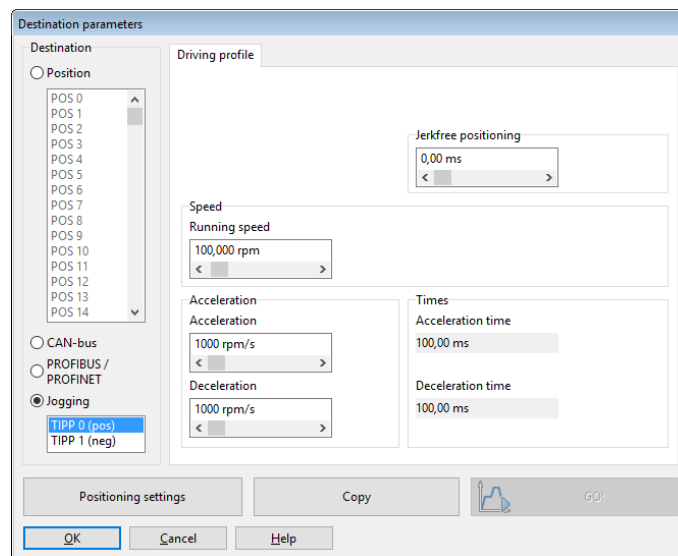


Figure 59: "Jogging" window

## 6.2.9 Setting of digital outputs



### Parameters/IOs/Digital outputs

The setting of digital outputs in the positioning mode can be used to inform a superordinate control system that a positioning run has been, or is being, completed:

Option 1	Position setpoint = target position
Option 2	Actual position = target position
Option 3	Remaining distance up to the end of a positioning run reached
Option 4	Homing position valid
Option 5	Position trigger

The configuration of the digital outputs is described in section 7.8 *Digital outputs* on page 172.

As far as the second option (actual position = target position) is concerned, it is possible to define a tolerance window in which the digital output will be set. See section 7.8.2 *Configuration of the messages for the digital outputs* on page 174.

For option 3, trigger messages can be parameterised in the field "Message" under **Parameters/Positioning/Destination parameters**. These messages can then be output via a digital output. These trigger messages indicate the remaining distance up to the end of a running positioning run. See also section 7.8 *Digital outputs* on page 172.

In the case of option 4, the servo drive sets the digital output after the drive has been homed successfully.

Option 5 can be used to define any positions at which a digital output should be set (see also section 7.9 *Position triggers* on page 178).

## 6.3 Applications with several angle encoders

So far, only applications with a single angle encoder have been discussed. The angle encoder provides information about the commutation position and about the actual speed and position. The individual pieces of information can also be provided by more than one encoder. To do so, open the menu **Operating mode/Encoder selection**.

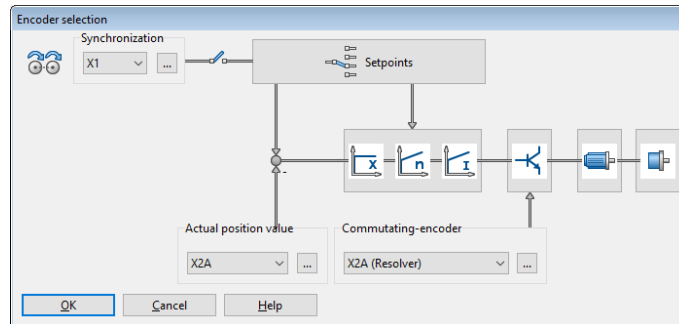


Figure 60: "Encoder selection" window

### **INFORMATION** Commutation position and actual speed value

The information about the commutation position and actual speed value is always provided by the same angle encoder!

Using a separate angle encoder for the position information may be useful in the following case:

The motor is connected to a positioning mechanism via a transmission. The positioning mechanism must fulfil extremely high requirements in terms of its accuracy. The positioning mechanism has a high-resolution angle encoder. In this case, it makes sense to use this information for the determination of the current position, while the speed and commutation position information is still provided by the motor encoder.

Another class of applications can be summarised under the concept of "synchronisation".

In this case, several servo drives are synchronised by coupling them in a master-slave setup. The master provides the slave with the position information via the master frequency output (X1) and the slave receives this information via the external master frequency input (X1). For this setup, the connectors must be connected by way of a cable.

The master operates in one of the operating modes described earlier (**speed control**, **positioning mode**), while the slave operates in synchronised mode.

Among others, the following applications are possible with this configuration:

- Speed-synchronous movement
- Position-synchronous movement
- Flying saw

### 6.3.1 Improved position control with two angle encoders

When a second encoder is used at the output, the control of a target position can be improved. At the same time, the servo drive can be synchronised with an external synchronisation source via an additional input (3-encoder operation).

The following picture shows the functional diagram in a setup with two encoders.

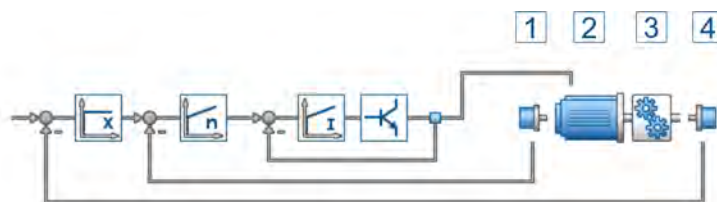


Figure 61: Control diagram in a setup with two encoders

Angle encoder (1) is responsible for the commutation of the motor (2). The position encoder (4) captures the position of the driven axis downstream of a downstream transmission.

As a result, an existing transmission (3) of the driven axis can be included in the actual position value and compensated for.

#### ➤ Using two angle encoders

##### **NOTICE** Damage to property due to uncontrolled movements

If two encoders are used, the system may perform uncontrolled movements if the signs or gear factors of the control circuits do not match.

This is why the following procedure is recommended: First, start the drive without the second encoder. Then, activate the encoder difference monitoring function and the following error monitoring function for the rest of the start-up process.

To configure a system with two angle encoders, proceed as follows:

The first encoder system (1, drive) provides the commutation position and actual speed value. This is why this encoder should be used for the start-up process.

To add the second encoder (4, output) for the superimposed position control, it must be ensured that the adaptation of the transmission matches the configuration of the main encoder on the motor. This is why it is recommended to configure a rotatory system in a first step and to ensure that the number of revolutions of the second encoder is the same as the number of revolutions of the main encoder. The easiest way to do this is to move the drive in a speed-controlled manner over the range of movement and to determine the position of the main encoder at both end points by way of the actual value window. Then, use the controller overview to select the second encoder as the actual value encoder. Once again, note down the actual position at the end points of the range of movement. The correct sign is particularly important.

In order to be able to detect errors of the two encoder systems, the encoder difference monitoring function should be activated. As a result, the system can detect a broken shaft coupling, for example.

The adaptation to the desired system of units can then be realised by way of the display units. It is important to select appropriate combinations.

Typical configurations of two encoders (drive/output):

- Resolver/incremental encoder
- Resolver/analogue SIN/COS encoder
- Resolver/serial encoder
- EnDat, HIPERFACE® encoder/incremental encoder X1

If a serial encoder with a parameter set (EnDat/HIPERFACE®) is used at the output, the commutation data of the encoder parameter set will be suppressed when the firmware is started. Instead, the commutation data for the main encoder taken from the internal parameter set of the servo drive will be used.

There must be no slack play between the drive and output. If possible, preloaded transmissions should be used.

### 6.3.2 Synchronisation/parameterisation of the master

In master-slave mode, the master emulates an incremental encoder which is described by the parameters in the menu [Operating mode/Incremental encoder emulation](#).

### 6.3.3 Synchronisation/parameterisation of the slave

In synchronisation mode, the slave must be informed that the angle encoder information will be provided via the master frequency input X1. This can be done in the command window where the option [Synchronised](#) (for position- and speed-synchronous applications) or [Flying saw](#) (only flying saw) must be selected:

To fine-tune the synchronous application, click the [Synchronisation wizard](#) button and follow the instructions. The settings can also be made manually. The following parameters must be checked:

- Selection of the correct encoder configuration under [Operating mode/Encoder selection](#)
- Selection of the correct encoder parameters under [Parameters/Device parameters/Angle encoder settings](#)
- Selection of the correct setpoint management (e.g. for speed-controlled operation) under [Operating mode/Setpoint selection](#)
- Selection of the correct position sets (for flying saw: synchronous or not) under [Parameters/Positioning/Destination parameters](#)

### 6.3.4 Position-synchronous operation

The BL 4000-C servo drives can be used in a master-slave configuration, hereinafter referred to as "synchronisation". The servo drives can be a master or a slave. If the servo drive is the master, it can provide the slave with its current rotor position via the incremental encoder output.

With this information, the slave can determine the current position and/or speed of the master via the incremental encoder input.

The synchronisation can be activated/deactivated via **communication interfaces** or **digital inputs**.

In purely position-synchronous operation, the position setpoint is taken directly from the encoder interface that has been selected for the synchronisation. The synchronous speed is used as a speed feedforward control value for the speed controller (speed setpoint).

To set up the purely position-synchronous operation, select the option **Synchronised** in the field **Synchronisation** of the command window. **Positioning** must be selected as the operating mode.

### 6.3.5 Special considerations concerning the resolution of the master frequency

In most cases, the setting for the resolution of the incremental signal must be comparatively small as there may be problems with the transmission of the digital signals if the frequency is too high. In addition, the maximum frequency must be smaller than the maximum input frequency of the incremental input.

This results in a high quantisation of the synchronous speed. This, in turn, leads to pronounced setpoint noise which can be heard in the drive. This influence can be reduced with a corresponding filter.

This filter can be configured under **Parameters/Controller parameters/Speed controller** on the **Filter** tab.

## 6.4 Flying saw

### **⚠ WARNING** Risk of injury due to unexpected automatic starting

Unexpected automatic starting may occur if the synchronisation process is started due to an external event.

Ensure that all of the drives are switched off before any person accesses the danger area.

### **INFORMATION** The following section is for experienced users

The following requirements must be fulfilled:

- Safe use of the servo drive and knowledge about the relevant safety regulations.
- A robust test setup with limit switches, emergency cut-out switches and non-bouncing trigger signals.
- Knowledge about electronic components (light barriers) and the operation of an oscilloscope.
- Safe use of the external control system.

"Flying saw" is a term used for cases in which the synchronisation is activated or deactivated depending on a position set: Synchronous position sets (for synchronisation with regard to the rotary motion of the master) are combined with unsynchronised position sets (for the movement to the rest position/holding position). The synchronisation is activated and deactivated to avoid jerky movements.



### 6.4.1 Conventional synchronisation

An external setpoint position can be specified for the servo drive via the master frequency input. This position will be converted by way of a certain factor (electronic transmission) in the synchronisation unit.

In the **Synchronised** mode (command window), this setpoint is directly supplied. The synchronisation activation and deactivation is possible at any time by applying or removing the synchronous position signal. However, if the synchronisation is activated or deactivated while the motor is running, the abrupt setpoint change causes a rather strong jerk. The maximum acceleration that occurs during this process is limited only by the maximum motor current. The resulting thrust can lead to strong oscillations which may damage the system. Since the servo drive can follow the abrupt setpoint change only slowly, rather large, temporary following errors result. This is why activating the synchronisation while the motor is running is not permissible in most cases.

In the **Flying saw** mode, the synchronisation activation and deactivation is performed during a positioning run. As a result, there will be no abrupt setpoint change.

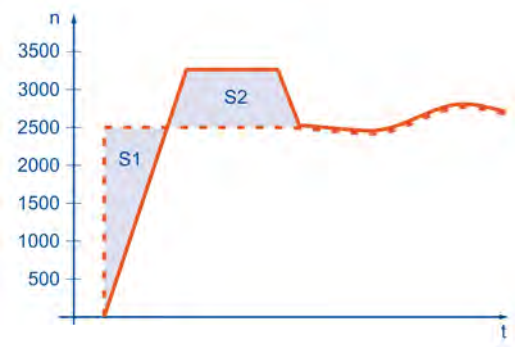


Figure 62: Synchronisation process

The servo drive follows the synchronous position signal with a delay in compliance with the acceleration and maximum excess speed specified in the position set. This leads to a position difference (area S1) that the servo drive makes up for in a controlled and defined manner and without a following error (area S2).

In addition, relative or absolute distances S can be taken into consideration for the positioning process. In this case, the following is true for S2:  $S2 = S1 + S$

## 6.4.2 Parameterisation and configuration

After the I/Os have been wired in a suitable manner for the sampling process and the start of the positioning process, a range of parameters must be configured in various menus to realise the "flying saw" function:

The synchronous position information is supplied to the servo drive by way of incremental encoder pulses (either by the servo drive that drives the conveyor belt or by another encoder that is installed on the conveyor belt). This is why the master frequency interface must be configured as an input. In the menu **Operating mode/Encoder selection**, the master frequency input X1 must be selected as the synchronisation source.

The index pulse is not required for this application. It should be deactivated. If it is still connected and activated, it must be ensured that at least one index pulse must be received by the servo drive after the system has been switched on and before the first synchronous motion is performed. If this is not the case, the first index pulse during a synchronous motion may cause jerking as the position will be reset.

The line of the incremental encoder or the master frequency of the master drive must be entered into the menu **Parameters/Device parameters/Angle encoder settings** on the **X1** tab.

To ensure that the linear drive moves at the same speed as the conveyor belt during a synchronous run, the gear ratio of the linear drive and the circumference of the drive rolls of the conveyor belt must be taken into consideration. The resulting factor must be entered as a fraction into the electronic transmission menu **Angle encoder settings** on the **X1** tab. The direction of rotation can be indicated by a corresponding sign of the numerator.

The settings can be checked by briefly activating the synchronous motion in the **command window** (**Synchronisation/Flying saw**). The drive should move in synchronism with the conveyor belt.

### › Position sets

The following processes must be parameterised in the position sets:

**Set 0:** Movement to the starting position

**Set 1:** Synchronisation activation and gripping of the object in a "synchronised movement"

**Set 2:** Synchronisation deactivation and depositing of the object on the pallet

### 6.4.3 Synchronisation activation and deactivation (example)

The following example describes how the function "Gripping of moving objects on a conveyor belt" can be realised. It is assumed that the objects move on a conveyor belt with the variable speed  $V_{\text{sync}}$ . The gripper is mounted on a linear drive. The gripping process is triggered by a light barrier.

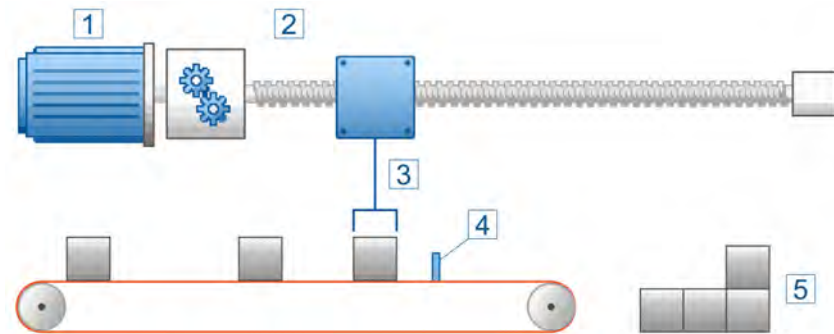


Figure 63: Flying saw overview

Pos.	Description
1	Motor
2	Linear unit (here: spindle axis)
3	Gripper
4	Light barrier
5	Deposit area

### 6.4.4 Starting position/position set 0

The gripper must move to its starting position P0. This is an absolute positioning process without any synchronisation. Only the starting position P0, speed of movement  $V_0$  and acceleration must be specified.

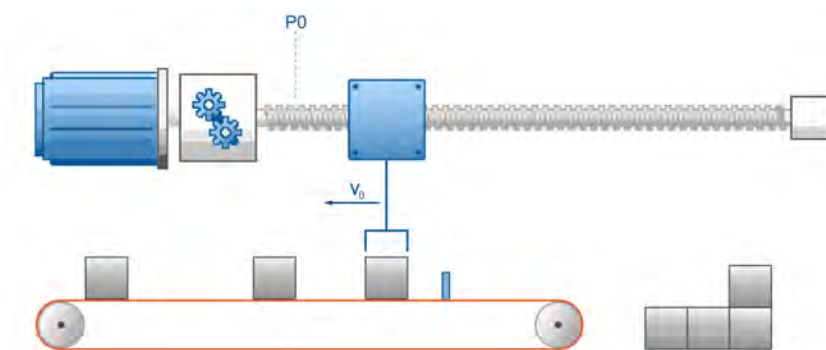


Figure 64: Movement to the starting position

### 6.4.5 Gripping of the object/position set 1

When the object reaches the light barrier, the gripper must move with the same speed  $V_{\text{sync}}$  as the conveyor belt. In addition, it must position itself precisely above the object. Consequently, P1 results from the position of the light barrier minus half of the width of the object. Since the starting position P0 is known, the positioning process can be performed in a **relative** or **absolute** manner.

The option **Synchronised** must be selected in the position set. As a result, the synchronisation will be activated when the positioning process begins. The offset, which is due to the controlled acceleration up to the speed of the conveyor belt, will be compensated in a controlled manner. The speed of movement, which is used for this purpose, corresponds to the speed of the master plus the speed of movement that is specified in the position set.

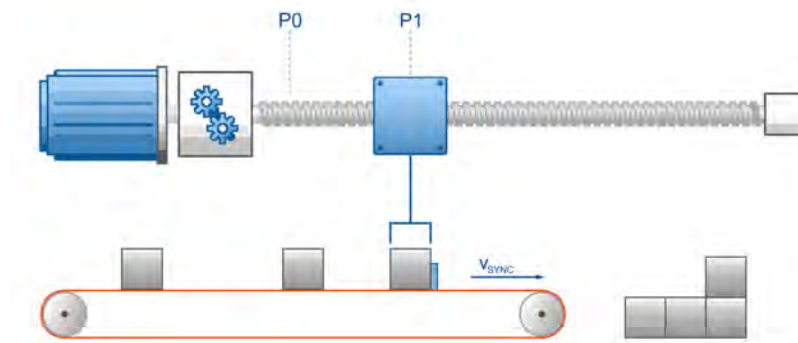


Figure 65: Gripping of the object and synchronous movement

When the gripper has reached the object and is located precisely above it, it signals to the system that it has reached its target. For example, the PLC can be informed via a digital output that the object can now be picked up. Alternatively, another process can be initiated by way of a motion program.

It is also possible to perform positioning processes relative to the conveyor belt. In all of the cases, the option **Synchronised** must be activated in the corresponding position sets. It is possible, for example, to move the objects on the conveyor belt to another location on the conveyor belt.

### 6.4.6 Depositing of the object/position set 2

The gripper must now deposit the object on the pallet. The precise starting position of this positioning process is not known. This is why the gripper must move to the pallet based on an absolute target position.

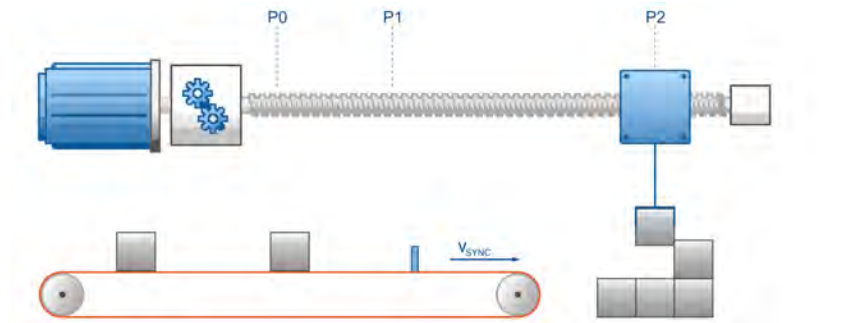


Figure 66: Depositing of the object

The option **Synchronised** must be deselected. As a result, the synchronisation will be deactivated when the positioning process begins. The positioning process begins with the current speed setpoint, i.e. with the speed of the master. This results in a controlled synchronisation deactivation.

### 6.4.7 Starting position/position set 0

When the object has been placed on the pallet, the gripper can return to the starting position using position set 0.

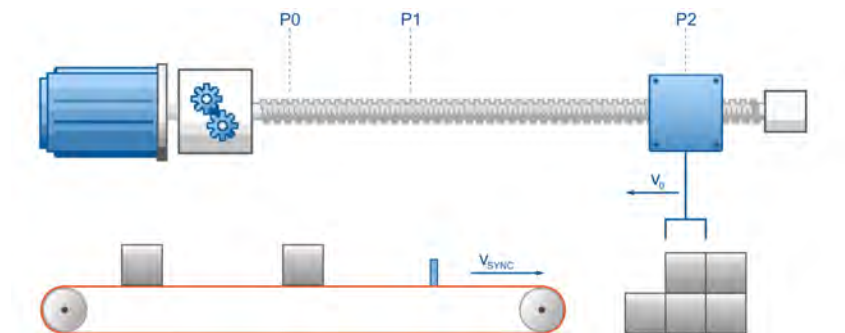


Figure 67: Return to the starting position

### 6.4.8 Wiring

To ensure the optimum precision of the synchronisation process, the signal of the light barrier must be supplied to the start/sample input without delay or jitter.

During the synchronisation process, any delay or jitter will lead to a position deviation based on the following relationship:

$$\Delta\varphi = \frac{n}{60Upm} \cdot \frac{\Delta t}{1000ms} \cdot 360^\circ$$

If the light barrier has a jitter of  $\pm 5$  ms, for example, a position deviation of  $\pm 90^\circ$  will result in the case of  $n = 3000$  rpm. This deviation can only be reduced by way of a better light barrier.

### 6.4.9 Compensation of constant delays

Constant delays of a light barrier can be compensated rather well. They will only have an effect if the conveyor belt runs at variable speed, e.g. when the system is started.

### 6.4.10 Mechanical compensation (lead)

If the system runs at a speed of  $2000 \text{ rpm} \pm 500 \text{ rpm}$ , for example, the light barrier can be positioned in such a manner that the delay is exactly compensated at  $2000 \text{ rpm}$ . At other speeds, only the speed difference will be taken into consideration. If, for example, the system, which is compensated at a speed of  $2000 \text{ rpm}$ , runs at  $2200 \text{ rpm}$ , the following error results if the light barrier has a delay of  $10 \text{ ms}$ :

$$\Delta\varphi = \frac{\Delta n}{60Upm} \cdot \frac{\Delta t}{1000ms} \cdot 360^\circ = \frac{2200Upm - 2000Upm}{60Upm} \cdot \frac{10ms}{1000ms} \cdot 360^\circ = 12^\circ$$

### 6.4.11 Compensation by calculation

If the delay of the light barrier is precisely known, it can be entered into the servo drive as a lead parameter, e.g. as an offset with regard to a relative target position. When the synchronisation process starts, the servo drive calculates the required lead based on the current synchronous position and takes it into consideration in terms of its position setpoint.

### 6.4.12 Triggering the starting process based on several sources

When connecting the light barrier, it must be ensured that the delay times are as short as possible. A connection through a PLC does not make any sense in many cases (high speed, high positioning requirements).

In these cases, the light barrier should be connected directly to the start input of the servo drive. However, as the PLC must also trigger starting processes, the signals must be merged in an appropriate manner.

Variant 1:

The signal of the PLC and the signal of the light barrier are both connected to the start input. Disadvantage: The light barrier may trigger unwanted positioning processes.

Variant 2:

The light barrier is connected to a relay via which the PLC can control the access of the light barrier.

### 6.4.13 Position offset due to cycle times

As far as positioning processes are concerned, the servo drive has a cycle time of approximately 400 µs. The necessary pieces of information (position, speed) are available in their entirety only at specific points of time and it is only at these points of time that a synchronisation process can be initiated. The system-inherent inaccuracy (jitter) results in a position error as follows:

$$\Delta\varphi = \frac{\Delta n}{60Upm} \cdot \frac{0,4ms}{1000ms} \cdot 360^\circ$$

To compensate for this, the sampling function can be used. For this purpose, the light barrier must be connected to the sample input. When a sampling event occurs, the actual position is saved together with the synchronisation position. This information is then used for the subsequent synchronisation process to compensate for the offset which is caused by the cycle times.

### 6.4.14 Lead of the actual position when the light barrier is not located in the range of movement of the drive

Sometimes, a trigger event, which must be used as the basis for a synchronisation, occurs, but the object to be gripped has not reached the range of motion of the axis yet. To handle this situation, a lead (menu [Parameters/Positioning/Global positioning settings](#)) must be specified together with a delay concerning the sampling process and start of the position set ([Parameters/Positioning/Destination parameters](#), [Experts](#) tab).

## 6.4.15 Summary

The checkbox **Synchronised** of the position set is used for the "flying saw" function. When the **Flying saw** mode is active in the command window, the synchronisation can be activated or deactivated by starting a position set. If the synchronisation is active, the position of the encoder (master) that has been selected for the synchronisation is added to the position setpoint. As a result, the drive follows the position changes of the master drive.

If the master is not at a standstill when the positioning process is started, the resulting offset will be compensated in a controlled manner. The speed of movement, which is used for this purpose, corresponds to the speed of the master plus the speed of movement that is specified in the position set. As far as the acceleration values are concerned, the values stored in the position set that has been started will be used.

If the checkbox in the position set is not ticked, the synchronisation process will be stopped when the positioning process starts. The positioning process begins with the current actual speed, i.e. with the speed of the master. This results in a controlled synchronisation deactivation.

The entire sequence can be automated rather well in the servo drive if the motion program option (course program) is used. A superordinate control system can poll the output **Signal 1 position set active** to determine whether a synchronisation process is active or not.

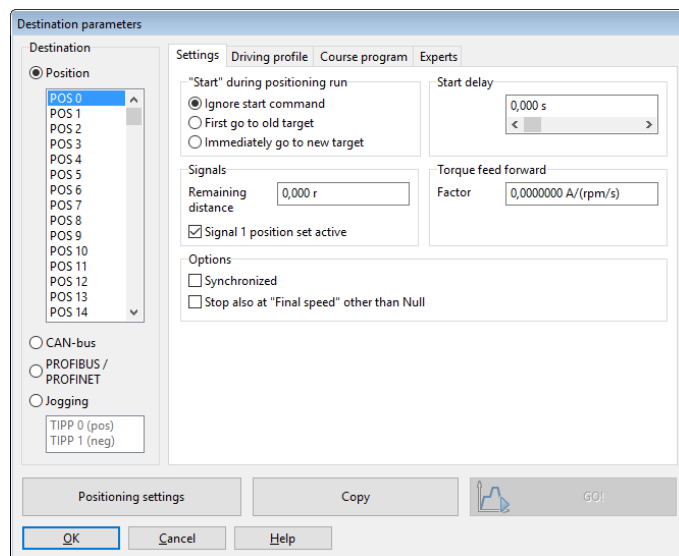


Figure 68: "Destination parameters" window - "Settings" tab



## 6.5 Rotary axis mode

### Parameters/Application parameters/Rotary axis

This menu is used for the configuration of rotary axis applications. They are used, for example, for indexing rotary tables. In the case of a rotary axis application, the actual position is artificially limited to a certain interval. If the actual position exceeds the limit of the interval on the right-hand side, it assumes the limit value for the left-hand side and vice versa.

A rotary axis configuration can be very useful for indexing rotary table applications in combination with motion programs and position triggers. Advantages:

- No accumulating position offset during continuous indexing in the same direction (this requires a gear factor that can be represented as an integer numerator and denominator)
- Sequences for retracting movements can be implemented by way of motion programs
- Position triggers inform the superordinate control system about specific positions or zero positions of the indexing rotary table
- Reduced programming at the control system side

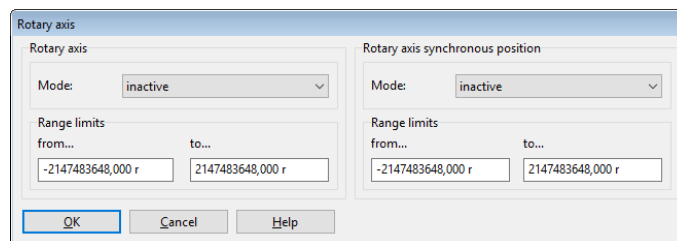


Figure 69: "Rotary axis" window

The window is divided into two areas:

The **Rotary axis** area can be used to configure the standard rotary axis functionality for the actual position.

The **Rotary axis synchronous position** area can be used to configure a separate rotary axis functionality for the synchronous position. As a result, the master position (synchronous position) and slave position can use different position ranges.

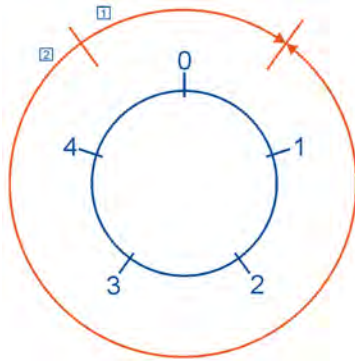


Figure 70: Rotary motion in the rotary axis mode

The options can be selected for the **Mode** of the rotary axis:

**Inactive:** The rotary axis is not active. The actual position will not be limited.

**Active:** The rotary axis is active. The synchronous position will be limited.

Apart from the activation, the way the servo drive performs the positioning process can also be specified for the standard rotary axis:

**Shortest distance:** The rotary axis is active. The shortest distance will be used for the positioning process. For example, if the rotary axis range is defined as the range from 0 r to 5 r and the current actual position is 4.5 r, the new position setpoint of 0.5 r will be approached by way of a movement in the positive direction as this is the shortest distance for reaching this position (movement 1).

**Direction from position set:** The rotary axis is active. The direction of rotation is specified in the position set. See also section 6.2.5 *Destination parameters: Experts tab* on page 92.

**Direction always positive:** The rotary axis is active. The system always selects the positive direction of movement for all of the positioning processes and movements (movement 1).

**Direction always negative:** The rotary axis is active. The system always selects the negative direction of movement for all of the positioning processes and movements (movement 2).

The area **Range limits** is used for defining the interval for the limitation of the actual position.

#### **INFORMATION** Interval limits

The lower limit of the interval is included in the interval while the upper limit is not part of the interval.

As a result, the user can adjust the values in a particular comfortable manner. If, for example, the user wants to define a rotary axis with exactly one revolution, the interval can be defined from 0 r to 1 r.

## 7 Additional settings

This chapter provides extensive information about additional settings for adapting the servo drive perfectly to your application, e.g.:

- Configuration of digital inputs and outputs
- Adaptation to different types of angle encoders
- Brake control

### 7.1 Bluetooth® communication

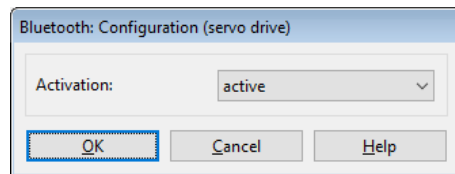


Figure 71: "Bluetooth: Configuration (servo drive)" window

Servo drives of the BL 4000-C series have an integrated Bluetooth® interface via which the control state, actual values, error message, etc. can be displayed on an Android or iOS device (smartphone, tablet PC, etc.).

The interface is activated by default. It can be deactivated under **Options\Communication\Communication parameters Bluetooth\Configuration (servo drive)**. The deactivation of the Bluetooth interface can be stored permanently in the parameter set.

Please contact the Technical Support team if you need more information about the Bluetooth® interface.

## 7.2 Oscilloscope



### Display/Oscilloscope

The oscilloscope function of the parameterisation program can be used to display the development of signals as well as the digital states of the servo drive. There are two windows: the actual oscilloscope and the window for configuring the oscilloscope.

### 7.2.1 Oscilloscope window

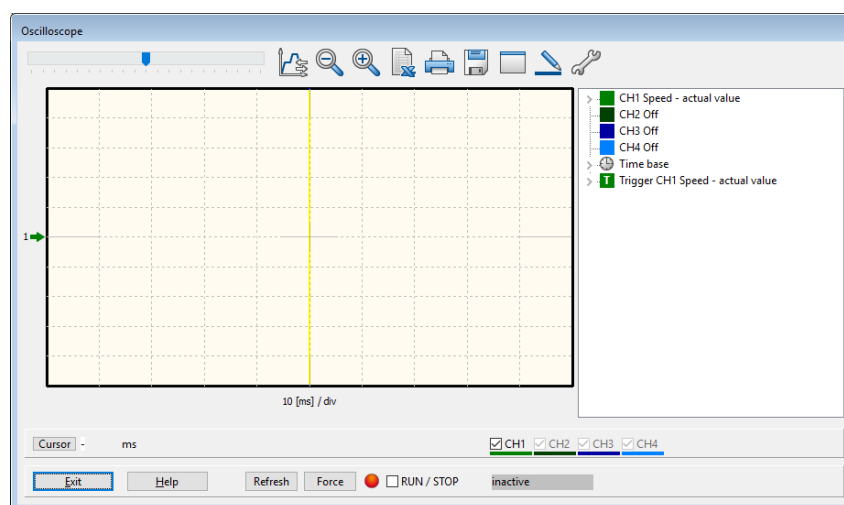






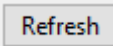
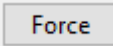


Figure 72: "Oscilloscope" window

#### > Oscilloscope buttons

The oscilloscope has several buttons to start specific activities:

Symbol	Meaning
	Shifts the displayed area in the horizontal direction.
	Opens the reversing generator menu.
	Stops the zoom function.
	Zoom function: Zooms in to the area of the oscilloscope window that has been selected by way of the mouse.
	Opens Excel and creates a spreadsheet containing the values of the last measurement (Excel must be installed on the PC).
	Prints the oscilloscope window.

Symbol	Meaning
	Saves the oscilloscope window as a bitmap file.
	Maximises the oscilloscope window.
	Minimises the oscilloscope window.
	Displays the signal curves as a thick/thin line.
	Opens the settings window.
<input checked="" type="checkbox"/> RUN / STOP	Defines/indicates whether the oscilloscope is activated or deactivated.
	Indicates whether the oscilloscope waits for a trigger event (green) or whether it reads out data (red).
	Refreshes the representation manually.
	Immediately initiates a trigger event. Can be used for testing the channel settings.

The current settings are displayed in the right-hand side area of the oscilloscope window. Double-clicking a channel opens the associated settings window.

## 7.2.2 Oscilloscope settings

The "Oscilloscope settings" window includes several tabs for precise settings.

- **CH1...CH8**: selection of the measured quantity of channel 1...4 (can be extended to 8)
- **Time base**: setting of the time base
- **Trigger**: configuration of the trigger
- **Options**: for example, for saving the oscilloscope settings

The tabs will be explained in detail in the following sections.

### 7.2.2.1 Tabs: CH1 ... CH8

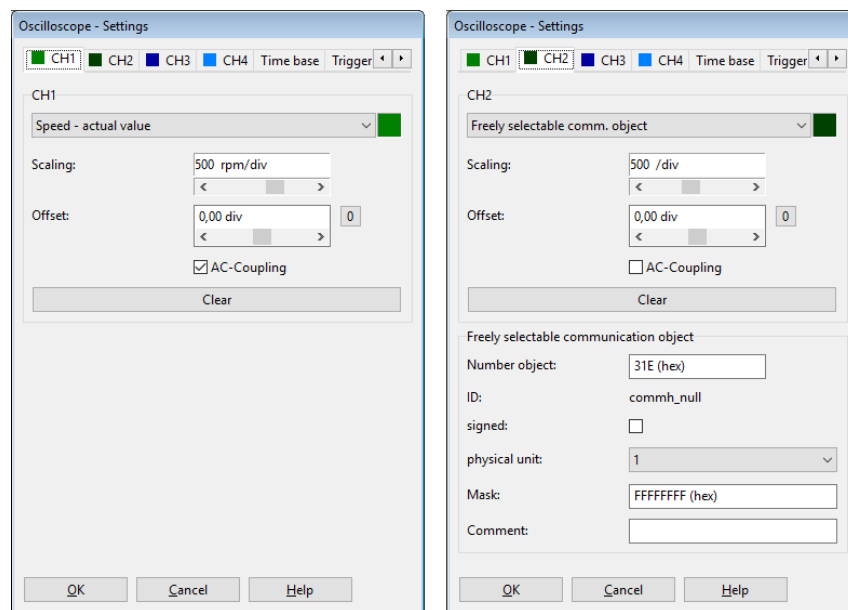


Figure 73: "Oscilloscope" window - "CHx" tab

The oscilloscope has up to eight channels. The following settings can be selected on the tabs CH1 ... CH8 for the corresponding channels:

#### Measured quantity to be displayed

Click the drop-down list of the channel and select the physical quantity or event that you would like to display.

#### Colour

Click the coloured field. A dialogue window for selecting a colour will be displayed.

#### Scaling

This field is used to define the Y-scaling of the value.

### Offset

This field is used for shifting the curve in the vertical direction. Click the button 0 to reset the offset to zero.

### AC-coupling

Select this option to display the signal without its mean value. This means, for example, that a sinusoidal voltage with a DC offset would be displayed around the neutral line regardless of the DC component.

If you click **Delete** (or Clear), the corresponding channel will be deactivated.

If **Freely selectable communication object** is selected as the quantity to be displayed, you can display any parameter of the servo drive (communication object) by way of the oscilloscope function. The following additional information is required:

- The object number of the communication object
- Information as to whether the object returns a value with a sign. In this case, the checkbox **signed** must be selected.
- The physical unit of the object
- A mask. This mask is used to single out and display individual bits of a communication object. In the case of analogue values, this mask should be set to FFFFFFFF (hex). The main purpose of this mask is to display the individual bits of a status word.

### 7.2.2.2 Tabs: Time base

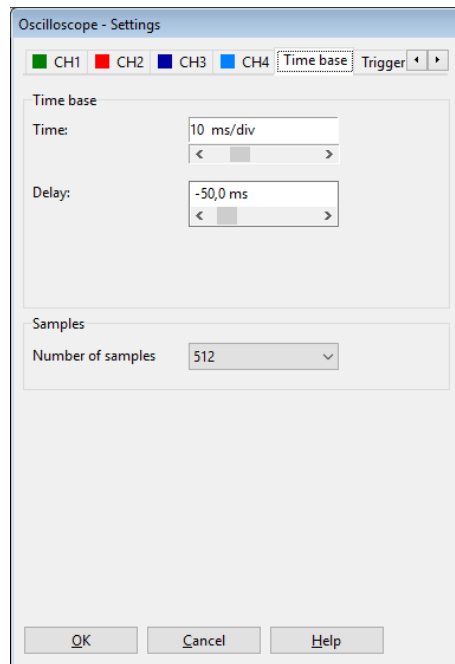


Figure 74: "Oscilloscope" window - "Time base" Tab

The upper **Time** slide can be used to define the time resolution. A value of 10 ms/div, for example, means that the width of one square of the oscilloscope display corresponds to 10 ms.

The **Delay** slide can be used to determine the position of the trigger event on the oscilloscope screen. 0 means that the trigger event will be displayed on the left-hand edge of the oscilloscope screen. A negative delay value means that the events prior to the occurrence of the trigger condition will also be recorded ("pretrigger"). In the case of a negative value, the trigger mark will be shifted to the right into the oscilloscope screen.

The drop-down list **Number of samples** in the field **Samples** can be used to change the number of recorded values per channel. Please note that the data transfer will take considerably more time if the maximum number of samples is selected.



### 7.2.2.3 Tabs: Trigger

The drop-down list **Trigger source** can be used to specify the channel that will be used for starting ("triggering") the oscilloscope recording process.

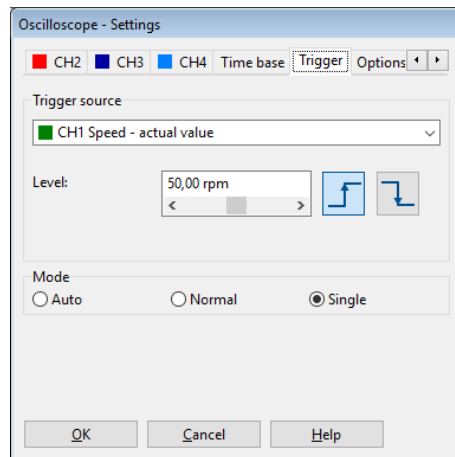


Figure 75: "Oscilloscope" window - "Trigger" Tab

A distinction is made between digital and analogue trigger sources. Digital trigger sources can only have the state yes or no (active or inactive).

An example is "target reached". Analogue trigger sources, on the other hand, can assume any numerical value (e.g. speed setpoint). This is why a trigger threshold (level) must be specified for analogue trigger sources. In addition, various buttons can be used to define whether a rising or falling edge of the signal will be used for triggering.

Depending on the selected trigger source, this means:

	Analogue trigger source	Digital trigger source
Rising edge	The threshold will be reached when the values increase.	The event occurs.
Falling edge	The threshold will be reached when the values decrease.	The event disappears.

Three different trigger modes can be selected in the field **Mode**:

**Auto**: The system triggers continuously and displays the results regardless of whether the trigger condition has been fulfilled or not.

**Normal**: The system triggers and displays the results when the trigger condition is fulfilled. After the results have been displayed and when the trigger condition is fulfilled again, the system triggers again.

**Single**: The system triggers only once when the trigger condition is fulfilled. Then, the system is set to inactive by deactivating the checkbox **RUN / STOP**.

## 7.3 Display units

By adapting the display units, physical variables such as the position, speed and acceleration can be displayed in the Kuhnke ServoCommander<sup>®</sup> program as required by your specific application. The "Display units" window can be opened by way of **Options/Display units**. The mode **Standard values** has already been explained in section 4.4.2 *Configuration of the display unit* on page 45. The following sections provide information about the modes **User-defined** and **Direct input**.

### **INFORMATION** Display units: representation in Kuhnke ServoCommander<sup>®</sup>

The display units only affect the representation in Kuhnke ServoCommander<sup>®</sup>. They have no effect on the scaling of data that are transferred via a fieldbus (e.g. CANopen Factor Group).

### 7.3.1 User-defined display units

All user-defined units (**User-defined**) are displayed with [...].

The scaling of the user-defined units per revolution can be defined in the field **Feed constant** on the tab **Display units**. In addition, the input fields **Time base** and **Time base acceleration** are available.

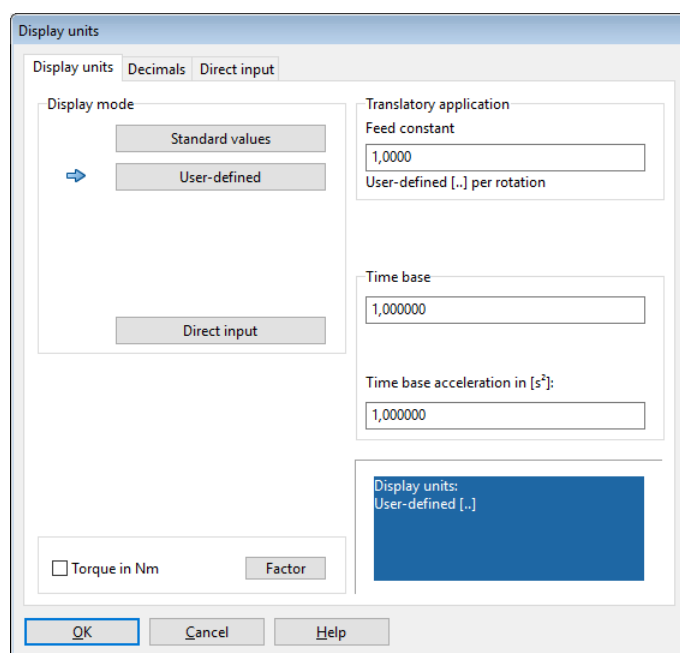


Figure 76: "Display units (user-defined)" window

Use the fields **Time base** and **Time base acceleration** to define your own speed and acceleration units.

**Example:** You have a drive with 20 mm per revolution, without a transmission. You would like to enter the speed in mm/min or the acceleration in (mm/min)/s. Enter 20 into the "Feed constant" field and 60 into the "Time base speed" field (60 seconds = 1 minute).

### 7.3.2 Direct input of the display units

The tab **Direct input** under **Options/Display units** can be used to directly enter the factor group of the position, speed and acceleration, provided that you have selected **Direct input** under **Options/Display units**.

Display units

Display units Decimals Direct input

Warning: This menu is reserved for experienced users!

Factor group position

Numerator: 1 User-defined [...]

Denominator: 1

Factor group speed

Numerator: 60 User-defined [...]

Denominator: 1

Factor group acceleration

Numerator: 60 User-defined [...]

Denominator: 1

☐ hexadecimal format

OK Cancel Help

Figure 77: "Display units (direct input)" window

In addition, you can select the following display units for the Kuhnke ServoCommander® parameterisation program:

- Increments
- Degree
- Radian
- Revolution
- Metre
- Millimetre
- Micrometre
- User-defined
- No unit

## 7.4 Parameter sets

The method for saving changed settings in the servo drive has already been explained in section 4.4.14 *Permanent storage of the parameters* on page 61. In addition, the method for saving the settings as a parameter file (DCO file) has also been briefly presented.

This section provides a detailed description of how you can save changed parameters, how you can transfer them to other servo drives and how you can reset them to the factory settings.

All of the functionalities of a parameter set are listed under **File/Parameter set**.

Kuhnke ServoCommander® can be used as an online parameterisation program. However, it can also be used offline. In this case, changes will not be transferred to the servo drive. Instead, only a parameter set file (DCO file) will be changed.

### 7.4.1 Online parameterisation: Overview



#### File/Parameter set/Save parameter set (FLASH)

The following Figure 78 shows all of the setting options of the servo drive, i.e. the parameter set management system:

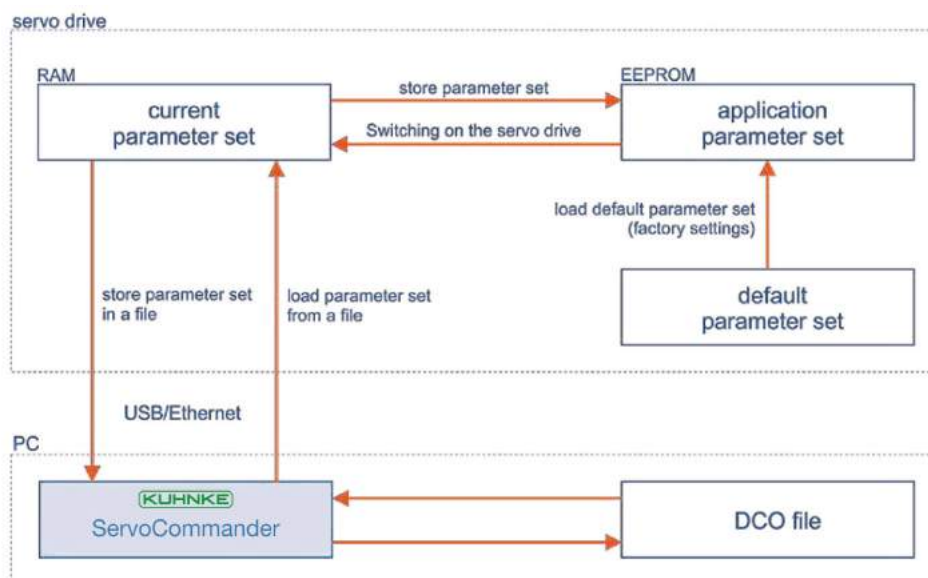


Figure 78: Parameter set management with Kuhnke ServoCommander®

The current parameter set of the servo drive is stored in the RAM. The RAM will be erased when the power supply is switched off. To save the parameter set in a non-volatile manner, it can be copied into the EEPROM (flash) by clicking the symbol shown above or by selecting the corresponding menu item. The EEPROM retains its contents even if the power supply is switched off.

Every time the servo drive is switched on, the content of the EEPROM will be copied into the RAM. A restart of the servo drive can be triggered by the following:

- Deactivation and reactivation of the 24 V power supply
- Activation of the menu **File/Reset servo**
- Click the **RESET** button on the menu bar

Every servo drive still has its default parameter set (factory settings). This parameter set is stored in the firmware in a non-volatile manner and cannot be overwritten. If a parameterisation is not successful for some reason, the default parameter set can be loaded to reset all of the parameters to the default values. To activate the default parameter set, select **File/Parameter set/Load default servo parameter set**. The application parameter set will be replaced with the default parameter set and the servo drive will be restarted.

## 7.4.2 Loading and saving parameter sets

Parameter sets can also be stored and managed externally (i.e. on a hard drive etc.). To this end, the parameter set is read out of the servo drive and stored in a file or it is read out of a file and stored in the servo drive. Parameter files on the PC have the extension DCO. This is why parameter files are often referred to as DCO files. DCO files can be read or saved in Kuhnke ServoCommander® as follows:

- **Reading a DCO file**  
**File/Parameter set/Load into servo drive**
- **Writing a DCO file**  
**File/Parameter set/Save as file**

Please note that when you save a parameter set to a file, you can fill in the fields **Motor type** and **Description**. In addition, you can enter a comment of up to 100 lines by way of the **Comment** tab. We highly recommend providing descriptions to prevent a mix-up of the parameter sets. The name of the parameter set should also be selected carefully so that it can be found easily later on.

### **INFORMATION** Handling of the parameter sets

The following should be taken into consideration when handling the parameter sets:

- The default parameter set should be loaded if a parameterised servo drive is to be adapted to a new application or if parameter changes have led to an undefined behaviour.
- Online changes of the parameters in the RAM of the servo drive can be overwritten with the most recent settings in the EEPROM when a reset of the servo drive is performed. As a result, you can perform quick tests (e.g. changed controller gains) without affecting the actual configuration in the EEPROM.
- Once a satisfactory setting of the servo drive is reached, the parameter set should be stored in the EEPROM.

### 7.4.3 Offline parameterisation:

The illustration below shows the offline parameterisation principle:



Figure 79: Offline parameterisation with Kuhnke ServoCommander®

#### **INFORMATION** Displaying the parameterisation

Usually, the offline parameterisation function is used for displaying the parameters of DCO files.

The modification of parameters is useful only in individual, specific cases since stability and functionality tests are not possible by simply loading a parameter set into the servo drive.

Values that are changed in Kuhnke ServoCommander® will not be transferred online. Instead, they will be saved in a DCO file. To activate the offline parameterisation, click **Options/Communication/Offline parameterisation**. Specify the DCO file that you would like to open. Select a corresponding file.

The DCO file has been created for a specific type of servo drive. If you want to use it for another type, select the new type now.

#### **NOTICE** Risk of irreparable damage due to incorrect settings

If you use a DCO file for another device type, the servo drive/motor may be destroyed.

Therefore, it is important to check the following settings: nominal current, maximum current, angle encoder offset, phase sequence, number of poles, current controller and speed controller.

### 7.4.4 Parameterisation via a microSD card

Servo drives of the BL 4000-C series have a card slot for microSD cards. It can be used for loading and saving parameter sets.

The process can be started explicitly via the parameterisation program or automatically after a restart of the servo drive (reset or power on). In this case, you can specify whether the most recent DCO file or a DCO file with a specific name will be loaded.

#### **INFORMATION** Firmware update via a microSD card

The servo drive can update the firmware via the microSD card. See the section 7.18 *Firmware download* on page 192.

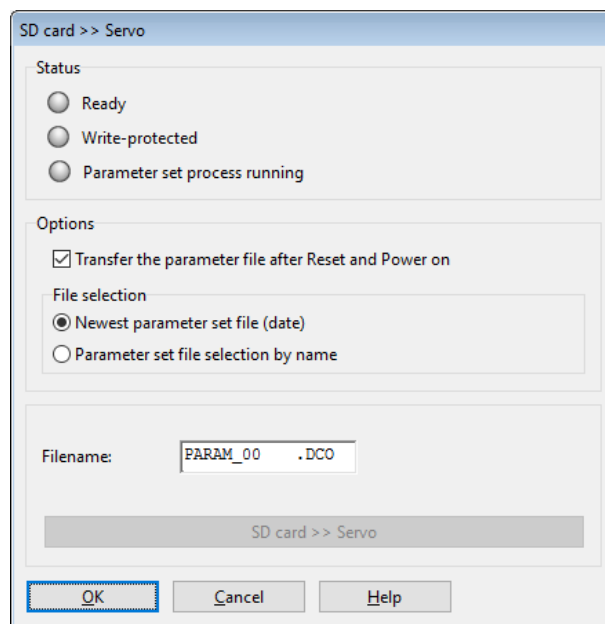


Figure 80: Parameterisation via a microSD card

#### ➤ Status

The LEDs indicate the status of the SD card:

**Ready:** The LED lights up green when an SD card is connected and ready.

**Write-protected:** This LED is irrelevant for microSD cards as they have no write protection.

**Parameter set process running:** This LED lights up green during a loading process.

## › Options

This is where you can configure the behaviour when DCO file is loaded from the SD card.

### **INFORMATION** Loading a DCO file

The selected settings are stored in the parameter set. When a DCO file is loaded, the current settings of the servo drive will be overwritten.

**Transfer the parameter file after reset and power on:** Select this option if a parameter file is to be loaded from the SD card into the servo drive automatically after every power on and after every reset.

## › File selection

Use the two options **Newest parameter set file (date)** and **Parameter set file selection by name** to specify the parameter file that is to be loaded from the microSD card.

## › File name

The DCO file stated here will not become effective unless the option **Parameter set file selection by name** has been selected. The name of the DCO file to be loaded can be stated. You can change all of the eight characters of the file name. The file extension DCO, however, cannot be changed.

### **INFORMATION** File name conventions

The system does not support any directories/subdirectories and file names must comply with the 8.3 file name convention. Lowercase letters will be automatically converted when they are entered.

## › "SD card >> servo" button

When all of the necessary settings have been made, click **SD card >> servo** to start the loading process. After the completion of the loading process, the new setting will be displayed in the field **File name**. The new parameter set is now stored in the servo drive and the servo drive performs a reset.

The parameterisation program cannot check whether the file that has been specified actually exists on the microSD card. The firmware of the servo drive will detect this once the loading process is started. If the loading process is not successful, the parameterisation program will display an error message and the firmware will issue error 29-x. Please contact the Technical Support team in this case.



### › Conditional loading of data from the SD card (autorun.ini)

An AUTORUN.INI file on the microSD card can be used to define specific conditions for loading DCO files. You can specify, for example, that only the fundamental parameters, certain position sets or complete parameter sets will be loaded into the servo drive. In addition, you can also specify whether these will be stored in the servo drive or not.

Conditional loading can be performed based on certain internal parameters or states of the servo drive. It is possible, for example, to use the status of the digital inputs.

The required AUTORUN.INI file can be created and customised with the aid of an Excel spreadsheet. Please contact the Technical Support team for detailed information about the AUTORUN.INI file and its creation.

#### **INFORMATION** AUTORUN.INI file on the microSD card

If there is an AUTORUN.INI file on the microSD card, the current settings for loading a DCO file after a reset will be ignored. If one of the defined conditions is fulfilled, the parameter set of the servo drive may be overwritten by the DCO file that is specified.

## 7.5 Angle encoder settings



Parameters/Device parameters/Angle encoder/Settings...

This section provides details about the various options of the encoder interface. It describes the manual configuration of the angle encoders connected to X1, X2A and X2B/X6.

### 7.5.1 "Commutating-generator" tab

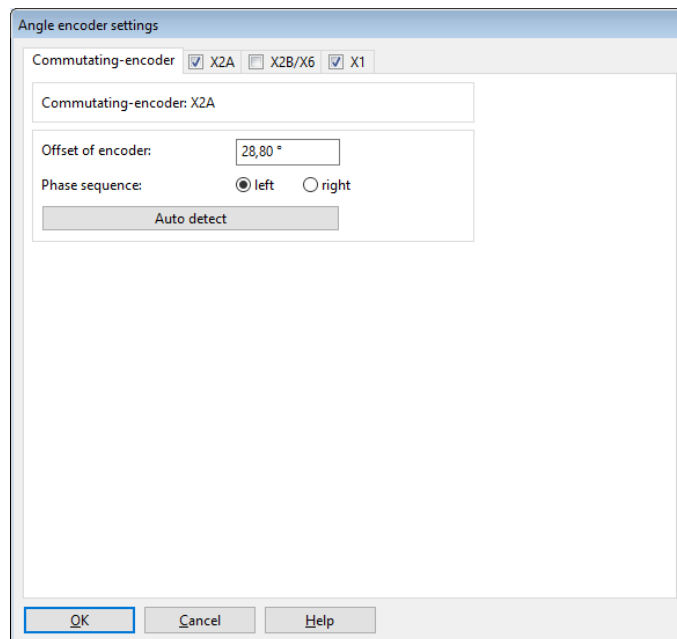


Figure 81: "Angle encoder settings" window - "Commutating-generator" tab

The **Offset of encoder** is the angle difference between the electrical and mechanical position that results from the installation position of the angle encoder on the motor shaft. In general, the angle encoder offset is determined automatically.

The **phase sequence** indicates the way of counting ("direction of rotation") of the angle encoders and depends on the wiring. The correct setting of the phase sequence is essential for the operation of the system. The phase sequence is also determined during the automatic determination of the angle encoder offset.

The automatic identification can be started with the button **Auto detect**. Ensure that the current limits have been set correctly and that the servo drive is free from errors. In addition, the shaft must move freely. The automatic identification process determines the following parameters:

- Number of pairs of poles
- Direction of rotation of the angle encoder/phase sequence
- Angle encoder offset

### 7.5.2 "X2A" tab

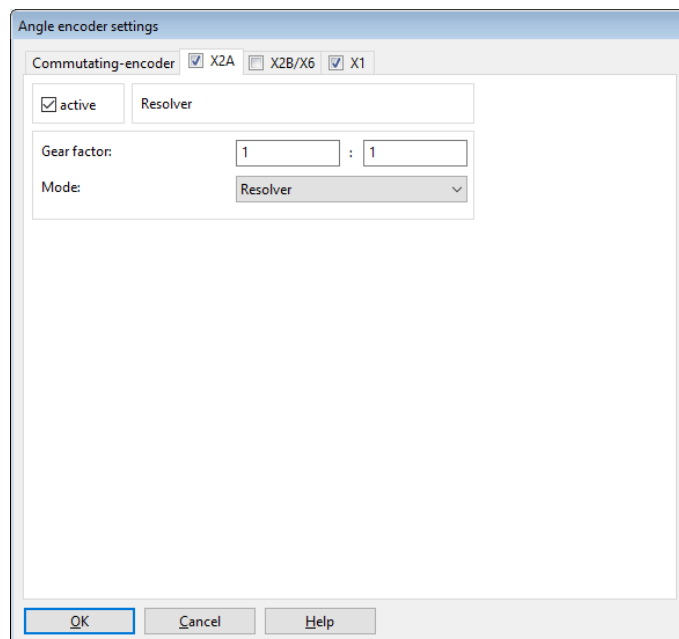


Figure 82: "Angle encoder settings" window - "X2A" tab

This tab is used for the parameterisation of an angle encoder connected to X2A. This can either be a resolver or an encoder with analogue Hall sensors. Single- and multi-pole resolvers are supported. For special applications, additional adaptations can be realised based on a gear factor to convert the angle into the actual position. In general, this is not necessary in the case of common motor/resolver combinations.

If the checkbox **active** is ticked, the firmware will analyse the encoder information provided via this connection. The checkbox must be ticked if the angle encoder is used for commutation and/or for determining position or speed values.

The default setting for the **Gear factor** is 1:1. These settings apply only to a gear factor between angle encoder and motor. If you want to parameterise an application with a gear unit, specify this gear factor under **Display units** to get parameters in the units of the driven side (output).

In the drop-down menu **Mode**, specify whether a resolver or an analogue Hall sensor is connected to X2A.

### 7.5.3 "X2B/X6" tab

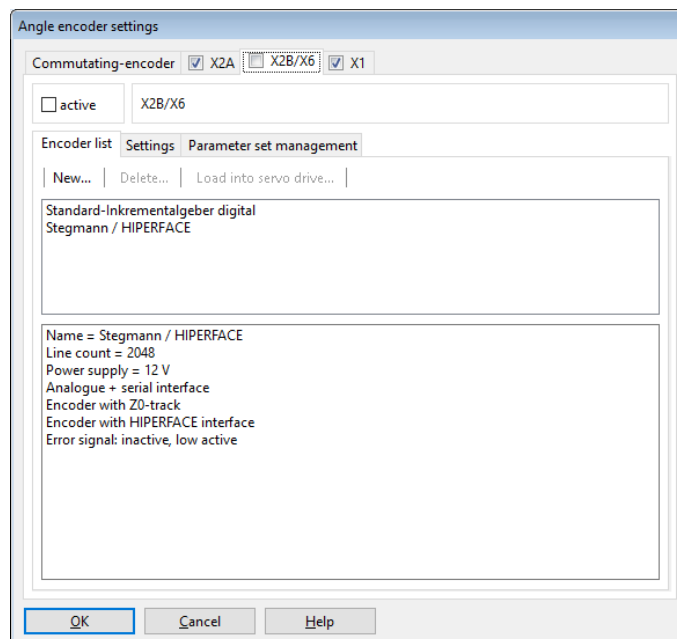


Figure 83: "Angle encoder settings" window - "X2B/X6" tab - "Encoder list"

Different types of encoders can be connected to X2B (see also section 12.7 *Encoder connector [X2B]* on page 225):

- Digital incremental encoders (RS422, HALL sensors)
- Analogue incremental encoders (1 V<sub>ss</sub>)
- Incremental encoders with a serial interface (RS485 level, e.g. EnDat, HIPERFACE®, BISS)

It is also possible to evaluate an optional error signal (AS/NAS) via pin 6.

HIPERFACE DSL® encoders that are connected to X6 can also be parameterised via this tab. To force the servo drive to evaluate an encoder connected to X2B/X6, the checkbox **Active** must be ticked. The angle encoder can be used for commutation, speed determination and position determination. In addition, it can be used as a position encoder (see section 6.3 *Applications with several angle encoders* on page 104).

### 7.5.3.1 General settings

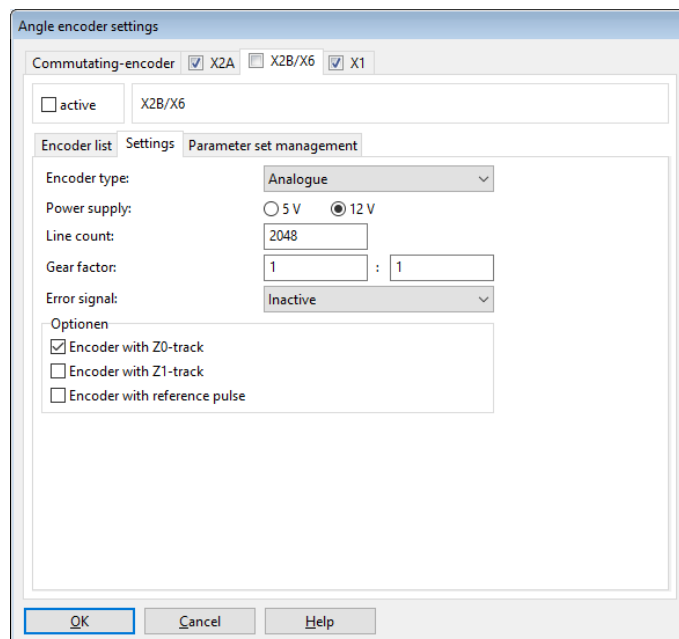


Figure 84: "Angle encoder settings" window - "X2B/X6" tab - "Settings"

The following settings are available for all types of encoders:

#### › Encoder type

This setting is used to define the encoder type. The encoder types and their parameters are described in detail in the following sections.

#### › Power supply

##### **NOTICE** Risk of destruction due to excessive voltage

If the voltage is too high, the angle encoder may be destroyed. Ensure that you have selected the correct supply voltage prior to connecting the encoder to the [X2B] connector.

Please state whether the angle encoder is supplied with 5 V or 10 V. You can find this information on the data sheet. In general, HIPERFACE® encoders are supplied with 7 V to 12 V. Heidenhain encoders are supplied with 5 V. In the case of long cables, sense leads must be used.

### › Line count

At a constant speed, incremental encoders provide two periodic signals with a phase shift of 90° between them (A/B track or Z0 track). The line count corresponds to the number of full periods per revolution. In most cases, the line count is stated on a data sheet or type plate of the angle encoder. There are digital incremental encoders that supply square (digital) track signals, and analogue incremental encoders that supply sine/cosine signals.

In the case of **digital** incremental encoders, the rising edge and the falling edge of the A track and B track are evaluated. This is why the resolution is fourfold higher than the line count itself (quadruple evaluation).

In the case of **analogue** incremental encoders, the amplitude of the signals is measured in addition to the zero crossings of the analogue sine signals. These values are included in the calculation for determining the angle (high resolution). The value **Line count** must be entered without the high resolution.

If the encoder has an index pulse, the line count of the angle encoder can be determined automatically. In this case, enter 0 into the line count field and then start the automatic identification of the angle encoder parameters (**Commutating encoder** tab, **Auto detect**). Note: After the completion of the parameter identification process, close the window and reopen it to refresh the **Line count** parameter.

### › Gear factor

The default setting of the gear factor is 1:1. It may be necessary to change it, for example, if the angle encoder provides more than 1 index pulse per revolution.

These settings apply only to a gear factor between angle encoder and motor. If you want to parameterise an application with a gear unit, specify this gear factor under **Display units** to get parameters in the units of the driven side (output).

### › Error signal

It is possible to evaluate an optional error signal (AS/NAS) of an incremental encoder via pin 6. This option can be used to activate/deactivate the AS or NAS evaluation and to determine whether the error signal is high-active or low-active. If the error signal evaluation is active and the system detects an encoder error, error 08-4 (digital incremental encoder) or error 08-2 (analogue incremental encoder) will be issued.

### › "Save & Reset" button:

Numerous optional settings of the angle encoder dialogue window will not become effective until a reset of the servo drive is performed (resulting in a restart of the encoder system). If such a setting is changed, the button **Save & Reset** will be displayed automatically. It can be used to save the parameter set of the servo drive. Then, a reset will be performed.

### 7.5.3.2 Digital incremental encoders

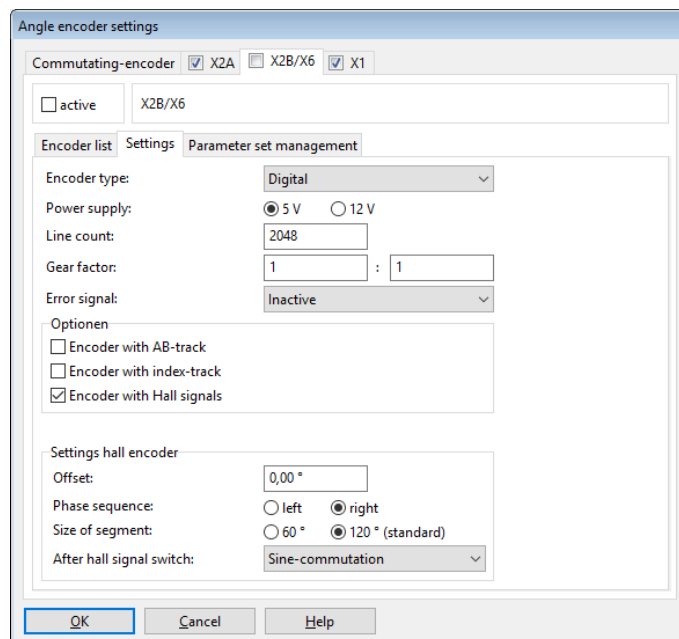


Figure 85: "Angle encoder settings" window - "X2B/X6" tab - "Settings" - "Encoder type: Digital"

#### › Encoder type

Select **Digital** if you want to use a digital incremental encoder.

#### › Options

- **Encoder with AB track**  
The AB track provides incremental (square) track signals. This option must be selected if you want to use a digital incremental encoder. It can be deselected if your encoder only has Hall signals. In this case, the option **Encoder with Hall signals** must be selected.
- **Encoder with index track**  
Usually, there is one index pulse during every revolution of a digital incremental encoder. The index track ensures consistent precision in the case of incremental encoder systems. If counting errors occur due to external interferences, they are corrected when the index pulse occurs. Information as to whether the angle encoder has such a pulse can be found on the data sheet of the angle encoder. If an index track is included and connected, the index pulse function can be suppressed by deselecting this checkbox.

#### **⚠ WARNING** Risk of injury due to uncontrolled drive movements.

The servo drive corrects the actual position if the index pulse is activated. In the case of encoders with unsymmetrical index pulses, this may cause the drive to overspeed. This is why, if in doubt, the index pulse evaluation should be deactivated.

Usually, linear motors do not include cyclic index pulses. However, there may be a single index pulse that can be used for homing.

- **Encoder with Hall signals**

Hall signals can be used for an initial determination of the commutation position if a digital incremental encoder is used. Following a reset, the commutation position can be determined with an accuracy of 30° using the Hall signals. This is sufficient for a starting process. The commutation position will then be corrected based on the segment limits and when the index pulse occurs for the first time, so that it corresponds to the specified angle encoder offset.

When this option is selected, the system will display further options concerning the Hall generator interface.

## › Hall generator settings

- **Offset**

The offset describes the angle difference between the permanent magnets of the rotor and the zero position of the Hall signals. This value is determined during the automatic angle encoder identification process and it should not be entered or optimised manually.

- **Phase sequence**

The phase sequence indicates the way of counting ("direction of rotation") of the Hall signals and depends on the wiring. The correct setting of the phase sequence is essential for the operation of the system. A manual determination of the phase sequence is difficult. We recommend performing an automatic determination (see above).

- **Size of segment**

The segment size indicates the angular range covered by one segment of a Hall signal, e.g. U. Information about the segment size can be found on the data sheet of the angle encoder. Standard Hall systems have a segment size of 120°. A segment size of 60° is reserved for special variants.

- **After Hall segment switch**

Here, you can select various options to specify how the commutation will continue after the first Hall segment change.

The option **Block commutation** means that the commutation position is determined only on the basis of the Hall signals. As a result, the commutation position is quantised very roughly, and the motor develops high losses. This option is reserved for special applications.

The option **Sine commutation** means that the commutation position will be corrected after the first Hall segment change. Then, it will be determined based on the incremental position information. This option leads to an optimum resolution and an optimum behaviour concerning the commutation position. We recommend using this option.

The option **Sine commutation supported with Hall** means that the commutation position will be corrected whenever the Hall segment changes. The commutation position will be calculated incrementally until the next change occurs. This option is useful in the case of highly disturbed signals in order to be able to continuously update the commutation position.



### 7.5.3.3 Analogue incremental encoders

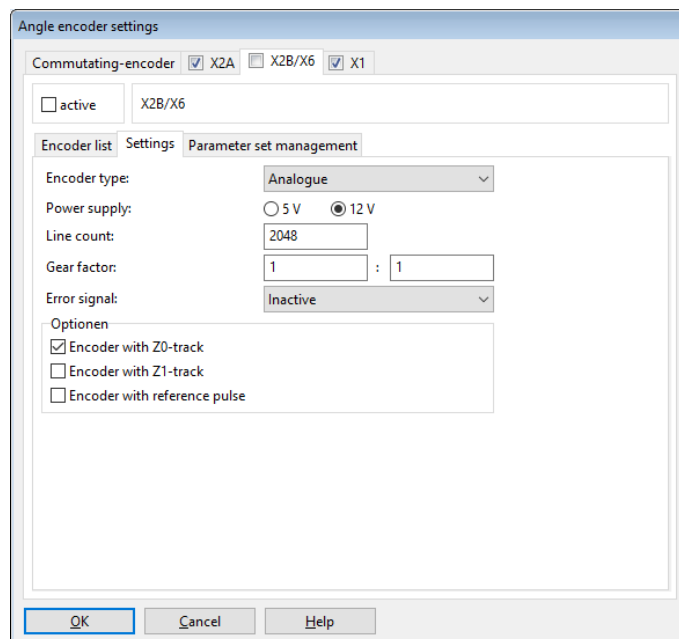


Figure 86: "Angle encoder settings" window - "X2B/X6" tab - "Settings" - "Encoder type: Analogue"

#### › Encoder type

Select **Analogue** if you want to use an analogue incremental encoder.

#### › Options

- **Encoder with Z0 track**  
The Z0 track (according to the Heidenhain terminology) is a term used for the actual, high-resolution analogue track signals. Other angle encoder manufacturers use the terms sine\_0 and cosine\_0 track or A and B track instead of the term Z0 track. The line count value (periods/revolution) is also based on the Z0 track. Information about the Z0 track can be found on the data sheet of the angle encoder.
- **Encoder with Z1 track**  
The Z1 track is the commutation track of an analogue incremental encoder. It consists of two signal pairs that enable a clear angle determination referred to 1 revolution. This method is used for determining the commutation position after a reset. Some encoder manufacturers use the terms sine\_1 and cosine\_1 track or C and D track instead of the term Z1 track. Information about the Z1 track can be found on the data sheet of the angle encoder. If there is no commutation track, the automatic commutation position determination function must be activated (see section 7.6.3.2 *Determining the commutation position in the case of linear motors* on page 158).

### › Encoders with reference pulse

The reference pulse of an analogue incremental encoder corresponds to the index pulse of a digital incremental encoder. Information as to whether the angle encoder has such a pulse can be found on the data sheet of the angle encoder.

**⚠ WARNING Risk of injury due to uncontrolled drive movements.**

The servo drive corrects the actual position if the index pulse is activated. In the case of encoders with unsymmetrical index pulses, this may cause the drive to overspeed. This is why, if in doubt, the index pulse evaluation should be deactivated.

Usually, linear motors do not include cyclic index pulses. However, there may be a single index pulse that can be used for homing.

### 7.5.3.4 Serial: EnDat 2.2

Heidenhain encoders with an EnDat 2.2 interface (ordering code ENDAT22) have a serial communication channel via which the servo drive can communicate with the encoder. This channel is used for the purely digital transfer of the position value from the encoder. In addition, it is possible to access the type plate of the encoder to read out certain characteristics such as the line count, for example. As a result, the line count does not need to be parameterised in the case of EnDat 2.2 encoders.

The EEPROM, which is often included in this type of encoder, can be used for saving and loading parameters in the servo drive (see section 7.5.3.8 *Storing parameters in the encoder* on page 148).

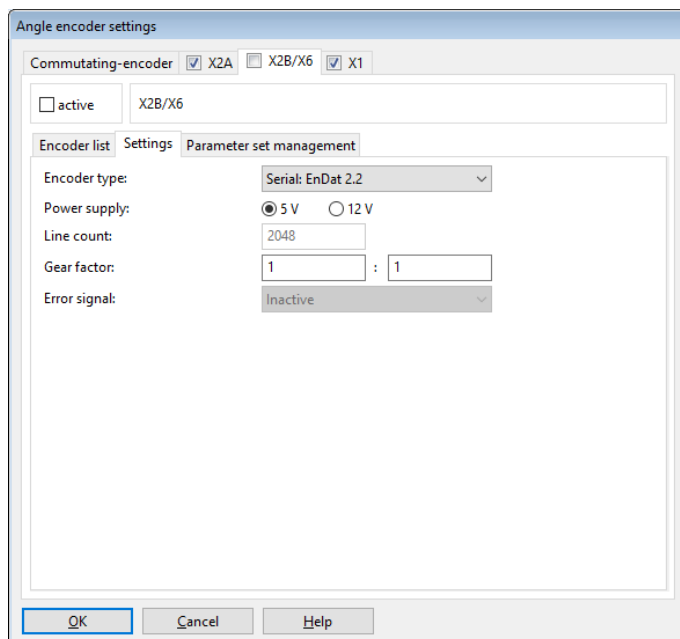


Figure 87: "Angle encoder settings" window – "X2B/X6" tab – "Encoder type: Serial: EnDat 2.2"

#### ➤ Encoder type

To use this type of encoder, **Serial: EnDat 2.2** must be selected.

### 7.5.3.5 Serial: HIPERFACE

Sick-Stegmann encoders with a HIPERFACE® interface have a serial communication channel via which the servo drive can communicate with the encoder. It is used, for example, to determine the commutation position. In addition, it is possible to access the type plate of the encoder to read out certain characteristics such as the line count, for example. As a result, the line count does not need to be parameterised in the case of HIPERFACE® encoders.

The EEPROM, which is often included in this type of encoder, can be used for saving and loading parameters in the servo drive (see section 7.5.3.8 *Storing parameters in the encoder* on page 148).

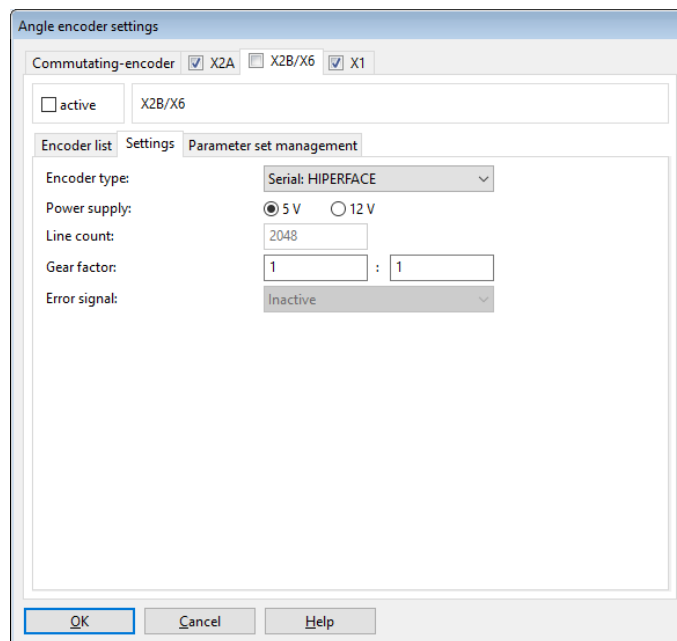


Figure 88: “Angle encoder settings” window – “X2B/X6” tab – “Settings” – “Encoder type: Serial: HIPERFACE”

#### ➤ Encoder type

To use this type of encoder, **Serial: HIPERFACE** must be selected.

### 7.5.3.6 Serial: HIPERFACE DSL

Sick-Stegmann encoders with a HIPERFACE DSL<sup>®</sup> interface have a serial communication channel via which the servo drive can communicate with the encoder. In the case of HIPERFACE DSL<sup>®</sup>, data are transferred via conductors that are integrated in the motor cable. As a result, a separate encoder cable is not required. The serial channel is used for the purely digital transfer of the position values from the encoder. In addition, it is possible to access the type plate of the encoder to read out certain characteristics such as the line count, for example. As a result, the line count does not need to be parameterised in the case of HIPERFACE DSL<sup>®</sup> encoders.

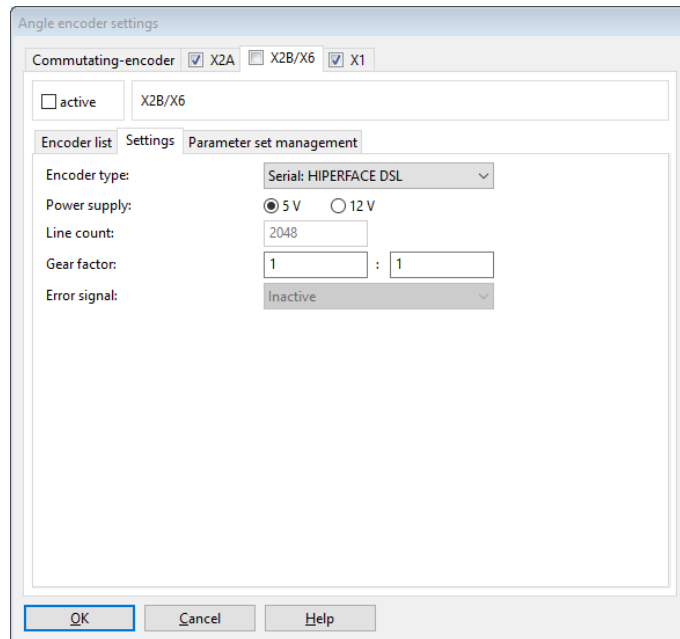


Figure 89: “Angle encoder settings” window – “X2B/X6” tab – “Settings” – “Encoder type: Serial: HIPERFACE DSL”

#### ➤ Encoder type

To use this type of encoder, **Serial: HIPERFACE DSL** must be selected.

### 7.5.3.7 Serial: BiSS

The BiSS interface is a non-proprietary, serial real-time interface. The support of BiSS encoders includes the following functions:

- Support of BiSS C
- Support of typical encoders made by Hengstler, Kübler and Balluff
- Mapping of a BiSS absolute encoder to variable pole lengths of a linear motor
- Support of frame lengths with absolute position information of 32 bits maximum in a 40-bit frame
- Generator polynomial 0x43 (6 bits)

Balluff encoders have a parallel analogue track. This track will not be evaluated in parallel to the BiSS encoder. The encoder can be connected either as an analogue encoder or as a BiSS encoder. Data storage in the encoder and the read-out of type plates are not supported.

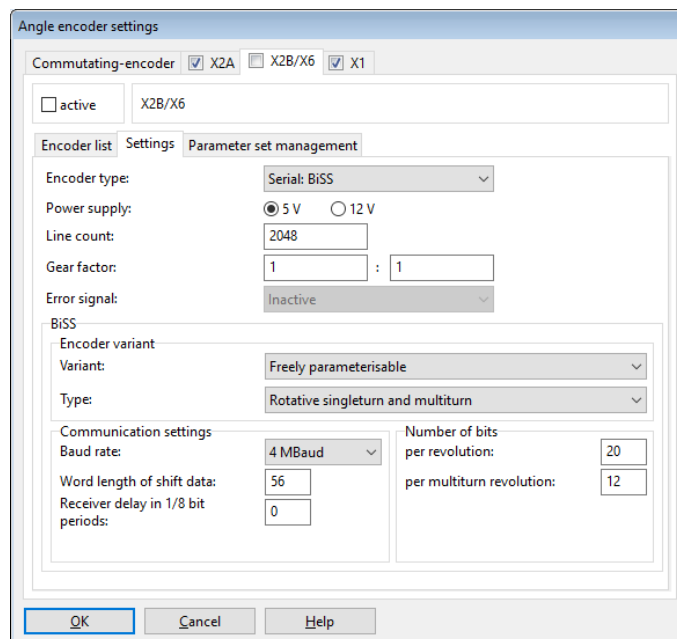


Figure 90: “Angle encoder settings” window – “X2B/X6” tab – “Settings” – “Encoder type: Serial: BiSS”

#### ➤ Encoder type

To use this type of encoder, **Serial: BiSS** must be selected.

To adapt the BiSS position taken from the digital raw value of the encoder to the internal absolute position and rotor position, the following variants can be used:

**Relative-linear:** The BiSS data are available only as a data frame without any connection with regard to the rotor position. The line count must be defined so that it matches the commutation position. The position is always different whenever the system is switched on and there is no connection with regard to the rotor position. For example, after a reset, the position is always zero (regardless of the position of the rotor) and it can become positive or negative. The encoder is installed on a linear motor. The commutation position must be determined, and homing is required.

**Rotative single-turn and multi-turn:** There is always a rotary motor and the data frame can be divided into single-turn and multi-turn segments .

**Absolute-linear:** A data frame that must be mapped to a rotary system with a freely selectable line count (no power of two). The encoder is installed on a linear motor. It is not necessary to determine the commutation position, and homing is not required.

### › Start-up notes

1. Perform the bit adaptation for single-turn und multi-turn revolutions in accordance with the encoder data sheet. There should not be any encoder error and the firmware can perform the CRC.
2. Check the actual position that is indicated in the status window. One mechanical revolution of the motor must correspond to one indicated revolution. If an adaptation is necessary, the line count can be modified.
3. In the case of linear motors, the offset of one pole pair must be mapped precisely to the rotor position (number of pole pairs 1).
4. To check the range of movement of absolute encoders without a homing run, tests concerning the repeatability of the actual position must be performed at various different positions within the range of movement.
5. Then, the indication of the actual position can be configured with "mm" as the display unit, for example, in the "Display units" window.

### 7.5.3.8 Storing parameters in the encoder

If the angle encoder connected to X2B has an EEPROM, the parameters can be stored in the encoder. This is particularly useful for parameters that refer to the characteristics of the motor (nominal and maximum current) or to the motor/encoder combination (phase sequence, offset angle). If the motor is connected to a different servo drive, these parameters will be loaded by the servo drive and the motor can be used directly without any additional parameterisation.

The following parameters are stored in the encoder:

- Number of pole pairs, phase sequence and angle encoder offset
- Nominal and maximum current and the current control settings
- Lateral displacement parameters concerning the actual position (e.g. after homing)
- Gear factor for the angle encoder

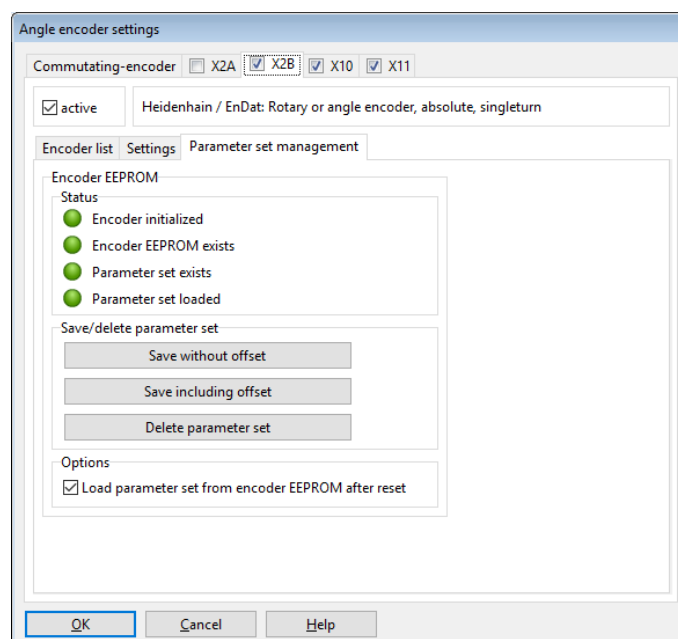


Figure 91: "Angle encoder settings" window - "X2B/X6" tab - "Parameter set management"

#### › Status

##### Encoder initialised

This LED lights up when the initialisation of the encoder is complete. The time required for the initialisation varies depending on the encoder. It is only when the encoder initialisation is complete that further information about the encoder and certain actions become possible.

This is why the following status LEDs are not valid until the encoder initialisation is complete.

##### Encoder EEPROM exists

This LED indicates that the connected encoder has an EEPROM.



**Parameter set exists**

This LED indicates that an encoder parameter set is stored in the EEPROM of the connected encoder. However, this parameter set may not be loaded.

**Parameter set loaded**

This LED indicates that the encoder parameter set has been loaded and that the corresponding settings of the internal parameter set of the servo drive have been overwritten.

**› Saving/deleting a parameter set****Save without offset**

The current settings of the servo drive will be stored in the EEPROM of the angle encoder as an encoder parameter set. A zero offset of the actual position, which has been created during a homing run, for example, will not be saved. This is why the home position before the homing run will be displayed after a reset.

**Save including offset**

The current settings of the servo drive will also be stored in the EEPROM of the angle encoder as an encoder parameter set. However, in this case, the zero offset of the actual position will also be saved.

**Delete**

When the button **Delete parameter set** is selected, the parameter set in the EEPROM will be deleted.

The deletion process may take several seconds. The completion of the process will be indicated in the associated status window. Then, the servo drive must be reset (**Save & Reset**). After the reset, the servo drive will use the parameters that are stored in its EEPROM.

**› Options****Load parameter set from encoder EEPROM after reset**

This option can be used to specify whether the encoder parameter set in the encoder EEPROM will be loaded, thereby overwriting the parameters of the servo drive. A change of this option will not become effective until the **Save & Reset** function is used.

**Notes concerning the deactivation of the option:**

If this option is deactivated after an encoder parameter set has already been loaded from the encoder EEPROM, and if then **Save & Reset** is selected, the (loaded) encoder parameters will be stored in the EEPROM of the servo drive. As a result, it may seem as if the encoder parameters of the encoder EEPROM are once again active after the reset. However, this is not the case. The parameters can be changed any time in the servo drive, and they will not be overwritten with the values of the encoder EEPROM.

To avoid this situation, we recommend the following:

1. Disconnect the encoder connector.
2. Perform a reset. The encoder parameter set cannot be loaded, and the parameters of the servo drive will not be overwritten.
3. Deactivate the option **Load parameter set from encoder EEPROM after reset**.
4. Click the **Save & Reset** button.
5. Reconnect the encoder connector.
6. Perform a reset to initialise the encoder.

**Notes concerning the activation of the option:**

The option can be activated when an encoder is connected as, in this case, the parameters of the servo drive will be overwritten with the encoder parameter set from the encoder EEPROM.

## 7.5.4 "X1" tab

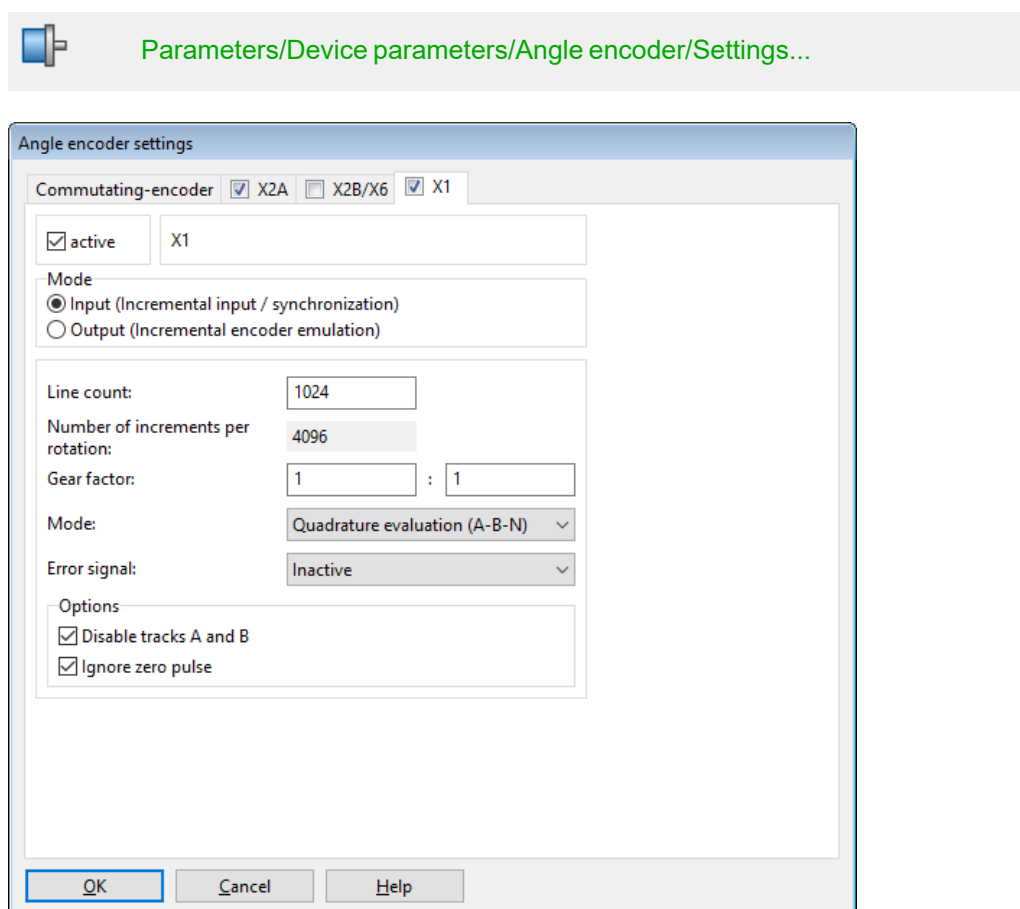


Figure 92: "Angle encoder settings" window - "X1" tab

Here, you can specify whether the inputs at connector X1 will be used as the master frequency input or output.

If **Input** is selected, you can either connect the master frequency output of another BL 4000-C servo drive or an incremental encoder (quadrature evaluation).

Alternatively, the connector can be used as a pulse direction interface or up/down counter.

### › Gear factor

The factory setting of the gear factor is 1. The gear factor determines the conversion of an external position setpoint with regard to the actual position.

## › Line count

Digital incremental encoders supply their angular information with the aid of track signals. They supply periodic square (digital) signals at constant speed. The line count corresponds to the number of full periods of a track per revolution. In most cases, the line count is stated on a data sheet or type plate of the angle encoder. The incremental encoder input always applies a quadruple evaluation. This is why the resolution is fourfold higher than the line count itself. The effective line count is presented under "Number of increments per rotation". If an index pulse is used, it is important that the number of lines between the index pulses matches this value.

## › Mode

### Quadrature evaluation (A-B-N)

The signals will be interpreted as standard incremental encoder signals. The system evaluates two square track signals with a phase shift of 90° between them. This mode has an optional zero track (index track) with a period signal "per line count".

### Pulse direction

In this mode, one signal provides information about the change in position. Another signal provides information about the direction of rotation. Due to the quadruple evaluation, the line count referred to 90° must be specified here.

### Up/down counter

This mode uses two signals that provide information about the change in position for a specific direction of rotation. This is why one of the signal lines should always be at rest when a pulse sequence is transmitted via the other signal line. Due to the quadruple evaluation, the line count referred to 90° must be specified here.

## › Options

### Ignore counter signals

The incremental signals will be ignored. The interface "sees" an encoder at a standstill.

### Ignore zero pulse

In general, only incremental encoders or drives with a master frequency (incremental encoder emulation) generate a periodic index pulse (zero pulse). This option can be used to suppress such a signal if it is not provided. The index pulse may cause a sudden change in position if, during operation, the individual increments of the AB track are not properly identified. The index pulse should be evaluated to ensure that the firmware can identify the completion of a revolution.

### Error signal

This option can be used to activate or deactivate the detection of soiling or other problems of the measuring system. The index pulse input is used for the error signal, i.e. the error signal can only be evaluated if no index pulse track is parameterised. If an error is detected, angle encoder error 08-7 will be issued. The evaluation of the error signal can be inverted (low-active, NAS signal) or not (high-active, AS signal).

## 7.6 Parameterisation of the motor and output stage

### 7.6.1 Methods for analysing motor problems

In most cases, motor problems are indicated by noise and poor concentricity. In a first step, the internal oscilloscope should be used to analyse the current ripple, for example at 100 rpm. A little ripple caused by unbalance must always be expected due to the design of the motor (10-20%). Good motors with a sinusoidal EMF show hardly any visible current ripple at all.

Insidious winding defects can be detected by way of the following methods:

- Measure the ohmic resistance and inductance of the armature winding. To do so, simply disconnect the motor connector from the servo drive and connect the measuring instrument to the cable at the motor side. The values should be nearly identical (max. difference 10%). If the resistance values differ strongly from one another, the winding is damaged, and the motor must be replaced. The design and rating of the drive must also be verified.
- A so-called coast-down test can be performed to see whether the EMF (induced voltage of the 3 phases) is sinusoidal and symmetric. To do so, connect an external oscilloscope with differential voltage probes to the motor phases. Accelerate the drive to approx. 3,000 rpm, and then switch the power section to passive, e.g. by activating the STO function or by switching off the mains power supply. As a result, the motor supplies an induced voltage (oscilloscope) that should match the specifications on the data sheet. It must be identical for all of the phases.

For an optimum configuration and adaptation of the control system to the mass that needs to be moved, a high force/mass ratio would be beneficial. As this ratio is not ideal in the case of so-called direct drives, the control quickly becomes instable.

Direct drives (examples):

- A torque motor without a transmission connected to a heavy, large-diameter rotary table.
- A motor shaft that is directly coupled to a load with a high mass. A gear on a motor shaft that engages with a toothed rack to move a large slide.

When adapting the control system in such a case, the following is recommended:

- Use an encoder with a high resolution.
- Increase the gain of the speed controller up to the oscillation limit.
- Decrease the gain and correction speed of the position controller.
- Decrease the acceleration values of the position set.
- Activate and adapt the torque feedforward of the position set.

## 7.6.2 Configuration of the output stage

This menu (**Parameters/Device parameters/Power stage**) can be used to configure the settings for the PWM generation by the output stage.

The option **Enhanced sine commutation** enables a better utilisation of the DC bus voltage and, consequently, approx. 14% higher maximum speeds. In certain applications, the control behaviour and the running characteristics of the motor may be impaired at very low speeds.

Option **Half power stage frequency**: The clock frequency with regard to the current controller cycle time  $t_i$  can be halved.

With a lower clock frequency, higher limits for the maximum current are possible. However, the motor may emit a singing noise. If you want the motor to run as quietly as possible, select the full clock frequency. In addition, the losses in the motor are slightly reduced if the full clock frequency is used (on the other hand, the losses in the servo drive increase, which is why the adjustable maximum current limits are slightly lower). The clock frequency has hardly any influence on the control behaviour.

### **INFORMATION** Settings

The output stage must be switched off when the settings need to be changed.

In addition, the servo drive must be reset.

## 7.6.3 Use of linear motors

Numerous applications require a translatory motion to perform their task. Often, linear axes are used for this purpose. They convert the rotatory motion of a standard servo drive into the desired linear motion by way of toothed belt drives or ball-type linear drives. However, these additional mechanical components lead to mechanical losses and are subject to the mechanical restrictions. This, in turn, has a negative effect on the process cycle times.

Linear motors are part of the group of direct drives. They convert the supplied electrical energy "directly" into a linear motion. If they are three-phase synchronous motors, they can be used in combination with a BL 4000-C servo drive.

As it is always the case with synchronous servo drives, the commutation position must be known before the drive is switched on for the first time. Due to its design, linear motors use linear measuring systems. These are either absolute systems or purely incremental systems. Purely incremental encoders do not supply the absolute position referred to one electrical revolution so that a method for the automatic determination of the commutation position must be applied when the servo drive is enabled.

Linear motors have a special design. As they are less compact compared to conventional servo motors, their heat transfer capacity is reduced. This is why the usual  $i^2t$  times for the motor are shorter than in the case of conventional servo motors.

Linear motors can be divided into two groups: air-core and iron-core motors. Most motors are air-core motors. This characteristic is relevant for selecting the method for determining the commutation position.

### 7.6.3.1 Fundamental parameterisation of linear motors

Linear motors with purely incremental encoder systems do not provide any commutation information. In these cases, the checkbox **Motor without commutating-generator** must be ticked. As a result, the servo drive performs an automatic determination of the commutation position when it is enabled (provided that this information is not known). The drive cannot perform any movements unless the commutation position has been determined. The end of the process can be read out by way of the DOUT function **Linear motor identified** or via a fieldbus.

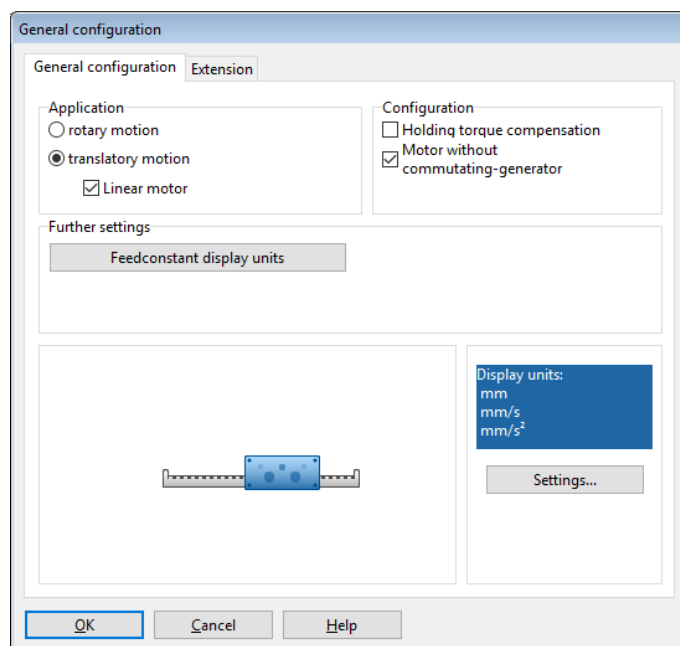


Figure 93: "General configuration" window

In order to obtain a translatory representation of the values in the Kuhnke ServoCommander® parameterisation program, open the window **Parameters/Application parameters/General configuration** and select the option **translatory motion** and tick the checkbox **Linear motor**.

The configuration of a feed constant in terms of the display units in the window **Options/Display units** only affects the representation in the parameterisation program. It has no effect on the behaviour of the servo drive.

## > Configuration:



### Parameters/Device parameters/Motor data

- **Motor i<sup>2</sup>t time:** The value can be found on the data sheet of the motor.
- **Number of pole pairs:** In the case of linear motors, this value must be set to 1. All the other settings always refer to this value (e.g. the setting concerning the line count of the angle encoder).
- **Nominal current and maximum current:** The values can be found on the data sheet of the motor. Pay attention to the scaling based on which the current value is stated. The current setting is the root-mean-square current.

#### **NOTICE** Risk of destruction due to excessive nominal current

When a linear motor is configured, the current should be reduced as much as possible in the beginning.

Linear motors can have very high peak currents. These current values should not be integrated in the configuration without prior testing.

We recommend beginning with only  $\frac{1}{4}$  of the stated nominal current and selecting a und peak current that is only 10% higher than the nominal current.

#### **INFORMATION** Configuring the number of pole pairs

A number of pole pairs  $> 1$  is necessary, for example, if the period length of an analogue angle encoder is not an integer multiple of the pole pair length. In this case, the number of pole pairs must be increased until an integer ratio between the pole pair length and the period duration is reached. The line count must then be determined based on the number of pole pair lengths.

In this case, one electrical revolution is a multiple of the number of poles which is reflected by the indicated actual position. The actual position must be set to 1 revolution per pair of poles by way of the display settings.



## › Configuration of the angle encoder settings:



Parameters/Device parameters/Angle encoder/  
Settings... X2B / X6 tab

- Active angle encoder setting concerning X2B/X6  
The setting must be adopted by way of "SAVE+RESET". The button will be displayed in the menu window.
- Configuration of the line count: The line count must be calculated based on the pole length. This is where the number lines per pole pair must be entered (see below).
- Angle encoder mode with the corresponding setting. The setting can be found on the data sheet of the angle encoder.  
Important: Ensure that the setting concerning the power supply is correct.
- The error signal evaluation can also be activated, if necessary or desired.

### **INFORMATION** Analogue angle encoders

In the case of an analogue angle encoder, the option "analogue" must be selected. In this case, one period signal length (e.g. one sine period) corresponds to one line.

The number of lines that is counted over a segment of the specified pole pair length is used to deduce the line count. It can be calculated based on the pole pair length and signal period.

#### **Digital signal (example):**

Signal period = 4  $\mu$ m, pole pair length = 30.48 mm, number of pole pairs = 1  $\Rightarrow$  line count = (number of pole pairs \* pole pair length) / signal period = 30.48 mm / 4  $\mu$ m = 7620

#### **Analogue signal (example):**

Signal period = 20  $\mu$ m, pole pair length = 40 mm, number of pole pairs = 1  $\Rightarrow$  line count = (number of pole pairs \* pole pair length) / signal period = 40 mm / 20  $\mu$ m = 2000

In the case of purely serial evaluation (only EnDat 2.2), the measuring increment of the serial position information, i.e. the distance corresponding to one bit, must be used instead of the signal period.

Usually, purely incremental encoders that are used in linear motors do not have an index pulse that matches the commutation!

### **⚠ WARNING Risk of injury due to uncontrolled overspeed**

The index pulse evaluation on the angle encoder X2B tab must be deselected in the case of linear motors because the commutation position will be adapted if an index pulse occurs that does not match the pole pair length precisely.

In this case, the drive may overspeed.

The index pulse connector at X2B can be used for the evaluation of a reference pulse for determining the reference position.

In the case of absolute length measuring systems (e.g. LC 483 by Heidenhain), the offset angle of the commutation encoder must be determined and saved once.

### 7.6.3.2 Determining the commutation position in the case of linear motors

In the case of linear motors with angle encoders without commutation signals, the method for the automatic determination of the commutation position must be applied. This can be specified in the window **Parameters/Application parameters/General configuration** on the **Extension** tab:

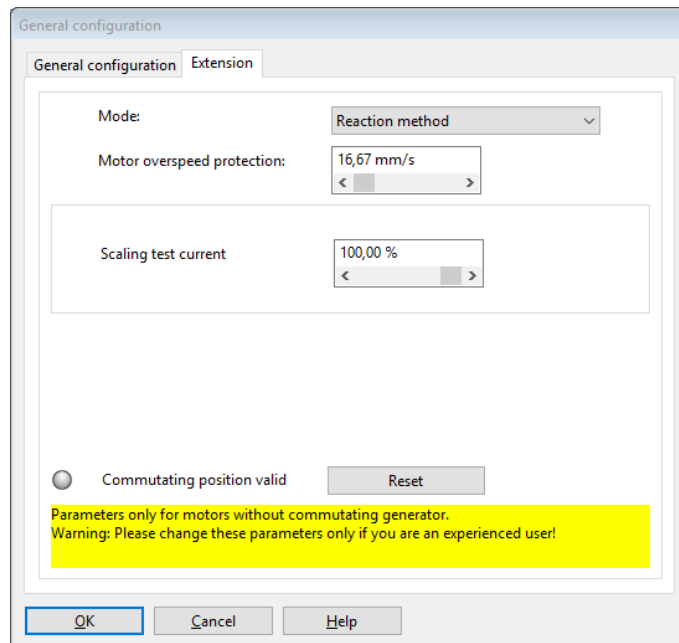


Figure 94: "General configuration" window

#### **INFORMATION** Configuration of the parameter

The configuration of the parameter **Motor overspeed protection** for the commutation position determination process is not the same as the configuration of the overspeed protection function that can be accessed via the menu **Parameters/Safety parameters**.

## › Mode

The **Mode** is mainly determined by the design and layout of the motor. Three different modes are available:

- **Self-adjustment method**: With this method, the drive moves over the double search range in a controlled manner. Depending on the initial position, the drive may jerk. This method is not suitable for vertical applications.
- **Reaction method** (recommended): This method is suitable for all types of drives without a braking system. It is suitable for horizontal and vertical applications. Only minimal mobility (the system is more or less motionless) is sufficient for determining the commutation position. This method can also be applied if the drive permits a certain degree of motion at the output side in spite of an active brake.
- **Saturation method**: This method is not suitable for air-core drives. It requires a drive with a fixed brake as the drive must be absolutely motionless during the determination of the commutation position. It is suitable for horizontal and vertical applications.

## › Reset

The button **Reset** can be used when the servo drive is set up for the first time. When the drive is adapted to the application for the first time, this function can help you during the configuration of the parameters. When the "Commutation position valid" status is reset, the process will be started when the servo drive is enabled. This means that the methods can be repeatedly activated in a targeted manner.

Most linear motors are air-core motors. This is why the so-called "reaction method" is optimally suitable for these motors. It also works well for motors that are vertically arranged on a stop.

If the current is too high, the reaction method may cause excessive movements. The current pulses ensure that the drive accelerates and decelerates. If the pulses are too strong, it may not be possible to stop this movement in time before the next pulse occurs, thereby leading to an incorrect, useless result. In these cases (e.g. in the case of easy-running motors), the current must be reduced with the aid of a reduction factor.

The saturation method requires hardly any parameterisation at all. However, if the drive is not decelerated "sufficiently", small movements may occur and render the measurement incorrect. In this case, the amplitude can be reduced for the measurement.

The LED **Commutation position valid** indicates that the commutation position has been successfully determined. This status will be reset, e.g. if an angle encoder error occurs. It is only relevant for motors with angle encoders without any commutation signals.

### 7.6.3.3 Settings in the homing menu for linear motors

After the commutation position of a motor without a commutation encoder has been determined, the configured homing run will be started automatically. This is necessary, as the system lacks reference with regard to the mechanical system of coordinates.

When a motor without a commutation encoder is started for the first time, it is possible to read in a reference pulse via the index pulse track at connector X2B (see below). However, in this case, it must be ensured that only one reference pulse occurs over the range of movement.

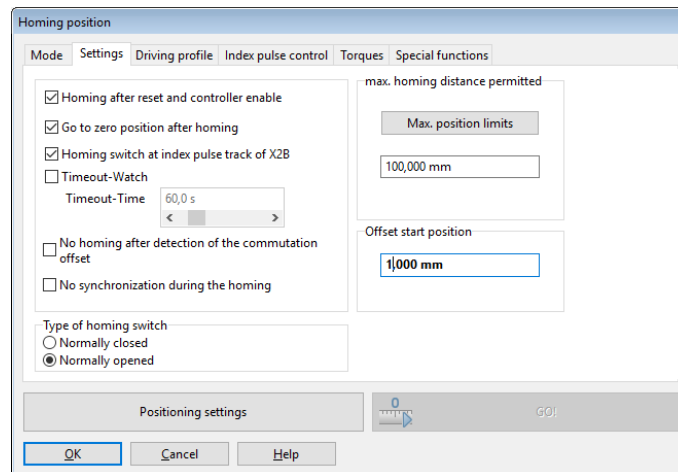


Figure 95: "Homing position" window

We recommend performing a homing run with an offset (1 mm) if a stop is used for homing (see section 6.1.1 *Methods -17 and -18: Stop* on page 74). Otherwise the drive may rest stuck to the stop (or to the compressed rubber buffer) and the  $I^2t$  value increases as the system permanently requires high current.

### 7.6.3.4 Necessary error reactions in the case of linear motors

The window **Error/Error management** can be used to define the reactions of the servo drive to various operating states. In the case of linear motors, a particularly "sharp" reaction must be parameterised for some events:

The following error settings must be realised or verified prior to using the linear motor for the first time:

No.	Error	Reaction	Note
03-x	Motor overtemperature (analogue or digital)	Disable servo drive	
08-x	Angle encoder error	Stop at maximum current	If this error occurs, the encoder system, its supply line and the setting must be checked: <b>Parameters/Device parameters/Angle encoder</b> , tab: X2B / X6.
17-0	Max. following error exceeded	Stop at maximum current	To perform the setting, open the menu <b>Parameters/Safety parameters</b>
27-0	Following error warning threshold	Stop at maximum current	To perform the setting, open the menu <b>Parameters/Signals</b> and select the tab <b>Following error</b> .
31-x	I <sup>2</sup> t check of the motor, servo drive, PFC and braking resistor	Stop at maximum current	To perform the setting, open the menu <b>Parameters/Device parameters/Motor data</b> .
35-0	Overspeed protection of linear motor	Stop at maximum current	To perform the setting, open the menu <b>Parameters/Safety parameters</b>

## 7.6.4 Manual optimisation of the controllers

### 7.6.4.1 Motor requirements

A servo drive used for controlling a motor consists of a DC bus that is supplied by way of the mains power supply (via a rectifier). The DC bus, in turn, supplies an inverter. This inverter uses switching transistors (e.g. insulated gate bipolar transistors, IGBTs) to generate a pulse-width-modulated (PWM) voltage. The mean of this voltage is the sinusoidal voltage of the desired frequency and amplitude. The current ripple, which is usually present, is smoothed by the inductance of the motor.

#### › Insufficient armature inductance

Some applications are subject to increased current ripple. These current harmonics are superimposed on the base current. In the case of insufficient armature inductance (e.g. < 0.2 mH), these currents lead to losses in the armature winding and to eddy-current losses in the stator iron core.

In the case of highly dynamic applications (e.g. linear drives), so-called position noise is generated if encoders with poor resolution are used.

Ignoring these current harmonics may lead to damage to the winding. In such a situation, even standard operation with rated current may cause a dangerous overload of the electric motor.

This is why the PWM switching frequency of the servo drive should be increased (e.g. by selecting a faster current controller cycle time  $t_i$  or by deactivating the option **Half power stage frequency**) during the parameterisation process. For a thorough analysis, the motor should be used at a standstill for a longer period of time to be able to analyse the temperature rise.

#### › Excessive armature resistance

Often, rather thin enamelled wires (usually grade 1) are used. However, in cheap motors, the minimum breakdown voltage (between the wires of the winding, not with regard to the housing) of these grade 1 enamelled wires is considerably lower than that of grade 2 enamelled wires. In this case, high voltage peaks damage the motor, thereby leading to local bridges in the winding package.

Often, motors with a relatively high ohmic armature resistance ( $> 10 \Omega$ ) are used. In this case, too, rather thin wires are used in order to realise high inductance and, thereby, high torque. The high DC resistance is a problematic factor as it can also cause losses in the armature. In addition, the dynamic response of the current controller circuit decreases as the rise time of the current controller is considerably delayed.

To improve the dynamic response, we recommend a temporary increase of the DC bus voltage via a series transformer, the manual parameterisation of the current and speed control settings and the use of the current feedforward control taken from the position set.

### › Measures

Current peaks and, thereby, harmonics can be reduced by way of suitable measures. The primary measure would be to increase the clock frequency. However, the clock frequency cannot be increased to an unlimited extent as it is accompanied by higher switching losses of the IGBTs that are used.

Servo drives made by Kuhnke enable a variable adjustment of the clock frequency in the current controller circuit. In most cases, the clock frequency can be configured by way of the Kuhnke ServoCommander® parameterisation program. In order to minimise switching losses, the clock frequency of the pulse width modulation can be reduced by half compared to the frequency in the current controller circuit. However, this does not have a positive effect on the current ripple.

Another measure (to reduce current peaks) is to increase the motor inductance by way of chokes. The chokes reduce the current ripple and, thereby, the stress on the motor caused by harmonics. In some cases, the use of ferrite cores is sufficient for a strong reduction of the current ripple.

To avoid damage to the motor (winding damage), these current harmonics should be taken into consideration right from the outset. The current harmonics are added to the base current (maximum current and nominal current). This is why the motor specifications concerning the maximum and rated current must include the value of these current harmonics.

In addition, external measures (see above) for reducing the current ripple are usually rather expensive and time-consuming.

If these current harmonics are taken into consideration during the rating of the drive and the parameterisation of the servo drive (maximum and nominal current limits), the risk of damage to the motor can be minimised right from the outset.

### 7.6.4.2 Reversing generator



#### Display/Reversing generator

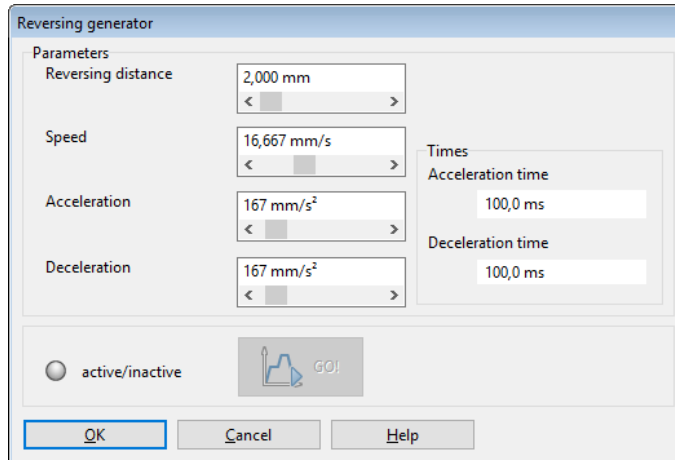


Figure 96: "Reversing generator" window

The reversing generator can be used to initiate a cycling positioning process to optimise the drive. The distance for the reversing movement (**Reversing distance**), the **Speed** and the acceleration values (**Acceleration**, **Deceleration**) can all be parameterised. Use the button **GO!/STOP** to start and stop the movement.

### 7.6.4.3 Manual speed control configuration



#### Parameters/Controller parameters/Speed controller

#### **NOTICE** Risk of damage to the motor and servo drive

The speed controller can only be optimised after a successful completion of the commissioning process. Otherwise, the motor and servo drive may be damaged! See chapter 4 *Quick-start guide* on page 30

#### **NOTICE** Risk of damage to the motor in reversing mode

In reversing mode, a drive coupled to the motor may be damaged. This is why the motor must be uncoupled.

To configure the speed controller, define a setpoint ramp via the reversing generator. The internal oscilloscope can be used to observe the reactions and following errors and to adjust the controller parameters. It is important to uncouple the motor from the mechanical output or, in the case of a linear system, to move it to the middle of the range of movement (jog mode).



Adjust the speed controller so that only a small overshoot of the actual speed value occurs. The overshoot should be approx. 15% higher than the speed setpoint. This setting applies to most motors that can be operated with the servo drive. If an even "harder" control response is required, the gain of the speed controller can be increased even further. In this case, we recommend using a setpoint ramp for the speed control (the limits of this method are reached when the drive starts to oscillate or to emit noise). The monitored  $I^2t$  value may increase as well, indicating that the motor is reaching its maximum current limit. The control quality depends on the load conditions so that it may be necessary to readjust it under different load conditions.

Open the menu **Options/Input limits** and select the maximum possible value for **Speed values/Maximum acceleration to set**.

Start the **Oscilloscope**:



Display/Oscilloscope

Set the following values:

Channel	Scaling	Offset
Channel 1: Actual speed value	1,000 rpm/div,	1 div
Channel 2: Speed setpoint	1,000 rpm/div,	1 div
Channel 3: Following error	0.2 rpm/div,	-1 div
Channel 4: Real current - actual value	5 A/div,	-2 div

**Time base:** 100 ms/div, delay 100 ms

**Trigger:** Source = speed setpoint; Level = 10 rpm;  
Mode = normal, rising trigger edge

The reversing generator must be parameterised as follows:

- Reversing distance: 10 rev
- Speed: 1,000 rpm
- Acceleration: (10,000 rpm at first)
- Deceleration: (10,000 rpm at first)

Enable the servo drive. Start the reversing generator. The motor will then reverse within the specified limits. Check the behaviour when the speed setpoint is reached. It must correspond to the well-dampened curve (middle curve in the following illustration).

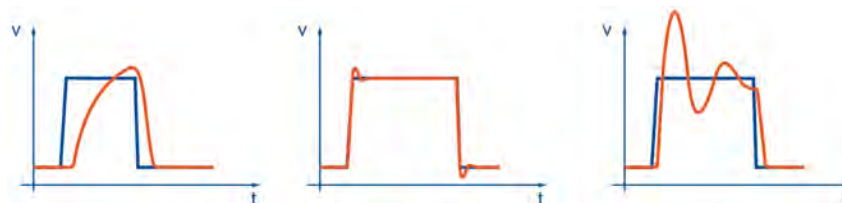


Figure 97: Speed controller: Step responses

Open the **Speed controller** menu (**Parameters/Controller parameters/Speed controller**) and optimise the control parameters.

Save the settings by way of **File/Parameter set/Save parameter set**.

After the numbers have been changed, there may be two different situations:

- If the setting is too hard, the speed controller will become unstable (diagram on the right).
- If the setting is too soft, the drive is not sufficiently rigid (diagram on the left). This results in following errors during operation.

#### **INFORMATION** Speed controller parameters

The speed controller parameters are interdependent. Measurement curves that differ from trial to trial can have various reasons. This is why only one parameter should be changed at a time: either the gain factor or the time constant.

To adjust the speed controller, increase the gain until oscillation occurs. Then, decrease the gain again in small steps until oscillation ceases. Then, decrease the time constant until oscillation occurs and then increase it again in small steps until the controller is sufficiently stable and rigid at setpoint = 0.

#### **INFORMATION** Optimising the speed controller

The drive does not need to be completely installed for the speed controller to be optimised! If you parameterise the speed controller with an idling motor shaft, the only thing you need to do after the installation is to increase the controller gain.

### › Optimising the speed filter

To optimise the control response, the measured actual speed value must be smoothed. This is realised with the aid of a speed filter. The effective filter time constant can be parameterised:

To parameterise the filter time constant, proceed as follows:

1. Open the menu **Parameters/Device parameters/Speed controller**.
2. Set the time constant of the **Speed filter** to 0.4 ms.
3. Click **OK**.
4. Save the settings with **File/Parameter set/Save parameter set**.

The speed filter is preset in line with the encoder system that is used to ensure a good resolution of the actual speed value with a short processing time.

Analogue encoders with a high line count always have a good resolution. In this case, a small time constant can be selected and a high level of dynamic behaviour and rigidity of the drive can be achieved.

Digital encoders with a low line count as well as resolvers require a high time constant as, otherwise, the quantisation of the actual speed value will be too rough and bit noise can be heard if the gain of the speed controller is high.

**INFORMATION** Time constant

An excessive time constant in the speed filter leads to decreased stiffness. If the time constant of digital encoders or resolvers is too small, noise will be produced.

Ensure to change the gain factor and time constant in small steps only.

#### 7.6.4.4 Manual optimisation of the position controller

**Parameters/Controller parameters/Position controller**

The position controller calculates a resulting speed based on the difference between the set position and actual position and transfers this speed value as a set value to the speed controller. The various functions of the position controller are described in section 4.4.13 *Configuration of the position controller* on page 59. This chapter explains the gain optimisation process.

If the position build-up takes too much time, the gain must be increased. If the speed starts to fluctuate during the stopping process, the gain must be decreased.

Please note that overshoots are due to insufficient acceleration and deceleration time values.

## 7.7 Digital inputs

### **⚠ WARNING Hazards for the user**

The digital inputs of the servo drive are not suitable for safety-oriented applications.

Nine digital inputs provide fundamental control functions (see section 12.12 *I/O Interface [X1]* on page 229).

The BL 4000-C servo drives have a target table in which the positioning targets can be stored and from which they can be retrieved at a later point of time. Four digital inputs are used for the target selection; one input is used as a start input.

The limit switches are used to limit the range of movement for reasons of safety. During homing, one of the two limit switches can be used as a reference point for positioning control. Together with the STO inputs, one input is used for enabling the servo drive. Two high-speed sampling inputs (DIN4 and DIN8) are used for position sampling. The digital inputs can be universally assigned to various functions (e.g. positioning start, reference switch, etc.).

The menu **Display/Digital inputs** provides an overview of the available digital inputs and their current assignment:

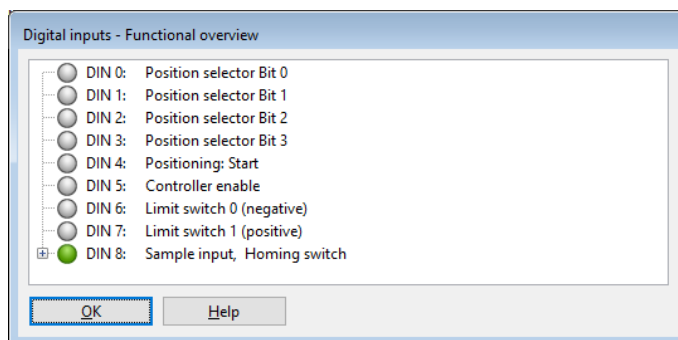


Figure 98: "Digital inputs - Functional overview" window

If digital inputs are used multiple times, this is indicated by a **+** symbol in the functional overview. In addition, some of the functions of the inputs are listed separated with commas, thereby ensuring a quick overview. Clicking the **+** symbol displays all of the functions of the associated input in a tree view.

### **INFORMATION Multiple use of digital inputs**

Multiple use of digital inputs is tolerated by the firmware. The user is responsible for checking whether the combinations are useful.

## 7.7.1 Configuration of the digital inputs



### Parameters/IOs/Digital inputs

The servo drives have numerous functions that can be triggered via the digital inputs. Some of these functions are assigned to special digital inputs in a fixed manner. The other functions can be assigned to the other digital inputs as required by the specific application.

For some of the functions, the digital inputs must fulfil special requirements so that not all of the available digital inputs can be used for all of the functions.

In general, a function can be assigned clearly to only one digital input. This means that it is not possible to activate the same function via two different digital inputs. However, it is possible to trigger two functions simultaneously via the same digital input. In this case, the user must ensure that no conflict ensues.

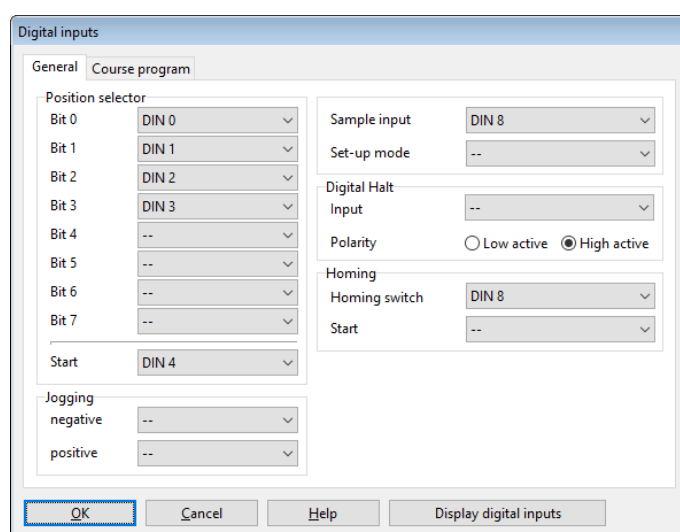


Figure 99: "Digital inputs" window

### › Position selector

To address a target position based on the 256 programmable targets, a position selector can be configured. In addition, a start input and a sample input can be used for the positioning process.

### › Jog mode

The input to be used for the negative or positive direction of rotation can be specified for the jog mode.

### › Digital stop

The "Digital stop" stop signal affects the positioning and speed control process.

### › Sample input

The sample input can be used for saving the current position in the internal memory so that it can be used for calculations (e.g. for length measurements or for increasing the resolution for flying saw applications).

### › Homing process

For homing, the start signal and the reference switches can be actuated by way of digital inputs.

The following table provides an overview of the permissible assignments between the various functions and digital inputs:

Digital input	0	1	2	3	4	5	6	7	8
Function									
Position selector bit 0	•	+	+	+	+	-	-	-	-
Position selector bit 1	+	•	+	+	+	-	-	-	-
Position selector bit 2	+	+	•	+	+	-	-	-	-
Position selector bit 3	+	+	+	+	+	-	-	-	-
Position selector bit 4	+	+	+	+	+	-	-	-	-
Position selector bit 5	+	+	+	+	+	-	-	-	-
Position selector bit 6	+	+	+	+	+	-	-	-	-
Position selector bit 7	+	+	+	+	+	-	-	-	-
Sample input	-	-	-	-	-	-	-	-	•
Positioning start	-	-	-	-	•	-	-	-	+
Controller enable signal	-	-	-	-	-	H	-	-	-
Limit switch 0	-	-	-	-	-	-	H	-	-
Limit switch 1	-	-	-	-	-	-	-	H	-
Digital stop	+	+	+	+	+	-	-	-	-
Jog left	+	+	+	+	+	-	-	-	-
Jog right	+	+	+	+	+	-	-	-	-
Start homing	+	+	+	+	+	-	-	-	-
HOME program	+	+	+	+	+	-	-	-	-
START program	+	+	+	+	+	-	-	-	-
NEXT1 program	+	+	+	+	+	-	-	-	-
NEXT2 program	+	+	+	+	+	-	-	-	-
Program stop	+	+	+	+	+	-	-	-	-
Program start/stop	+	+	+	+	+	-	-	-	-
Reference switch	-	-	-	-	+	-	-	-	•
Set-up mode	+	+	+	+	+	-	-	-	-

**Explanation:** + permissible, • permissible (default), - not permissible, H hard-wired

Digital input	Affects	See section		
Position selector	Positioning process	6.2.8	<i>Jog mode</i>	Page 1
Start	Positioning process	6.2	<i>Positioning process</i>	Page 86
Sample input	Positioning process	6.4	<i>Flying saw</i>	Page 108
Digital stop	Speed control process	5.2.2	<i>Speed-controlled mode (speed control)</i>	Page 66
	Positioning process	5.2.3	<i>Position-controlled mode and positioning mode (positioning process)</i>	Page 67
Start homing	Homing process	6.1	<i>Homing process</i>	Page 73
Reference switch	Homing process	6.1	<i>Homing process</i>	Page 73
HOME program	Motion program	6.2.7.3	<i>Digital inputs - Motion program</i>	Page 101
START program	Motion program	6.2.7.3	<i>Digital inputs - Motion program</i>	Page 101
NEXT1 program	Motion program	6.2.7.3	<i>Digital inputs - Motion program</i>	Page 101
NEXT2 program	Motion program	6.2.7.3	<i>Digital inputs - Motion program</i>	Page 101
Program stop	Motion program	6.2.7.3	<i>Digital inputs - Motion program</i>	Page 101
Combined start/stop	Motion program	6.2.7.3	<i>Digital inputs - Motion program</i>	Page 101
(Jogging) negative	Jog mode	6.2.8	<i>Jog mode</i>	Page 102
(Jogging) positive	Jog mode	6.2.8	<i>Jog mode</i>	Page 102

## 7.8 Digital outputs

### **⚠ WARNING Hazards for the user**

The digital outputs of the servo drive are not suitable for safety-oriented applications.

There are three digital outputs available for displaying the operating states of the servo drive.

The menu **Display/Digital outputs** provides an overview of the available digital outputs and their current function assignment.

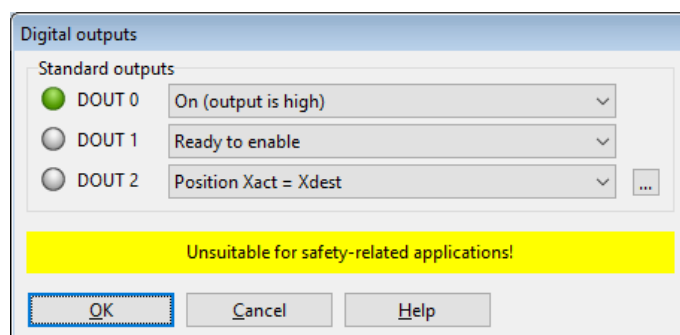


Figure 100: "Digital outputs" windows



## 7.8.1 Configuration of the digital outputs



### Parameters/IOs/Digital outputs

The following functions can be assigned to a digital output:

Digital output	See section		
OFF			
ON			
I <sup>2</sup> t monitoring active	4.4.4	<i>Configuration of the motor data</i>	Page 47
Comparison speed	7.8.2.2	<i>Speed message window: "Comparison speed reached"</i>	Page 175
Xact = Xdest	7.8.2.3	<i>Target position message window: "Xactual = Xtarget"</i>	Page 176
Remaining distance	6.2.3	<i>Destination parameters: Settings tab</i>	Page 88
Homing active	6.1	<i>Homing process</i>	Page 73
Homing position valid	6.1	<i>Homing process</i>	Page 73
Undervoltage	7.11	<i>Configuration of the DC bus monitoring function</i>	Page 184
Following error	4.4.13	<i>Configuration of the position controller</i>	Page 59
Output stage enabled	5	<i>Enabling the servo drive and selecting the set values</i>	Page 62
Holding brake released	7.10	<i>Brake control and automatic brake</i>	Page 182
Linear motor identified	4.4.1	<i>General configuration</i>	Page 41
Position triggers 1..4	7.9	<i>Position triggers</i>	Page 178
Setpoint lock active	4.4.11	<i>Configuring the polarity of the limit switches</i>	Page 56
Comparison torque reached	7.8.2.1	<i>Torque message window: "Comparison torque"</i>	Page 174
Position set active	6.2.7	<i>Motion program</i>	Page 97
Ready to enable	5	<i>Enabling the servo drive and selecting the set values</i>	Page 62
General error	9	<i>Fault messages</i>	Page 208

## 7.8.2 Configuration of the messages for the digit

Under the menu **Parameters/Signals**, a window appears in which the target position messages and following error messages can be para

### 7.8.2.1 Torque message window: "Comparison torque"

The tab **Comparison torque** offers the following setting options:

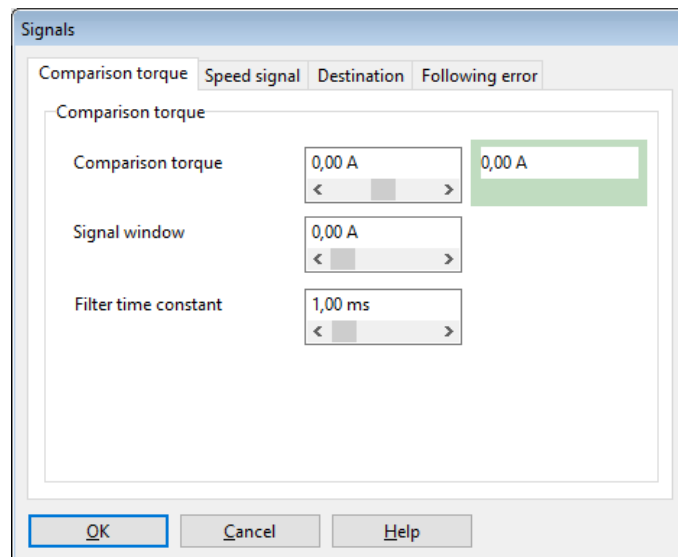


Figure 101: "Signals" window - "Comparison torque" tab

The parameters **Comparison torque**, **Signal window** and **Filter time constant** can be used to control the function **Comparison torque reached** of a digital output.

The output becomes active when the filtered actual current is in the range of  $(I_{\text{comparison}} - I_{\text{message}} \dots I_{\text{comparison}} + I_{\text{message}})$ . The actual current is filtered by way of a PT1 filter. The **Filter time constant** of this filter can be configured.

### 7.8.2.2 Speed message window: "Comparison speed reached"

The tab **Speed signal** offers the following setting options:

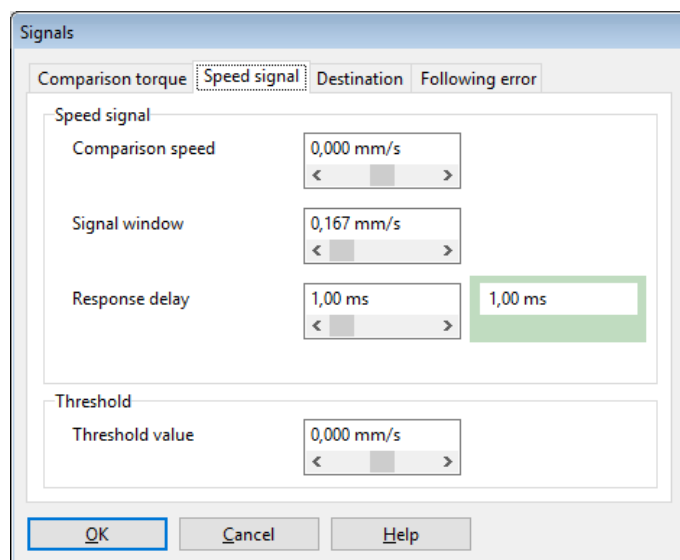


Figure 102: "Signals" window - "Speed signal" tab

The parameters **Comparison speed**, **Signal window** and **Response delay** can be used to control the function **Speed reached** of a digital output.

The output becomes active when the current speed is in the range of  $(n_{\text{comparison}} - n_{\text{message}} \dots n_{\text{comparison}} + n_{\text{message}})$ . However, it will only be activated if the speed remains within this range at least for the time  $t_{\text{response}}$  (**Response delay**).

The parameter **Threshold value** is used for the configuration of a second comparison speed. At present, it is evaluated only by fieldbus systems based on status words.

### 7.8.2.3 Target position message window: " $X_{\text{actual}} = X_{\text{target}}$ "

The tab **Destination** (target position) offers the following setting options:

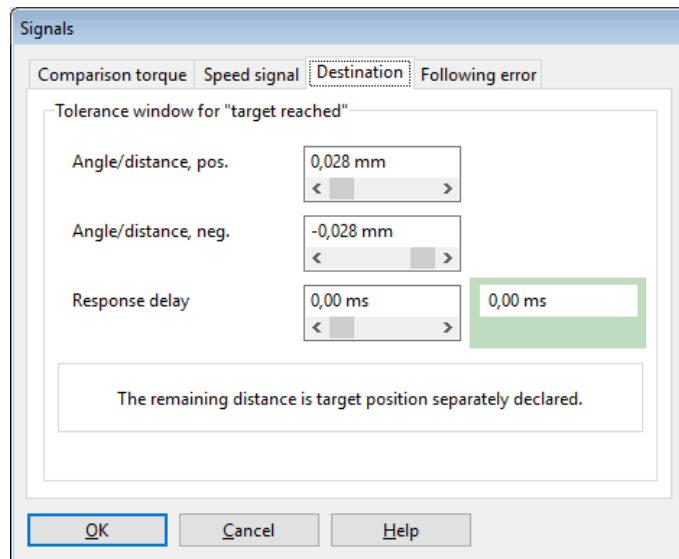


Figure 103: "Signals" window - "Destination" tab

These parameters can be used to control the function  $X_{\text{actual}} = X_{\text{target}}$  of a digital output.

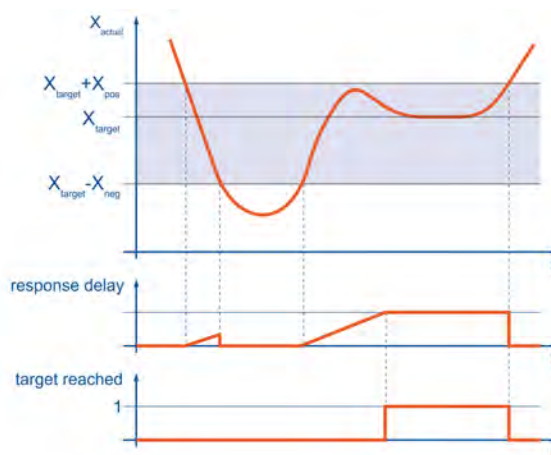


Figure 104: "Target position reached" message

The output will become active when the current position is within the range of  $(X_{\text{target}} - X_{\text{neg}} \dots X_{\text{target}} + X_{\text{pos}})$ . However, it will only be activated if the position remains within this range at least for the time that is specified under **Response delay**. The output will not become inactive until the position leaves the range of the target window. For example, the output remains active when a positioning run is started and the new target is still within the target window.

### 7.8.2.4 Following error message window: "Following error"

The tab **Following error** offers the following setting options:

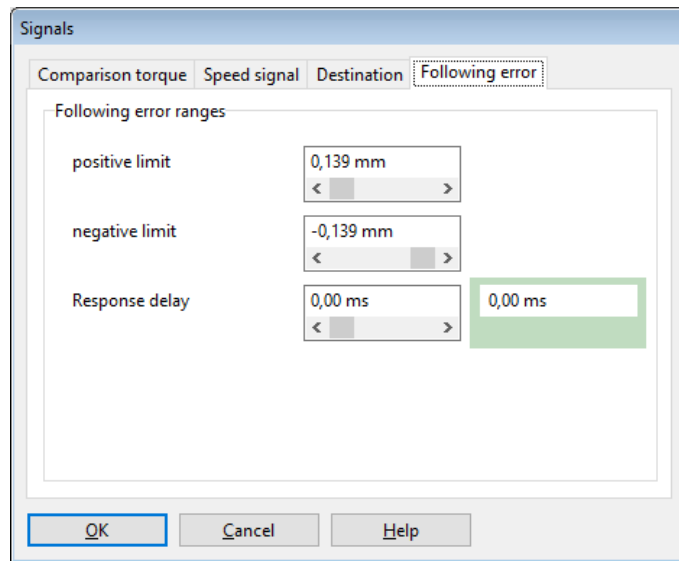


Figure 105: "Signals" window - "Following error" tab

These parameters can be used to control the "following error" function of a digital output.

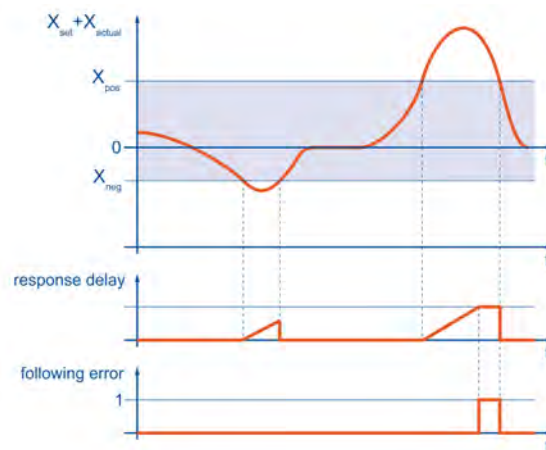


Figure 106: "Following error" message

The output becomes active when the actual position is out of range ( $X_{\text{set}} - X_{\text{neg}} \dots X_{\text{set}} + X_{\text{pos}}$ ). However, it will only be activated if the position remains within this range at least for the time that is specified under **Response delay**.

#### **INFORMATION** Following error message

The "Following error" message and the "Shutdown level of following error" are not identical. The latter must be configured in the "Safety parameters" menu. See the section 4.4.5 *Safety parameters* on page 49.

## 7.9 Position triggers

The menu can be found under **Parameters/I/Os/Position trigger**.

The position triggers can be used to transfer information concerning the logic states of the position triggers and rotor position triggers to the digital outputs. 4 position triggers can be configured (vertical lines).

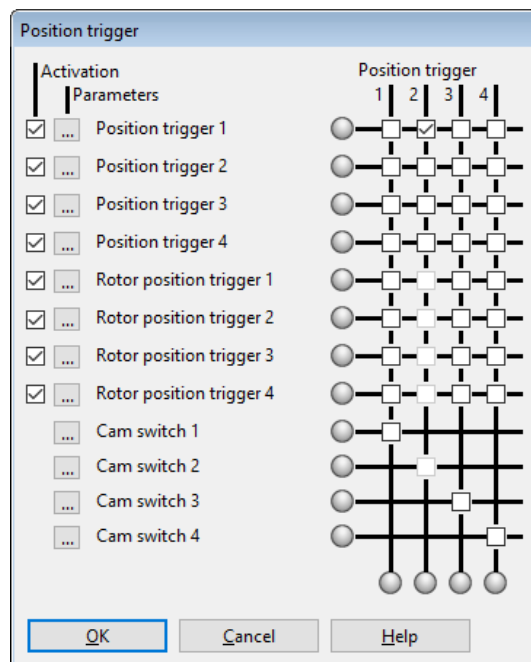


Figure 107: "Position trigger" window

The following sources are available (horizontal lines):

- 4 position triggers (see section 7.9.1 *Position triggers* on page 180)
- 4 rotor position triggers (see section 7.9.2 *Rotor position triggers* on page 181)

The function of a digital output in the "Digital outputs" menu must be set to "Position trigger 1...4" to ensure that the information can be transferred to a digital output (see section 7.8.1 *Configuration of the digital outputs* on page 173).

In order to assign a source to a position trigger output, tick the associated checkboxes in the corresponding column. It is possible to assign several position triggers or rotor position triggers to a specific position trigger output. The logic information will then be combined by way of an OR function.

### **INFORMATION** Combining triggers by way of an OR function

Please note that the combination by way of an OR function can only be performed for one group. Using an OR function for position triggers and rotor position triggers, for example, is not possible.

The vertical LEDs indicate the logic states of the sources. The horizontal LEDs indicate the resulting states.


### › Activation

The checkboxes are used to assign the sources to the targets.

If a checkbox is greyed out, a connection with a higher-ranking group is not possible. In this case, clear all of the checkboxes that are located above this line.

If there is no checkbox at all, this means that the source cannot be selected as it has not been activated. If you want to activate a source, tick the corresponding checkbox on the left.

### › Options button (parameter)

The options button  can be used for a precise configuration of the position triggers or rotor position triggers.

The following is an example of a combination of signals by way of an OR function:

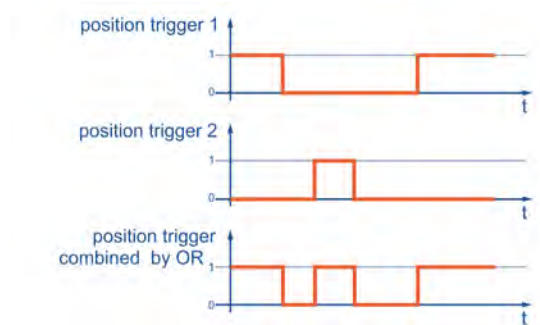


Figure 108: Combination of trigger signals by way of an OR function (example)

## 7.9.1 Position triggers

The menu can be found under **Parameters/I/Os/Position trigger - Parameters**.

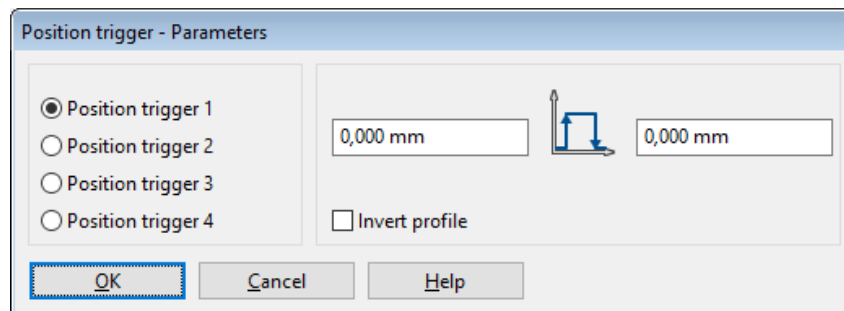


Figure 109: "Position trigger – Parameters" window

This menu is used for the configuration of the position trigger channels 1...4. The position trigger channels 1...4 are logic channels, i.e. they can have the logic values 0 and 1. In order to use these position trigger channels, they can be linked logically in the position trigger menu and then assigned to a digital output. The logic value of the position trigger depends on the current actual position value.

### › Position trigger 1...4

Here, you can select the position trigger that is to be parameterised.

### › Input field: left-hand edge

If the actual position is smaller than the position of the left-hand edge (in the example: 1.00 revolutions), the position trigger has the logic value 0 if the profile is not inverted (see below). If the profile is inverted, the value is 1.

### › Input field: right-hand edge

If the actual position is greater than the position of the right-hand edge (in the example: 2.3 revolutions), the position trigger has the logic value 0 if the profile is not inverted (see below). If the profile is inverted, the value is 1.

### › Invert profile

If the profile is not inverted, the logic level of the position trigger outside the two edges is "logic 0". If the profile is inverted, the level outside the two edges is "logic 1".



## 7.9.2 Rotor position triggers

The menu can be found under **Parameters/I/Os/Rotor position trigger - Parameters**.

This menu is used to configure the rotor position trigger channels 1..4. These channels are logic channels, i.e. they can have the logic values 0 and 1.

In order to use these rotor position trigger channels, they can be linked logically in the position trigger menu and then assigned to a digital output.

The logic value of the rotor position trigger depends on the current encoder angle of the rotor. This means that the state changes periodically with every revolution.

### › Rotor position trigger 1...4

Here, you can select the rotor position trigger that is to be parameterised.

#### › Input field: left-hand edge

If the encoder angle is smaller than the value of the left-hand edge (in the example: 13.22°), the rotor position trigger has the logic value 0 if the profile is not inverted (see below). If the profile is inverted, the value is 1.

You can enter values between -180.0° and +180.0°.

#### › Input field: right-hand edge

If the encoder angle is greater than the value of the right-hand edge (in the example: 17.20°), the rotor position trigger has the logic value 0 if the profile is not inverted (see below). If the profile is inverted, the value is 1. You can enter values between -180.0° and +180.0°.

#### › Invert profile

If the profile is inverted, the logic level of the rotor position trigger outside the two edges is "logic 1".

## 7.10 Brake control and automatic brake

If your motor has a holding brake, this brake can be actuated as required by the application. The servo drive can only control holding brakes with a rated voltage of 24 V DC. If you want to edit the parameter for controlling the holding brake, open the menu **Parameters/Device parameters/Brake functions**. The following window will be displayed:

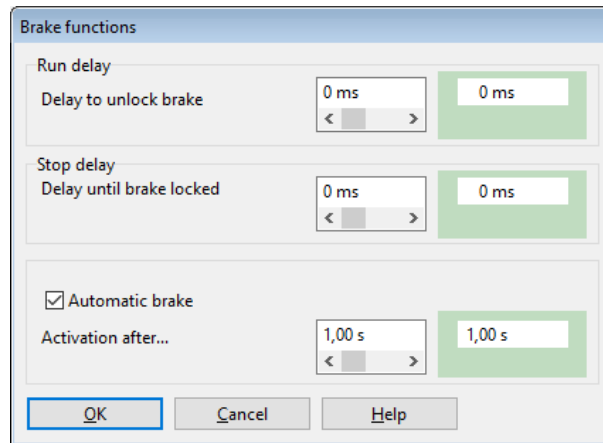


Figure 110: "Brake functions" window

One of the digital outputs is reserved for controlling the holding brake of the motor. The brake will be enabled when the servo drive is enabled. Delays can be configured for holding brakes with high mechanical inertia.

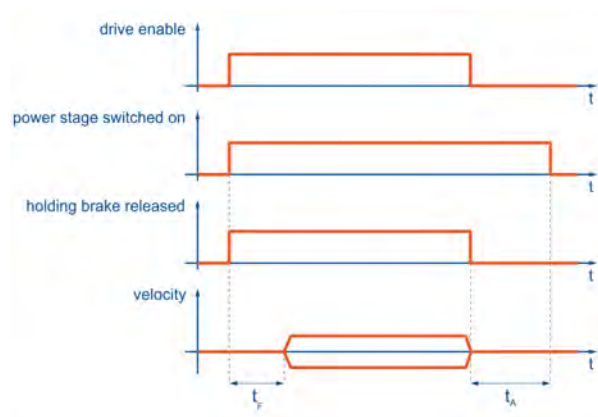


Figure 111: Brake control: run delay and stop delay

The **Run delay**  $t_F$  is used to adapt the actuation of the holding brake to its mechanical inertia. If the servo drive is enabled, the speed setpoint will be set to zero during this delay. As a result, the drive stands still until the brake has been completely released.

**INFORMATION** Speed setpoints

- After the servo drive has been enabled, speed setpoints or positioning start commands will not become effective until the run delay has elapsed.
- In **Torque control** mode, the torque setpoints become active immediately, i.e. the delays are inactive.

**Stop delay  $t_A$ :** When the servo drive is disabled, the speed setpoint will be set to zero. When the actual speed is approximately zero, the holding brake will be activated. This is when the stop delay becomes effective. During this delay time, the drive will be held in its current position until the holding brake has developed its full holding torque. When the delay time is over, the servo drive will be disabled. In both cases, the mechanical wear of the holding brake is reduced.

**NOTICE** Damage to the brake or system

In certain applications (e.g. during synchronisation processes), the brake and/or the system may be damaged when the automatic brake is activated. Always check the conditions of use before you activate the automatic brake.

The servo drive has an **Automatic brake** function. If the drive has not moved during a parameterisable time  $t_E$  (**Activation after...**), the servo drive will automatically activate the brake and deactivate the output stage.

The automatic brake helps you to save energy.

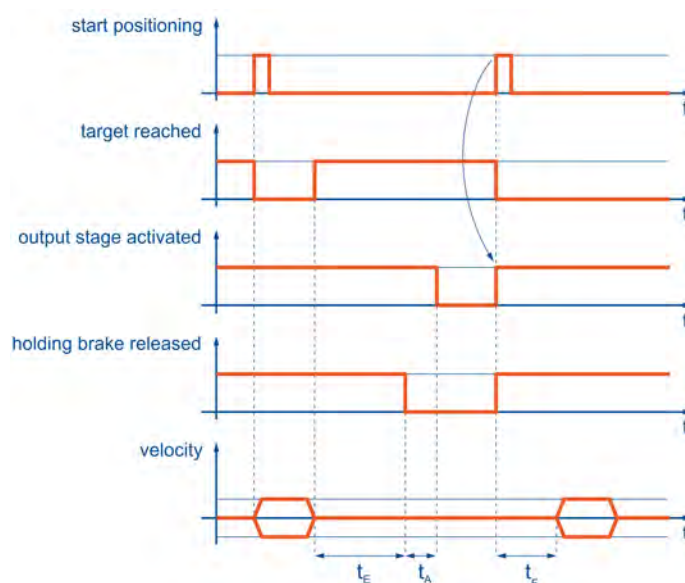


Figure 112: Brake control parameters: automatic brake

The advantage of this function is that it reduced the stress on the motor and servo drive. The drive is switched off during a break, so to speak. A potential disadvantage is the increased level of brake wear. Even if the automatic brake function has deactivated the output stage, the servo drive is still in the "servo drive enabled" state. This is also indicated by the CANopen status word, for example. When a new positioning process is started, the output stage will be activated automatically without the need for an activity of the control system.

## 7.11 Configuration of the DC bus monitoring function

In special cases, the DC bus voltage may become too high or too low. If the DC bus voltage becomes too high (overvoltage), an integrated brake chopper activates a parallel resistor in a first step. If the voltage continues to rise, the servo drive will be switched off due to overvoltage and the drive coasts down.

### **NOTICE** Risk of irreparable damage to the drive

If the servo drive is deactivated due to overvoltage, the driven component will not be actively decelerated any longer. Instead it will coast down. In the case of limited ranges of movement, the stops and the machine may be damaged.

Start with small acceleration values and increase them gradually. For analysis, check the I<sup>2</sup>t indicator in the status window in order to be able to detect an overload of the internal brake resistor in time.

The overvoltage switch-off threshold is factory-set and cannot be changed.

In addition, it is possible to trigger an error if the DC bus voltage is too *low*, provided that this has been parameterised by the operator. The menu can be activated under **Parameters/Device parameters/Intermediate circuit control**.

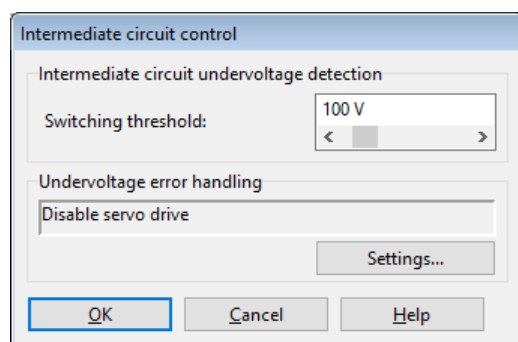


Figure 113: "Intermediate circuit control" window

The field **Switching threshold** can be used to define the value below which the voltage must fall so that the servo drive detects an undervoltage.

The flag that is set in the servo drive can be read by way of several different status enquiries. For example, a digital output can be parameterised so that it indicates an undervoltage event in the DC bus. See section 7.8 *Digital outputs* on page 172.

The field **Undervoltage error handling** can be used to define whether an error message is to be generated and the servo drive is to be deactivated in the event of an undervoltage (see section 9.1 *Error management* on page 210).

**NOTICE Risk of damage to the servo drive**

Activate the undervoltage monitoring function to ensure that the servo drive will not be damaged due to mains power fluctuations or brief mains power failures.

Brief mains power failures may cause high compensation currents in the DC circuit and input rectifier and the servo drive may be damaged as a result of these currents.

## 7.12 External braking resistor

The servo drive has a DC bus which is the energy store for the application to be driven. If the application itself requires energy, e.g. for accelerating an inertial mass, this energy will be withdrawn from the DC bus. If, on the other hand, an inertial mass is decelerated, the excess energy will be fed into the DC bus. As a result, the DC bus voltage increases.

As the DC bus voltage must not exceed a certain limit, there is an electronic switch (brake chopper) that discharges the DC bus via the so-called braking resistor. As a result, the excess energy of the application will be converted into heat by the braking resistor.

### › I<sup>2</sup>t monitoring function

The I<sup>2</sup>t monitoring function protects the integrated braking resistor and switches the brake chopper off before the internal braking resistor will be overloaded. If the braking process is not complete at this point of time, the DC bus voltage will rise again, and the servo drive will be switched off due to overvoltage. As a result, the motor will coast down without being actively decelerated.

In order to not be forced to perform the braking process more slowly, the brake power can be increased by connecting an external braking resistor. See section 12 *Technical data* on page 215.

Alternatively, it is possible to couple the DC buses of several drives in order to increase the DC bus capacity (see section 7.13 *DC bus coupling* on page 186)

Use the menu **Parameters/Device parameters/External resistor** to specify whether an external resistor is connected. The firmware needs this information to calculate the power loss of the brake chopper.

## 7.13 DC bus coupling

The coupling of DC buses is interesting for applications with high braking energy levels or for applications requiring movements to be performed after a power failure. No special parameterisation is required for the DC link coupling of servo drives from the BL 4000-C series, but some important instructions must be observed. These instructions are due to the circuit design of the inrush current limitation feature.

### › Inrush current limitation and precharging function

Servo drives have a DC bus. This DC bus buffers various power flows that result from the power supply via the supply network with a fixed frequency and the positive or negative power flow of the motor with a variable frequency.

Following the activation after the electric equivalent circuit, the capacitors of the DC bus represent a short circuit. Very high short-circuit current during the activation of the power supply is avoided by way of suitable measures. To this end all of the devices of the BL 4000-C series have an integrated precharging circuit.

Kuhnke servo drives are designed for different supply voltages (single-phase/three-phase) and DC bus voltages. For this reason, only the DC bus of the following devices can be coupled together:

BL 4100-C with servo drives from the BL 4100-C series.  
BL 4300-C with servo drives from the BL 4300-C series.

Even for devices with the same DC bus voltage, there are certain restrictions in terms of the possible combinations. The type of supply must be known. In addition, the circuit-related characteristics for the inrush current limitation must be taken into consideration.

#### **NOTICE** Damage to property due to high electrical current

In the event of a short circuit or similar faults, high current may flow through the coupling. A maximum of 4 BL 4000-C servo drives can be coupled.

Please verify the technical data of the products and of the mains power supply. If in doubt, contact the Technical Support team of your sales partner.

#### **NOTICE** Damage to property due to different mains phases

If the DC buses of single-phase devices are coupled, the mains connectors of the servo drives must be connected to the **same** mains phase, e.g. all connected to L1/N, L2/N or L3/N.

It is **strictly forbidden** to connect the devices to different mains phases, e.g. servo drive 1 to L1/N and servo drive 2 to L2/N, when the DC buses are coupled!

## 7.14 Control circuit cycle times

### **NOTICE** Risk of irreparable damage due to incorrect settings

Only experienced users should change the configuration.

Incorrect settings can cause the drive to oscillate, thereby destroying the motor.

Use the menu **Parameters/Controller parameters/Cycle times** to change the cycle times of the internal control circuits, e.g. of the current control circuit. The following window will be displayed:

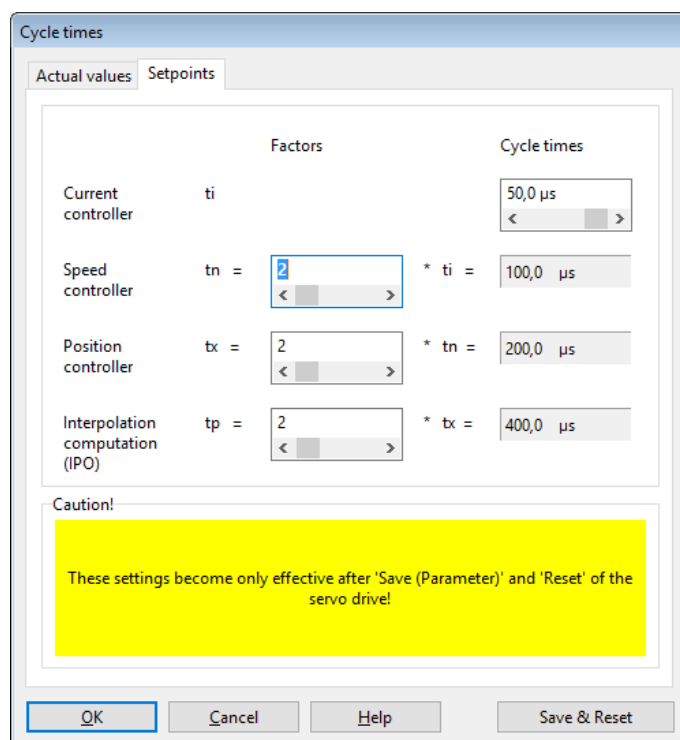


Figure 114: "Cycle times" window - "Setpoints" tab

To open the **Setpoints** tab, click the **Settings** button.

The time interval for the current controller can be configured. If the time interval is too short, an internal overflow may occur as in this case the processor does not have a sufficient amount of computing time. If the time interval is too long, the dynamic response will deteriorate, i.e. disturbances will be compensated only very slowly.

The speed controller is subordinate to the current controller. Normally, it is requested during every second current controller cycle. If the factor is increased, the dynamic response will also decrease as the speed controller request rate will be reduced. If the factor is increased, the computing time reserves will be increased.

The position controller, on the other hand, is subordinate to the speed controller. Normally, it is requested during every second cycle. The information provided above applies in this case, too, including the last point "Interpolation calculation".

Variable cycle times became necessary in order to be able to support functions requiring, for example, a synchronisation of the current controller intervals of several devices via a fieldbus system. In this case, the cycle time of the current controller is set to a certain value based on experience. During operation, the cycle time will be automatically and continuously adapted within a very narrow correction range.

To extend the computing time reserve, we recommend changing the cycle time of the current controller in the range of a few  $\mu\text{s}$ . This is sufficient in most cases. The factors should be increased only for special applications, e.g. for the "Interpolated Position Mode" under CANopen.

### › Operation in an interpolated operating mode

When using the servo drive in an interpolated operating mode (e.g. 7 or 8 under CANopen/EtherCAT), the interpolator cycle  $t_p$  must be adapted to the cycle time of the external bus system. The following table includes possible combinations for reaching the bus cycle time with 1 ms.

$t_i$	Factor $t_n$	Factor $t_x$	Factor $t_p$	$t_p$
31,2 $\mu\text{s}$	2	3	8	998.4 $\mu\text{s}$
33,3 $\mu\text{s}$	2	3	5	999.0 $\mu\text{s}$
35,7 $\mu\text{s}$	2	2	7	999.6 $\mu\text{s}$
37,0 $\mu\text{s}$	3	3	3	999.0 $\mu\text{s}$
41,7 $\mu\text{s}$	2	2	6	1000.8 $\mu\text{s}$
47,7 $\mu\text{s}$	2	3	4	1000.8 $\mu\text{s}$
50,0 $\mu\text{s}$	2	2	5	1000.0 $\mu\text{s}$



## 7.15 Band-stop filters

Some applications are prone to oscillations due to their design. These oscillations are further promoted by hard settings of the control circuits. Band-stop filters are used to eliminate these frequencies from the closed control circuit in a targeted manner. This leads to shorter process cycle times as the gain in the speed control circuit can be set to a higher value.

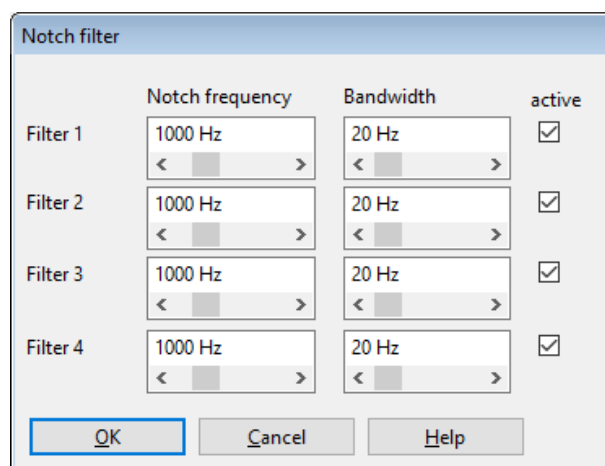
The notch frequency (stop frequency) and bandwidth for up to 4 band-stop filters can be viewed and changed in the menu **Parameters/Controller parameters/Notch filter**.

### **NOTICE** Risk of irreparable damage due to incorrect settings

Only experienced users should change the configuration.

Incorrect settings can cause the drive to oscillate, thereby destroying the motor.

Band-stop filters are used to suppress resonant frequencies.



	Notch frequency	Bandwidth	active
Filter 1	1000 Hz < [ ] >	20 Hz < [ ] >	<input checked="" type="checkbox"/>
Filter 2	1000 Hz < [ ] >	20 Hz < [ ] >	<input checked="" type="checkbox"/>
Filter 3	1000 Hz < [ ] >	20 Hz < [ ] >	<input checked="" type="checkbox"/>
Filter 4	1000 Hz < [ ] >	20 Hz < [ ] >	<input checked="" type="checkbox"/>

OK Cancel Help

Figure 115: "Notch filter" window

Enter the centre frequency of the band-pass filter (highest dampening level) into the **Notch frequency** fields. The **Bandwidth** fields are used to specify the frequency range in which the damping is below -3dB. The individual band-stop filters can be activated by way of the **active** checkboxes. Do not activate a band-stop filter unless this is really required by the application.

### **NOTICE** Risk of unstable control circuits

In the case of a drive without the corresponding resonant frequencies, the activation of a band-stop filter may lead to control circuit instability.

## 7.16 Motor temperature monitoring system

The menu **Parameters/Device parameters/Temperature monitoring** can be used to configure the motor temperature sensors. The selection of standard temperature sensors has already been described in section 4.4.6 *Motor temperature monitoring* on page 52. The following section explains the configuration of a single sensor.


Temperature sensors can be connected via three different connectors (X2A, X2B and X6) that are internally connected to the same analogue evaluation system. This is why it is not possible to connect more than one sensor at a time.

### **⚠ DANGER** Dangerous electrical voltage! ⚠

The signals for the temperature sensor "MT-" and "MT+" at the motor connector [X6] must be connected to protective extra-low voltage (PELV) on the motor side and they must be insulated against the motor phases.

### 7.16.1 Parameterising the characteristic (linear/non-linear sensor)

If your motor temperature sensor has a linear characteristic, select **Generic type (linear)**.

Clicking the button  opens a detail window in which two data points of the characteristic (**Motor resistor at 25°C** or **Motor resistor at 100°C**) can be specified.

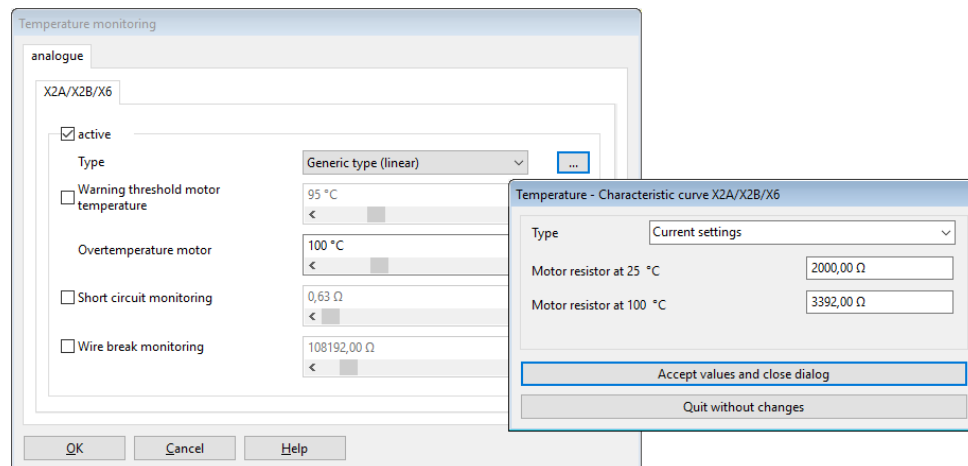


Figure 116: Temperature characteristic - linear sensor

If your motor temperature sensor has a non-linear characteristic, select **Generic type (non-linear)**.

Clicking the button opens a detail window in which ten data points of the characteristic can be specified. You can specify the relationship between the individual resistance values and temperature values.

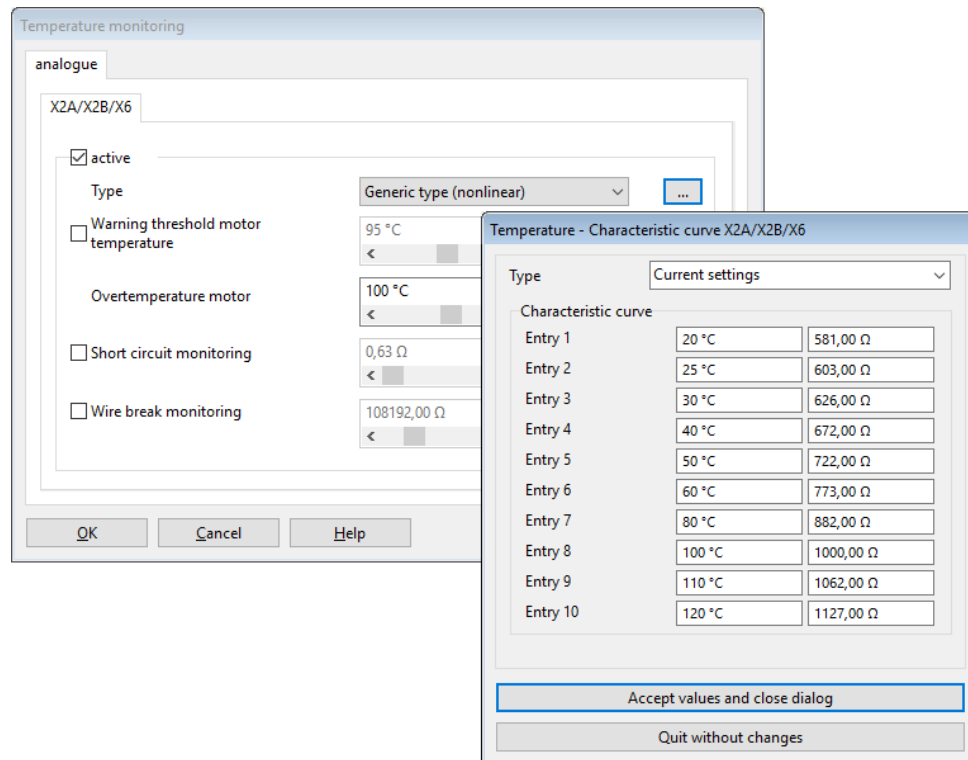


Figure 117: Temperature characteristic - non-linear sensor

## 7.16.2 Temperature limits and monitoring functions

The value stated for **Overtemperature motor** defines the temperature at which error 03-0 will be issued. The value stated for **Warning threshold motor temperature** indicates the temperature at which error 18-0 will be issued. While in the case of error 03-0 the servo drive will be disabled, error 18-0 can be parameterised as a warning.

In addition, the following monitoring functions can be activated and parameterised:

**Short circuit monitoring** field: Specify the resistance below which the system will detect a short circuit of the sensor.

**Wire break monitoring** field: Specify the resistance above which the system will detect a broken wire.

## 7.17 Limit switch, setpoint direction limitation

The "Setpoint direction limitation" function is activated when a drive reaches a hardware limit switch. Its purpose is to prevent the drive from continuing to move in the direction of the limit switch (e.g. because of a new setpoint value issued by a superordinate control system). When the setpoint direction limitation function is active, the drive can only move in the opposite direction.

When the drive has left the limit switch, the setpoint direction limitation function can be deactivated by way of an error acknowledgement. This can be realised via a fieldbus, the parameterisation program or a falling edge at the digital input for enabling the servo drive (if configured).

## 7.18 Firmware download

The firmware is the operating program of the servo drive. The servo drives come supplied with the current firmware as standard. However, older servo drives can benefit from new features by way of a firmware update.

Select a suitable firmware file under [File/Firmware download](#). If the selected firmware file is not suitable for the device, a corresponding message will be displayed. This may be the case, for example, if the firmware is intended for a different device series.

The firmware download itself is a completely automatic process. Do not interrupt the power supply during the firmware update. If this is the case, an error message will be displayed. The servo drive will be reset and restarted with the old firmware.

### › Firmware download via a microSD card

The firmware of the servo drives can also be updated via a microSD card. With this method, several servo drives can be supplied with a new firmware very quickly. If a suitable firmware file is available on the microSD card, it will be automatically identified by the servo drive. Then, the servo drive downloads the firmware, provided that it has not already been loaded into the device. If there is more than one firmware file on the microSD card, the most recent file will be used.

## 8 STO (safe torque off)

The purpose of this chapter is to ensure the safe use of the STO (safe torque off) safety function that is integrated in the servo drive.

This documentation refers to the following versions:

- SmartServo BL 4000-C with the STO function, revision 1.0 or higher
- Kuhnke ServoCommander® parameterisation program version 5.0.0.1.1 or higher.

### 8.1 Special safety instructions

**⚠ DANGER** Dangerous electrical voltage! ⚠

Always follow the safety instructions for electric drives and control systems in section 2 *For your own safety* on page 16.

**⚠ WARNING** Hazards due to the loss of the safety function

If you do not comply with the specified ambient and connection conditions, the safety function will be lost. This may lead to injuries in the worst case.

Always comply with the specified ambient and connection conditions. This applies particularly to the input voltage tolerances. See section 12.13 *STO [X3]* on page 235.

### 8.2 Certification/safety level

A servo drive of the BL 4000-C series with an integrated safety function is a safety device in accordance with the EC Machinery Directive 2006/42/EC and it bears the CE mark. Information about the product-relevant EC Directives can be found in the declaration of conformity in section 15.2 *CE conformity (Machinery Directive)* on page 273.

The achievable safety level depends on the other components that are used to implement a safety function. This has been certified by an independent testing authority.

## 8.3 Requirements for using the product

Make this documentation available to the design engineer, installation technician and personnel responsible for commissioning the machine or system in which this product is used.

Ensure that the specifications of the documentation are always complied with. Also take into account the documentation for the other components (e.g. safety relays, cables, etc.).

Take into consideration the legal regulations applicable at the installation site as well as:

- regulations and standards
- regulations of the testing organisations and insurers
- national specifications
- all of the safety instructions in section 2 *For your own safety* on page 16
- the special safety instructions in section 8.1 *Special safety instructions* on page 193

For emergency stop applications, protection against automatic restarting must be provided in accordance with the required safety category. This can be realised, for example, by way of an external safety relay.

### 8.3.1 Qualification of the specialist personnel (personnel requirements)

The device may only be set into operation by a qualified electrical technician who is familiar with:

- the installation and operation of electrical control systems
- the applicable regulations for operating safety-oriented systems
- the applicable regulations for accident protection and industrial safety
- the documentation for the product.

### 8.3.2 Diagnostic coverage (DC)

The diagnostic coverage depends on the integration of the safety functions, which are integrated in the servo drive, into the overall system and on the implemented diagnostic measures.

If a malfunction is detected during the diagnosis process, appropriate measures must be taken to maintain the safety level.

#### **INFORMATION** Cross-circuit detection

Check whether your application requires a cross-circuit detection of the input circuit and of the connecting wiring.

If necessary, use a safety relay with cross-circuit detection for actuating the safety function.

## 8.4 Purpose

As processes become increasingly automated, protecting persons against potentially hazardous movements is continuously gaining in importance. Functional safety describes the necessary measures in the form of electrical or electronic devices for the reduction or elimination of hazards caused by malfunctions. Under normal operating conditions, protective devices and guards prevent human access to danger areas. However, in certain operating modes, e.g. during set-up, persons are required to be present in these danger areas. In these situations, the machine operator must be protected by way of drive- and control-system-related measures.

The integrated functional safety technology provides the control-system- and drive-specific conditions for the optimal realisation of protective functions. As a result, planning and installation become less labour-intensive. The use of integrated functional safety technology leads to an enhanced machine functionality and availability compared to the levels achieved by conventional safety technology.

## 8.5 Principle of operation and use

The STO function includes the feature "Realisation of the "Safe Torque Off" (STO) function".

The "Safe Stop 1" (SS1) function can be realised with a suitable external safety relay and by suitable wiring of the servo drive.

### 8.5.1 Description of the STO safety function

Use the "Safe Torque Off" (STO) function if you need to disconnect the motor safely from the energy supply for your application. The "Safe Torque Off" function switches off the driver supply for the power semiconductors. This prevents the power output stage from providing the voltage that is required by the motor. As a result, the motor cannot start unexpectedly. See the following illustration.

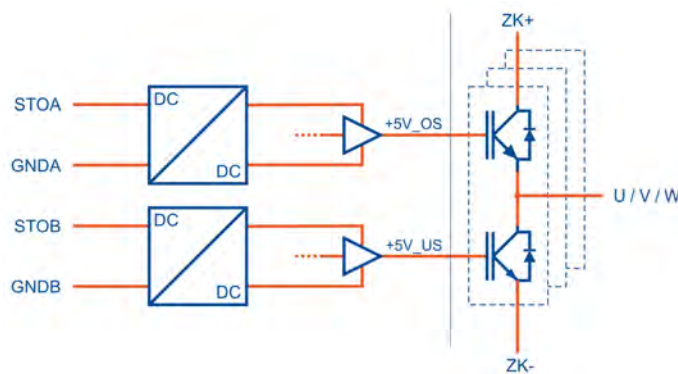


Figure 118: "Safe Torque Off" - principle of operation

When the "Safe Torque Off" (STO) function is active, the energy supply to the drive is interrupted in a safe manner. The drive can neither generate any torque nor any dangerous movements. In the case of suspended loads or other external forces, additional measures must be taken in order to prevent the load from sagging (e.g. mechanical holding brakes). In the "Safe Torque Off" (STO) state, the standstill position will not be monitored.

#### **NOTICE** Risk of a jerky movement of the drive in the case of multiple errors

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

Examples:

- Rotary axis, synchronous machine, 8 poles  
→ movement < 45° of the motor shaft.
- Linear motor, pole pitch 20 mm  
→ movement < 20 mm of the moved part.



## 8.5.2 Overview of the [X3] interface



Figure 119: Position of connector X3

At its front, the servo drive has an 8-pin connector [X3] for

- the STO control inputs,
- the digital output DOUT0, and
- the digital inputs DIN 6 and DIN 7

The STO safety function is requested exclusively via the two digital control inputs STOA and STOB. The safety-oriented integration of additional interfaces is not necessary/intended.

The servo drive does not monitor the input circuit for cross-circuit faults.

The [X3] interface enables the direct connection of active and passive sensors as DOUT0/GND provide a short-circuit-proof 24 V supply voltage (see section 13.14 *Connector: STO [X3]* on page 268).

### 8.5.3 Control inputs STOA, GNDA/STOB, GNDB [X3]

The control inputs STOA and STOB are used for requesting the STO safety function ("Safe Torque Off") via two channels. They enable the direct connection of safe semiconductor outputs (electronic safety relays, active safety sensors, e.g. light grid with OSSD signals) and of switching contacts (safety relays with relay outputs, passive safety sensors, e.g. positively driven position switches). See, for example, section 13.14 *Connector: STO [X3]* on page 268.

To request the STO safety function ("Safe Torque Off"), the 24 V control voltage is switched off at both control inputs STOA and STOB (0 V). If both control inputs are switched off simultaneously or within a predefined discrepancy time, the STO function becomes active.

The table in section 12.13.1 *Electrical data of the STO function* on page 235 includes the technical data of the control inputs for the specified operating range of logic voltages.

Certain tolerance ranges have been defined for the input voltage range of the control inputs STOA and STOB. The amount of energy that is stored in the components of the STO circuit (e.g. capacitors) depends on this input voltage. During switching processes, this energy must be charged or discharged. This results in specific values for the switch-off time for the transition to the safe state (STO) and for the tolerance time with regard to the OSSD signals (buffer time). These values depend on the input voltage.

The time response is described in section 12.13.2 *Time response* on page 236.

### 8.5.4 Discrepancy time

The transition between the safe and unsafe state is initiated by level changes at the control inputs STOA and STOB of the servo drive. In accordance with the specification of the safety function, both levels must be identical. Otherwise, an error message will be generated. The finite state machine in the servo drive monitors the driver supply voltage as a result of the actuation of the control inputs. Usually, these level changes do not occur exactly at the same time, e.g. due to component tolerances or bouncing outputs of safety control systems. The firmware tolerates this as long as the second input follows within a predefined time, the so-called discrepancy time. If it is exceeded, the servo drive will generate an error message.

A discrepancy time of 100 ms is preset. **Recommendation:** Ensure to always switch STOA and STOB simultaneously.

In addition, to the integrated STO circuit, the finite state machine in the servo drive has its own status. Due to the evaluation of the discrepancy time, this finite state machine may reach the "safe state" only with a considerable delay. Consequently, this state can only be signalled via the digital outputs or a fieldbus with a considerable delay. The power output stage has already been "switched off safely" when this happens. The status of the finite state machine is processed every 10 ms.

### 8.5.5 Test pulses

Temporary test pulses from safety control systems are tolerated, i.e. they do not trigger any STO function request.

The tolerance with regard to test pulses from sensors with OSSD signals is rated for the operating range as per section 12.13.1 *Electrical data of the STO function* on page 235.

### 8.5.6 Auxiliary supply [X3]

The servo drive with an integrated STO function provides a switchable 24 V output DOUT0 at [X3]. It can be used for the supply of external active sensors.

### 8.5.7 Additional diagnostics functions

The following functions integrated in the servo drive are not certified in accordance with the Machinery Directive 2006/42/EC. They are functional extensions and offer additional diagnostics options.

Error messages that are generated by the integrated STO circuit, e.g. when the discrepancy time is exceeded, are registered and evaluated by the non-safety-relevant finite state machine of the servo drive. If the conditions for an error state are detected, an error message will be generated. In this case, it cannot be absolutely guaranteed that the power output stage has been switched off safely.

The integrated STO function does not have any inherent error assessment mechanisms and it cannot indicate any errors.

#### **INFORMATION** Acknowledgement of error messages

When error messages are acknowledged, all of the acknowledgeable errors concerning the functional safety technology will also be acknowledged at the same time. See section 8.11 *Diagnostics and fault clearance* on page 207.

The servo drive monitors the status of the control inputs STOA and STOB.

This enables the firmware of the servo drive to detect the request of the STO safety function ("Safe Torque Off") and various non-safety-oriented functions will be performed:

- Detection of the disconnection of the driver supply for the power semiconductors by the integrated STO circuit
- Deactivation of the drive control and also of the actuation of the power semiconductors (PWM)
- Deactivation of the holding brake actuation (if configured)
- Finite status machine of the servo drive including an assessment of the actuation (discrepancy time monitoring)
- Detection of application-related error states
- Hardware diagnosis
- Status and error indication via displays, digital outputs, fieldbuses, etc.

**⚠ WARNING Brake output not safety-oriented**

The brake is actuated via the non-safety-oriented firmware of the servo drive. If the application requires the safe actuation of the brake, additional external measures must be implemented.

**NOTICE Motor coasts down in an unbraked manner**

If one of the control inputs STOA or STOB is deactivated while the power output stage is active, the drive will coast down in an unbraked manner if the holding brake is not connected. As a result, the machine will be damaged.

Connect the holding brake to the servo drive.

**NOTICE Undersized holding brake**

Check whether your motors with a holding brake are suitable for braking and stopping the motor in the event of an error by way of the holding brake.

It is possible to request the safe state while the actuation of the power semiconductors (PWM) is active. However, an acknowledgeable error message will be issued. The status of the voltages will be checked and assessed every 10 ms. If they are unequal over a longer period of time, an error message will be issued. See section 8.11 *Diagnostics and fault clearance* on page 207.

## 8.6 Circuit examples

The following sections provide circuit examples with detailed drawings and notes. The wiring is identical for all servo drives of the BL 4000-C series. The examples show the connection of a BL 4104-C.

### 8.6.1 Safe torque off (STO)

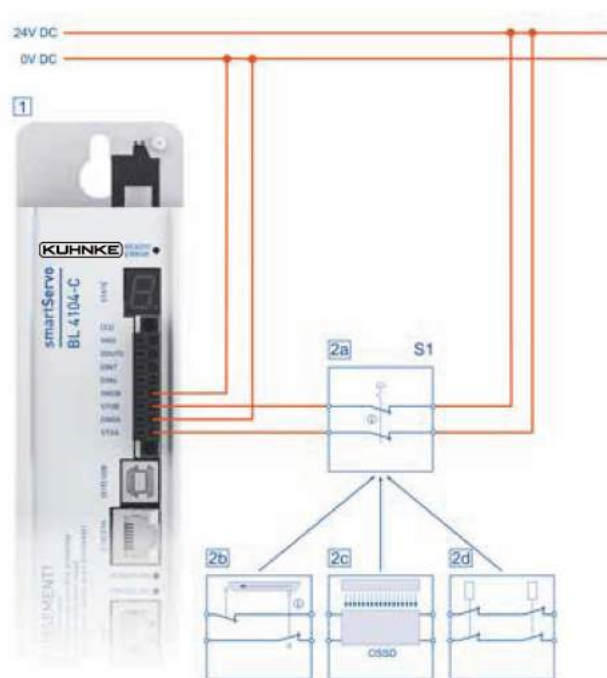


Figure 120: Connection of the integrated STO function (single-phase servo drive)

Pos.	Description
1	Servo drive with an integrated STO function (only the relevant connections are shown)
2a	Emergency stop button
2b	Safety gate
2c	Light grid
2d	Safety relay

The "Safe Torque Off" (STO) safety function can be requested by various devices. Switch S1 can be, for example, an emergency-stop switch, a switch of a protective gate, a light grid or a safety relay. The safety request is realised via two channels and via the switch S1. As a result, the output stage will be switched off via two channels.

### › Notes concerning the circuit example

- The servo drive with an integrated STO function does not include any cross-circuit detection. In the case of a direct wiring of light grids, the cross-circuit detection will be performed by the light grid, provided that it is suitable for this purpose.
- The circuit example has a two-channel structure that is suitable for category 3 and 4 if additional measures are implemented. The additional measures depend on the area of application and on the safety concept of the machine.

## 8.6.2 Deceleration and safe torque switch off (SS1, "Safe Stop 1")

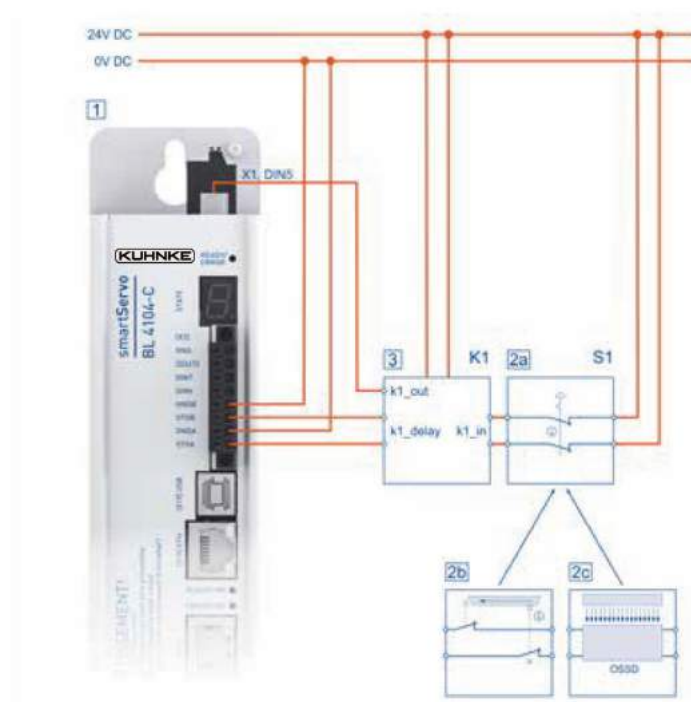


Figure 121: Circuit example "Deceleration and safe torque switch-off" (SS1, "Safe Stop 1") (single-phase servo drive)

Pos.	Description
1	Servo drive with an integrated STO function (only the relevant connections are shown)
2a	Emergency stop button
2b	Safety gate
2c	Light grid
3	Safety relay K1 with a delayed output

The safety function "Safe Stop 1" (SS1, type C) can be requested by various devices. The switch S1 can be, for example, an emergency-stop switch, the switch of a safety gate or a light grid. The safety request is transferred to the safety relay via two channels and via the switch S1.

The safety relay disables the servo drive. When the servo drive is disabled, the movement will be automatically decelerated. If a brake is configured, the system waits for the activation of the brake. Then, the control circuit will be switched off. After a certain time that is defined in the safety relay, the output stage will be switched off via two channels via STOA/B.

**▲ WARNING Hazards due to the loss of the safety function**

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

Use the integrated STO safety function only if all of the required safety measures have been implemented.

Validate the safety function at the end of the commissioning process. See section 8.9 *Functional test, validation* on page 207.

Incorrect wiring or the use of external components that have not been selected in line with the safety category will result in a loss of the safety function.

Perform a risk assessment for your application and select the circuitry and components accordingly.

**› Notes concerning the circuit example**

- The safety relay that is used must switch off the servo drive enable signal (X1, pin 9, DIN5) without any delay and the inputs STOA and STOB (X3, pin 1, pin 3) with a delay.
- The necessary delay depends on the application and must be determined specifically for the application. The delay must be chosen so that, even at top speed, the drive is decelerated to zero speed by way of the quick-stop ramp before the inputs STOA and STOB are switched off.
- The electrical installation must fulfil the requirements of the applicable standards listed in section 1.4 *Applicable standards* on page 15. If, for example, the safety relay and the servo drive are located inside the same control cabinet, it can be assumed that cross-circuit and earth faults between the individual wires are excluded (acceptance inspection of the control cabinet for correct wiring).
- The circuit example has a two-channel structure that is suitable for category 3 and, if additional measures are implemented, also for category 4. The additional measures depend on the area of application and on the safety concept of the machine.

## 8.7 Prior to commissioning

Perform the following steps as a preparation for the commissioning process:

1. Ensure that the servo drive has been properly installed (see section 14 *Maintenance, cleaning, repair and disposal* on page 270 and section 13 *Electrical installation* on page 240).
2. Check the electrical installation (connecting cables, pin assignment, see section 13.14 *Connector: STO [X3]* on page 268).
3. Check whether all of the PE conductors are connected.

## 8.8 Kuhnke ServoCommander® safety functions

The window **Safety module (integrated)** of Kuhnke ServoCommander® can be used to view status data concerning the integrated STO safety function. The integrated STO safety function itself does not require any parameterisation.

### 8.8.1 Servo drive type indication and safety function

At the lower edge of the MSC main screen, there is a status bar. This is where the servo drive type and information about the integrated safety function (in the case of the BL 4000-C servo drive always "STO integrated") is displayed.



Figure 122: STO status bar

In addition, the window **Safety module (integrated)** provides also information about the circuit design of the integrated STO safety function. See section 8.8.3 *"Safety module (integrated)" window* on page 206.



## 8.8.2 Status indication of the finite state machine

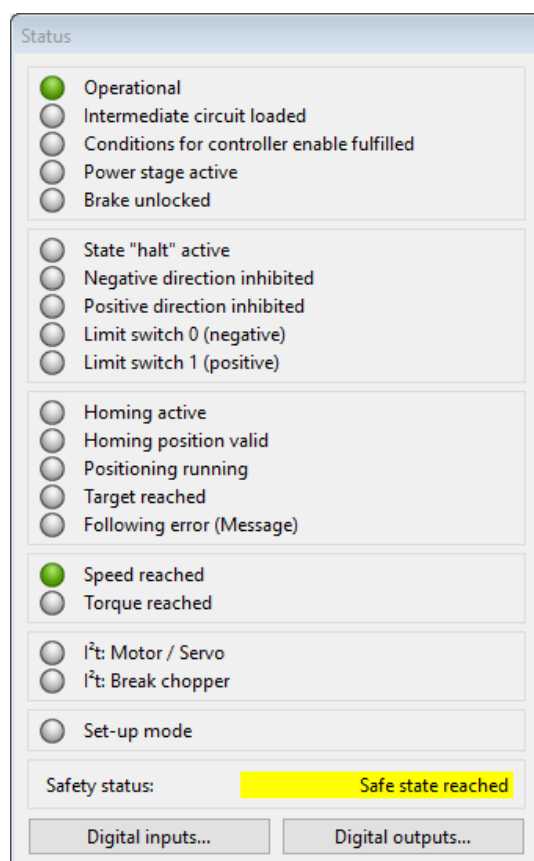


Figure 123: Status window with an indication of the safety status

The status window (permanent window in the online mode) also displays the status of the functional safety system of the servo drive firmware.

It is not a representation of the electrical status of the two STO inputs though. Instead it is an indication of the status of the finite state machine that results from the evaluation of the driver supply voltages of the integrated STO safety function. Regardless of the indication, the power output stage may have already been switched off safely by the integrated STO safety function.

The status of the internal finite state machine is also indicated in the window [Safety module \(integrated\)](#).

### 8.8.3 "Safety module (integrated)" window

The window **Safety module (integrated)** can be opened as follows in Kuhnke ServoCommander®:



The window shows the status data of the integrated STO safety function.

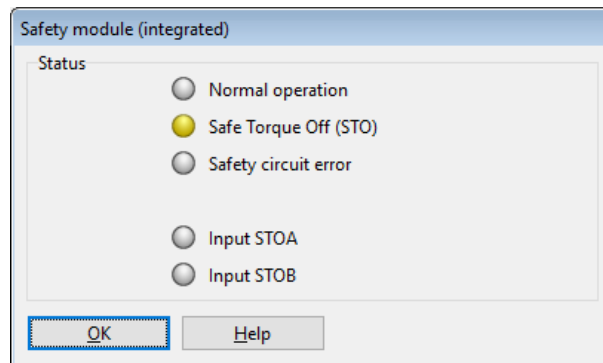


Figure 124: "Safety module (integrated)" window

The window has several areas:

The first three LEDs indicate the status of the functional safety system in the servo drive firmware as it has been recognised by the finite state machine of the servo drive.

The LEDs **Input STOA** and **Input STOB** indicate the state of the digital inputs as it has been recognised by the servo drive firmware. The indication in ServoCommander is of an informative nature and not part of the safety function itself.

## 8.9 Functional test, validation

The STO function must be validated after the installation or after the installation has been changed.

This validation must be documented by the person performing the commissioning process. To assist you with the commissioning process, section 15 *Appendix* on page 271 provides example checklists with questions for a risk reduction. However, these checklists are no substitute for safety training. No guarantee can be provided for the completeness of the checklists.

## 8.10 Operation

### › Obligations of the owner/operator

The safety system must be checked for correct operation at appropriate intervals. It is the responsibility of the owner/operator to choose the type of check and the time intervals in the specified time period. The check is to be conducted such that the correct operation of the safety system can be verified based on an interaction of all of the components.

### › Maintenance and care

A servo drive of the BL 4000-C series with an integrated STO function is maintenance-free.

## 8.11 Diagnostics and fault clearance

The servo drive indicates the safe state as well as error messages by way of its seven-segment display. See section 4.2 *Operating mode and error indication* on page 38.

### › STO-based fault messages

Error messages that are issued with regard to the functional safety system have error numbers from 51 to 52. These messages are described in the error table.

If an error message cannot be acknowledged, its cause must be remedied by applying the recommended measures. Then, reset the servo drive and check whether the cause of the error, and the error message, have been eliminated.

## 9 Fault messages

Servo drives of the BL 4000-C series have an extensive sensor system that monitors the controller unit, power output stage and motor as well as the communication with the outside world. Most errors will cause the controller unit to shut down the servo drive and the power output stage. The power output stage cannot be switched back on until the cause of the error has been eliminated and the error has been cleared.

If an error occurs, the servo drive will display an error message cyclically by way of its seven-segment display. The error message consists of the letter E (for error), a main index and a subindex, e.g.: E 0 1 0. Warnings have the same number as an error message. As a distinguishing feature, warnings have centre segment before and after the number, e.g. - 1 7 0 -.

A complete list of events, warnings and error messages can be found in section 15.6 *Error messages and warnings* on page 283.

### **NOTICE** Damage to property caused by errors

In most cases, the drive will be caused to coast down if an error occurs. However, if the range of movement of the axis is limited, the coast-down may lead to damage to the machine.

On the other hand, errors of the shaft encoder lead to a quick stop of the drive (even if there is no information about the commutation position). It is only then that the power output stage will be switched off.

The operator must check whether the parameterisation of the error responses is correct.

When an error occurs, the following three steps must be performed:

1. **Error analysis:** If the error text displayed by MSC is not sufficiently self-explaining, additional error causes are listed in the online help of MSC or in section 15.6 *Error messages and warnings* on page 283.
2. **Error elimination:** Eliminate the cause of the error in compliance with the safety instructions (section 2.4 *General safety instructions* on page 18).
3. **Error acknowledgement:** Clear the error by clicking the button **Clear** in the MSC error window. Alternatively, the error can also be acknowledged via a bus system.

**NOTICE** Risk of damage to property

Clearing an error via MSC can lead to a sudden restart if the superordinate control system or an external logic system enables the power automatically.

If the drive is checked in order to find the cause of an error, suitable interrupting devices (STO inputs, deactivation of the power supply) must be present and activated.

The following precautionary measures can be applied:

- Disconnection of the mains power supply connector
- Activation of the STO safety function
- Deactivation of the bus system via MSC or by disconnecting the bus connector
- Interruption of the connection to the motor
- Disconnection of the shaft connection (coupling) between the motor and output shaft in order to test the motor without damaging the machine.

## 9.1 Error management

The window **Error/Error management** can be used to define the reactions of the servo drive to various operating states. The following window will be displayed:

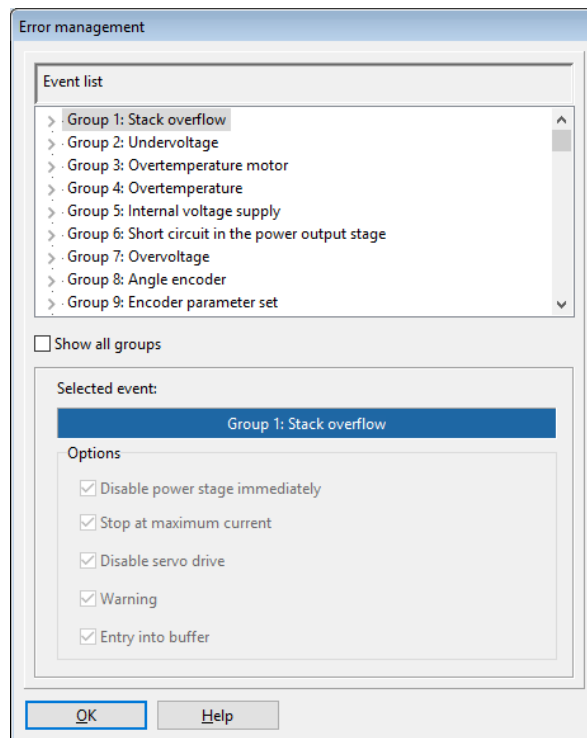


Figure 125: "Error management" window

You can use this window to define the reaction of the servo drive in the event of an error. Different responses can be assigned to every individual group. First select the group (by clicking) and then assign the responses. The following list shows the responses with a rising priority.

**Entry into buffer:** The event will simply be saved in the error buffer. The event will not be displayed, and the application continues to run without being affected by the event.

**Warning:** The event will be displayed briefly on the seven-segment display of the servo drive.

**Disable servo drive:** The application will be stopped by way of the emergency stop ramp (see also section 4.4.5 *Safety parameters* on page 49).

**Stop at maximum current:** The drive will be stopped with maximum current.

**Disable power stage immediately:** The drive will coast down as the power output stage is disconnected from the power supply.

Some of the events are so serious that certain responses cannot be deselected. In this case, the associated checkboxes are greyed out.

The configuration always applies to an entire group of errors. It is not possible to apply it to individual events.

## 9.2 Error buffer



### Error/Error buffer

The **Error buffer** window shows all of the errors, warnings and events that have occurred since the last activation.

The following information is provided:

- Error number
- System time (hours, minutes, seconds)
- Error description (text)
- Constant and free parameter

The window itself does not check whether there are any new errors. If a new error occurs while the window is open, select the button **Refresh** to refresh the error buffer.

If you want to print the error events, select the **Print** button. The button **Save** can be used to store the list of error messages or warnings and events as a text file or CSV file (comma-separated list).

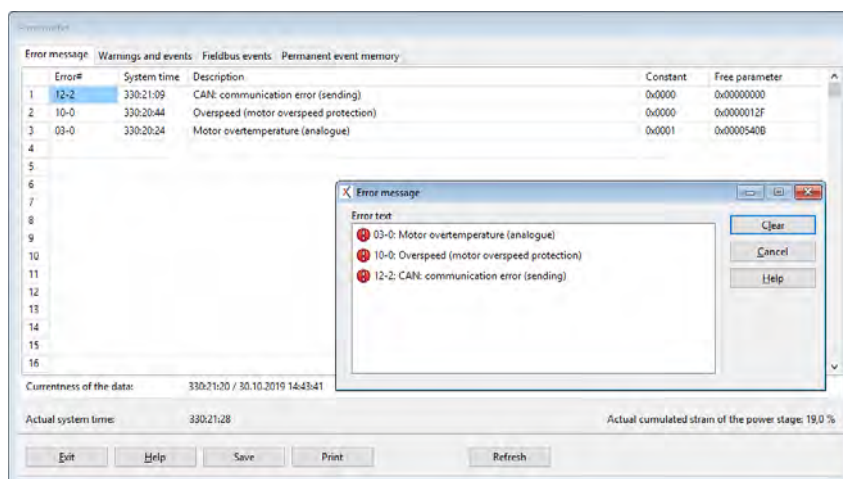


Figure 126: "Error buffer" and "Error messages" windows

### **INFORMATION** Error messages for the Application Engineering department

If you want to forward an error to the Application Engineering department, you should always save the error messages as a file and hand over this file as well. The file includes all of the relevant information (system time, constant, free parameter) that can be useful for the quick identification of the error cause.

The tab **Permanent event memory** shows error messages that are stored in the internal EEPROM of the servo drive in a non-volatile manner so that they can still be read out after a "power off". Error messages with the main index 00 are no runtime errors. They include information that is stored in the permanent event memory of the servo drive and that will not be displayed on the seven-segment display (e.g. the event "Error acknowledged"). In general, no activities by the user are required.

# 10 Storage/transport

The following requirements must be fulfilled for the storage and transport of the servo drive:

## > Storage

- Store the servo drive in line with the specified storage temperatures. Use only its original packaging.
- After approximately six months of storage, the oxide layer of the capacitors may become damaged. This is why the servo drive must be supplied with power for approximately 1 hour every six months (24 V and 230 V) in order to preserve the oxide layer.

## > Transport

### **⚠ CAUTION** Risk of injury due to improper transport

Follow these instructions to ensure the safe transport of the servo drive and to avoid injuries.

- Use only qualified personnel for the transport of the servo drive.
- Transport the servo drive only in its original packaging.
- Use only suitable transport equipment.
- Use suitable personal protective equipment.
- If you notice that the packaging is damaged, notify the carrier without delay. Then, inspect the servo drive for any signs of external or internal damage.

## > Transport damage

### **⚠ DANGER** Dangerous electrical voltage! ⚠

Transport damage to the servo drive may compromise the insulation between the low-voltage part and the high-voltage part. This results in an extremely dangerous electrical voltage.

Do not use the servo drive in this case. The servo drive needs to be checked by the sales partner or manufacturer.

In case of external damage (dents, deformed mounting flange, etc.) it must be presumed that some of the components have come loose and the breakdown strength concerning the high-voltage part may no longer be existent.



# 11 Installation

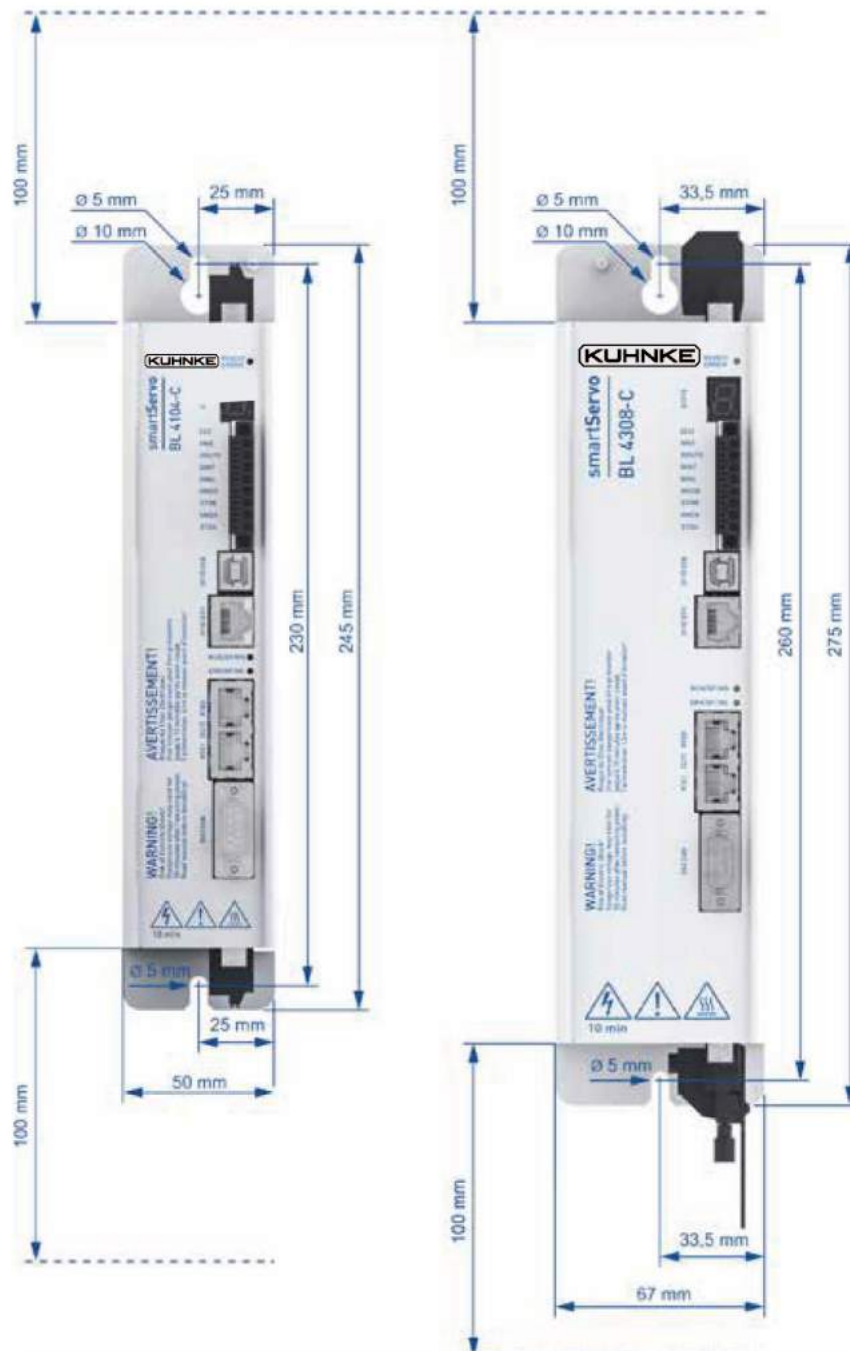


Figure 127: Servo drive BL 4100-C (left) and BL 4300-C (right)

The following requirements must be fulfilled for the installation of the servo drive:

- Follow the general set-up and safety rules and regulations concerning the installation.
- Follow the safety instructions in section 2.6 *Safety notes for installation and maintenance* on page 19.
- Use only suitable tools. If specified, use special tools.
- Always use suitable personal protective equipment, see section 2.5 *Personal protective equipment* on page 19.
- Servo drives of the BL 4000-C series are intended for use as devices installed in control cabinets.
- Installation position: Vertical with supply lines [X9] on top.
- The BL 4000-C servo drives have fastening tabs at the top and bottom. These tabs are used to mount the servo drive vertically to a control cabinet plate with two M5 screws. Recommended tightening torque for an M5 screw of property class 5.6: 2.8 Nm.
- Keep a minimum distance of 100 mm above and under the device with regard to other components in order to ensure sufficient ventilation. For optimal wiring of the motor cable and angle encoder cable under the device, an installation clearance of 150 mm is recommended.
- The BL 4000-C servo drives may be installed directly next to one another on a heat-dissipating back plate, provided that they are installed properly and used as intended. Excessive heating may cause premature ageing and/or damage.

# 12 Technical data

This chapter provides all of the relevant technical data of the BL 4000-C servo drive with an integrated "Safe Torque Off (STO)" saf

## 12.1 General technical data

### > Qualification

Characteristic	Value
Low Voltage Directive	2014/30/EU by applying the harmonised standard EN 61800-5-1 See section 15.1 <i>CE conformity (EMC, RoHS, Low Voltage Directive)</i> on page 271
EMC	2014/35/EU by applying the harmonised standard EN 61800-3 See section 15.1 <i>CE conformity (EMC, RoHS, Low Voltage Directive)</i> on page 271 and section 13.1 <i>Notes concerning the safe and EMC-compliant installation</i> on page 240
Machinery Directive	2006/42/EC See section 15.2 <i>CE conformity (Machinery Directive)</i> on page 273
UL	Listed according to UL 61800-5-1, C22.2 No. 274-13 See section 15.3 <i>cULus certification</i> on page 277 and section 13.2 <i>Additional requirements for the UL approval</i> on page 243

### > Ambient conditions

Characteristic	Value
Storage temperature	-25°C to +70°C
Ambient temperature	0°C to +40°C +40°C to +50°C with a power reduction of 2.5%/K
Permissible installation altitude	Max. installation altitude 2,000 m above MSL; with a power reduction of 1% per 100 m as of 1,000 m above MSL
Atmospheric humidity	Relative humidity up to 90%, non-condensing
Type of enclosure	IP20
Protection class	I
Pollution degree rating	2
Operational environment according to EN 61800-3	Without additional measures: BL 4100-C: First and second environment (C2/C3) BL 4300-C: Second environment (C3)

**INFORMATION Compliance with the pollution degree rating**

The integrated safety technology requires compliance with pollution degree rating 2 and thus a protected enclosure (IP54). This must always be ensured through appropriate measures, e.g. through installation in a control cabinet.

**⚠ WARNING Use in residential environment**

In a residential environment, servo drives of the BL 4000-C device family can cause high-frequency interference, which makes interference suppression measures necessary.

**NOTICE Use in the public low voltage network**

BL 4300-C servo drives are not suitable for use in a public low-voltage network that supplies residential areas.

**› Dimensions and weight<sup>\*)</sup>**

Characteristic	BL 4100-C	BL 4300-C
Dimensions including the mounting plate (H * W * D)	245 mm * 50 mm * 163 mm	275 mm x 67 mm x 200 mm
Housing dimensions (H * W * D)	200 mm * 50 mm * 163 mm	230 mm x 67 mm x 200 mm
Weight	approx. 1.5 kg	approx. 2.9 kg

<sup>\*)</sup> Device dimensions without the mating connector.

## 12.2 BL 4100-C: Power supply [X9]

### > Power data

Characteristic	BL 4102-C	BL 4104-C
Supply voltage	1 x 75 ... 230 VAC [ $\pm 10\%$ ], 50 ... 60 Hz	
Supply network type	TN, TT	
Maximum mains current in continuous operation (S1) * <sup>1)</sup>	3 A <sub>eff</sub>	6 A <sub>eff</sub>
DC bus voltage	325 VDC (with U <sub>mains</sub> = 230 VAC)	
24 V supply	24 VDC [ $\pm 20\%$ ] (0.35 A) * <sup>2)</sup>	

\*<sup>1)</sup> with a supply voltage of 230 V and power factor 0.6

\*<sup>2)</sup> plus the current consumption of a holding brake and I/Os (if included)

#### **INFORMATION** Low-voltage operation

If low-voltage operation is necessary, we recommend using a series transformer or isolating transformer for decreasing the voltage.

#### **NOTICE** DC supply

The BL 4000-C servo drives cannot be supplied with DC voltage via the DC link terminals nor via L1/N or L1/L2/L3 (DC supply).

### > Internal braking resistor

Characteristic	Value
Braking resistor	75 $\Omega$
Peak power	2 kW
Continuous power	8 W

### > External braking resistor

Characteristic	Value
Braking resistor	$\geq 75 \Omega$
Nominal power	$\geq 8 \text{ W}$
Peak power	$\geq 2,5 \text{ kW}$
Operating voltage	$> 500 \text{ VDC}$

#### **INFORMATION** Additional information

The external braking resistor must be connected in parallel to the internal braking resistor. As a result, the continuous power and pulse power can be doubled if a 75  $\Omega$  resistor is used.

## 12.3 BL 4300-C: Power supply [X9], [X9A], [X9B]

### › Power data

Characteristic	BL 4304-C	BL 4308-C	BL 4312-C
Supply voltage	3 x 230 ... 480 VAC [ $\pm 10\%$ ], 45 ... 66 Hz		
Supply network type	TN, TT		
Maximum mains current in continuous operation (S1) <sup>*1)</sup>	4 A <sub>eff</sub>	8 A <sub>eff</sub>	12 A <sub>eff</sub>
DC bus voltage	565 VDC (with U <sub>mains</sub> = 400 VAC)		
24 V supply	BL 4304-C: 24 VDC [ $\pm 20\%$ ] (0,35 A) <sup>*2)</sup> BL 4308-C: 24 VDC [ $\pm 20\%$ ] (0,45 A) <sup>*2)</sup> BL 4312-C: 24 VDC [ $\pm 20\%$ ] (0,65 A) <sup>*2)</sup>		

<sup>\*1)</sup> with a supply voltage of 400 V and power factor 0.6

<sup>\*2)</sup> plus the current consumption of a holding brake and I/Os (if included)

#### **INFORMATION** Low-voltage operation

If low-voltage operation is necessary, we recommend using a series transformer or isolating transformer for decreasing the voltage.

#### **NOTICE** DC supply

The BL 4000-C servo drives cannot be supplied with DC voltage via the DC link terminals nor via L1/N or L1/L2/L3 (DC supply).

### › Internal braking resistor

Characteristic	Value
Braking resistor	30 $\Omega$
Peak power	24 kW
Continuous power	50 W

### › External braking resistor

Braking resistors with the following characteristics can be connected.

Characteristic	Value
Braking resistor	$\geq 30 \Omega$
Nominal power	$\geq 100 \text{ W}$
Peak power	$\geq 24 \text{ kW}$
Operating voltage	$\geq 850 \text{ VDC}$

## 12.4 BL 4100-C: Motor connector [X6]

### > Performance data

Supply voltage 230 VAC [ $\pm 10\%$ ], 50 Hz,  $f_{\text{PWM}} = 10 \text{ kHz}$ ,  $f_{\text{el}} > 2 \text{ Hz}$

Characteristic	BL 4102-C	BL 4104-C
Nominal output power	400 W	800 W
Maximum output power for 2 s	1 kW	2 kW
Nominal output current	2 A <sub>eff</sub>	4 A <sub>eff</sub>
Max. output current for 2 s	6 A <sub>eff</sub>	12 A <sub>eff</sub>
Power loss/efficiency*)	5 % / 95 %	

\*) As a guide value for the control cabinet cooling system.

### > Current derating

The BL 4100-C series servo drives have a current derating during nominal operation. The rated current and the duration of the maximum permissible peak current of the servo drive depend on several factors. These factors are:

- Output current level: The higher the output current is, the shorter the permissible time will be.
- Clock frequency of the power output stage: The higher the clock frequency is, the shorter the permissible time will be.
- Rotational frequency of the motor: The lower the rotational frequency is, the shorter the permissible time will be.

The current derating begins as of a PWM frequency of 10 kHz ( $f_{\text{PWM}}$ ) and is linear between the reference values that are stated in the following table:

PWM frequency $f_{\text{PWM}}^*)$	BL 4102-C		BL 4104-C	
	I <sub>nominal</sub>	I <sub>max</sub>	I <sub>nominal</sub>	I <sub>max</sub>
10 kHz	2 A	6 A	4 A	12 A
16 kHz	1.5 A	4.5 A	3 A	9 A

\*) The PWM frequency is the reciprocal of half of the current controller cycle time  $t_i$ . The variable cycle times enable particularly high dynamics combined with reduced power data.

The maximum overload time is also subject to derating as a function of the rotational frequency (= rotational speed \* number of pole pairs). It begins with values below 2 Hz and is linear up to 0.

$f_{\text{el}}$	$t_{\text{max}}$
0	200 ms
$\geq 2 \text{ Hz}$	2 s

### › Motor cable requirements

Characteristic	Value
Cable length	$l \leq 25 \text{ m}$ See section 13.1 <i>Notes concerning the safe and EMC-compliant installation</i> on page 240
Cable capacity	$C' \leq 160 \text{ pF/m}$ of one phase against shield or between two lines

### › Motor temperature monitoring system

**⚠ DANGER** Dangerous electrical voltage! ⚠

The signals for the temperature sensor "MT-" and "MT+" at the motor connector [X6] must be connected to protective extra-low voltage (PELV) on the motor side and they must be insulated against the motor phases.

Characteristic	Value
Sensor type	Analogue
Sensor type	Silicon temperature sensor PTC/NTC, e.g. KTY84-130 or similar
Characteristic curve	Linear/non-linear, parameterisable (10 nodes)
Measuring range	from 300 $\Omega$ to 20 k $\Omega$ (+/-10%)
Output voltage	+ 3.3 V
Output current	1.7 mA max. (via 2 k $\Omega$ measuring resistor)
Internal resistance	approx. 2 k $\Omega$

### › Output for the holding brake in the motor

Characteristic	Value
Nominal voltage	24 V
Nominal current	2 A (total of all digital outputs and of the holding brake: 2.5 A max.)
Voltage drop referred to the 24 V input with a load current of 2 A	approx. 1.5 V
Overload protection	Yes, current limitation to 3 A max.
Overvoltage protection	up to 60 V
Internal flyback diode	Yes



**> HIPERFACE DSL<sup>®</sup> connector [X6]**

Characteristic	Value
HPF_DSL-, HPF_DSL+	In accordance with the HIPERFACE DSL <sup>®</sup> specification RS485
Baud rate	9.37 MHz
Frame rate	12.1 to 27 $\mu$ s
Supply voltage	10 V (250 mA)
Supported transfer modes	Transfer of short and long messages with storage of the set of parameters in the encoder
Characteristic impedance of the cable and line termination	110 $\Omega$

## 12.5 BL 4300-C: Motor connector [X6], [X6A]

### > Performance data

Supply voltage 400 VAC [ $\pm 10\%$ ], 50 Hz,  $f_{\text{PWM}} = 8 \text{ kHz}$ ,  $f_{\text{el}} > 3 \text{ Hz}$

Characteristic	BL 4304-C	BL 4308-C	BL 4312-C
Nominal output power	1,6 kW	3,2 kW	4,8 kW
Maximum output power for 2 s	4,8 kW	9,6 kW	12 kW
Nominal output current	4 A <sub>eff</sub>	8 A <sub>eff</sub>	12 A <sub>eff</sub>
Max. output current for 2 s	12 A <sub>eff</sub>	24 A <sub>eff</sub>	30 A <sub>eff</sub>
Power loss/efficiency*)	5 % / 95 %		

\*) As a guide value for the control cabinet cooling system.

### > Current derating

The BL 4300-C series servo drives have a current derating during nominal operation. The rated current and the duration of the maximum permissible peak current of the servo drive depend on several factors. These factors are:

- Output current level: The higher the output current is, the shorter the permissible time will be.
- Clock frequency of the power output stage: The higher the clock frequency is, the shorter the permissible time will be.
- Rotational frequency of the motor: The lower the rotational frequency is, the shorter the permissible time will be.

The current derating begins as of a PWM frequency of 8 kHz ( $f_{\text{PWM}}$ ) and is linear between the reference values that are stated in the following table:

PWM frequency $f_{\text{PWM}}^*)$	BL 4304-C		BL 4308-C		BL 4312-C	
	I <sub>nominal</sub>	I <sub>max</sub>	I <sub>nominal</sub>	I <sub>max</sub>	I <sub>nominal</sub>	I <sub>max</sub>
8 kHz	4 A	12 A	8 A	24 A	12 A	30 A
16 kHz	2.5 A	7.5 A	5 A	15 A	7.5 A	18.8 A

\*) The PWM frequency is the reciprocal of half of the current controller cycle time  $t_i$ . The variable cycle times enable particularly high dynamics combined with reduced power data.

The maximum overload time is also subject to derating as a function of the rotational frequency (= rotational speed \* number of pole pairs). It begins with values below 3 Hz and is linear up to 2 Hz.

Rotational frequency $f_{\text{el}}$	BL 4304-C	BL 4308-C	BL 4312-C
	t <sub>max</sub>	t <sub>max</sub>	t <sub>max</sub>
< 2 Hz	100 ms	100 ms	50 ms
$\geq 3 \text{ Hz}$	2 s	2 s	2 s

### › Motor cable requirements

Characteristic	Value
Cable length	$l \leq 25 \text{ m}$ See section 13.1 <i>Notes concerning the safe and EMC-compliant installation</i> on page 240
Cable capacity	$C' \leq 160 \text{ pF/m}$ of one phase against shield or between two lines

### › Motor temperature monitoring system

**⚠ DANGER** Dangerous electrical voltage! ⚠

The signals for the temperature sensor "MT-" and "MT+" at the motor connector [X6] must be connected to protective extra-low voltage (PELV) on the motor side and they must be insulated against the motor phases.

Characteristic	Value
Sensor type	Analogue
Sensor type	Silicon temperature sensor PTC/NTC, e.g. KTY84-130 or similar
Characteristic curve	Linear/non-linear, parameterisable (10 nodes)
Measuring range	from $300 \Omega$ to $20 \text{ k}\Omega$ (+-10%)
Output voltage	+ 3.3 V
Output current	1.7 mA max. (via $2 \text{ k}\Omega$ measuring resistor)
Internal resistance	approx. $2 \text{ k}\Omega$

### › Output for the holding brake in the motor

Characteristic	Value
Nominal voltage	24 V
Nominal current	2 A (total of all digital outputs and of the holding brake: 2.5 A max.)
Voltage drop referred to the 24 V input with a load current of 2 A	approx. 1.5 V
Overload protection	Yes, current limitation to 3 A max.
Overvoltage protection	up to 60 V
Internal flyback diode	Yes

### › HIPERFACE DSL® connector [X6]

Characteristic	Value
HPF_DSL-, HPF_DSL+	In accordance with the HIPERFACE DSL® specification RS485
Baud rate	9.37 MHz
Frame rate	12.1 to 27 µs
Supply voltage	10 V (250 mA)
Supported transfer modes	Transfer of short and long messages with storage of the set of parameters in the encoder
Characteristic impedance of the cable and line termination	110 Ω

## 12.6 Resolver connector [X2A]

Characteristic	Value
Transformation ratio	1:2 to 1:4
Carrier frequency	5-10 kHz
Excitation voltage	5-6 V <sub>eff</sub> , short-circuit-proof
Excitation impedance (at 10 kHz)	4 Ω
Stator impedance	> 30 Ω
Measuring range (for Hall sensors)	7 V <sub>ss</sub>
Resolution	14 bits
Signal detection delay	< 200 µs
Speed resolution	approx. 5 rpm
Actual speed value filter	400 µs
Absolute angle detection accuracy	< 0.022°
Max. speed	16,000 rpm

## 12.7 Encoder connector [X2B]

For the correct parameterisation of the multi-encoder interface, see section 7.5.3 "X2B/X6" tab on page 136.

### **INFORMATION** Possibly not all encoders of a manufacturer are supported

It is possible that not all encoders of a manufacturer are fully supported. In individual cases it is therefore always recommended to test the encoder in advance in the intended application.

### › Power supply output

The power supply for the encoders can be changed.

### **NOTICE** Risk of destruction due to excessive voltage

If the voltage is too high, the angle encoder may be destroyed. Ensure that you have selected the correct supply voltage prior to connecting the encoder to the [X2B] connector.

Characteristic	Value A	Value B
Output voltage	5.4 V	10.4 V
Output current	250 mA	200 mA
Short-circuit strength	Yes	Yes
Control via sense leads	Yes	Yes

### › Digital incremental encoders

Digital incremental encoders with RS422-compatible A/B/N signals with a line count of up to 16,384 lines can be connected (e.g. ERN 420). In addition, Hall generator signals with a TTL level for determining the commutation position can also be connected.

Characteristic	Value
Parameterisable number of encoder lines	1 to $2^{18}$ lines/revolution
Track signals A, B (Z0 track)	In accordance with RS422 Input 0.4 V with a common-mode level of -0.3 to 5 V
Track signal N (index pulse)	In accordance with RS422 Input 0.4 V with a common-mode level of -0.3 to 5 V
Hall generator input	TTL level (<0.5 V = Low, > 2 V = Hi) 2 k $\Omega$ pull-up
Error input (pin 6)	TTL level (<0.5 V = Low, > 2 V = Hi) 2 k $\Omega$ pull-up
Track signal input impedance	Differential input 120 $\Omega$
Limit frequency	10 MHz

### › Analogue incremental encoders with commutation signals

Analogue incremental encoders with RS422-compatible 1 V<sub>SS</sub> signals (e.g. ERN 1387) can be connected.

Characteristic	Value
Parameterisable number of encoder lines	1 to 2 <sup>18</sup> lines/revolution
High position resolution of the AB track (Z0) and commutation track (Z1)	12 bits/period
Track signals A, B (Z0 track)	1.2 V <sub>SS</sub> differential
Track signal N (index pulse) switching threshold	0.1 V <sub>SS</sub> differential
Commutation track (Z1 track)	1.2 V <sub>SS</sub> differential
Error input (pin 6)	TTL level (<0.5 V = Low, > 2 V = Hi) 2 kΩ pull-up
Track signal input impedance	Differential input 120 Ω
Z0 track limit frequency	f <sub>limit</sub> > 300 kHz
Z1 track limit frequency	f <sub>limit</sub> approx. 10 kHz (commutation track)

### › HIPERFACE® encoders

Shaft encoders with HIPERFACE® made by Sick-Stegmann are supported in the single-turn and multi-turn variants. The following encoder models can be connected:

- Single-turn SinCos encoders: SCS 60/70, SKS 36, SRS 50/60/64, SEK 34/37/52
- Multi-turn SinCos encoders: SCM 60/70, SKM 36, SRM 50/60/64, SEL 34/37/52
- Single-turn SinCos encoders for hollow shaft drives: SCS-Kit 101, SHS 170, SCK 25/35/40/45/50/53
- Multi-turn SinCos encoders for hollow shaft drives: SCM-Kit 101, SCL 25/35/40/45/50/53

In addition, the following Sick-Stegmann encoder systems can be connected and evaluated:

- Absolute, non-contact length measuring systems L230 and TTK70 (HIPERFACE®)
- Digital incremental encoder CDD 50

Characteristic	Value
Parameterisable number of encoder lines	depending on the encoder
Track signals A, B (Z0 track)	As per RS485 Input: 0.4 V, output: 0.8 V to 2 V
Hall generator input	TTL level (<0.5 V = Low, > 2 V = Hi) 2 kΩ pull-up
Error input (pin 6)	TTL level (<0.5 V = Low, > 2 V = Hi) 2 kΩ pull-up
Track signal input impedance	Differential input 120 Ω
Limit frequency	Up to 10 MHz, depending on the encoder system
Supported operating modes	Storage of the parameter set in the encoder in the case of Endat and HIPERFACE®

Angle encoders made by Sick with the HIPERFACE DSL® interface (e.g. EKM36) are supported. They must be connected to X6. See section 12.4 *BL 4100-C: Motor connector [X6]* on page 219 or section 12.5 *BL 4300-C: Motor connector [X6], [X6A]* on page 222.

### › Endat encoders

Incremental and absolute encoders by Heidenhain with the ordering code ENDAT22 can be evaluated. The following encoder models can be connected:

- Analogue incremental encoders: ROD 400, ERO 1200/1300/1400, ERN 100/400/1100/1300
- Single-turn encoders (ENDAT22): ROC 425, ECI 119/1118/1319, ECN 125/425/1023
- Multi-turn encoders (ENDAT22): ROQ 437/1035, EQI 1131/1331, EQN 437/1035/1135/1337
- Absolute length measuring systems (ENDAT22): LC 115/415
- Battery-buffered encoders (ENDAT22): EBI 135/1135/4010
- Angle encoder modules (ENDAT22): MRP 2010/5010/8010

### › BiSS encoders®

Type C BiSS encoders are supported. The evaluation of the internal type plate, however, is not supported. The storage of data in the encoder is not possible.

Encoders made by Hengstler, Kübler and Balluff are supported.

## 12.8 USB [X19]

Communication interface	Value
Function	USB 2.0, USB-B, slave-client
Connector type	USB-B
Current consumption	None (self-powered)
Protocol	Kuhnke-specific (generic device)

## 12.9 Standard Ethernet [X18]

Communication interface	Value
Function	Ethernet, 10/100 Mbaud, UDP communication
Connector type	RJ45
Protocol	TCP/IP

## 12.10 Real-time Ethernet [X21]

At present, the servo drives of the BL 4100-C product range support the following fieldbuses and application protocols:

Fieldbus	Profile
CAN	CiA DS 402 CANopen V 2.0
PROFINET	Kuhnke-specific protocol (based on PROFIdrive V3.1)
EtherCAT	CoE (Can over EtherCAT)

The support of these fieldbus types is integrated in the servo drive. Additional modules are not required. The parameterisation is performed with the aid of Kuhnke ServoCommander®.

For further information about the fieldbus connection, see the fieldbus-specific product manuals (see the section 1.2 *Additional documents* on page 14).

Suitable EDS (CANopen), GSDML (PROFINET) and XML (EtherCAT) files for the integration of the fieldbus slave into the environment of an external control system can be found at.

### **INFORMATION** Compatibility with servo drives of the ARS 2000 series

The behaviour on the bus and the object directory is largely compatible with the behaviour of the ARS 2000 series. There are certain differences, e.g. in terms of the device IDs (CANopen product\_code ID 1018\_02).



## 12.11 CAN bus [X4]

Communication interface	Value
Standard	ISO/DIS 11898-2, CAN 2.0A
Baud rates	50, 100, 125, 250, 500, 1000 kbit/s
Protocol	CANopen, as per DS301 and DSP402

## 12.12 I/O Interface [X1]

Servo drives of the BL 4000-C series have 3 digital outputs (DOUT), 9 digital inputs (DIN) and 2 analogue inputs (AIN).

### › Digital outputs

Characteristic	Value
Nominal voltage	24 V
Output current	Approx. 1 A per output, but 2.5 A max. in total, including the brake output

### › Digital inputs

Characteristic	Value
Nominal voltage	24 V as per DIN EN 61131-2 (15 V, < 10 V low to 30 V high)
Current consumption	3.2 mA max.

The mode of operation of the digital outputs can be configured to a large extent. The default setting is stated in brackets.

Characteristic	Value	Filter time	Max. jitter
DIN0...DIN3	Freely configurable (position selector)	4 x $t_x$ *)	1 x $t_x$
DIN5	Controller enable signal	4 x $t_x$	1 x $t_x$
DIN6, DIN7	Limit switch 0, 1	4 x $t_x$	1 x $t_x$
DIN4	Freely configurable (positioning start)	4 x $t_x$	1 x $t_x$ , (15 ns for sampling)
DIN8	Freely configurable (sampling, flying saw)	4 x $t_x$	1 x $t_x$ , (15 ns for sampling)

\*)  $t_x$  corresponds to the configurable position controller cycle time

### ➤ Analogue input AIN0

Characteristic	Value
Input range	$\pm 10\text{ V}$
Resolution	12 Bit
Filter time	configurable: $2 \times t_i$ to 200 ms

\*)  $t_i$  corresponds to the configurable current controller cycle time

### ➤ Analogue input AIN1

Characteristic	Value
Input range	$\pm 10\text{ V}$
Resolution	12 bits
Filter time	$4 \times t_i$

\*)  $t_i$  corresponds to the configurable current controller cycle time

### ➤ Master frequency input X1

This input cannot only be used for the connection of the master frequency output of another BL 4000-C, BL 4000-M or BL 4000-D. It can also be used for the connection of encoders as per the RS422 industry standard or of encoders with "single-ended" TTL output or "open-collector" outputs. If TTL encoders are used, it must be taken into consideration that the hysteresis is negligible. In addition, the requirements concerning the signal shield must be fulfilled.

As an alternative, the A and B track signals of the device are interpreted as pulse direction signals by the device so that the servo drive can also be controlled by stepper motor control boards.

Ensure the correct configuration of the interface. This is important since the master frequency input can also be used as the master frequency output.

Characteristic	Value
Parameterisable line count	1 to $2^{18}$ lines/revolution
Track signals A, B, N	as per the RS 422 specification
Special feature	N track can be deactivated
Maximum input frequency	10 MHz
Filtering	Quadruple oversampling
Supply output	5 V, 200 mA, short-circuit-proof – not overvoltage-proof

### › Master frequency output X1

The connector X1 also accommodates the master frequency output (encoder emulation). To use this function, X1 must be configured as the master frequency output.

Characteristic	Value
Number of lines	Programmable 1 to $2^{13}$ and $2^{14}$ lines/revolution
Track signals A, B, N	as per the RS422 specification
Special feature	N track can be deactivated
Limit frequency	$f_{\text{limit}} > 10 \text{ MHz}$

The signals are generated based on the angle of rotation of the encoder with a freely programmable line count.

In addition to the track signals A and B, the master frequency output also provides an index pulse. Once per revolution, this index pulse turns high (for the programmed number of lines) for half of a signal period.

Please also note that the track signals will not be automatically output with a constant frequency. They may also be generated as so-called "pulse packets" depending on the covered rotational angle of the source. This means that the interface for any downstream circuits must be suitable for incremental encoders. As a result, the measurement of gate times or the analysis of the time between two lines for determining a speed value is possible only to a limited extent.

### 12.12.1 Time response of the digital inputs

The digital inputs are digitally filtered to improve the interference suppression. The following illustration shows the filter time mechanism. In addition, the special reaction to the "Positioning start" function is also shown. Although the signal is evaluated during the position controller cycle  $t_x$  the start of a movement will be performed within the interpolation cycle time matrix  $t_p$ .

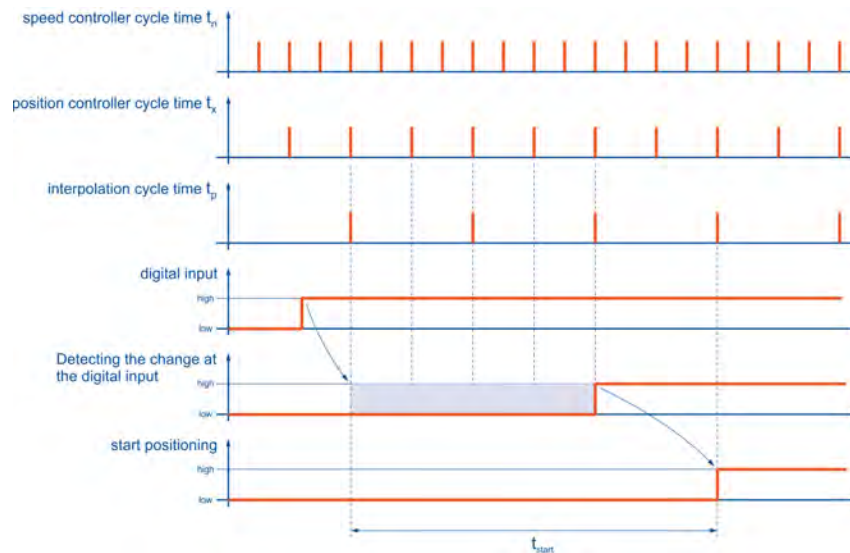


Figure 128: Filter time mechanism in the case of digital inputs

Parameter	Max.
Maximum delay until the start of a position set becomes active $t_{start}$	$5 \cdot t_x + t_p$
Current rise time (with current feedforward control)	$t_n + t_i + t_{pwm}$

$t_x$  = position controller cycle time (typically 200  $\mu s$  with a current controller cycle time  $t_i$  of 50  $\mu s$ )

$t_n$  = speed controller cycle time (typically 100  $\mu s$  with a current controller cycle time  $t_i$  of 50  $\mu s$ )

$t_{pwm}$  = half the cycle time of the PWM (corresponds to  $t_i$ )

## 12.12.2 Time response of the digital outputs

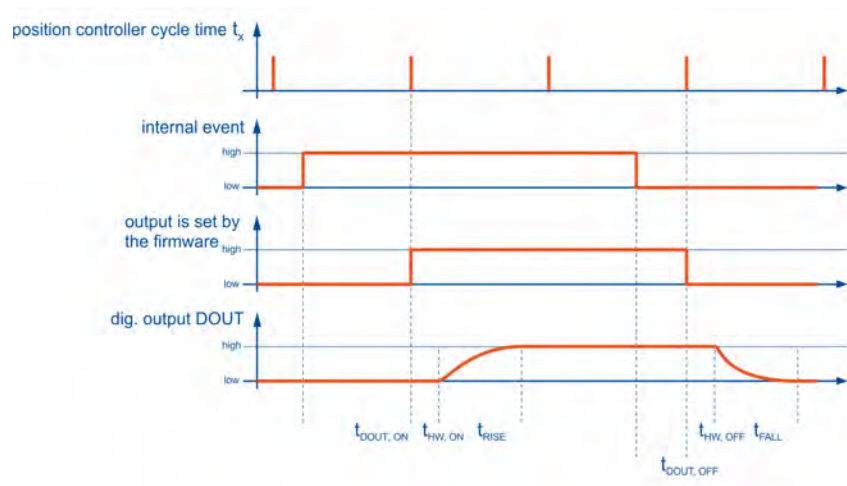


Figure 129: Filter time mechanism in the case of digital outputs

Parameter	Value
Delay caused by the firmware $t_{DOUT\_ON}/t_{DOUT\_OFF}$	$t_x$
DOUT $t_{HW,ON}$	typically 100 $\mu s$
DOUT $t_{HW,OFF}$	typically 300 $\mu s$
$t_{RISE}$	typically 100 ms with 2 A and inductive load
$t_{FALL}$	typically 100 ms with 2 A and inductive load

$t_x$  = position controller cycle time (typically 200  $\mu s$  with a current controller cycle time  $t_i$  of 50  $\mu s$ )

### 12.12.3 Time response during power ON

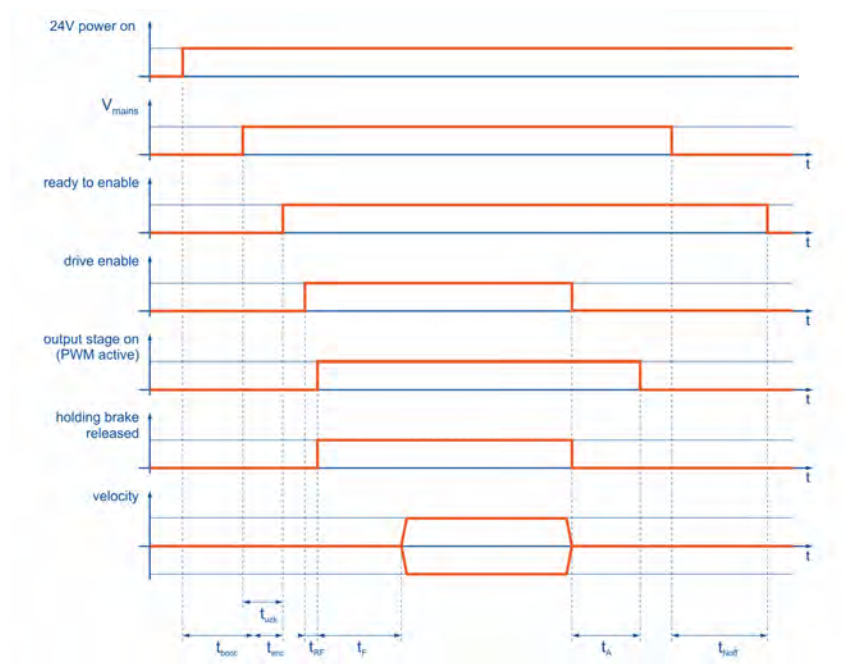


Figure 130: Time diagram of the servo drive

Parameter	Min.	Typ.	Max.
Start of the firmware after power ON $t_{boot}$			4 s
Encoder start time $t_{enc}$	0.7 s (resolver)		2 s (HIPERFACE DSL®)
DC bus charging time $t_{UZK}$		1 s	
Output stage active after servo drive enabling $t_{RF}$		6 ms	
Movement start delay $t_F$ (parameterisable)	0		32 s
Stop delay $t_A$ (parameterisable)	0		32 s
Detection of mains power OFF $t_{Noff}$		0.6 s	

## 12.13 STO [X3]

### > Characteristic values

Characteristic	Value
Safety level	Category 4 and performance level e or SIL3/SIL CL3.
PFH (probability of dangerous failure per hour)	$3 \times 10^{-11}$
PFD (probability of dangerous failure on demand)	$5 \times 10^{-6}$
DCavg (average diagnostic coverage)	High
MTTFd (mean time to dangerous failure)	Limited to 100 years (cat. 3) Limited to 2,500 years (cat. 4)

See also section 15.2 *CE conformity (Machinery Directive)* on page 273.

#### **INFORMATION** Proof-testing of the STO function

Comply with the following test intervals in order to reach the specified values:

- For SIL 2, PL d/category 3: 1x per year
- For SIL 3, PL e/category 3: every 3 months
- For SIL 3, PL e/category 4: daily

### 12.13.1 Electrical data of the STO function

#### > Control inputs STOA/STOB [X3]

Characteristic	Value
Nominal voltage	24 V (referred to GNDA/GNDB)
Voltage range	19.2 V... 28.8 V
Permissible ripple	2 % (referred to a nominal voltage of 24 V)
Nominal current	20 mA typ., 30 mA typ.
Switch-on input voltage threshold	$\geq 16$ V
Switch-off input voltage threshold	$< 5$ V

For the technical data of the digital inputs DIN6 and DIN7 or of the digital output DIN0, see the section 12.12 *I/O Interface [X1]* on page 229.

### › Response time until power output stage inactive and maximum OSSD test pulse duration

Characteristic	Value		
Input voltage (STOA/STOB)	19.2 V	24 V	28.8 V
Typical response time	2 ms	3 ms	4 ms
Max. test pulse duration (OSSD)	0.5 ms	1 ms	1.5 ms

The maximum response time  $t_{\text{STOAB/OFF}}$  is described in section 12.13.2.1 *Time response of the STO activation during operation with a restart* on page 236.

## 12.13.2 Time response

### **INFORMATION** Equal inputs in terms of their functionality

The inputs STOA and STOB are absolutely equal in terms of their functionality, which is why the switching sequence of STOA/STOB is interchangeable in all of the diagrams.

### 12.13.2.1 Time response of the STO activation during operation with a restart

The illustration shows the time response starting with the disconnection of the control voltage at STOA/B and the sequence that is necessary for restarting the device.

- The actuation of the holding brake is realised via the basic device and not in a safety-oriented manner.
- The illustration shows the coasting of the motor regardless of the activation/deactivation of the brake
- The setpoint will not be enabled until the holding brake delay  $T_F$  has elapsed.
- An error will be issued as the STO inputs are deactivated while the output stage is active. It is not included in the drawing.



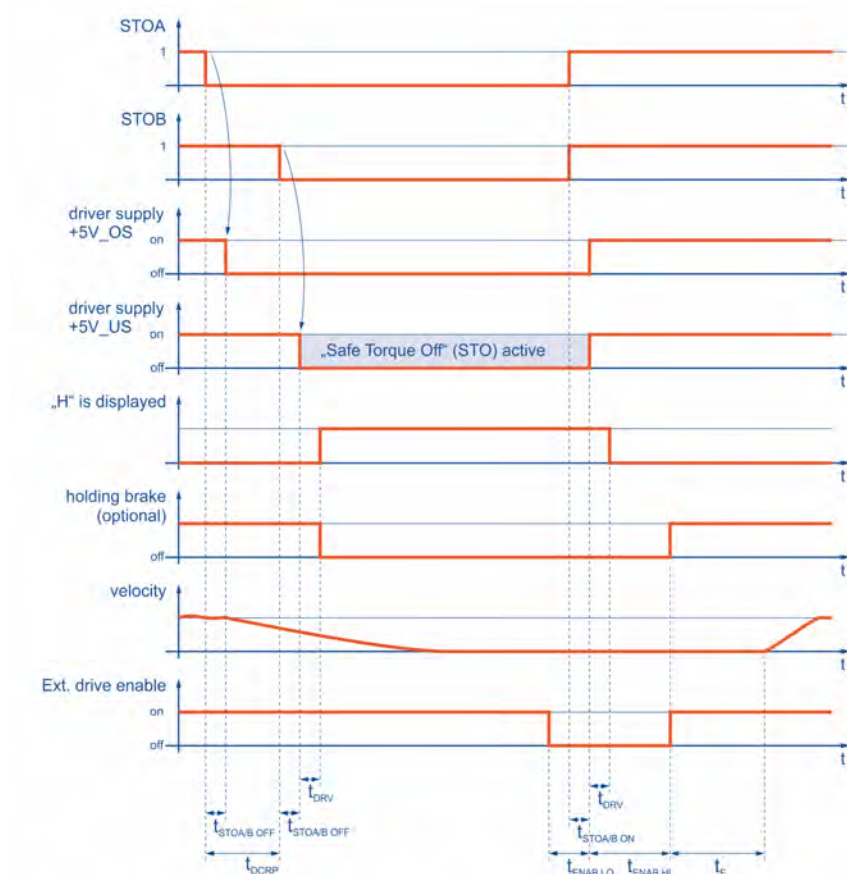


Figure 131: Time response of the activation of the STO safety function with a restart

Time	Description	Value
$t_{DCRP}$	Maximum permissible discrepancy time without the servo drive issuing an error	100 ms
$t_{STOA/B\ OFF}$	STOA/B – switching time from high to low (See also section Response time until power output stage inactive and maximum OSSD test pulse duration on page 1)	Maximum response time 5 ms
$t_{STOA/B\ ON}$	STOA/B switching time from low to high	0.6 ms typ., 1 ms max.
$t_{DRV}$	Delay of the internal sequence control of the servo drive	10 ms max.
$t_{ENAB\ LO}$	Time that the servo drive enable signal (DIN5 or bus enable signal) must be low before STO A/B will be activated	0
$t_{ENAB\ HI}$	Time that the servo drive enable signal (DIN5 or bus enable signal) must be low after STO A/B has been reactivated and the status of the STO circuit has changed	> 20 ms
$t_F$	Switch-on delay of the holding brake	See section 7.10 Brake control and automatic brake on page 182.

### 12.13.2.2 Time response of the SS1 activation during operation with a restart

The time response is based on the SS1 example circuit in section 8.6.2 *Deceleration and safe torque switch off(SS1, "Safe Stop 1")* on page 202.

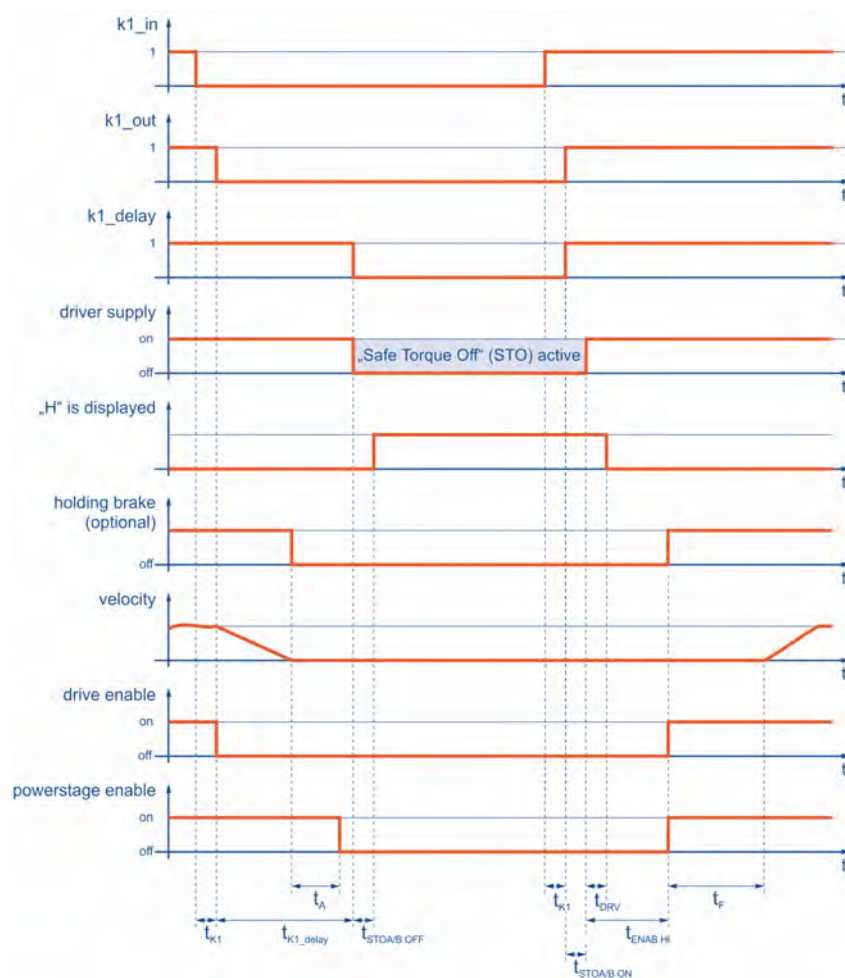


Figure 132: Time response during the activation of the SS1 safety function (external switching) with a restart

Time	Description	Value
$t_{K1}$	Delay between the switching of S1 and the closing of the undelayed contact K1	See the data sheet of the safety relay
$t_{K1\_delay}$	Delay between S1 and the opening of the off-delayed contacts K1	Can be adjusted on the safety relay
$t_{STOA/B\ OFF}$	STOA/B – switching time from high to low (See also section <i>Response time until power output stage inactive and maximum OSSD test pulse duration</i> on page 236)	Maximum response time 5 ms
$t_{STOA/B\ ON}$	STOA/B – switching time from high to low	0.6 ms typ., 1 ms max.

Time	Description	Value
$t_{DRV}$	Delay of the internal sequence control of the servo drive	10 ms max.
$t_{ENAB HI}$	Time that DIN5 must be low after STOA/B has been reactivated and the status of the STO circuit has changed	> 20 ms
$t_A$	Switch-off delay of the holding brake	See section 7.10 <i>Brake control and automatic brake</i> on page 182.
$t_F$	Switch-on delay of the holding brake	See section 7.10 <i>Brake control and automatic brake</i> on page 182.

## 12.14 MicroSD card

Communication interface	Value
File system	FAT16, FAT32
Connector type	microSD card
File names	Only file and folder names that comply with the 8.3 standard are supported.

# 13 Electrical installation

This chapter provides all of the relevant information for the electrical installation of a servo drive of the BL 4000-C series with an integrated "Safe Torque Off (STO)" safety function.

## 13.1 Notes concerning the safe and EMC-compliant installation

### 13.1.1 Explanations and terminology

Electromagnetic compatibility (EMC) or electromagnetic interference (EMI) includes the following requirements:

- Sufficient **immunity** of an electrical installation or an electrical device against external electrical, magnetic or electromagnetic interferences via cables or the environment.
- Sufficiently small **unwanted emission** of electrical, magnetic or electromagnetic interference from an electrical installation or an electrical device to other devices in the vicinity via cables or the environment.

### 13.1.2 General information about electromagnetic compatibility

The interference emission and interference immunity of a servo drive always depend on the overall drive concept consisting of the following components:

- Power supply
- Servo drive
- Motor
- Electromechanical system
- Configuration and type of wiring
- Superordinate control system

In order to increase interference immunity and to decrease interference emissions, the servo drive has integrated filters so that it can be used without additional shielding and filtering devices in most applications.

### 13.1.3 Proper wiring

Comply with following instructions to ensure the safe and EMC-compliant set-up of the drive system:

**⚠ DANGER Dangerous electrical voltage! ⚡**

For safety reasons, all of the PE earth (ground) conductors must be connected prior to the initial operation of the system.

The shields must be connected on both sides.

The EN 61800-5-1 regulations concerning protective earthing (grounding) must be complied with during the installation.

- In order to keep the leakage currents and losses in the motor connecting cable as small as possible, the servo drive should be located as close to the motor as possible (see also section 13.1.4 *Operation with long motor cables* on page 242)
- The motor cable and angle encoder cable must be shielded.
- Connect the shield of the motor cable to the back panel of the control cabinet by way of suitable shield terminals. The unshielded cable end should not be longer than 80 mm.
- The mains-end PE connector must be connected to the PE connection point of the supply connector [X9].
- The earthing (grounding) screw of the mounting plate (see section 3.2 *Device view* on page 25) must also be connected to the mains-side PE connector via a separate earth lead.
- The cross-section of each earth lead must not be smaller than the cross-section of the supply leads (L/N or L1-L3).
- The inner PE conductor of the motor cable must be connected to the PE connection point of the motor connector [X6].
- The signal lines must be as far away from the power cables as possible. They should not be laid in parallel. If intersections cannot be avoided, they should be installed at right angles if possible.
- Unshielded signal and control lines should not be used. If their use is inevitable, they should at least be twisted.
- Even shielded cables will inevitably have short unshielded ends (unless shielded connector housings are used).

In general, the following applies:

- Connect the inner shields to the associated pins of the connectors.
- Connect the overall shield on the motor side to the connector or motor housing over a large contact area.

### 13.1.4 Operation with long motor cables

**INFORMATION** Compliance with the EMC standard EN 61800-3

Compliance with the EMC standard EN 61800-3 is ensured only for a motor cable length of 25 m maximum.

Operation with longer cables is not permissible.

In applications involving long motor cables and/or in the case of unsuitable motor cables with a non-permissible high cable capacity, the filters, power output stage and sensors may be overloaded.

### 13.1.5 ESD protection

**NOTICE** Damage to property due to ESD (electrostatic discharge)

At unassigned plug connectors, damage can occur to the device or to other system parts as a result of ESD (electrostatic discharge).

To prevent this type of damage, comply with the following:

- Ensure proper earthing of all of the system components and wire the servo drive completely prior to switching on the voltage supply.
- The person commissioning the system as well as the service and maintenance personnel must have undergone ESD training and wear corresponding footwear.
- When handling the system, e.g. the USB connector, it is useful to touch the control cabinet housing (should be at PE potential) with your hand prior to touching one of the connectors of the servo drive.

## 13.2 Additional requirements for the UL approval

### › Mains power supply protection

Integral solid state short circuit protection does not provide branch circuit protection. Branch circuit protection must be provided in accordance with the Manufacturer Instructions, National Electrical Code and any additional local codes.

- **BL 4100-C:**

Suitable For Use On A Circuit Capable Of Delivering Not More Than 5,000 rms Symmetrical Amperes, 240 Volts Maximum When Protected by A Circuit Breaker Having An Interrupt Rating Not Less Than 10 rms Symmetrical Amperes, 240 Volts Maximum.

Observe the following specification for the main fuse: Listed Circuit Breaker according to UL 489, rated 277 Vac, 10 A, SCR 10 kA

- **BL 4300-C:**

Suitable For Use On A Circuit Capable Of Delivering Not More Than 5,000 rms Symmetrical Amperes, 480 Volts Maximum When Protected by A Circuit Breaker Having An Interrupt Rating Not Less Than ( $I_n$ ) rms Symmetrical Amperes, 480 Volts Maximum.

Observe the following specification for the main fuse: Listed Circuit Breaker according to UL 489, rated 480Y/277 Vac, ( $I_n$ ) A, SCR 10 kA

BL 4304-C: ( $I_n$ ) = 10

BL 4308-C: ( $I_n$ ) = 10

BL 4312-C: ( $I_n$ ) = 16

### › Wiring requirements and environmental conditions

- Use 60 / 75 °C copper conductors.
- For use in Pollution Degree 2 Environment only.

### › Motor overload protection

For effective motor protection, the motor parameters and the  $I^2t$ -Integral must be parameterised appropriately (see section 4.4.4 *Configuration of the motor data* on page 47).

## 13.3 BL 4100-C: Connector: power supply [X9]

Servo drives of the BL 4100-C series must be connected to the voltage supply and an optional brake resistor in accordance with the following illustration.

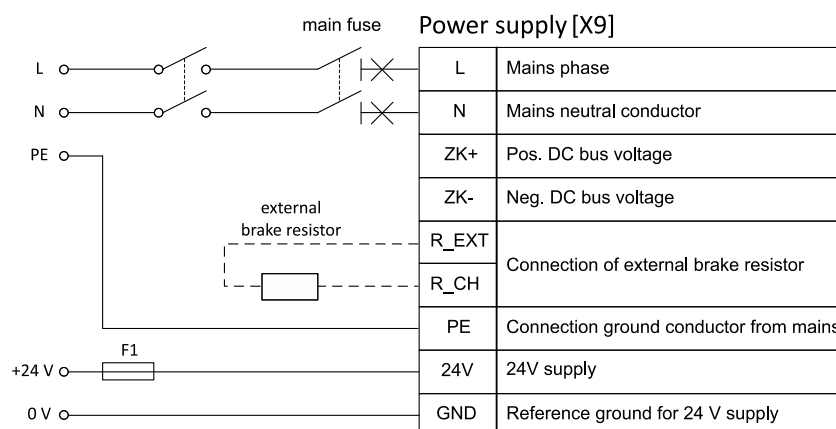


Figure 133: Connection of a BL 4100-C to the power supply [X9]

### NOTICE Risk of damage to the servo drive

The servo drive will be damaged in the following cases:

- reverse connection of the 24 V operating voltage connections,
- excessive operating voltage, or
- accidental interchanging of the operating voltage and motor connectors.

### NOTICE Risk of destruction due to a connection with reverse polarity

If the polarity of the 24 V supply at [X9] or [X9B] is reversed, the servo drive and the PC will be destroyed. It is essential that you follow the correct connection instructions.

A 24 V supply and a single-phase mains power supply are required to operate a BL 4100-C. A single-phase automatic circuit breaker must be installed in the mains power supply line (see section *Cable type and configuration [X9]* on page 245). Direct DC coupling of the DC buses of several devices with equal DC bus voltage is possible by way of the terminals ZK+ and ZK- (see section 7.13 *DC bus coupling* on page 186). The servo drive has an internal brake chopper and an internal braking resistor. For higher braking power, an external braking resistor can be connected to connector [X9] in parallel to the internal braking resistor.

The servo drive must be connected to earth (ground) with its PE connectors (section 13.1.3 *Proper wiring* on page 241).

First, wire the servo drive completely. Then, switch on the 24 V supply and the mains power supply.



### › Configuration on the device [X9]

Weidmüller SL 5.08HC/09/90G 3.2SN BK BX

### › Mating connector [X9]

Weidmüller BLF 5.08HC/09/180 SN BK BX

### › Pin assignment [X9]

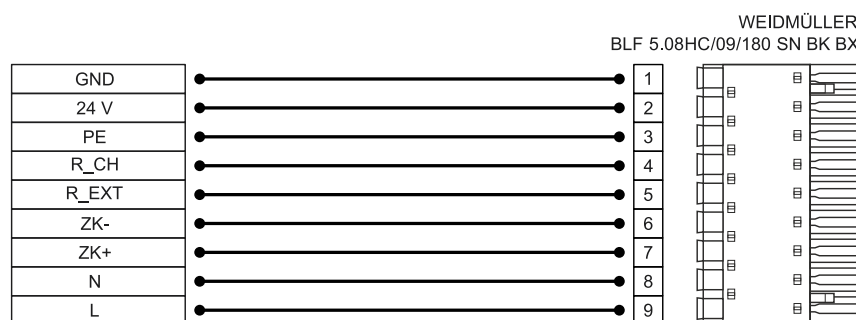


Figure 134: Pin assignment: power supply connector [X9]

Pin	Name	Specification
1	GND	Supply voltage reference potential
2	24V	Supply voltage for the control module and holding brake
3	PE	Connection of the protective earth (ground) conductor of the mains power supply
4	R_CH	Braking resistor connection
5	R_EXT	Braking resistor connection
6	ZK-	Neg. DC bus voltage
7	ZK+	Pos. DC bus voltage
8	N	Neutral conductor
9	L	Phase conductor/mains phase

### › Cable type and configuration [X9]

The cable names that are stated refer to cables made by Lapp. They have proved to be reliable and are successfully used in many applications. However, it is also possible to use comparable cables from other manufacturers, for example Lütze or Helukabel.

A single-phase circuit breaker with the listed characteristics ("Circuit breaker") must be used in the mains supply line.

LAPP KABEL ÖLFLEX CLASSIC 110

Device type	Cable type	Specification (L, N, PE)	Circuit breaker
BL 4102-C	3 G 1.0	3 x 1,0 mm <sup>2</sup> (AWG 18)	B 10
BL 4104-C	3 G 1.0	3 x 1,0 mm <sup>2</sup> (AWG 18)	B 10

## 13.4 BL 4300-C: Connector: power supply [X9], [X9A], [X9B]

Servo drives of the BL 4300-C series must be connected to the voltage supply and an optional brake resistor in accordance with the following illustration.

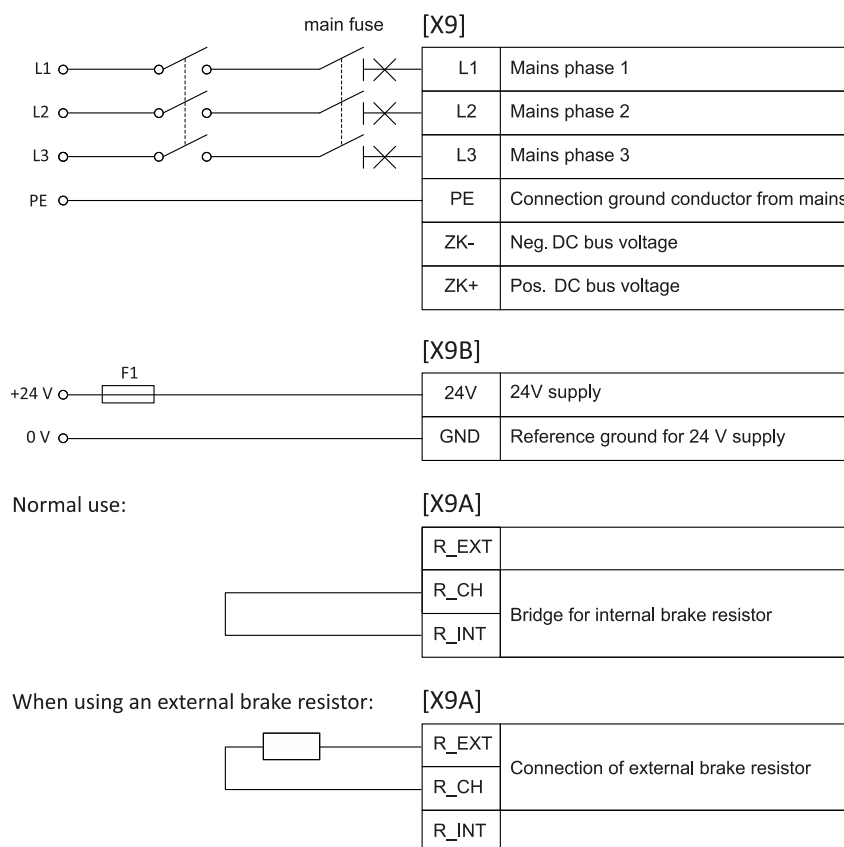


Figure 135: Connection of a BL 4300-C to the power supply [X9]

### NOTICE Risk of damage to the servo drive

The servo drive will be damaged in the following cases:

- reverse connection of the 24 V operating voltage connections,
- excessive operating voltage, or
- accidental interchanging of the operating voltage and motor connectors.

### NOTICE Risk of destruction due to a connection with reverse polarity

If the polarity of the 24 V supply at [X9] or [X9B] is reversed, the servo drive and the PC will be destroyed. It is essential that you follow the correct connection instructions.

A 24 V supply and a three-phase mains power supply are required for operation. A three-phase automatic circuit breaker must be installed in the mains power supply line (see section *Cable type and configuration* [X9], [X9A], [X9B] on page 248). Direct DC coupling of the DC buses of several devices with equal DC bus voltage is possible by way of the terminals ZK+ and ZK- (see section 7.13 *DC bus coupling* on page 186). The servo drive

has an internal brake chopper and an internal braking resistor. If this is used, a bridge must be wired to [X9A]. For more braking power, an external braking resistor can be connected to the connector [X9A] instead of the bridge.

The servo drive must be connected to earth (ground) with its PE connectors (section 13.1.3 *Proper wiring* on page 241).

First, wire the servo drive completely. Then, switch on the 24 V supply and the mains power supply.

### › Configuration on the device [X9], [X9A], [X9B]

X9: Weidmüller SV 7.62HP/06/90G 3.5SN BK BX

X9A: Weidmüller SV 7.62HP/03/90G 3.5SN BK BX

X9B: Weidmüller SC 3.81/02/90F 3.2SN BK BX

### › Mating connector [X9], [X9A], [X9B]

X9: Weidmüller BVF 7.62HP/06/180 SN BK BX

X9A: Weidmüller BVF 7.62HP/03/180 SN BK BX

X9B: Weidmüller BCF 3.81/02/180F SN BK BX

### › Pin assignment [X9], [X9A], [X9B]

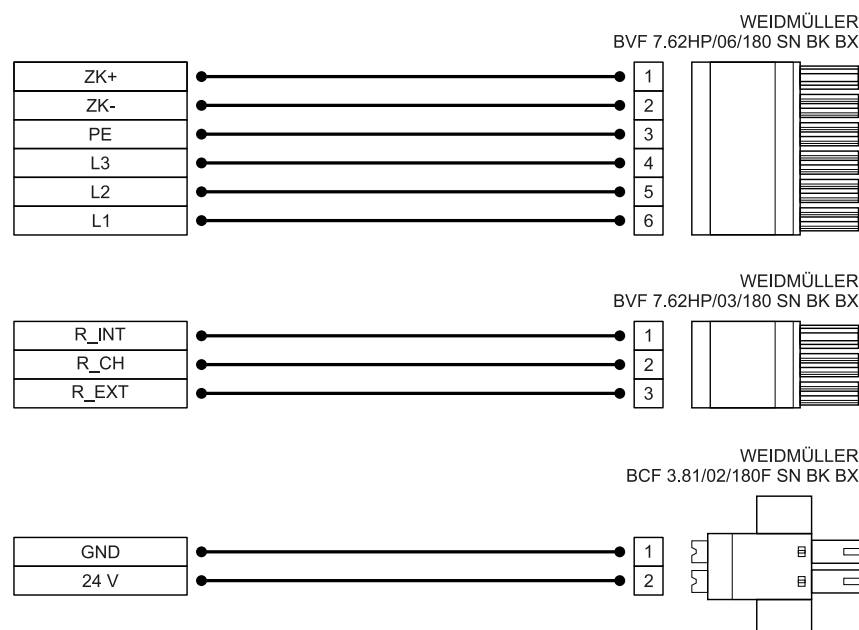


Figure 136: Pin assignment: power supply connector [X9]

Pin X9	Name	Specification
1	ZK+	Pos. DC bus voltage
2	ZK-	Neg. DC bus voltage
3	PE	Connection of the protective earth (ground) conductor of the mains power supply
4	L3	Phase conductor/mains phase 3
5	L2	Phase conductor/mains phase 2
6	L1	Phase conductor/mains phase 1

Pin X9A	Name	Specification
1	R_INT	Internal braking resistor connection
2	R_CH	Braking resistor connection
3	R_EXT	External braking resistor connection

Pin X9B	Name	Specification
1	GND	Supply voltage reference potential
2	24V	Supply voltage for the control module and holding brake

### › Cable type and configuration [X9], [X9A], [X9B]

The cable names that are stated refer to cables made by Lapp. They have proved to be reliable and are successfully used in many applications. However, it is also possible to use comparable cables from other manufacturers, for example Lütze or Helukabel.

A three-phase circuit breaker with the listed characteristics ("Circuit breaker") must be used in the mains supply line.

LAPP KABEL ÖLFLEX CLASSIC 110

Device type	Cable type	Specification (L1, L2, L3, PE)	Circuit breaker
BL 4304-C	4 G 1.0	4 x 1,0 mm <sup>2</sup> (AWG 18)	B 10
BL 4308-C	4 G 1.5	4 x 1,5 mm <sup>2</sup> (AWG 16)	B 10
BL 4312-C	4 G 2.5	4 x 2,5 mm <sup>2</sup> (AWG 14)	B 16

## 13.5 BL 4100-C: Connector: motor [X6]

The motor is connected to the terminals U, V, W. An analog motor temperature sensor can be connected to the terminals MT+ and MT- if it is routed together with the motor phases in one cable. Alternatively, it can be connected via the encoder cable to [X2A] or [X2B] (see section 7.16 *Motor temperature monitoring system* on page 190). A holding brake of the motor can be connected to terminals BR+ and BR-. If a motor with a HIPERFACE DSL® encoder is used, this encoder is also connected via [X6].

### › Configuration on the device [X6]

Weidmüller SL 5.08HC/09/90G 3.2SN BK BX

### › Mating connector [X6]

Weidmüller BLF 5.08HC/09/180 SN BK BX

### › Pin assignment: motor with a motor temperature sensor

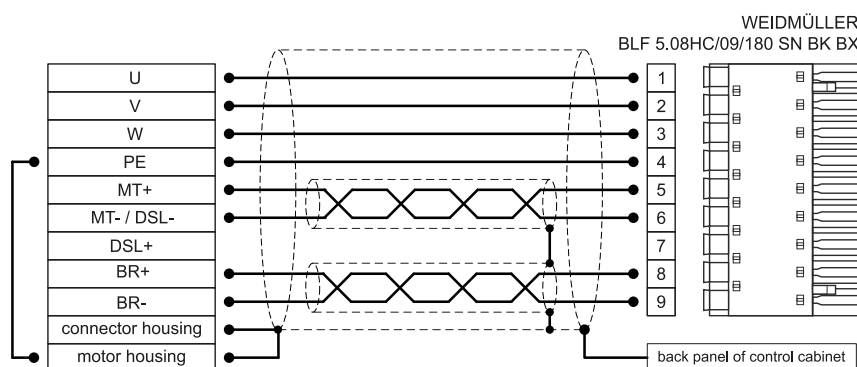


Figure 137: Pin assignment: motor connector (motor temperature sensor) [X6]

Pin	Name	Specification
1	U	Motor phase U
2	V	Motor phase V
3	W	Motor phase W
4	PE	Protective earth conductor of the motor
5	MT+	Motor temperature sensor +
6	MT- / DSL-	Motor temperature sensor -
7	DSL+	
8	BR+	Holding brake +
9	BR-	Holding brake -

### › Pin assignment: motor with HIPERFACE DSL®

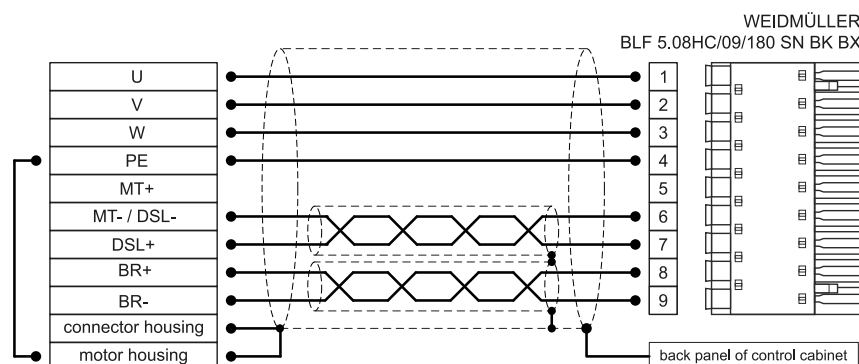


Figure 138: Pin assignment: motor connector (HIPERFACE DSL®) [X6]

Pin	Name	Specification
1	U	Motor phase U
2	V	Motor phase V
3	W	Motor phase W
4	PE	Protective earth conductor of the motor
5	MT+	
6	MT- / DSL-	HIPERFACE DSL -
7	DSL+	HIPERFACE DSL +
8	BR+	Holding brake +
9	BR-	Holding brake -

### › Cable type and configuration [X6]

The cable names that are stated refer to cables made by Lapp. However, it is also possible to use comparable cables from other manufacturers, for example Lütze or Helukabel.

For fixed installation: LAPP KABEL ÖLFLEX SERVO 719 CY

For highly flexible use (drag chains): LAPP KABEL ÖLFLEX SERVO FD 796 CP

Device type	Cable type	Specification (U, V, W, PE)
BL 4102-C	4 G 1,0 + 2 x (2 x 0,75)	4 x 1,0 mm <sup>2</sup> (AWG 18)
BL 4104-C	4 G 1,0 + 2 x (2 x 0,75)	4 x 1,0 mm <sup>2</sup> (AWG 18)

#### **INFORMATION** Comply with the required minimum cross-section

Always observe the minimum cross-sections for the lines U, V, W and PE according to the above table. Comply also with the maximum permissible cable capacity as per section 12.4 *BL 4100-C: Motor connector [X6]* on page 219.

**> Connection notes [X6]**

Connect the inner and outer cable shield with the greatest possible surface area to the back panel of the control cabinet by way of suitable EMC terminals (e.g. icotek LFZ/SKL, SFZ/SKL or PFSZ-MSKL). The unshielded cable end should not be longer than 80 mm.

An existing holding brake in the motor must be connected to the terminals BR+ and BR-. Please note the maximum output current that is provided by the servo drive.

**⚠ DANGER Dangerous electrical voltage! ⚠**

The signals for the temperature sensor "MT-" and "MT+" at the motor connector [X6] must be connected to protective extra-low voltage (PELV) on the motor side and they must be insulated against the motor phases.

**⚠ WARNING Risk of injury**

The brake output of the servo drive (BR+, BR-) must not be used as the sole stop element in safety-oriented applications.

**NOTICE Risk of destruction due to the mix-up of connectors**

The servo drive may be irreparably damaged if the connectors for the motor [X6] and supply [X9] are mixed up.

## 13.6 BL 4300-C: Connector: motor [X6], [X6A]

The motor is connected to the terminals U, V, W. An analog motor temperature sensor can be connected to the terminals MT+ and MT- if it is routed together with the motor phases in one cable. Alternatively, it can be connected via the encoder cable to [X2A] or [X2B] (see section 7.16 *Motor temperature monitoring system* on page 190). A holding brake of the motor can be connected to terminals BR+ and BR-. If a motor with a HIPERFACE DSL® encoder is used, this encoder is connected via [X6A].

### › Configuration on the device [X6], [X6A]

X6: Weidmüller BVL 7.62HP/04/90 3.5SN BK BX + mounting blocks(shield connection)

X6A: Weidmüller SC 3.81/05/90F 3.2SN BK BX

### › Mating connector [X6], [X6A]

X6: Weidmüller SVZ 7.62HP/04/180RSH180I SN BK BX

X6A: Weidmüller BCF 3.81/05/180F SN BK BX

### › Pin assignment [X6], [X6A]: motor with a motor temperature sensor

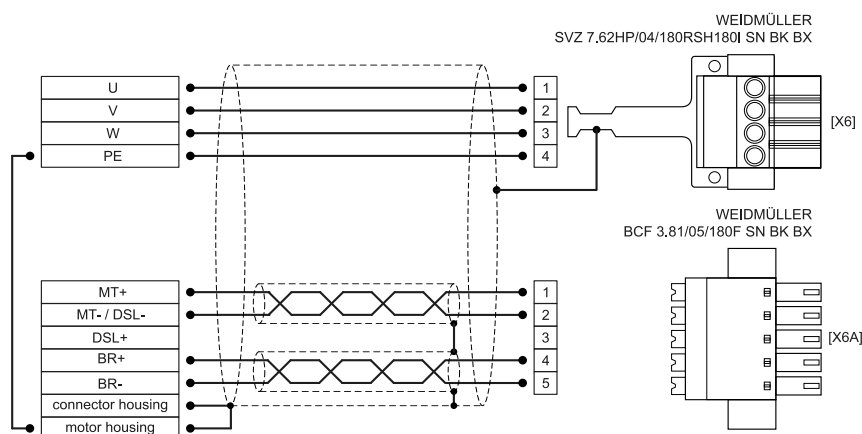


Figure 139: Pin assignment: motor connector (motor temperature sensor) [X6]

Pin X6	Name	Specification
1	U	Motor phase U
2	V	Motor phase V
3	W	Motor phase W
4	PE	Protective earth conductor of the motor



Pin X6A	Name	Specification
1	MT+	Motor temperature sensor +
2	MT-/ DSL-	Motor temperature sensor -
3	DSL+	
4	BR+	Holding brake +
5	BR-	Holding brake -

### ➤ Pin assignment [X6], [X6A]: motor with HIPERFACE DSL®

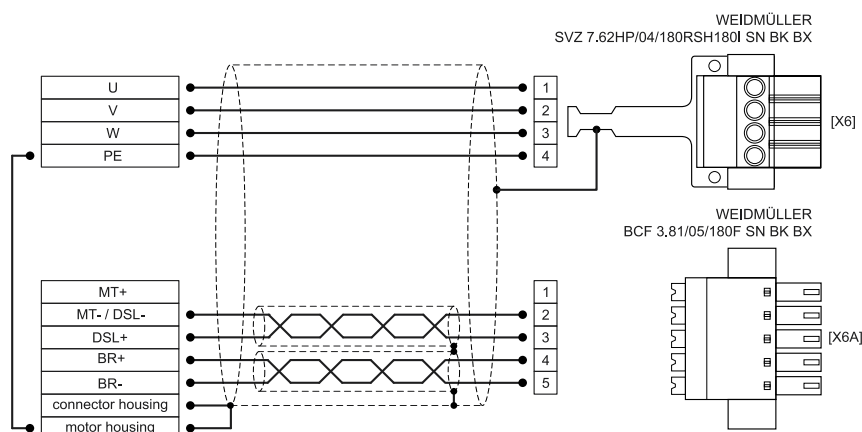


Figure 140: Pin assignment: motor connector (HIPERFACE DSL®) [X6]

Pin X6	Name	Specification
1	U	Motor phase U
2	V	Motor phase V
3	W	Motor phase W
4	PE	Protective earth conductor of the motor

Pin X6A	Name	Specification
1	MT+	
2	MT-/ DSL-	HIPERFACE DSL-
3	DSL+	HIPERFACE DSL+
4	BR+	Holding brake +
5	BR-	Holding brake -

### ➤ Cable type and configuration [X6], [X6A]

The cable names that are stated refer to cables made by Lapp. However, it is also possible to use comparable cables from other manufacturers, for example Lütze or Helukabel.

For fixed installation: LAPP KABEL ÖLFLEX SERVO 719 CY

For highly flexible use (drag chains): LAPP KABEL ÖLFLEX SERVO FD 796 CP

Device type	Cable type	Specification (U, V, W, PE)
BL 4304-C	4 G 1,0 + 2 x (2 x 0,75)	4 x 1,0 mm <sup>2</sup> (AWG 18)
BL 4308-C	4 G 1,5 + 2 x (2 x 0,75)	4 x 1,5 mm <sup>2</sup> (AWG 16)
BL 4312-C	4 G 2,5 + 2 x (2 x 1,0)	4 x 2,5 mm <sup>2</sup> (AWG 14)

**INFORMATION** Comply with the required minimum cross-section

Always observe the minimum cross-sections for the lines U, V, W and PE according to the above table. Comply also with the maximum permissible cable capacity as per section 12.5 *BL 4300-C: Motor connector [X6], [X6A]* on page 222.

**Connection notes [X6], [X6A]**

Connect the inner and outer cable shield with the greatest possible surface area to the shield connection of [X6] and fix the cable for example with cable ties. The fixing screws must be firmly tightened to ensure a good PE connection. The unshielded cable end should not be longer than 50 mm.

An existing holding brake in the motor must be connected to the terminals BR+ and BR-. Please note the maximum output current that is provided by the servo drive.

**⚠ DANGER** Dangerous electrical voltage! ⚠

The signals for the temperature sensor "MT-" and "MT+" at the motor connector [X6] must be connected to protective extra-low voltage (PELV) on the motor side and they must be insulated against the motor phases.

**⚠ WARNING** Risk of injury

The brake output of the servo drive (BR+, BR-) must not be used as the sole stop element in safety-oriented applications.

**NOTICE** Risk of destruction due to the mix-up of connectors

The servo drive may be irreparably damaged if the connectors for the motor [X6] and supply [X9] are mixed up.

## 13.7 Connector: resolvers/analogue Hall encoders [X2A]

Two different encoder types can be connected to the 9-pin D-Sub connector:

- Resolvers
- Analogue Hall generators with tracks that are offset by 90° (sine/cosine)

Diverging from the analogue evaluation via the X2B interface, this input has a higher resolution and it is possible to read in higher amplitudes.

### › Configuration on the device [X2A]

D-SUB connector, 9-pin type, female

### › Mating connector [X2A]

- D-SUB connector, 9-pin type, male
- Housing for a 9-pin D-SUB connector with locking screws of type 4/40 UNC

### › Pin assignment [X2A]

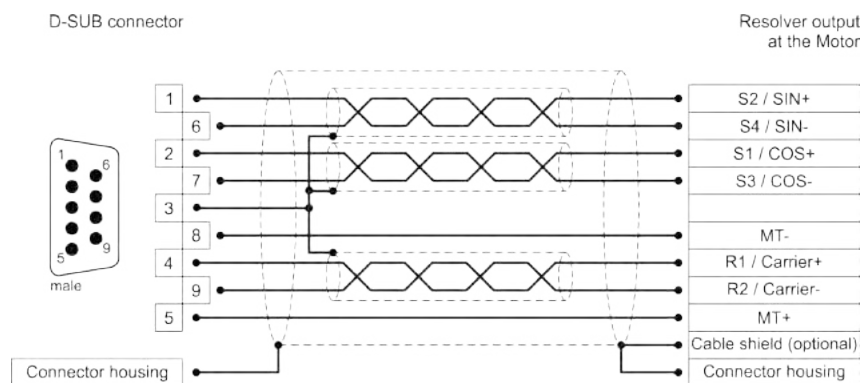


Figure 141: Pin assignment: resolver connector [X2A]

- The outer shield is always connected to PE (connector housing) on the servo drive side.
- The three inner shields are connected to PIN 3 of X2A on one side of the servo drive.

Pin	Name	Specification
1	S2	SINE track signal, differential
6	S4	Analogue Hall sensor (SINE)
2	S1	COSINE track signal, differential
7	S3	Analogue Hall sensor (COSINE)
3	GND	Shield for signal pairs (inner shield)
8	MT-	Temperature sensor reference potential
4	R1	Carrier signal for the resolver
9	R2	
5	MT+	Motor temperature sensor, normally closed contact, PTC, NTC, KTY

**INFORMATION** Only one motor temperature sensor can be connected

The motor temperature sensor can either be connected to X2A, X2B or X6. It is not possible to connect several sensors at a time.

**INFORMATION** Avoiding EMC interferences

The outer cable shield must be connected to the housing of the angle encoder connector with the greatest possible surface area (with low impedance).

### › Cable type and configuration [X2A]

The cable names that are stated refer to cables made by Lapp. However, it is also possible to use comparable cables from other manufacturers, for example Lütze or Helukabel.

LAPP KABEL ÖLFLEX SERVO 728 CY; 3 x (2 x 0.14) + 2 x (0.5);

with an overall tinned CU shield, angle measurement error up to approx. 0.7° with a cable length of 25 m, to be used 2 x (0.5) for the resolver carrier.

**For highly flexible applications:**

LAPP KABEL ÖLFLEX SERVO FD 798 CP; 3 x (2 x 0.14) + 2 x (0.5);

with an overall tinned CU shield, angle measurement error up to approx. 0.7° with a cable length of 25 m, to be used 2 x (0.5) for the resolver carrier.

## 13.8 Connector: encoder [X2B]

Different types of encoders can be connected to the 15-pin D-Sub connector (see section 12.7 *Encoder connector [X2B]* on page 225):

- Analogue incremental encoders ( $1 V_{SS}$ )
- Incremental encoders with a serial interface (RS485 level, e.g. EnDat, HIPERFACE®, BISS)
- Digital incremental encoders (RS422, HALL sensors)

It is also possible to evaluate an optional error signal (AS/NAS) via pin 6. With some incremental encoders, it is possible to detect and signal soiling or other faults/malfunctions of the measuring system via an output (AS or NAS). The error signal can be evaluated by digital as well as analogue incremental encoders.

In the case of analogue incremental encoders, the evaluation is only possible if no commutation track (Z1) is parameterised and connected. The evaluation of the error signal can be inverted.

### › Configuration on the device [X2B]

D-SUB connector, 15-pin type, female

### › Mating connector [X2B]

- D-SUB connector, 15-pin type, male
- Housing for a 15-pin D-SUB connector with locking screws of type 4/40 UNC

#### **NOTICE** Damage to property caused by an incorrect power supply

If an incorrect power supply is used, the encoder may be destroyed. Ensure that the correct voltage is activated prior to connecting the encoder to [X2B].

To do so, start the Kuhnke ServoCommander® parameterisation software and select the **Parameters/Device parameters/Angle encoder settings**.

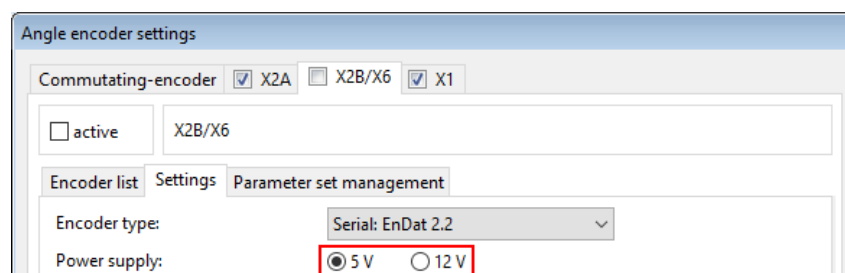


Figure 142: Angle encoder settings: Parameterisation of supply voltage

### > Pin assignment: analogue incremental encoders

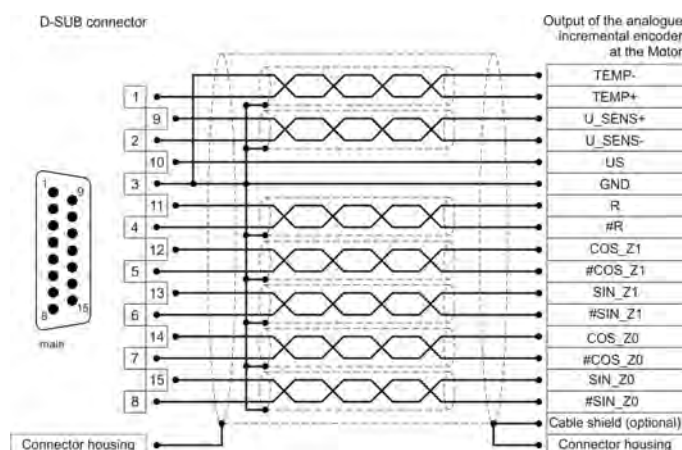


Figure 143: Pin assignment: analogue incremental encoders [X2B]

Pin	Name	Specification
1	MT+	Motor temperature sensor, normally closed contact, PTC, NTC, KTY
9	U_SENS+	Sensor cables for the encoder supply. In case of long cables, connect to US/GND at the motor end.
2	U_SENS-	
10	US	Operating voltage for incremental encoders
3	GND	Associated reference potential
11	R	Index pulse track signal (differential) of the high-resolution incremental encoder
4	#R	
12	COS_Z1 / D+	COSINE commutation signal (differential) of the high-resolution incremental encoder
5	#COS_Z1 / D-	
13	SIN_Z1 / C+	SINE commutation signal (differential) of the high-resolution incremental encoder
6	#SIN_Z1 / C-	
14	COS_Z0 / B+	COSINE track signal (differential) of the high-resolution incremental encoder
7	#COS_Z0 / B-	
15	SIN_Z0 / A+	SINE track signal (differential) of the high-resolution incremental encoder
8	#SIN_Z0 / A-	

#### **INFORMATION** Avoiding EMC interferences

The outer cable shield must be connected to the housing of the angle encoder connector with the greatest possible surface area (with low impedance).

### > Pin assignment: incremental encoder with a serial interface

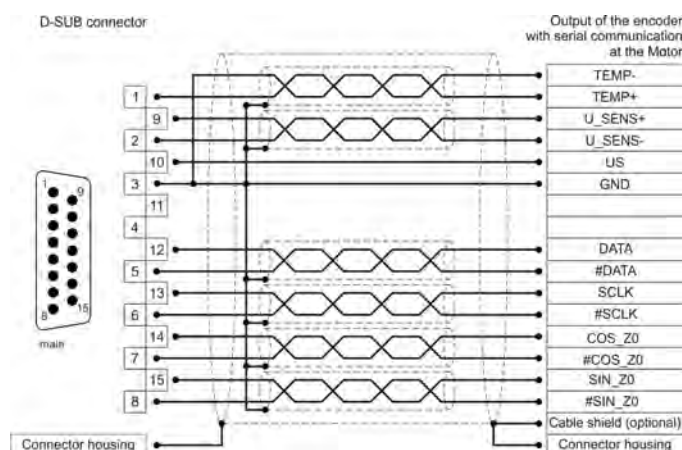


Figure 144: Pin assignment: incremental encoder with a serial interface [X2B]

Pin	Name	Specification
1	MT+	Motor temperature sensor, normally closed contact, PTC, NTC, KTY
9	U_SENS+	Sensor cables for the encoder supply. In case of long cables, connect to US/GND at the motor end.
2	U_SENS-	
10	US	Operating voltage
3	GND	Associated reference potential
11		
4		
12	DATA / SL+	Bidirectional RS485 data line (differential) (EnDat/HIPERFACE®, BiSS)
5	#DATA / SL-	
13	SCLK / MA+	Clock pulse output RS485 (differential) (EnDat, BiSS)
6	#SCLK / MA-	
14	COS_Z0 / B+	COSINE track signal (differential) of the high-resolution incremental encoder
7	#COS_Z0 / B-	
15	SIN_Z0 / A+	SINE track signal (differential) of the high-resolution incremental encoder
8	#SIN_Z0 / A-	

#### **INFORMATION** Avoiding EMC interferences

The outer cable shield must be connected to the housing of the angle encoder connector with the greatest possible surface area (with low impedance).

### ➤ Pin assignment: digital incremental encoder (RS422)

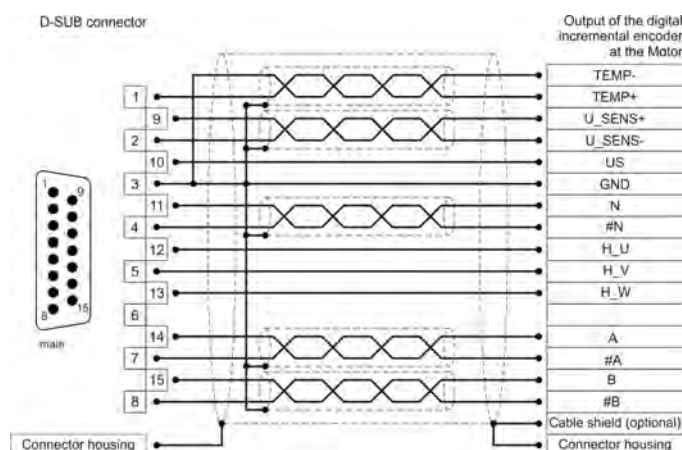


Figure 145: Pin assignment: digital incremental encoder (RS422) [X2B]

Pin	Name	Specification
1	MT+	Motor temperature sensor, normally closed contact, PTC, NTC, KTY
9	U_SENS+	Sensor cables for the encoder supply. In case of a long cable, connect to US/GND at the motor end.
2	U_SENS-	
10	US	Operating voltage for incremental encoders
3	GND	Associated reference potential
11	N / $U_{a0}$	Index pulse RS422 (differential) of the digital incremental encoder
4	#N / $\overline{U}_{a0}$	
12	H_U	Phase U of the Hall sensor for commutation
5	H_V	Phase V of the Hall sensor for commutation
13	H_W	Phase W of the Hall sensor for commutation
6		
14	A / $U_{a1}$	A track signal RS422 (differential) of the digital incremental encoder
7	#A / $\overline{U}_{a1}$	
15	B / $U_{a2}$	B track signal RS422 (differential) of the digital incremental encoder
8	#B / $\overline{U}_{a2}$	

#### **INFORMATION** Avoiding EMC interferences

The outer cable shield must be connected to the housing of the angle encoder connector with the greatest possible surface area (with low impedance).

### ➤ Cable type and configuration [X2B]

We recommend a minimum cross-section of 0.25 mm<sup>2</sup> for the angle encoder supply US and GND.



## 13.9 Connector: USB [X19]

The BL 4100-C servo drive has a Type B USB connector.

The correct operation requires a short USB cable (< 3 m) and the correct installation and earthing of the servo drive. If excessive malfunctions/faults lead to communication problems (frozen communication), the USB connector can be briefly disconnected to restart the communication.

In addition, we recommend using certified, double-shielded cables of the AB type (USB 2.0 connecting cable, type A connector to type B connector) AWG28-1P, AWG24-2C with shielded connectors.

### **INFORMATION** Non-EMC-compliant wiring of the servo drive and motor

In case of non-EMC-compliant wiring of the servo drive and motor, compensating electric current may flow via the connected computer and the USB interface. This may lead to communication problems.

To avoid this, we recommend using an electrically isolated USB adapter "Delock USB Isolator" (type 62588 by Delock) or a comparable adapter.

### › Configuration on the device [X19]

USB connector (female), type B

### › Mating connector [X19]

USB connector (male), type B

### › Pin assignment USB [X19]

Interface cable for the USB interface, 4 cores, shielded and twisted (type B).

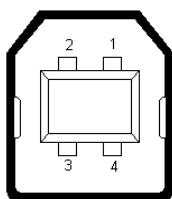


Figure 146: Pin assignment of the USB connector

Pin	Name	Specification
1		
2	D-	Data -
3	D+	Data +
4	GND	GND

## 13.10 Connector: standard Ethernet [X18]

The BL 4100-C servo drive has a network connector of the RJ45 type.

### › Configuration on the device [X18]

Female RJ45 connector, cat. 6

### › Mating connector [X18]

Male RJ45 connector

### › Pin assignment of the network connector [X18]

Cat.6 patch cable RJ45 LAN cable S-FTP/PIMF.

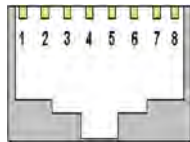


Figure 147: Pin assignment of the network connector

Pin	Name	Description	Colour
1	TX+	Transmission signal +	Yellow
2	TX-	Transmission signal -	Orange
3	RX+	Reception signal +	White
4	-	-	
5	-	-	
6	RX-	Reception signal -	Blue
7	-	-	
8	-	-	

## 13.11 Connector: real-time Ethernet [X21]

The connection to an EtherCAT or PROFINET network must be realised via two female RJ45 connectors. Details can be found in the Fieldbus manuals.

### › Configuration on the device [X21]

Female RJ45 connector, cat. 6

### › Mating connector [X21]

Male RJ45 connector

### › Pin assignment of the real-time Ethernet connector [X21]

Cat.6 patch cable RJ45 LAN cable S-FTP/PIMF.

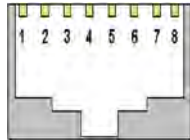


Figure 148: Pin assignment of the real-time Ethernet connector

Pin	Name	Description	Colour
1	TX+	Transmission signal +	Yellow
2	TX-	Transmission signal -	Orange
3	RX+	Reception signal +	White
4	-	-	
5	-	-	
6	RX-	Reception signal -	Blue
7	-	-	
8	-	-	

## 13.12 Connector: CAN bus [X4]

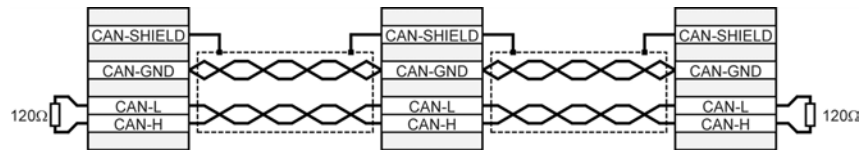


Figure 149: CAN bus cabling example

- Ideally, the individual nodes of the networks are always connected in a linear manner so that the CAN cable is looped through from servo drive to servo drive.
- A terminating resistor of 120  $\Omega$ , 5%, must be present on both ends of the CAN bus cable.
- Shielded cables with exactly two twisted pairs must be used for cabling.
- Use one twisted pair to connect CAN-H and CAN-L.
- The cores of the other pair are used jointly for CAN-GND.
- The shield of the cable is led to the CAN shield connections for all nodes.
- We advise against the use of plug adaptors for cabling the CAN bus. However, if this is necessary, use metal connector housings for connecting the cable shield.

In order to keep interferences as low as possible ensure that

- the motor cables are not installed parallel to signal lines
- the motor cables comply with the Kuhnke specification
- the motor cables are properly shielded and earthed (grounded)

### › Configuration on the device [X4]

D-SUB connector, 9-pin type, male

### › Mating connector [X4]

- D-SUB connector, 9-pin type, female
- Housing for a 9-pin D-SUB connector with locking screws of type 4/40 UNC

### › Pin assignment [X4]

Pin		Name	Specification
1			Not used
	6	GND	CAN-GND, directly coupled to GND in the servo drive
2		CANL	CAN low signal line
	7	CANH	CAN high signal line
3		GND	See pin no. 6
	8		Not used
4			Not used
	9		Not used
5		Shield	Connector for the cable shield

\*) To terminate the CAN bus at both ends, an external terminating resistor is required.

### › Cable type and configuration [X4]

The cable names that are stated refer to cables made by Lapp. However, it is also possible to use comparable cables from other manufacturers, for example Lütze or Helukabel.

**Technical data of the CAN bus cable:** 2 pairs of 2 twisted cores,  $d \geq 0.22 \text{ mm}^2$ , shielded, loop resistance  $< 0.2 \Omega/\text{m}$ , characteristic impedance 100-120  $\Omega$

LAPP KABEL UNITRONIC BUS CAN; 2 x 2 x 0.22; 7.6 mm, with CU shielding

**For highly flexible applications:**

LAPP KABEL UNITRONIC BUS CAN FD P; 2 x 2 x 0.25; 8.4 mm, with CU shielding

## 13.13 Connector: I/O interface [X1]

The BL 4100-C servo drive has two differential inputs (AIN) for analogue input voltages in the range of  $\pm 10$  V. The inputs AIN and #AIN are connected to the control system via twisted cables (twisted-pair type). Alternatively, it is also possible to use a shielded cable.

If the control system is equipped with single-ended outputs, the output is connected to AIN and #AIN is connected to the reference potential of the control system. If the control system is equipped with a differential output, it must be connected 1:1 to the differential inputs of the servo drive.

The reference potential GND24 must be connected to the reference potential of the control system. This is necessary in order to prevent the differential input of the servo drive from being overridden by high "common-mode interference".

Despite the differential design of the analogue input, using unshielded cables for the analogue signals is not recommended, since interferences, e.g. caused by switching contactors, or output stage interferences of the converters can reach high amplitudes.

The 24 V connections inside the control cabinet can be made without a shield. In the case of long cables ( $l > 2$  m) towards the PLC or outside the control cabinet, shielded cables must be used. The shields of these cables must be connected to PE on both ends. The cable shield can then be connected to the back panel of the control cabinet, for example.

For optimal interference suppression on the analogue signal lines, the cores for the analogue signal must be shielded separately. It may be useful to run the analogue signal in a separate, shielded cable.

The servo drive provides an auxiliary voltage of 24 V. As a result, the inputs can be activated directly via switches.

The digital outputs are designed as so-called "high-side switches". This means that only these 24 V are supplied to the output in the active state. In the passive state, the output has a high resistance and the level is defined only by the flyback diode and a high internal resistance.

### › Configuration on the device [X1]

D-SUB connector, 25-pin type, female

### › Mating connector [X1]

- D-SUB connector, 25-pin type, male
- Housing for a 25-pin D-SUB connector with locking screws of type 4/40 UNC

### › Pin assignment [X1]

Pin	Name	Specification
1	#AIN1	Analogue input 1, input voltage 30 V max.
14	AIN1	
2	#AIN0	Analogue input 0, input voltage 30 V max.
15	AIN0	
3	A / CLK	Incremental encoder signal A/stepper motor signal CLK
16	A# / CLK	Incremental encoder signal A#/stepper motor signal CLK
4	B / DIR	Incremental encoder signal B/stepper motor signal DIR
17	B# / DIR	Incremental encoder signal B#/stepper motor signal DIR
5	N	Incremental encoder index pulse N
18	#N	Incremental encoder index pulse N#
6	GND24	Reference potential for I/Os at X1
19	DIN0	Digital input 0 (target 0)
7	DIN1	Digital input 1 (target 1)
20	DIN2	Digital input 2 (target 2)
8	DIN3	Digital input 3 (target 3)
21	DIN4	Digital input 4 (input)
9	DIN5	Digital input 5 (servo drive enable signal)
22	DIN6	Digital input 6 (limit switch 0)
10	DIN7	Digital input 7 (limit switch 1)
23	DIN8	Input (flying saw)
11	5 V	Encoder supply (see pin 3 to 18)
24	24 V	Auxiliary voltage for I/Os at X1
12	DOUT0	Freely programmable output
25	DOUT1	Freely programmable output
13	DOUT2	Freely programmable output

### › Cable type and configuration [X1]

The cable name that is stated refers to a cable made by Lapp. However, it is also possible to use comparable cables from other manufacturers, for example Lütze or Helukabel.

LAPP KABEL UNITRONIC LiYCY (TP); 25 x 0.25mm<sup>2</sup>

## 13.14 Connector: STO [X3]

**⚠ DANGER** Dangerous electrical voltage! 

Use only PELV circuits for the STO wiring!

Make sure that no jumpers or the like can be inserted parallel to the safety wiring. For example, use the maximum wire cross-section of 1.5 mm<sup>2</sup> or suitable wire end sleeves with insulating collars for the connection to the associated connector.

### › Configuration on the device [X3]

SC 3.81/08/90F 3.2SN BK BX

### › Mating connector

BCF 3.81/08/180F SN BK BX

### › Pin assignment [X3]



Figure 150: STO connector [X3]

Pin	Name	Description
1	STOA	Control input A for the STO function
2	GNDA	Reference potential for STO-A
3	STOB	Control input B for the STO function
4	GNDB	Reference potential for STO-B
5	DIN6	Connected to X1, pin 22
6	DIN7	Connected to X1, pin 10
7	DOUT0	Connected to X1, pin 12
8	GND	Reference potential for the auxiliary supply voltage

To ensure the STO ("Safe Torque Off") function, the control inputs STOA and STOB must be connected in a dual-channel manner with parallel wiring. See section 8.6.1 *Safe torque off (STO)* on page 201. This type of connection can be part of an emergency stop circuit or safety door setup, for example.



### › Cable type and configuration [X3]

Characteristic	Value
Max. cable length, unshielded	30 m
Max. cable length, shielded	> 30 m
Shielding	In the case of wiring outside the control cabinet and with cable lengths > 30 m, the shield must be led into the control cabinet.
Cable cross-section (flexible conductors, wire end sleeve with insulating collar), one conductor	0.25 mm <sup>2</sup> ... 0.5 mm <sup>2</sup>

### › Minimum wiring for commissioning [X3]

#### **⚠ DANGER** Danger to life due to bypassed safety functions

Safety functions must never be bypassed.

For the commissioning of the system without any safety systems, STOA and STOB can be connected to the 24 V supply and GNDA and GNDB can be connected to GND in a fixed manner.

Perform the minimum wiring of the inputs STOA/STOB and GNDA/GNDB for the commissioning process in such a way that it must be removed when the final safety wiring is performed.

# 14 Maintenance, cleaning, repair and disposal

The following requirements must be fulfilled for the maintenance, cleaning, repair and disposal of the servo drive:

## > Maintenance

Servo drives of the BL 4000-C device series are maintenance-free.

## > Cleaning

### **NOTICE** Damage to the servo drive due to improper cleaning

To remove surface soiling, e.g. residues of adhesive labels, the servo drive can be cleaned carefully on the outside with suitable tools.

It must be absolutely ensured that liquids of any kind cannot penetrate the servo drive. Seals may be destroyed which, in turn, would lead to short circuits.

Use the servo drive in a clean environment. Soiling due to dust, oil, oil vapour, grease, fibres or similar inside the device will compromise the insulation with regard to the high-voltage part. Stop using the device immediately if this is the case.

## > Repair

Opening the device is not permissible and will render the warranty null and void. Only the manufacturer is authorised to perform repairs. Please contact your sales partner.

## > Disposal, removal, decommissioning, replacement

### **⚠ DANGER** Dangerous electrical voltage!

Following the instructions stated hereinbelow to ensure the safe decommissioning of the servo drive.

- Switch the power supply completely off.
- Disconnect the mains power connectors.
- Lock the system so that it cannot be reactivated.
- Check whether the device is really voltage-free (measure the voltage at the mains power connectors and between the ZK+ and ZK- connectors at X9).
- Wait 10 minutes. Do not attempt to remove the device before this waiting period has elapsed.
- Contact a sales partner in terms of a return or replacement of the device.

## 15.4 Safety technology glossary

Term/abbreviation	Description
CCF	Common cause failure in accordance with EN ISO 13849-1.
DC avg	Average diagnostic coverage in accordance with IEC 61508 and EN 61800-5-2.
HFT	Hardware fault tolerance in accordance with IEC 61508.
Cat.	Safety category in accordance with EN ISO 13849-1, level 1-4.
MSC	Kuhnke ServoCommander®, software for configuration and start-up.
MTTFd	Mean time to dangerous failure. Time in years until the first dangerous failure will have occurred with 100% probability, in accordance with EN ISO 13849-1.
Emergency off	In accordance with EN 60204-5-1 Electrical safety is ensured in case of an emergency by switching off the electrical energy supply to the entire installation or part of it. An emergency off is to be used where a risk of electric shock or other electrical risk exists.
Emergency stop	In accordance with EN 60204-5-1 In an emergency, functional safety is ensured by stopping a machine or moving parts. An emergency stop is used to stop a process or a movement which has become hazardous.
OSSD	Output signal switching device, output signals with 24 V level cycle rates for error detection.
PFD	Probability of failure on demand in accordance with IEC 61508.
PFH	Probability of dangerous failures per hour in accordance with IEC 61508.
PL	Performance level in accordance with EN ISO 13849-1: Levels a to e
PWM	Pulse width modulation. Stands for the digital actuation of the power semiconductors with a variable duty cycle in order to adjust a voltage at the motor output.
SFF	Safe failure fraction [%], ratio between the failure rates of safe and dangerous (but recognisable) failures and the total number failures in accordance with IEC 61508.
Safety relay	Device for executing safety functions or for establishing a safe state of the machine by switching off the energy supply for dangerous machine functions. The desired safety function can be achieved only in combination with other risk reduction measures, e.g. by switching off a servo drive.

Term/abbreviation	Description
SIL	Safety integrity level. Discrete levels for defining the requirements for the safety integrity of safety functions in accordance with IEC 61508, EN 62061 and EN ISO 13849.
SIL CL	Maximum SIL that can be required from a sub-system.
SS1	Safe stop 1 in accordance with EN 61800-5-2.
STO	Safe torque off in accordance with EN 61800-5-2.
T	Duration of use in accordance with EN ISO 13849-1.

## 15.5 Risk reduction questions

### › Questions for a validation in accordance with EN ISO 12100-1:2010 (example)

No.	Question	Yes/No		Completed
1	Have all of the operating conditions and interventions been taken into account?	Yes	No	
2	Has the "3-step method" for risk reduction been applied? <ul style="list-style-type: none"> <li>• Inherently safe design</li> <li>• Technical safety measures and additional safeguarding (if necessary)</li> <li>• User information about the residual risk</li> </ul>	Yes	No	
3	Have the hazards been eliminated or has the hazard risk been reduced as far as practically possible?	Yes	No	
4	Can it be guaranteed that the implemented measures will not pose new hazards?	Yes	No	
5	Have the users been adequately informed and warned about the residual risks?	Yes	No	
6	Can it be guaranteed that the operators' working conditions have not deteriorated due to the safeguarding undertaken?	Yes	No	
7	Is the safeguarding mutually compatible?	Yes	No	
8	Has adequate consideration been given to the potential consequences of using a machine designed for commercial/industrial purposes in a non-commercial/industrial area?	Yes	No	
9	Can it be guaranteed that the implemented measures will not severely impair the machine's ability to perform its function?	Yes	No	

➤ **Questions for a validation in accordance with EN ISO 13849-1 and -2 (example)**

No. Questions		Yes/No		Completed
1	Has a risk assessment been conducted?	Yes	No	
2	Have an error list and a validation plan been drawn up?	Yes	No	
3	Has the validation plan, including an analysis and test/inspection, been executed and has a validation report been compiled? The validation procedure must include the following tests/inspections as a minimum:	Yes	No	
a.	Inspection of components: Is the servo drive a BL 4000-C servo drive (check against the type plates)?	Yes	No	
b.	Is the wiring correct (check against the wiring diagram)?	Yes	No	
	Have any jumpers been removed?	Yes	No	
	Has a safety relay been connected to X3?	Yes	No	
	Has the safety relay been certified and wired in accordance with the requirements of the application?	Yes	No	
c.	Functional tests: Actuation of the emergency cut-out switch of the system. Does the drive stop?	Yes	No	
	If only STO-A is activated, does the drive stop immediately and is the error "Discrepancy time" (52-1) signalled after the discrepancy time has elapsed?	Yes	No	
	If only STO-B is activated, does the drive stop immediately and is the error "Discrepancy time" (52-1) signalled after the discrepancy time has elapsed?	Yes	No	
	Does the system detect a short circuit between STO-A and STO-B or has a suitable fault exclusion been defined?	Yes	No	
	Is a restart effectively prevented? This means that if the emergency cut-out switch has been actuated and if the enable signals are active, there will be no movement following a start command unless an acknowledgement has been given.	Yes	No	

## 15.6 Error messages and warnings

Group 0: Events		
0-0	Invalid error	An invalid (corrupted) entry in the error buffer has been marked with this error number. Entry in the permanent event memory. No measures required.
0-1	Invalid error detected and corrected	An invalid (corrupted) error entry has been detected and corrected in the error buffer. The debug information includes the original error number. Entry in the permanent event memory. No measures required.
0-2	Error cleared	The active errors have been acknowledged. Entry in the permanent event memory. No measures required.
0-4	Serial number / device type (module replacement)	A replaceable error memory module (service module) has been plugged into another device. Entry in the permanent event memory. No measures required.
0-7	Additional log entry	Entry in the permanent event memory. No measures required.
0-8	Servo drive switched on	Log entry proving that the servo drive has been switched on. Entry in the permanent event memory. No measures required.
0-9	Servo drive: safety parameters changed	Logging of the parameterisation of the FSM 2.0 - MOV. Entry in the permanent event memory. No measures required.
0-11	FSM module replacement (previous type)	Logging of the module replacement. Entry in the permanent event memory. No measures required.
0-12	FSM module replacement (current type)	Logging of the module replacement. Entry in the permanent event memory. No measures required.
0-21	Log entry from the FSM	Logging of events in the FSM. Entry in the permanent event memory. No measures required.
0-22	Default parameter set loaded	Log entry proving that the default parameter set has been loaded. Entry in the permanent event memory. No measures required.
Group 1: Stack overflow		
1-0	Stack overflow	Incorrect firmware? Load the most recent firmware. Please contact the Technical Support team.

Group 2: Undervoltage		
2-0	Undervoltage of DC bus circuit	Check the error handling settings (error management). Check the power supply voltage. Check (measure) the DC bus circuit voltage. Check the response threshold of the DC bus monitoring system.
Group 3: Overtemperature motor		
3-0	Motor overtemperature (analogue)	Motor too hot? Check the parameterisation (current controller, current limits). Correct sensor? Sensor defective?
3-1	Motor overtemperature (digital)	Check the parameterisation of the sensor or the sensor characteristics. If the error still occurs after the sensor has been bypassed, replace the servo drive.
3-2	Motor overtemperature (analogue): wire break	Check the connecting cables of the temperature sensor (broken wire). Check the parameterisation of wire break detection system (threshold value).
3-3	Motor overtemperature (analogue): short circuit	Check the connecting cables of the temperature sensor (short circuit). Check the parameterisation of the short-circuit monitoring system (threshold value).
Group 4: Overtemperature		
4-0	Overtemperature power output stage	Plausible temperature indication? Check the installation conditions. Are the filter mats of the control cabinet fan soiled?
4-1	Overtemperature DC bus circuit	Is the fan defective?
Group 5: Internal voltage supply		
5-0	Failure of internal voltage 1	Disconnect the servo drive from the entire periphery and check whether the error is still present after a reset. If the error is still present, replace the servo drive.
5-1	Failure of internal voltage 2	
5-2	Driver supply failure	
5-3	Undervoltage digital I/Os	Check the outputs for short circuits or specified load.
5-4	Overcurrent digital I/Os	Please contact the Technical Support team.
5-5	Technology module voltage supply failure	Technology module defective? Replace the technology module. Please contact the Technical Support team.
5-6	X10, X11 or RS232 voltage supply failure	Check the pin assignment of the connected peripheral equipment. Check the connected peripheral equipment for short-circuits.
5-7	Safety module internal voltage failure	Is the technology module defective? Replace the technology module. Please contact the Technical Support team.



5-8	Failure of internal voltage 3	Replace the servo drive.
5-9	Failure of encoder supply	
Group 6: Short circuit in the power output stage		
6-0	Short circuit in the power output stage	Is the motor defective? Is there a short circuit in the cable? Is the power output stage defective?
6-1	Brake chopper overcurrent	Check the external braking resistor for short circuits. Check whether the resistance value is too small. Check the brake chopper output of the servo drive.
Group 7: Overvoltage		
7-0	Overvoltage DC bus circuit	Check the connection to the braking resistor (internal/external). Is the external braking resistor overloaded? Check the rating.
7-1	Overvoltage at power input	Disconnect the device immediately from the mains power supply and check the voltage at the main power input. Check the quality of the power supply (voltage peaks).
Group 8: Angle encoder		
8-0	Resolver/Hall angle encoder error	See the measures for 08-2 to 08-8.
8-1	Rotating direction of serial and incremental position evaluation not identical	Have the A and B tracks been mixed up? Check the connection of the track signals.
8-2	Incremental encoder: Z0 track signals error	Is the angle encoder connected? Is the angle encoder cable defective? Is the angle encoder defective? Check the configuration of the angle encoder interface. The encoder signals are disturbed: Check the installation for compliance with the EMC recommendations.
8-3	Incremental encoder: Z1 track signals error	
8-4	Digital incremental encoder: track signals error	
8-5	Incremental encoder: hall signals error	
8-6	Angle encoder communication error	
8-7	Master frequency input: Incorrect signal amplitude incremental track	

8-8	Internal angle encoder error	The internal monitoring system of the angle encoder at [X2B] has detected an error. Communication error? Please contact the Technical Support team.
8-9	Encoder at [X2B/X6] not supported	Please contact the Technical Support team.
<b>Group 9: Encoder parameter set</b>		
9-0	Encoder parameter set: out-of-date format	Save the parameter set in the encoder EEPROM (reformatting).
9-1	Encoder parameter set cannot be decoded	Is the angle encoder defective? Check the configuration of the angle encoder interface. The encoder signals are disturbed. Check the installation for compliance with the EMC recommendations.
9-2	Encoder parameter set: unknown version	Save the data into the encoder again.
9-3	Encoder parameter set: corrupted data structure	If necessary, redetermine the data and save it in the encoder.
9-4	Encoder parameter set: faulty customer-specific configuration	Motor repaired: Perform a homing run and save the parameter set in the angle encoder. Then, save it in the servo drive. Motor replaced: Parameterise the servo drive, perform a homing run, save the data in the angle encoder, and then save to the servo drive.
9-5	Encoder parameter set: read/write error	Please contact the Technical Support team.
9-7	Encoder EEPROM is write protected	Please contact the Technical Support team.
9-9	Too small memory size of encoder EEPROM	Please contact the Technical Support team.
<b>Group 10: Motor overspeed protection</b>		
10-0	Overspeed (motor overspeed protection)	Check the offset angle. Check the parameterisation of the limit value.
10-1	Overspeed according to Dual-Use Regulation 600 Hz	Please contact the Technical Support team.
<b>Group 11: Homing run</b>		
11-0	Error when homing run is started	Servo drive not enabled.
11-1	Error during homing run	The homing run has been interrupted, e.g. because the enable signal has been withdrawn.
11-2	Homing: no valid index pulse	The required index pulse is not provided. Check the index pulse. Check the angle encoder settings

11-3	Homing: timeout	The maximum permissible time for the homing run has been reached before the homing run could be completed. Check the time value
11-4	Homing: incorrect / invalid limit switch	Has the associated limit switch not been connected? Have the limit switches been mixed up?
11-5	Homing: I <sup>2</sup> t / following error	Unsuitable parameterisation of the acceleration ramps. The stop has been reached, e.g. because no reference switch has been installed.
11-6	Homing: end of search distance reached	The maximum distance for the homing run has been covered, but the reference point or the target of the homing run have not been reached.
11-7	Homing: encoder difference monitoring	The deviation fluctuates, e.g. due to gear slackness. If necessary, increase the switch-off threshold. Check the connection of the actual value encoder.
<b>Group 12: CAN communication</b>		
12-0	CAN: duplicate node number	Check the configuration of the devices that are connected to the CAN bus.
12-1	CAN: communication error, bus OFF	Check the wiring: compliance with the cable specification, cable break, maximum cable length exceeded, correct terminating resistors, cable shield earthed, all signals connected?
12-2	CAN: communication error (sending)	
12-3	CAN: communication error (receiving)	
12-4	CAN: Node Guarding	Failure of the PLC or the cycle time of the remote frames of the servo drive and PLC do not match.
12-5	CAN: RPDO too short	The number of bytes of a received RPDO is smaller than the number that is parameterised in the servo drive.
12-9	CAN: protocol error	Please contact the Technical Support team.
<b>Group 13: Timeout CAN bus</b>		
13-0	Timeout CAN bus	Check the CAN parameterisation.
<b>Group 14: Motor and resolver identification</b>		
14-0	Insufficient DC bus circuit voltage	Check the power supply voltage. Check the motor resistance.
14-1	Identification current controller: measuring cycle insufficient	The automatic parameter identification process delivers a time constant beyond the value range that can be parameterised. The parameters must be optimised manually.
14-2	Power output stage could not be enabled	The power output stage has not been enabled. Check the connection of DIN4.
14-3	Power output stage prematurely disabled	The power stage has been disabled while the identification process was still running (for example via DIN 4 or via PLC).

14-4	Angle encoder not supported	The identification cannot be performed with the current angle encoder settings. Check the angle encoder configuration. Please contact the Technical Support team.
14-5	Index pulse not found	The index pulse could not be found after the maximum permissible number of electrical revolutions. Check the index pulse signal. Check the angle encoder settings.
14-6	Invalid hall signals	The pulse sequence or the segmentation of the Hall signals is unsuitable. Check whether the encoder provides 3 Hall signals with 120° or 60° segments. Check the wiring.
14-7	Identification not possible	Check the DC bus voltage. Check whether the motor is blocked (for example holding brake not released).
14-8	Invalid number of pole pairs	The calculated number of pole pairs is beyond the parameterisation range. Check the data sheet of the motor. Please contact the Technical Support team.
Group 15: Mathematics		
15-0	Division by zero	Please contact the Technical Support team.
15-1	Out of range error	
15-2	Mathematical underflow	
Group 16: Program execution		
16-0	Incorrect program execution	Please contact the Technical Support team.
16-1	Illegal interrupt	
16-2	Initialisation error	
16-3	Unexpected state	
16-4	Unexpected hardware error	
Group 17: Max. following error exceeded		
17-0	Max. following error exceeded	Increase the error window. Decrease the acceleration.
17-1	Encoder difference monitoring	External angle encoder not connected or defective? The deviation fluctuates, e.g. due to gear slackness. If necessary, increase the switch-off threshold.
17-2	Current spike monitoring	Please contact the Technical Support team.

Group 18: Temperature warning threshold		
18-0	Analogue motor temperature: warning threshold reached	Motor too hot? Check the parameterisation (current controller, current limits). Correct sensor? Sensor defective? Check the parameterisation of the sensor or the sensor characteristics. If the error still occurs after the sensor has been bypassed, replace the servo drive.
Group 21: Current measurement		
21-0	Error 1 current measurement U	Please contact the Technical Support team.
21-1	Error 1 current measurement V	
21-2	Error 2 current measurement U	
21-3	Error 2 current measurement V	
Group 22: PROFIBUS		
22-0	PROFIBUS: incorrect initialisation	Is the technology module defective? Please contact the Technical Support team.
22-2	PROFIBUS: communication error	Check the specified slave address. Check the bus termination. Check the wiring.
22-3	PROFIBUS: invalid slave address	The communication has been started with slave address 126. Select another slave address.
22-4	PROFIBUS: range overflow	Mathematical error during the conversion of physical units. The value ranges of the data and of the physical units do not match. Please contact the Technical Support team.
22-5	PROFIBUS: access violation	Please contact the Technical Support team.
Group 23: Actual position saving/restoring		
23-0	No usable record	Failure of the actual position saving and restoration process. Perform a homing run of the drive.
23-1	Record with invalid checksum	
23-2	Flash content inconsistent	
Group 24: Analogue input monitoring		
24-0	Analogue input above maximum limit	Check the parameterisation of the maximum limit. Check the wiring.
24-1	Analogue input below minimum limit	Check the parameterisation of the minimum limit. Check the wiring.

Group 25: Invalid device type		
25-0	Invalid device type	Replace the device.
25-1	Device type not supported	
25-2	Hardware revision not supported	Load the most recent firmware. Please contact the Technical Support team.
25-3	Device functionality restricted	The desired functionality is not available on this servo drive. Please contact the Technical Support team.
25-4	Invalid power output stage type	Load the most recent firmware. Please contact the Technical Support team.
25-5	Incompatibility Firmware/Hardware	The customer-specific firmware is not compatible with the servo drive. Please contact the Technical Support team.
Group 26: Flash		
26-0	No user parameter set	Load the default parameter set. If the error is still present, replace the servo drive.
26-1	Checksum error	The error cannot be eliminated by the user. Please contact the Technical Support team.
26-2	Flash: write error	
26-3	Flash: erase error	
26-4	Flash: error in internal flash	
26-5	No calibration data	
26-6	No user position data sets	Save the parameter set and perform a reset. If the error is still present, contact the Technical Support team.
26-7	Error in data tables (CAM)	Load the default parameter set. If the error is still present, contact the Technical Support team.
Group 27: Following error monitoring		
27-0	Following error warning threshold	Check the parameterisation of the following error. Is the motor blocked?
Group 28: Operating hours meter		
28-0	Missing operating hours meter	Please contact the Technical Support team.
28-1	Operating hours meter: write error	
28-2	Operating hours meter corrected	Acknowledge the error. If the error recurs, contact the Technical Support team.
28-3	Operating hours meter converted	
Group 29: SD card		
29-0	No SD card	The option "Transfer the parameter file after Reset and Power on" is active, but an SD card has not been inserted. Insert an SD card.

29-1	SD card: initialisation error	Unsuitable SD card? Card write protection activated? BOOT DIP switch activated (firmware download)? Please contact the Technical Support team.
29-2	SD card: parameter set error	
29-3	SD card: write error	
29-4	SD card: firmware download error	
Group 30: Internal calculations		
30-0	Internal calculation error	Please contact the Technical Support team.
Group 31: I <sup>2</sup> t		
31-0	I <sup>2</sup> t motor	Is the motor blocked? Check the power rating of the drive
31-1	I <sup>2</sup> t servo drive	Check the power rating of the drive package.
31-2	I <sup>2</sup> t PFC	Check the power rating of the drive package. Select operation without PFC.
31-3	I <sup>2</sup> t braking resistor	Braking resistor overloaded. Use external braking resistor.
31-4	I <sup>2</sup> t active power overload	Check the power rating of the drive package.
Group 32: PFC		
32-0	DC bus circuit charging time exceeded	Bridge for the internal braking resistor installed? Check the connection of the external braking resistor. Please contact the Technical Support team.
32-1	Undervoltage for active PFC	Check whether the power supply complies with the nominal data.
32-5	Brake chopper overload. DC bus circuit could not be discharged	Check the power on/off cycles of the power supply. Check the braking resistor.
32-6	Discharging period DC bus circuit exceeded	Bridge for the internal braking resistor installed? Check the connection of the external braking resistor. Please contact the Technical Support team.
32-7	Supply voltage missing for enabling	No DC bus voltage.
32-8	Supply voltage breakdown while servo drive enabled	Interruption/failure of the mains power supply. Check the power supply.
32-9	Phase failure	Failure of one or several phases. Check the power supply.
Group 33: Following error encoder emulation		
33-0	Following error encoder emulation	Check the settings of the incremental encoder emulation (line count).
Group 34: Fieldbus		
34-0	No synchronisation via fieldbus	No synchronisation messages from the master?

34-1	Fieldbus synchronisation error	No synchronisation messages from the master? Insufficient synchronisation interval?
<b>Group 35: Linear motor</b>		
35-0	Overspeed protection of linear motor	The encoder signals are disturbed. Check the installation for compliance with the EMC recommendations.
35-5	Error during the commutating position determination	The selected method is not suitable for the motor. Please contact the Technical Support team
<b>Group 36: Parameters</b>		
36-0	Parameter limited	Check the user parameters set.
36-1	Parameter not accepted	
<b>Group 37: Sercos</b>		
37-0	Sercos: received data disturbed	Check the Sercos wiring (clean the optical fibre, for example). Check the optical output settings. Check the baud rate.
37-1	Sercos: fiber optic ring interrupted	Check the Sercos wiring (optical fibre) for breaks. Check the connections.
37-2	Sercos: MST missing twice	Check the Sercos wiring (fiber optic cables). Check the control system (are all of the MSTs being transmitted?)
37-3	Sercos: invalid phase requested by master	Check the program in the Sercos master.
37-4	Sercos: MDT missing twice	Check the Sercos wiring (optical fibre). Check the control system: Are all of the MDTs being sent?
37-5	Sercos: unknown operation mode selected	Check the settings for the operating modes in the IDNs S-0-0032 to S-0-0035.
37-6	Sercos: T3 invalid	Increase the baud rate. Shift T3 manually.
37-7	Sercos III: communication error	Please contact the Technical Support team.
<b>Group 38: Sercos</b>		
38-0	Sercos: SERCON Status event	No measures required.
38-1	Sercos: no module present	Sercos has been activated, but no technology module has been inserted. Is the technology module correctly inserted? Is the technology module defective? Replace the technology module. Please contact the Technical Support team.
38-2	Sercos: defective module	Replace the technology module. Please contact the Technical Support team.



38-3	Sercos: S-0-0127: invalid data in S-0-0021	Check the configuration (cyclic data for MDT and AT). Check the time slot calculation by the master.
38-4	Sercos: S-0-0127: impermissible IDNs in AT or MDT	Check the configuration for the cyclic data transfer.
38-5	Sercos: S-0-0128: invalid data in S-0-0022	Check the scaling settings. Check the operating mode settings. Check the internal/external angle encoder settings.
38-6	Sercos: S-0-0128: incorrect scaling	Check the scaling settings.
38-7	Sercos: invalid IDN in S-0-0026 / S-0-0027	Check the configuration of the signal status and signal control word (S-0-0026/S-0-0027).
38-8	Sercos: conversion error	Check the scaling settings. Please contact the Technical Support team.
38-9	Sercos: SERCON 410b mode active	Replace the technology module. Please contact the Technical Support team.
Group 39: Sercos		
39-0	Sercos: list S-0-0370: incorrect configuration of the MDT data container	Please contact the Technical Support team.
39-1	Sercos: list S-0-0371: incorrect configuration of the AT data container	
39-2	Sercos: error in the cyclic channel MDT	
39-3	Sercos: error in the cyclic channel AT	
39-4	Sercos: error in the cyclic data container MDT	
39-5	Sercos: error in the cyclic data container AT	
Group 40: SW limit switches		
40-0	Negative SW limit switch reached	Check the permissible positioning range.
40-1	Positive SW limit switch reached	
40-2	Target position beyond the negative SW limit switch	The start of a positioning run has been suppressed, since the target is located beyond the respective software limit switch.
40-3	Target position beyond the positive SW limit switch	Check the target position. Check the positioning range.

Group 41: Course program		
41-0	Course program: synchronisation error	Flying saw: Check the parameterisation of the lead distance.
Group 42: Positioning		
42-0	Positioning: no follow-up position: stop	The positioning target cannot be reached with the current options. Check the parameterisation of the position sets.
42-1	Positioning: reversal of rotation not permissible: stop	
42-2	Positioning: reversal of rotation after stop not permissible	
42-3	Positioning start rejected: wrong operation mode	The change of the mode of operation could not be performed by way of the position set.
42-4	Homing run required	Reset the option "Homing run required". Perform a homing run.
42-5	Rotary axis: rotating direction not permissible	The calculated direction of rotation of the rotary axis is not permissible in the selected mode. Check the selected mode.
42-9	Error at positioning start	Check the speed and acceleration parameters. Please contact the Technical Support team.
Group 43: HW limit switches		
43-0	Limit switch: negative setpoint inhibited	The drive has left the intended range of movement. Technical defect of the system? Check the limit switches.
43-1	Limit switch: positive setpoint inhibited	
43-2	Limit switch: positioning suppressed	
Group 44: CAM disc		
44-0	CAM table error	Check whether the index has been assigned correctly. Check whether there are cam discs present in the device.
44-1	CAM: drive not referenced	Ensure that the drive has been homed prior to the activation of the cam disc. Deselect the option "Homing run required". Ensure that a cam disc will not be started during a homing run.
Group 45: IGBT driver supply		
45-0	Driver supply cannot be switched off	Technical defect? Please contact the Technical Support team.
45-1	Driver supply cannot be switched on	
45-2	Driver supply has been activated	

Group 47: Set-up mode		
47-0	Set-up mode: timeout	The speed has not fallen below the speed required for the set-up mode in time. Check the processing of the request by the PLC. Check the speed threshold. Check the timeout.
Group 48: Operation mode		
48-0	Homing run required	Perform a homing run.
Group 49: DCO (Device Communication Objects)		
49-1	DCO file: servo drive password protected, wrong password	Enter the correct password into the DCO file.
49-2	DCO file: data error	Please contact the Technical Support team.
Group 50: CAN communication		
50-0	Too many synchronous PDOs	Deactivate some of the PDOs or increase the SYNC interval. The maximum number of PDOs must not be greater than the factor tp between the position controller and IPO. Please contact the Technical Support team.
50-1	SDO error occurred	Please contact the Technical Support team.
Group 51: FSM 2.0		
51-0	No / unknown FSM module or driver supply faulty	Cause: No safety module detected or unknown module type. Measure: - Install a safety module or fieldbus activation module that is suitable for the firmware and hardware. - Load a firmware that is suitable for the safety module or fieldbus activation module into the servo drive. See the type designation on the module. Cause: Internal voltage error of the safety module or fieldbus activation module. Measure: - The module may be defective. Replace it, if possible.
51-2	FSM: unequal module type	Cause: Type or revision of the module does not fit the project planning. Measure: - Check whether correct module type and correct version are being used. - After module replacement: Module type not yet accepted. Accept currently integrated safety or fieldbus activation module.

51-3	FSM: unequal module version	<p>Cause: Type or revision of the module is not supported.</p> <p>Measure: - Install safety or fieldbus activation module appropriate for the firmware and hardware. - Load firmware appropriate for the module into the servo drive, see type designation on the module.</p> <p>Cause: The module type is correct but the module version is not supported by the servo drive.</p> <p>Measure: - Check module version; if possible use module of same version after replacement. Install suitable safety or fieldbus activation module for the firmware and hardware. - If only a module with a more recent version is available: Load firmware appropriate for the module into the servo drive, see type designation on the module.</p>
51-4	FSM: error in SSIO communication	<p>Cause: Error in the internal communication connection between the servo drive and the safety module.</p> <p>Measure: - Identify any source of interfering radiation in the environment of the servo drive. - Replace the module or the servo drive. - Please contact the Technical Support team.</p>
51-5	FSM: error in brake activation	<p>Cause: Internal hardware error (brake activation control signals) of the safety module or fieldbus activation module.</p> <p>Measure: Module presumably defective. If possible, replace with another module.</p> <p>Cause: Error in brake driver circuit section in the servo drive.</p> <p>Measure: Servo drive presumably defective. If possible, replace with another servo drive.</p>

51-6	FSM: unequal serial number	<p>Cause: Serial number of currently inserted safety module is different from the stored serial number.</p> <p>Measure: Error only occurs after replacement of the FSM 2.0 – MOV.</p> <p>After module replacement: Module type not yet accepted. Accept currently inserted FSM 2.0 – MOV. Check the parameterisation of the FSM 2.0 – MOV in view of the application, since the modules have been replaced.</p>
<b>Group 52: FSM 2.0 STO</b>		
52-1	FSM: discrepancy time expired	<p>Cause: Control ports STO-A and STO-B are not actuated simultaneously.</p> <p>Measure: Check discrepancy time.</p> <p>Cause: Control ports STO-A and STO-B are not wired in the same way.</p> <p>Measure: Check circuitry of the inputs.</p> <p>Cause: Upper and lower switch supply not simultaneously activated (discrepancy time exceeded)</p> <ul style="list-style-type: none"> <li>- Error in control / external circuitry of safety module.</li> <li>- Error in safety module.</li> </ul> <p>Measure:  <ul style="list-style-type: none"> <li>- Check circuitry of the safety module – are the inputs STO-A and STO-B switched off on two channels and simultaneously?</li> <li>- Replace safety module if you suspect it is defective.</li> </ul> </p>
52-2	FSM: STOA/STOB deactivated while power output stage enabled	<p>Cause: Failure of driver supply voltage with active PWM.</p> <p>Measure: The safe status was requested with power output stage enabled. Check integration into the safety-orientated wiring.</p>

52-3	FSM: Limitation error	<p>Cause: Servo drive reports error if the currently requested direction of movement is not possible because the safety module has blocked the setpoint value in this direction.</p> <p>Error may occur in connection with the SSFx safe speed functions if an asymmetrical speed window is used where one limit is set to zero. In this case, the error occurs when the servo drive moves in the blocked direction in the Positioning mode.</p> <p>Measure: Check application and change if necessary.</p>
<b>Group 53: FSM: Violation of safety conditions</b>		
53-0	USF0: safety condition violated	<p>Cause: Violation of monitored speed limits of the SSF0 in operation / when USF0 / SSF0 requested.</p> <p>Measure: Check when the violation of the safety condition occurs: a) During dynamic braking to safe rotational speed b) After the drive has reached the safe speed. - With a) Check of braking ramp – record the speed - can the drive follow the ramp? - Change parameters for the slowdown ramp or start time / delay times for monitoring. - With b) Check how far the current speed is from the monitored limit speed; increase distance if necessary (parameter in safety module) or correct speed specified by control.</p>
53-1	USF1: safety condition violated	<p>Cause: Violation of monitored speed limits of the SSF1 in operation / when USF1 / SSF1 requested.</p> <p>Measure: See USF0, error 53-0.</p>
53-2	USF2: safety condition violated	<p>Cause: Violation of monitored speed limits of the SSF2 in operation / when USF2 / SSF2 requested.</p> <p>Measure: See USF0, error 53-0.</p>
53-3	USF3: safety condition violated	<p>Cause: Violation of monitored speed limits of the SSF3 in operation / when USF3 / SSF3 requested.</p> <p>Measure: See USF0, error 53-0.</p>

Group 54: FSM: Violation of safety conditions		
54-0	SBC: safety condition violated	<p>Cause: Brake should engage; no feedback received within the expected time.</p> <p>Measure:</p> <ul style="list-style-type: none"> <li>- Check how the feedback signal is configured – was the correct input selected for the feedback signal?</li> <li>- Does the feedback signal have the correct polarity?</li> <li>- Check whether the feedback signal is actually switching.</li> <li>- Is the parameterised time delay for the analysis of the feedback signal appropriate to the used brake (measure switching time if necessary)?</li> </ul>
54-2	SS2: safety condition violated	<p>Cause: Actual speed outside permitted limits for too long.</p> <p>Measure:</p> <p>Check when the violation of the safety condition occurs:</p> <ol style="list-style-type: none"> <li>During dynamic braking to zero.</li> <li>After the drive has reached zero speed.</li> </ol> <ul style="list-style-type: none"> <li>- With a) Check of braking ramp – record the speed - can the drive follow the ramp? Change parameters for the slowdown ramp or start time / delay times for monitoring.</li> <li>- With a) If the option "Activate quick stop ramp in base device" is activated: Check of the servo drive's quick stop ramp.</li> <li>- With b) Check whether the drive continues to oscillate after reaching the zero speed or remains at idle and stable – increase monitoring tolerance time if necessary.</li> <li>- With b) If the actual speed value is very noisy when at rest. Check and if necessary adjust expert parameters for speed recording and detection of standstill.</li> </ul>
54-3	SOS: safety condition violated	<p>Cause:</p> <ul style="list-style-type: none"> <li>- Angle encoder analysis reports "Motor running" (actual speed exceeds limit).</li> <li>- Drive has rotated out of its position since reaching the safe state.</li> </ul> <p>Measure:</p> <ul style="list-style-type: none"> <li>- Check the position tolerance for the SOS monitoring and increase if necessary, if this is permissible.</li> <li>- If the actual speed value is very noisy when at rest: Check and if necessary adjust expert parameters for speed recording and detection of idling.</li> </ul>

54-4	SS1: safety condition violated	<p>Cause: Actual speed outside permitted limits for too long.</p> <p>Measure: Check when the violation of the safety condition occurs:</p> <p>a) During dynamic braking to zero. b) After the drive has reached zero speed.</p> <p>- With a) Check of braking ramp – record the speed - can the drive follow the ramp? Change parameters for the slowdown ramp or start time / delay times for monitoring.</p> <p>- With a) If the option "Activate quick stop ramp in base device" is activated: Check of the servo drive's quick stop ramp.</p> <p>- With b) Check whether the drive continues to oscillate after reaching the zero speed or remains at idle and stable – increase monitoring tolerance time if necessary.</p> <p>- With b) If the actual speed value is very noisy when at rest: Check and if necessary adjust expert parameters for speed recording and detection of standstill.</p>
54-5	STO: safety condition violated	<p>Cause: Internal hardware error (voltage error) of the safety module.</p> <p>Measure: Module presumably defective. If possible, replace with another module.</p> <p>Cause: Error in driver circuit section in the servo drive.</p> <p>Measure: Servo drive presumably defective. If possible, replace with another servo drive.</p> <p>Cause: No feedback received from servo drive to indicate that output stage was switched off.</p> <p>Measure: Check whether the error can be acknowledged and whether it occurs again upon a new STO request – if yes: Servo drive presumably defective. If possible, replace with another servo drive.</p>



54-6	SBC: brake not released for > 24 hrs	<p>Cause:</p> <p>Error occurs when SBC is requested and the brake has not been released by the servo drive in the last 24 hours.</p> <p>Measure:</p> <ul style="list-style-type: none"> <li>- If the brake is actuated via the brake drivers in the servo drive [X6]: The brake must be energised at least once within 24 hours before the SBC request because the circuit breaker check can only be performed when the brake is switched on (energised).</li> <li>- Only if brake control takes place via DOUT4x and an external brake controller: Deactivate 24 hr monitoring in the SBC parameters if the external brake controller allows this.</li> </ul>
54-7	SOS: SOS requested > 24 hrs	<p>Cause:</p> <p>If SOS is requested for more than 24 hours, the error is triggered.</p> <p>Measure:</p> <p>Terminate SOS and move axle at least once during this time.</p>
<b>Group 55: FSM: Actual value evaluation 1</b>		
55-0	FSM: no actual speed / position value available or standstill for > 24 hrs	<p>Cause:</p> <ul style="list-style-type: none"> <li>- Subsequent error when a position encoder fails.</li> <li>- Safety function SSF, SS1, SS2 or SOS requested and actual rotational speed value is not valid.</li> </ul> <p>Measure:</p> <p>Check the function of the position encoder(s) (see following error).</p>
55-1	FSM: SINCOS encoder [X2B] - signal error	<p>Cause:</p> <ul style="list-style-type: none"> <li>- Vector length <math>\sin^2 + \cos^2</math> is outside the permissible range.</li> <li>- The amplitude of one of the two signals is outside the permissible range.</li> <li>- Offset between analogue and digital signal is greater than 1 quadrant.</li> </ul> <p>Measure:</p> <ul style="list-style-type: none"> <li>- Error may occur with SIN/COS and HIPERFACE encoders.</li> <li>- Check the position encoder.</li> <li>- Check the connection wiring (broken wire, short between two signals or signal / shield).</li> <li>- Check the supply voltage for the position encoder.</li> <li>- Check the motor cable / shield connection on motor and drive side. EMC malfunctions may trigger the error.</li> </ul>

55-2	FSM: SINCOS encoder [X2B] - standstill > 24 hrs	<p>Cause:</p> <p>Input signals of the SinCos encoder have not changed by a minimum amount for 24 hours (when safety function is requested).</p> <p>Measure:</p> <p>Terminate SS2 or SOS and move axle at least once during this time.</p>
55-3	FSM: Resolver [X2A] - signal error	<p>Cause:</p> <ul style="list-style-type: none"> <li>- Vector length <math>\sin^2 + \cos^2</math> is outside the permissible range.</li> <li>- The amplitude of one of the two signals is outside the permissible range.</li> <li>- Input signal is static (same values to right and left of maximum).</li> </ul> <p>Measure:</p> <ul style="list-style-type: none"> <li>- Check the resolver.</li> <li>- Check the connection wiring (broken wire, short between two signals or signal / shield).</li> <li>- Check for a failure of the exciting current.</li> <li>- Check the motor and encoder cable / shield connection on motor and drive side. EMC malfunctions can trigger the error.</li> </ul>
55-7	FSM: other encoder [X2B] - Faulty angle information	<p>Cause:</p> <ul style="list-style-type: none"> <li>- "Angle faulty" message is sent from servo drive when status lasts for longer than the allowed time.</li> <li>- Encoder at X2B is analysed by the servo drive</li> <li>- Encoder is defective.</li> </ul> <p>Measure:</p> <ul style="list-style-type: none"> <li>- Check the position encoder at X2B.</li> <li>- Check the connection wiring (broken wire, short between two signals or signal / shield).</li> <li>- Check the supply voltage for the EnDat encoder.</li> <li>- Check the motor cable / shield connection on motor and drive side. EMC malfunctions may trigger the error.</li> </ul>

55-8	FSM: impermissible acceleration detected	<p>Cause:</p> <ul style="list-style-type: none"> <li>- Error in connected position encoder.</li> <li>- EMC malfunctions affecting the position encoder.</li> <li>- Impermissibly high acceleration rates in the movement profiles.</li> <li>- Acceleration limit parameterised too low.</li> <li>- Angle jump after homing run in the position data transmitted from the servo drive to the safety module.</li> </ul> <p>Measure:</p> <ul style="list-style-type: none"> <li>- Check the connected position encoders: If further error messages occur in conjunction with the encoders, then eliminate their cause first.</li> <li>- Check the motor and encoder cable / shield connection on motor and drive side. EMC malfunctions can trigger the error.</li> <li>- Check the setpoint specifications / motion profiles of the control: Do they contain impermissibly high accelerations above the limit value for acceleration monitoring (P06.07)?</li> <li>- Check whether the limit value for acceleration monitoring was parameterised correctly - the limit value (P06.07) should be at least 30% ... 50% above the maximum acceleration actually occurring.</li> <li>- In case of an angle jump in the position data transmitted from the servo drive - acknowledge error once.</li> </ul>
<b>Group 56: FSM: Actual value evaluation 2</b>		
56-8	FSM: speed / angle difference encoder 1 - 2	<p>Cause:</p> <ul style="list-style-type: none"> <li>- Rotational speed difference between encoders 1 and 2 of one <math>\mu\text{C}</math> outside the permissible range for longer than the allowed time.</li> <li>- Angle difference between encoders 1 and 2 of one <math>\mu\text{C}</math> outside the permissible range for longer than the allowed time.</li> </ul> <p>Measure:</p> <ul style="list-style-type: none"> <li>- Problem may occur if two position encoders are used in the system and they are not "rigidly coupled".</li> <li>- Check for elasticity or backlash, improve mechanical system.</li> <li>- Adjust the expert parameters for the position comparison if this is acceptable from an application point of view.</li> </ul>

56-9	FSM: error cross comparison encoder evaluation	<p>Cause: Cross-comparison between <math>\mu</math>C1 and <math>\mu</math>C2 has detected an angle difference or rotational speed difference or a difference in capture times for the position encoders.</p> <p>Measure: Timing disrupted. If the error occurs again after a reset, the safety module is presumably defective.</p>
<b>Group 57: FSM: Inputs/Outputs</b>		
57-0	FSM: I/O - Self test error (internal/external)	<p>Cause:</p> <ul style="list-style-type: none"> <li>- Internal error of digital inputs DIN40 ... DIN43 (detected via internal test signals).</li> <li>- Error at brake output at X6 (signalling, detected by test pulses).</li> <li>- Internal error of brake output (detected via internal test signals).</li> <li>- Internal error of digital outputs DOUT40 – DOUT42 (detected via internal test signals).</li> </ul> <p>Measure:</p> <ul style="list-style-type: none"> <li>- Check the connection wiring for the digital outputs DOUT40...DOUT42 (short circuit, cross circuit, etc.).</li> <li>- Check the connection wiring for the brake (short circuit, cross circuit, etc.).</li> <li>- Brake connection: The error may occur with long motor cables if:               <ol style="list-style-type: none"> <li>1. The brake output X6 was configured for the brake (this is the case with factory settings!) and</li> <li>2. A motor without a holding brake is used and the brake connection lines in the motor cable are terminated at X6. In this case: Disconnect the brake connection lines at X6.</li> </ol> </li> <li>- If there is no error in the connection wiring, there may be an internal error in the module (check by replacing the module).</li> </ul>
57-1	FSM: digital inputs - signal level error	<p>Cause: Exceeding / violation of discrepancy time with multi-channel inputs (DIN40 ... DIN43, two-handed control device, mode selector switch).</p> <p>Measure:</p> <ul style="list-style-type: none"> <li>- Check the external active and passive sensors – do they switch on two channels and simultaneously (within the parameterised discrepancy time).</li> <li>- Two-handed control device: Check how the device is operated by the user – are both pushbuttons pressed within the discrepancy time? Give training if necessary.</li> <li>- Check the set discrepancy times – are they sufficient?</li> </ul>

57-2	FSM: digital inputs - test pulse error	<p>Cause:</p> <ul style="list-style-type: none"> <li>- One or more inputs (DIN40 ... DIN49) were configured for the analysis of the test pulses of the outputs (DOUT40 ... DOUT42). The test pulses from DOUTx do not arrive at DIN4x.</li> </ul> <p>Measure:</p> <ul style="list-style-type: none"> <li>- Check the wiring (shorts after 0 V, 24 V, cross circuits).</li> <li>- Check the assignment – correct output selected / configured for test pulse?</li> </ul>
57-6	FSM: overtemperature	<p>Cause:</p> <ul style="list-style-type: none"> <li>- The safety module's temperature monitor has been triggered; the temperature of <math>\mu C1</math> or <math>\mu C2</math> was below <math>-20^{\circ}</math> or above <math>+75^{\circ}\text{C}</math>.</li> </ul> <p>Measure:</p> <ul style="list-style-type: none"> <li>- Check the operating conditions (ambient temperature, control cabinet temperature, installation situation in the control cabinet).</li> <li>- If the servo drive is experiencing high thermal load (high control cabinet temperature, high power consumption / output to motor, large number of occupied slots), a servo drive of the next higher output level should be used.</li> </ul>
<b>Group 58: FSM: Communication / Parameterisation</b>		
58-0	FSM: plausibility check of parameters	<p>Cause:</p> <p>The plausibility check in the safety module has revealed errors, e.g. an impermissible angle encoder configuration; the error is triggered when a validation code is requested by the SafetyTool and when parameters are backed up in the safety module.</p> <p>Measure:</p> <p>Note instructions for SafetyTool for complete validation; check parameterisation.</p>
58-1	FSM: general error parameterisation	<p>Cause:</p> <p>Parameterisation session active for <math>&gt; 8</math> hrs. The safety module has thus terminated the parameterisation session. The error message is saved in the permanent event memory.</p> <p>Measure:</p> <p>Terminate parameterisation session within 8 hrs. If necessary, start a new parameterisation session and continue.</p>

58-4	FSM: buffer internal communication	<p>Cause:</p> <ul style="list-style-type: none"> <li>- Communication connection disturbed.</li> <li>- Timeout / data error / incorrect sequence (packet counter) in data transmission between the servo drive and the safety module.</li> <li>- Too much data traffic, new requests are being sent to safety module before old ones have been responded to.</li> </ul> <p>Measure:</p> <ul style="list-style-type: none"> <li>- Check communication interfaces, cabling, shield connection etc.</li> <li>- Check whether other devices have read access to the servo drive and the safety module during a parameterisation session. This may overload the communication connection.</li> <li>- Check whether the firmware versions of safety module and servo drive and the versions of parameterisation program and SafetyTool are compatible.</li> </ul>
58-5	FSM: communication safety module - servo drive	<p>Cause:</p> <ul style="list-style-type: none"> <li>- Packet counter error during transmission between <math>\mu C1</math> and <math>\mu C2</math>.</li> <li>- Checksum error during transmission between <math>\mu C1</math> and <math>\mu C2</math>.</li> </ul> <p>Measure:</p> <ul style="list-style-type: none"> <li>- Internal malfunction in the servo drive.</li> <li>- Check whether the firmware versions of safety module and servo drive and the versions of parameterisation program and SafetyTool are compatible.</li> </ul>

58-6	FSM: error in cross comparison for processors 1 - 2	<p>Cause:</p> <p>Timeout during cross-comparison (no data) or cross-comparison faulty (data for <math>\mu C1</math> and <math>\mu C2</math> are different).</p> <ul style="list-style-type: none"> <li>– Error in cross-comparison for digital I/O.</li> <li>– Error in cross-comparison for analogue input.</li> <li>– Error in cross-comparison for internal operating voltage measurement (5 V, 3.3 V, 24 V) and reference voltage (2.5 V).</li> <li>– Error in cross-comparison for SIN/COS angle encoder analogue values.</li> <li>– Error in cross-comparison for programme sequence monitoring.</li> <li>– Error in cross-comparison for interrupt counter.</li> <li>– Error in cross-comparison for input map.</li> <li>– Error in cross-comparison for violation of safety conditions.</li> <li>– Error in cross-comparison for temperature measurement.</li> </ul> <p>Measure:</p> <p>This is an internal error in the module that should not occur during operation.</p> <ul style="list-style-type: none"> <li>- Check the operating conditions (temperature, air humidity, condensation).</li> <li>- Check the EMC wiring as specified and shield design; are there any external interference sources?</li> <li>- Safety module may be defective – is error eliminated after replacing the module?</li> <li>- Check whether a new firmware for the servo drive or a new version of the safety module is available.</li> </ul>
<b>Group 59: FSM: Internal Error</b>		
59-1	FSM: failsafe supply / safe pulse inhibitor	<p>Cause:</p> <p>Internal error in module in failsafe supply circuit or in the driver supply for the upper and lower switches.</p> <p>Measure:</p> <p>Module defective, replace.</p>
59-2	FSM: error external power supply	<p>Cause:</p> <ul style="list-style-type: none"> <li>- Reference voltage 2.5 V outside tolerance.</li> <li>- Logic supply overvoltage +24 V detected.</li> </ul> <p>Measure:</p> <p>Module defective, replace.</p>
59-3	FSM: error internal power supply	<p>Cause:</p> <p>Voltage (internal 3.3 V, 5 V, ADU reference) outside the permissible range.</p> <p>Measure:</p> <p>Module defective, replace.</p>

59-4	FSM: error management: too many errors	<p>Cause: Too many errors have occurred simultaneously.</p> <p>Measure:</p> <ul style="list-style-type: none"> <li>- Clarify: What is the status of the inserted safety module - does it contain a valid parameter set?</li> <li>- Read out and analyse the permanent event memory of the servo drive via the parameterisation program.</li> <li>- Eliminate causes of error step by step.</li> <li>- Install safety module with "delivery status" and perform commissioning of servo drive.</li> <li>- If this is not available: Set factory settings in the safety module, then copy data from the servo drive and perform complete validation.</li> <li>- Check whether the error occurs again.</li> </ul>
59-7	FSM: flash checksum error	<p>Cause:</p> <ul style="list-style-type: none"> <li>- Voltage interruption / power off while parameters were being saved.</li> <li>- Flash memory in safety module corrupted (e.g. by extreme malfunctions).</li> </ul> <p>Measure:</p> <p>Check whether the error recurs after a reset. If it does: parameterise the module again and validate the parameter set again. If error persists: safety module defective, replace.</p>
59-8	FSM: internal monitoring, processor 1 - 2	<p>Cause:</p> <ul style="list-style-type: none"> <li>- Serious internal error in the safety module: Error detected while dynamising internal signals</li> <li>- Disrupted programme sequence, stack error or OP code test failed, processor exception / interrupt.</li> </ul> <p>Measure:</p> <p>Check whether the error recurs after a reset. If it does: Safety module defective, replace.</p>
59-9	FSM: other unexpected error	<p>Cause:</p> <p>Triggering of internal programme sequence monitoring.</p> <p>Measure:</p> <ul style="list-style-type: none"> <li>- Check the firmware version of the servo drive and the version of the safety module – update available?</li> <li>- Safety module defective, replace.</li> </ul>
<b>Group 60: Ethernet</b>		
60-0	Ethernet user-specific (1)	Please contact the Technical Support team.
<b>Group 61: Ethernet</b>		
61-0	Ethernet user-specific (2)	Please contact the Technical Support team.



Group 62: EtherCAT		
62-0	EtherCAT: general bus error	There is no EtherCAT bus. Check the wiring.
62-1	EtherCAT: initialisation error	Replace the technology module. Please contact the Technical Support team.
62-2	EtherCAT: protocol error	Is the protocol incorrect (no CAN over EtherCAT)? Check the EtherCAT wiring.
62-3	EtherCAT: invalid RPDO length	Check the RPDO configuration of the servo drive and PLC.
62-4	EtherCAT: invalid TPDO length	Check the TPDO configuration of the servo drive and PLC.
62-5	EtherCAT: faulty cyclic data transfer	Check the EtherCAT wiring. Check the configuration of the PLC.
Group 63: EtherCAT		
63-0	EtherCAT: defective module	Replace the technology module.
63-1	EtherCAT: invalid data	Check the protocol. Check the wiring.
63-2	EtherCAT: TPDO data have not been read	Reduce the cycle time (EtherCAT bus).
63-3	EtherCAT: no distributed clocks active	Check whether the control system supports the "Distributed Clocks" feature. Please contact the Technical Support team.
63-4	EtherCAT: Missing SYNC message in IPO cycle	Check the cycle times of the servo drive and PLC.
63-5	EtherCAT: wrong firmware found	Please contact the Technical Support team.
63-6	EtherCAT: mode of operation requires DC	Activate Distributed Clocks (DC) in the PLC or select a different mode of operation.
Group 64: DeviceNet		
64-0	DeviceNet: duplicate MAC ID	Change the MAC ID.
64-1	DeviceNet: bus power missing	Check the DeviceNet wiring. 24 V must also be connected to the DeviceNet module.
64-2	DeviceNet: RX queue overrun	Decrease the scan rate.
64-3	DeviceNet: TX queue overrun	Increase the baud rate. Decrease the number of nodes. Decrease the scan rate.
64-4	DeviceNet: I/O send error	Check the DeviceNet wiring. Check whether the wiring complies with the EMC specifications.
64-5	DeviceNet: Bus Off	Check the DeviceNet wiring. Check whether the wiring complies with the EMC specifications.

64-6	DeviceNet: CAN controller overrun	Increase the baud rate. Decrease the number of nodes. Decrease the scan rate.
<b>Group 65: DeviceNet</b>		
65-0	DeviceNet active, but no module	Deactivate the DeviceNet communication or insert a module.
65-1	Timeout I/O Connection	An I/O message has not been received within the expected time.
<b>Group 66: Modbus</b>		
66-0	Modbus: no free TCP/IP connection	Reduce the number of TCP/IP connections.
<b>Group 67: Modbus</b>		
67-0	Modbus: timeout TCP/IP	Check the connection to the master.
67-1	Modbus: timeout Modbus TCP/IP	Check the connection to the master.
67-2	Modbus: buffer overflow	In the master, reduce the cycle time for the transfer of messages to the servo drive.
67-3	Modbus: message length too short	Check the configuration of the master.
67-4	Modbus: message length too long	Check the configuration of the master.
<b>Group 68: Ethernet/IP</b>		
68-0	Ethernet/IP: general error	Replace the module. Please contact the Technical Support team.
68-1	Ethernet/IP: communication error	Check the connection to the PLC.
68-2	Ethernet/IP: connection closed	Re-establish the connection.
68-3	Ethernet/IP: connection timeout	Check the wiring.
68-4	Ethernet/IP: duplicate IP address	Use an IP address only once on an Ethernet/IP network.
<b>Group 69: Ethernet/IP</b>		
69-0	Ethernet/IP: general error	No measures required.
69-1	Ethernet/IP: invalid IP configuration	Check the IP configuration.
69-2	Ethernet/IP: no technology module	Insert an Ethernet/IP module into TECH2 or deactivate Ethernet/IP.
69-3	Ethernet/IP: unequal module version	Update the firmware of the servo drive.
<b>Group 72: PROFINET</b>		
72-0	PROFINET: initialisation error	Replace the PROFINET module.

72-1	PROFINET: bus error	Communication is not possible, e.g. because the bus cable has been disconnected. Check the wiring and restart the PROFINET communication.
72-2	PROFINET: range overflow	Mathematical error during the conversion of physical units. Adapt the parameterisation.
72-3	PROFINET: invalid IP configuration	Check whether the IP address, subnet mask and gateway address are valid or permissible. Change the IP configuration.
72-4	PROFINET: invalid device name	Use a valid PROFINET device name (Name of Station).
72-5	PROFINET: defective module	Replace the PROFINET module.
72-6	PROFINET: invalid / unsupported indication	The PROFINET feature that has been used is not supported by the module. Please contact the Technical Support team.
72-7	PROFINET: different module configuration Master/Slave	Check whether the telegram lengths set in the PROFINET telegram editor match the setting in the master.
72-8	PROFINET: failure in cyclic data	Check wiring.
72-9	PROFINET: communication error	Check the telegram configuration in the master.
<b>Group 73: PROFINET</b>		
73-0	PROFInergy: state not possible	Request the PROFInergy state again when the motor is stopped.
73-1	PROFINET: wrong firmware found	Please contact the Technical Support team.
<b>Group 78: NRT communication</b>		
78-0	NRT: frame send error	In general, no measure is required. It may be helpful to reduce the bus load, e.g. by reducing the number of devices connected to a branch.
<b>Group 79: RS232 communication</b>		
79-0	RS232 communication	Please contact the Technical Support team.
<b>Group 80: IRQ_0_3</b>		
80-0	Time overflow current control IRQ	Select longer cycle times for the current, speed and position controllers or interpolator. Please contact the Technical Support team.
80-1	Time overflow speed control IRQ	
80-2	Time overflow position control IRQ	
80-3	Time overflow interpolator IRQ	

<b>Group 81: IRQ_4_5</b>		
81-4	Time overflow low-level IRQ	Please contact the Technical Support team.
<b>Group 82: Internal sequence control</b>		
82-0	Sequence control	Internal sequence control: The process was aborted. For information only. No measures required.
82-1	Concurrent CO write access	Please contact the Technical Support team.
<b>Group 83: Technology modules</b>		
83-0	Technology module: slot/combination	The technology module cannot be used in the current slot or the combination of technology modules is not permissible. Contact the Technical Support team.
83-1	Technology module not supported	Load the most recent firmware.
83-2	Technology module: HW revision not supported	Load the most recent firmware.
83-3	Service module: write error	Please contact the Technical Support team.
83-4	MC2000 Watchdog	Please contact the Technical Support team.
<b>Group 84: Internal sequence control</b>		
84-0	Conditions for controller enable not fulfilled	Enable the servo drive again after a short period of time. If the error recurs, check the following: <ul style="list-style-type: none"> <li>- Are there still errors?</li> <li>- Is the angle encoder ready?</li> <li>- Has DIN4 been set?</li> <li>- Is MOTID still being executed?</li> <li>- Is there a running TFTP download?</li> <li>- Has an energy-saving mode been activated via PROFIenergy?</li> <li>- Does the FSM 2.0 – MOV (SBC) block the enable signal?</li> </ul>

Group 90: HW initialisation		
90-0	Missing hardware component (SRAM)	Please contact the Technical Support team.
90-1	Missing hardware component (FLASH)	
90-2	Error during booting of FPGA	
90-3	Error during start of SD-ADUs	
90-4	Synchronisation error SD-ADU after start	
90-5	SD-ADU not in synchronism	
90-6	IRQ0 (current controller): trigger error	
90-7	CAN controller not available	
90-8	Device parameters checksum error	
90-9	DEBUG-Firmware loaded	
Group 91: SW initialisation		
91-0	Internal initialisation error	Please contact the Technical Support team.
91-1	Memory error (copy)	
91-2	Reading of the controller/power output stage type failed	
91-3	Internal software initialization error	
Group 92: Bootloader/Firmware update		
92-0	Error during firmware download	The firmware file is corrupted, e.g. due to a mail client or virus scanner.
92-1	Error during bootloader update	Request the firmware file again or transfer it as a ZIP file.
92-2	Erase error (int. flash)	If the error is still present, contact the Technical Support team.
92-3	Programming error (int. flash)	
92-4	Erase error (int. flash)	
92-5	Programming error (ext. flash)	
92-6	Firmware file: format error	