![metronix servo drives logo]

Product Manual

Servo drive
DIS-2 48/10 FB FS STO

Translation of the original instructions

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1   General

1.1   Documentation

This manual serves the purpose of a safe use of the DIS-2 48/10 FB FS STO servo drive. It contains safety notes, which must be complied with.

Further information can be found in the following manuals of the DIS-2 product range:

❖ **Mounting Instructions "Servo drive DIS-2 48/10 FB FS STO":** Instructions on the installation of the DIS-2 48/10 FB FS STO servo drive (English version).

❖ **CANopen Manual "Servo drive DIS-2":** Description of the implemented CANopen protocol as per DSP402.

❖ **PROFIBUS Manual "Servo drive DIS-2 48/10 FB":** Description of the implemented PROFIBUS-DP protocol.

❖ **EtherCAT Manual "Servo drive DIS-2 48/10 FB":** Description of the implemented EtherCAT protocol (German version).

❖ **User Manual "DIS-2 48/10, DIS-2 48/10 IC, DIS-2 48/10 FB":** Description of the device functionality and the software functionalities of the firmware including the RS232 communication. Description of the parameterisation program DIS-2 ServoCommander^{TM} with instructions for the commissioning of a DIS-2 series servo drive.

You can find all these documents on our homepage at the download area (http://www.metronix.de).

Furthermore, the manuals are part of the CD-ROM DIS-2 ServoCommander™.

Certificates and declarations of conformity for the products described in this manual can be found at http://www.metronix.de.

The functions described in this product manual refer to the firmware version 3.4.

1.2 Scope of supply

The DIS-2 48/10 FB FS STO servo drive is available in the following three versions. The corresponding technology modules (CAN, PROFIBUS, EtherCAT) are factory-integrated and are not designed for an exchange by the user.

Table 1:   Scope of supply DIS-2 48/10 FB FS STO CANopen

1x	Servo drive DIS-2 48/10 FB FS STO CANopen	Metronix part number: 9019-0248-13
1x	STO connection cable pre-fabricated on both sides with the device interface M12 (circular connector) for rear panel installation.	
1x	Counterplug for the STO interface	

Table 2:   Scope of supply DIS-2 48/10 FB FS STO PROFIBUS

1x	Servo drive DIS-2 48/10 FB FS STO PROFIBUS	Metronix part number: 9019-0248-14
1x	STO connection cable pre-fabricated on both sides with the device interface M12 (circular connector) for rear panel installation.	
1x	Counterplug for the STO interface	

Table 3:   Scope of supply DIS-2 48/10 FB FS STO EtherCAT

1x	Servo drive DIS-2 48/10 FB FS STO EtherCAT	Metronix part number: 9019-0248-15
1x	STO connection cable pre-fabricated on both sides with the device interface M12 (circular connector) for rear panel installation.	
1x	Counterplug for the STO interface	

Counterplugs, control panel, mains filter, communication cables, brake resistor and parameterisation program are not part of the standard scope of supply. They can be ordered as accessories:

Table 4: **Accessories DIS-2 48/10 FB FS STO**

1x	Connector set for motor, encoder, holding brake:			Metronix part number: 9019-0210-01
	Content:	1x	3 pcs insulated blade receptacles 6,3 mm for motor connection	
		1x	16-pole counterplug für angle encoder, incl. crimp contacts	
		1x	2-pole counterplug for holding brake, incl. crimp contacts	
1x	Connector set for power supply and I/Os 1x 2-pole VARICON counterplug (for DIS-2 48/10 FB FS STO) 1x 6-pole VARICON counterplug (for DIS-2 310/2 FB FS STO) 2x 8-pole VARICON counterplug incl. sleeve frame, sleeve housing and EMC cable gland			Metronix part number: 9019-3120-01
1x	Control panel DIS-2 FB with Phoenix connector			Metronix part number: 9019-0320-00
1x	RS232 connection cable for DIS-2 48/10 FB Pre-fabricated connection cable for the servo drive parameterisation, length approximately 150 cm, M8 circular connector for the connection to the servo drive, DSUB9 connector for the connection to the COM-Port of the PC			Metronix part number: 9019-0221-00
1x	Brake resistor for DIS-2 48/10 FB Plate resistor, Metallux PLR100.55.43, 5 Ω ±10%, 30 W continuous power output, dimensions 55 mm x 43 mm, height: 1,5 mm, in the area of the connecting cables height 4 mm, with strands l = 100 mm			Metronix part number: 9519-0001-00
1x	Parameterisation program DIS-2 ServoCommander^{TM}			Metronix part number: 9019-0900-00

2   Safety notes for electrical drives and controllers

2.1   Used symbols

	Information
	Important information and notes.

	Caution!
	Nonobservance may result in severe property damages.

	DANGER!
	Nonobservance may result in **property damages** and in **personal injuries**.

	Caution! Dangerous voltages.
	The safety note indicates a possible perilous voltage.

2.2   General notes

In case of damage resulting from non-compliance with the safety notes in this manual, Metronix Meßgeräte und Elektronik GmbH will not assume any liability.

> Prior to the initial use you must read *chapter* 2 *Safety notes for electrical drives and controllers* and *section 8.4 Notes concerning the safe and EMC-compliant installation*

If the documentation in the language at hand is not understood accurately, please contact and inform your supplier.

Sound and safe operation of the servo drive requires proper and professional transportation, storage, assembly and installation as well as proper operation and maintenance.

Only trained and qualified personnel is authorised to handle electrical devices and systems:

TRAINED AND QUALIFIED PERSONNEL

in the sense of this product manual or the safety notes on the product itself are persons who are sufficiently familiar with the project, the setup, assembly, commissioning and operation of the product as well as all warnings and precautions as per the instructions in this manual and who are sufficiently qualified in their field of expertise:

❖ Education and instruction or authorisation to switch devices/systems on and off and to ground them as per the standards of safety engineering and to efficiently label them as per the job demands.

❖ Education and instruction as per the standards of safety engineering regarding the maintenance and use of adequate safety equipment.

❖ First aid training.

The following notes must be read prior to the initial operation of the system to prevent personal injuries and/or property damages:

> These safety notes must be complied with at all times.

> Do not try to install or commission the servo drive before carefully reading all safety notes for electrical drives and controllers contained in this document. These safety instructions and all other user notes must be read prior to any work with the servo drive.

> In case you do not have any user notes for the servo drive, please contact your sales representative. Immediately demand these documents to be sent to the person responsible for the safe operation of the servo drive.

> If you sell, rent and/or otherwise make this device available to others, these safety notes must also be included.

The user must not open the servo drive for safety and warranty reasons.

Professional control process design is a prerequisite for sound functioning of the servo drive!

> **DANGER!**
> **Inappropriate handling of the servo drive and non-compliance with the warnings as well as inappropriate intervention in the safety features may result in property damage, personal injuries, electric shock or in extreme cases even death.**

2.3   Danger resulting from misuse

DANGER!

High electrical voltages and high load currents!

Danger to life or serious personal injury from electrical shock!

DANGER!

High electrical voltage caused by wrong connections!

Danger to life or serious personal injury from electrical shock!

DANGER!

Surfaces of device housing may be hot!

Risk of injury! Risk of burning!

DANGER!

Dangerous movements!

Danger to life, serious personal injury or property damage due to unintentional movements of the motors!

2.4   Safety notes

2.4.1   General safety notes

The servo drive corresponds to IP54 degree of protection as well as pollution degree 2. Make sure that the environment corresponds to this degree of protection and pollution degree.

Only use replacement parts and accessories approved by the manufacturer.

The devices must be connected to the mains supply as per EN regulations and VDE regulations, so that they can be cut off the mains supply by means of corresponding separation devices (for example main switch, contactor, power switch).

Gold contacts or contacts with a high contact pressure should be used to switch the control contacts.

Preventive interference rejection measures should be taken for control panels, such as connecting contactors and relays using RC elements or diodes.

The safety rules and regulations of the country in which the device will be operated must be complied with.

The environment conditions defined in the product documentation must be kept. Safety-critical applications are not allowed, unless specifically approved by the manufacturer.

For notes on installation corresponding to EMC, please refer to *section 8.4 Notes concerning the safe and EMC-compliant installation*. The compliance with the limits required by national regulations is the responsibility of the manufacturer of the machine or system.

The technical data and the connection and installation conditions for the servo drive are to be found in this product manual and must be met.

DANGER!

The general setup and safety regulations for work on power installations (for example DIN, VDE, EN, IEC or other national and international regulations) must be complied with.

Non-compliance may result in death, personal injury or serious property damages.

Without claiming completeness, the following regulations and others apply:

VDE 0100	Erection of power installations with nominal voltages up to 1000 V
EN 1037	Safety of maschinery - Prevention of unexpected start-up
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 ISO 12100	Safety of machinery - General principles for design - Risk assessment and risk reduction
EN ISO 13849-1	Safety of machinery - Safety-related parts of control systems Part 1: General principles for design
EN ISO 13849-2	Safety of machinery - Safety-related parts of control systems Part 2: Validation

2.4.2   Safety notes for assembly and maintenance

The appropriate DIN, VDE, EN and IEC regulations as well as all national and local safety regulations and rules for the prevention of accidents apply for the assembly and maintenance of the system. The plant engineer or the operator is responsible for compliance with these regulations:

The servo drive must only be operated, maintained and/or repaired by personnel trained and qualified for working on or with electrical devices.

Prevention of accidents, injuries and/or damages:

Additionally secure vertical axes against falling down or lowering after the motor has been switched off, for example by means of:

> ➢ Mechanical locking of the vertical axle,
>
> ➢ External braking, catching or clamping devices or
>
> ➢ Sufficient balancing of the axle

The motor holding brake supplied by default or an external motor holding brake driven by the servo drive alone is not suitable for personal protection!

Keep the electrical equipment voltage-free using the main switch and protect it from being switched on again until the DC bus circuit is discharged, in the case of:

> ➢ Maintenance and repair work
>
> ➢ Cleaning
>
> ➢ long machine shutdowns

Prior to carrying out maintenance work make sure that the power supply has been turned off, locked and the DC bus circuit is discharged.

Be careful during the assembly. During the assembly and also later during operation of the drive, make sure to prevent drill chips, metal dust or assembly parts (screws, nuts, cable sections) from falling into the servo drive.

Also make sure that the external power supply of the servo drive (24 V) is switched off.

The DC bus circuit or the mains supply must always be switched off prior to switching off the 24 V servo drive supply.

Carry out work in the machine area only, if AC and/or DC supplies are switched off. Switched off output stages or servo drive enablings are no 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 "Safe Torque Off" (STO) feature (see *chapter 6*).

Initial operation must be carried out with idle motors, to prevent mechanical damages for example due to the wrong direction of rotation.

Electronic devices are never fail-safe. It is the user's responsibility, in the case an electrical device fails, to make sure the system is transferred into a secure state.

The servo drive and in particular the brake resistor, externally or internally, can assume high temperatures, which may cause serious burns.

2.4.3 Protection against electrical shock by means of protective extra-low voltage (PELV)

All connections and terminals with voltages of up to 50 Volts at the servo drive are protective extra-low voltage, which are designed safe from contact in correspondence with the following standards:

❖ International: IEC 60364-4-41

❖ European countries within the EU: EN 61800-5-1

> ⚠ **DANGER!**
> High electrical voltages due to wrong connections!
> Danger to life, risk of injury due to electrical shock!

Only devices and electrical components and wires with a protective extra low voltage (PELV) may be connected to connectors and terminals with voltages between 0 to 50 Volts.

Only connect voltages and circuits with protection against dangerous voltages. Such protection may be achieved by means of isolation transformers, safe optocouplers or battery operation.

2.4.4   Protection against dangerous movements

Dangerous movements can be caused by faulty control of connected motors, for different reasons:

❖ Improper or faulty wiring or cabling

❖ Error in handling of components

❖ Error in sensor or transducer

❖ Defective or non-EMC-compliant components

❖ Software error in superordinated control system

These errors can occur directly after switching on the device or after an indeterminate time of operation.

The monitors in the drive components for the most part rule out malfunctions in the connected drives. In view of personal protection, particularly the danger of personal injury and/or property damage, this may not be relied on exclusively.

Until the built-in monitors come into effect, faulty drive movements must be taken into account; their magnitude depends on the type of control and on the operating state.

> ⚠ **DANGER!**
> Dangerous movements!
> Danger to life, risk of injury, serious personal injuries or property damage!

For the reasons mentioned above, personal protection must be ensured by means of monitoring or superordinated measures on the device. These are installed in accordance with the specific data of the system and a danger and error analysis by the manufacturer. The safety regulations applying to the system are also taken into consideration. Random movements or other malfunctions may be caused by switching the safety installations off, by bypassing them or by not activating them.

2.4.5 Protection against contact with hot parts

> **DANGER!**
>
> Housing surfaces may be hot!
>
> Risk of injury! Risk of burning!

Do not touch housing surfaces in the vicinity of heat sources! Danger of burning!

Before accessing devices let them cool down for 10 minutes after switching them off.

Touching hot parts of the equipment such as the housing, which contain heat sinks and resistors, may cause burns!

2.4.6 Protection during handling and assembly

Handling and assembly of certain parts and components in an unsuitable manner may under adverse conditions cause injuries.

> **DANGER!**
> Risk of injury due to improper handling!
> Personal injury due to pinching, shearing, cutting, crushing!

The following general safety notes apply:

Comply with the general setup and safety regulations on handling and assembly.

Use suitable assembly and transportation devices.

Prevent incarcerations and contusions by means of suitable protective measures.

Use suitable tools only. If specified, use special tools.

Use lifting devices and tools appropriately.

If necessary, use suitable protective equipment (for example goggles, protective footwear, protective gloves).

Do not stand underneath hanging loads.

Remove leaking liquids on the floor immediately to prevent slipping.

3   Product description

3.1   General

3.1.1   Basic information

Servo drives of the DIS-2 series (**D**ecentralised **I**ntelligent **S**ervo **2**nd Generation) are intelligent servo drives with extensive parameterisation options. Due to this flexibility, they can be adapted to numerous areas of application.

Type key:

DIS-2 48/10 FB FS STO

"Safe Torque Off"
integrated functional safety
variant / fieldbus
continuous currrent in amperes
intermediate circuit voltage
2nd generation
type
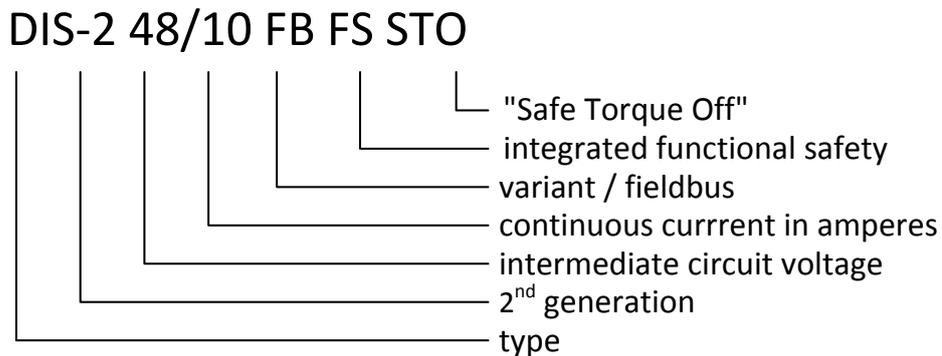
Figure 1:   Type key

3.1.2   Area of application and intended use

The DIS-2 48/10 FB FS STO servo drive was designed for the decentralised control of three-phase permanent-magnet synchronous machines. Thanks to numerous encoder feedback options and various control methods, such as "block commutation" and "sine commutation", the servo drive can be adapted optimally to the motor characteristics.

Normally, the servo drive is mounted directly on the motor. However, it is also possible to separate the DIS-2 from the motor and to connect it to the motor using a short, shielded cable. Further information concerning the installation can be found in *chapter 7*.

The DIS-2 servo drive is supplied with 24 V DC or 48 V DC safety extra-low voltage (SELV) via a power supply unit or battery. At the motor connection, it supplies the synchronous machine with a pulse-width-modulated, symmetrical, 3-phase rotating field with variable frequency, current, and voltage.

The DIS-2 was designed for continuous torque, speed, and position control in typical industrial applications, such as:

❖ Positioning and feed drives in machines

❖ Palletising and packaging machines

❖ Wood-processing machines

❖ Drives of winding machines, wire-drawing machines, etc.

❖ Drives in screw and press-fitting applications

❖ Conveying applications

Prior to using the DIS-2 in special areas of application with particularly high normative requirements, e.g. medical technology or avionics, or in areas of application that require particularly high levels of device safety, the user must check whether the DIS-2 fulfils the applicable standards. In case of doubt, please contact your local distributor.

The DIS-2 may only be used if the specified operating conditions and the technical data that are stated in *chapter 4* are fulfilled. In addition, the mounting and start-up instructions must be followed (see *chapters 7,8 and 9*).

3.1.3   Performance characteristics of the DIS-2 48/10 FB FS STO

The DIS-2 48/10 FB FS STO has the following performance characteristics:

❖ Compact design – the housing (closed on five sides) can be mounted on the motor either directly or by way of an adapter plate (see *section 7.4 Mounting*)

❖ Highly precise control thanks to a high-quality sensor system

❖ Full integration of all of the components of the controller and power unit

❖ RS232 interface for the PC communication and a fieldbus interface (CAN, PROFIBUS, or EtherCAT) realised via a device-integrated technology module that is connected to the basic device via an expansion slot

❖ Fieldbus connection to CANopen in accordance with CAN in Automation (CiA) DSP402

❖ PROFIBUS in accordance with DP-V0, based on PROFIDRIVE, version 3.1

❖ EtherCAT (CoE - CANopen over EtherCAT)

❖ Easy connection to a superordinate control system, e.g. to a PLC, via the I/O level or fieldbus

❖ Integrated universal rotary encoder evaluation for the following encoder types:
   ➢ Resolvers
   ➢ Analogue Hall sensors
   ➢ Stegmann incremental encoders, single-turn and multi-turn absolute encoders with a HIPERFACE$^{®}$ interface
   ➢ Digital Hall sensors (six-step encoders)
   ➢ Incremental encoders with Hall sensors

❖ Integrated driver for the 24 V holding brakes

❖ Device-integrated filters for the 24 V supply and for the inputs and outputs in order to fulfil the EMC requirements

❖ EMC-optimised metal housing for direct mounting on the motor; IP54 degree of protection (IP67 is possible, depending on the mounting method and seals)

❖ Can be used as a torque controller, speed controller, or position controller

❖ Synchronisation mode possible via the digital I/O interface

❖ Integrated positioning control with extensive functionality

❖ Jerk-free or time-optimal positioning, relative or absolute with regard to a reference point

❖ Point-to-point positioning with or without smooth position transitions

❖ Speed- and angle-synchronous operation with an electronic gear unit

❖ Numerous homing methods

❖ Integrated path program to create simple positioning sequences with or without dependence on digital inputs

❖ Jogging mode

❖ Teach-in mode

❖ Short cycle times, 100 μs in the current control circuit, 200 μs in the speed control circuit, and 400 μs in the position control circuit

❖ Programmable digital outputs

❖ High-resolution 12-bit analogue input

❖ User-friendly parameterisation with the DIS-2 ServoCommander™ parameterisation software

❖ Automatic motor identification

❖ I²t monitoring to limit the average power loss in the power output stage and motor

❖ Integrated brake chopper; the braking resistor is mounted on a mounting plate between the motor and servo drive (see *section 7.4 Mounting*)

❖ Integrated functional safety feature "Safe Torque Off, STO" (see *chapter 6*)

3.2   Power supply

3.2.1   DC supply

❖ Nominal voltage 48 V DC

3.2.2   Protection

A circuit breaker (20 A) with delayed action and a DC specification or a type C fuse (15 A) must be installed in the supply line. See also *section 8.1*.

3.3   Brake chopper

The DIS-2 48/10 FB FS STO servo drive has an integrated brake chopper. A braking resistor is available as an accessory part (see also *section 1.2 Scope of supply*) in the form of a plate-type resistor. Ideally, it is mounted on the mounting plate between the motor and servo drive (see *section 7.4 Mounting)*. If the permissible charging capacity of the intermediate circuit is exceeded during the regenerative feedback, the braking resistor can convert the braking energy into heat. The brake chopper is controlled by the software.

3.4   Communication interfaces

The DIS-2 48/10 FB FS STO servo drive has several communication interfaces. Apart from the RS232 interface, various fieldbus interfaces are also available. The servo drive always operates as a slave on the fieldbus.

3.4.1   RS232 interface

The RS232 protocol is mainly used as a parameterisation interface. The parameterisation is performed by way of the parameterisation software DIS-2 ServoCommander™. However, it can also be used to control the DIS-2 48/10 FB FS STO servo drive.

3.4.2   CAN bus

The CANopen interface is implemented with the application profile DSP402 in accordance with the CAN in Automation (CiA) protocol DS301.

3.4.3   PROFIBUS

The PROFIBUS communication is realised in accordance with DP-V0. For drive applications, the functions are available based on PROFIDRIVE version 3.1. The functionality includes functions in accordance with application class 1 (speed control) and application class 3 (point-to-point positioning).

In addition, it is possible to integrate the device into a control system by way of an I/O image via PROFIBUS. As far as the control is concerned, this option has the same functionality as a standard PLC coupling via parallel wiring of the digital I/Os.

A specific Metronix telegram can be used to go beyond the functionality that is defined by PROFIDRIVE and to access all of the device-specific functions.

3.4.4   EtherCAT

The EtherCAT interface of the DIS-2 48/10 FB FS STO servo drive supports the CoE protocol (CANopen over EtherCAT) with the FPGA image ESC10.

Performance characteristics: EtherCAT in accordance with IEEE-802.3u (100Base-TX) with 100 Mbps (full duplex)

3.4.5   I/O functions and device control

A maximum of ten digital inputs provide basic control functions (see *section 4.5.2 I/O interface [X1]*).

The DIS-2 48/10 FB FS STO servo drive has a target table in which positioning targets can be stored and from where they can be retrieved at a later point of time. At least 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.

One input is used for enabling the servo drive.

The DIS-2 48/10 FB FS STO servo drive has two analogue inputs for input levels in the range of *+10 V* to *-10 V*. Both inputs are differential inputs (12 bits) in order to guarantee a high level of interference immunity. The analogue signals are quantised and digitised by the analogue-digital-converter with a resolution of 12 bits. The analogue signals are used to define setpoints (speed or torque) for the control. If necessary, the analogue inputs can also be used as digital inputs.

Synchronous operation is possible via the I/O interface. In this case, the digital inputs DIN4, DIN5, and DIN6 are used as incremental encoder inputs and the digital outputs DOUT1 and DOUT2 as incremental encoder outputs.

4   Technical data

4.1   Ambient conditions and qualification

Table 5:   **Technical data: Ambient conditions and qualification**

Range	Values
Admissible temperature ranges	Storage temperature: -25°C to +70°C
	Operating temperature: 0°C to +50°C +50°C to +70°C at reduced power 2%/K Temperature switch-off at approx. 80°C
Admissible installation height	Mounting height maximum 2000 m above msl, above 1000 m above msl with power reduction 1% per 100 m
Humidity	Relative humidity up to 90%, no bedewing
Protection degree	IP54, dependent on mounting IP67 may be achieved
Protection class	III
Pollution degree	2
EC type-examination for integrated safety function „Safe Torque Off (STO)"	See *chapter 6*
CE conformity: Low-voltage directive: EMC directive: Interference emission: Interference immunity:	 not applicable Directive 2004/108/EG (Standard DIN EN 61800–3) First environment category C2 Second environment

Table 6:   **Technical data: Dimensions and weight**

Parameter	Values
Dimensions basic device (H*W*D) (without counterplug und mounting plate)	56 x 80 x 112 mm
Weight	approx. 0,5 kg

4.2   Supply [X1]

Table 7:   **Technical data: Performance data power supply [X1]**

Parameter	Values
DC bus voltage	0 V... 60 V DC (48 V DC nominal / 15 A nominal) [1]
24 V logic supply	24 V DC [± 20%] / approx. 200 mA [2] + 700 mA [3] + 100 mA [4] internally protected with poly-switch, triggered at approx. 1 A
Brake chopper switching threshold ON: switching threshold OFF:	 U_{CHOP_ON} = 60 V [± 5%] U_{CHOP_OFF} = 55 V [± 5%]
External brake resistor	possible mounting on mounting plate (Type: PLR of Metallux, Metronix order no: 9519-0001-00)
Resistance	5 Ω
Continuous power / pulse power	30 W / 750 W

[1] An external fuse 15A is recommended, see *section 3.2.2*.

[2] Current consumption of the DIS-2 48/10 without additional wiring

[3] Maximum admissible current consumption of an optional holding brake

[4] Maximum current consumption when DOUT0 to DOUT2 and the CAN bus are active

4.3   Motor connection [X301-X303]

Table 8:   **Technical data: Motor connection specifications [X301-X303]**

Parameter	Values
Specifications for operation with 48 V / $T_{Housing\ max.}$ = 50°C	
Output power	500 VA
Max. output power for 2 s	1500 VA
Output current	15 A_{rms} @ $T_{PowerStage} \leq$ 50°C 10 A_{rms} @ $T_{PowerStage} \leq$ 70°C
Max. output current for 2 s	40 A_{rms} @ $T_{PowerStage} \leq$ 50°C 32 A_{rms} @ $T_{PowerStage} \leq$ 70°C
PWM frequency	10 kHz / 20 kHz

Table 9:   Technical data: Motor temperature monitoring [X2]

Parameter	Values
Digital sensor	Normally closed contact: $R_{cold} < 500\ \Omega$ $R_{hot} > 100\ k\Omega$
Analogue sensor	Silicon temperature sensors, KTY series
	KTY81-2x0; KTY82-2x0 $R_{25} \approx 2000\ \Omega$
	KTY81-1x0; KTY81-2x0 $R_{25} \approx 1000\ \Omega$
	KTY83-1xx $R_{25} \approx 1000\ \Omega$
	KTY84-1xx $R_{100} \approx 1000\ \Omega$

4.4   Angle encoder connector [X2]

The DIS-2 48/10 FB FS STO servo drive evaluates different types of encoder feedback systems via the universal rotary encoder interface:

❖ Resolvers

❖ Analogue Hall sensors

❖ Digital Hall sensors (six-step encoders)

❖ Incremental encoders with digital Hall sensors

❖ Stegmann incremental encoders, single-turn and multi-turn absolute encoders with a HIPERFACE® interface

The parameterisation of the relevant encoder evaluation in the servo drive is performed with the aid of the parameterisation software DIS-2 ServoCommander™.

Table 10:   Technical data: Resolver evaluation [X2]

Parameter	Values
Suitable resolvers	Industry standard
Transformation ratio	0.5
Carrier frequency	10 kHz
Resolution	> 12 Bit (typ. 15 Bit)
Delay time signal detection	< 200 μs
Speed resolution	ca. 4 min^{-1}
Absolute accuracy of angle detection	< 10´
Max. rotational speed	16.000 min^{-1}

Table 11:   Technical data: Evaluation of analogue Hall sensor signals [X2]

Parameter	Values
Suitable Hall sensors	HAL400 (Micronas), SS495A (Honeywell) and others Type: differential analogue output, V_{CM} = 2.0 V...3.0 V Signal amplitude: max. 4,8 V_{ss} differential [1]
Resolution	> 12 Bit (typ. 15 Bit)
Delay time signal detection	< 200 µs
Speed resolution	approx. 10 min^{-1}
Absolute accuracy of angle detection	< 30´
Max. rotational speed	16.000 min^{-1}

[1] Other Signal levels on request as customer specific version, please contact your local supplier.

Table 12:   Evaluation of Six-Step-Sensors (Hall) and block commutation mode [X2]

Parameter	Values
Suitable Hall sensors	Hall sensors with +5V supply, 120° phase shift between phases, open collector or push-pull output; i_{out} > 5 mA
Resolution	6 steps per electric turn
Delay time signal detection	< 200 µs
Speed resolution	Depends on number of poles of the motor
Max. rotational speed	3.000 min^{-1} on motors with two pole pairs

Table 13:   Technical data: Evaluation of Incremental encoder [X2]

Parameter	Values
Pulse counts	Programmable 32 to 1024 lines per revolution, equivalent to 128 to 4096 increments / revolution
Input signal level	5 V differential inputs / RS422 standard
Power supply for encoder	+5 V / 100 mA max.
Input impedance	$R_i \approx 1600 \ \Omega$
Max. input frequency	f_{max} > 100 kHz (pulses/s)

Table 14:   **Technical data: Evaluation of HIPERFACE® Encoders [X2]**

Parameter	Values
Suitable encoders	Stegmann HIPERFACE®; SCS60/70, SCM60/70; SRS50/60, SRM50/60; SNS50/60; SKS36 / SKM36; SEK 34/37/52, SEL 34/37/52; for other types, please contact your supplier.
Resolution	Up to 16 Bit (depends on number of increments)
Delay time signal detection	< 200 µs
Speed resolution	approx. 4 min^{-1}
Absolute accuracy of angle detection	< 5´
Max. rotational speed	6.000 min^{-1} / 3.000 min^{-1} at 1024 increments / revolution

4.5   Communication interfaces

4.5.1   RS232 [X5]

Table 15:   Technical data: RS232 [X5]

Parameter	Values
RS232	as per RS232 specification, 9600 Baud to 115,2 kBaud

4.5.2   I/O interface [X1]

Table 16:   Technical data: Digital inputs and outputs [X1]

Parameter	Values
Signal level	24V (14V … 30V) active high
DIN0 DIN1 DIN2 DIN3	Bit 0 \\ Bit 1, \\ Target selection for positioning Bit 2, / 16 targets selectable from target table Bit 3 /
DIN4 (usable as incremental input A-signal) DIN5 (usable as incremental input B-signal)	Bit 4 \\ \\ Target selection for positioning / 4 target groups with separate positioning parameter Bit 5 / selectable (e.g. speed, acceleration)
DIN6 (usable as incremental input N-signal)	Control signal start positioning
DIN7	End switch input 0
DIN8	End switch input 1
DIN9	Servo drive enable at high signal, acknowledge error with falling edge
Logic outputs general	24V (8V... 30V) active high, short circuit rated to GND
DOUT0	Operational state / Ready 24 V, max. 20 mA
DOUT1	Freely configurable, usable as 24 V, max. 20 mA Encoder output A-signal
DOUT2	Freely configurable, usable as 24 V, max. 20 mA Encoder output B-Signal
DOUT3 (**on [X3]**)	Holding brake 24 V, max. 700 mA

Table 17:   Technical data: Analogue inputs and outputs [X1]

Parameter	Values
High resolution analogue inputs	±10V input range, 12 Bit resolution, differential, < 250µs delay time, Input protection up to 30V
Analogue input: AIN0 / #AIN0	Analogue input, usable as input for current or speed setpoint. (Pins shared with DIN0 and DIN1)
Analogue input: AIN1 / #AIN1	Analogue input, usable as input for current or speed setpoint. (Pins shared with DIN2 / DIN3)
Analogue output: AMON0	0... 10V output range, 8 Bit resolution, $f_{Limit} \approx 1kHz$

4.5.3   Incremental encoder input and output [X1]

The digital incremental encoder inputs and outputs can be used to realise a master-slave synchronisation.

In addition, the incremental encoder input can be used for the synchronisation with an external, single-ended ABN signal.

Alternatively, the A and B inputs can also be interpreted as pulse-direction signals.

Table 18:   Technical data: Incremental encoder input [X1] (DIN4, DIN5, DIN6):

Parameter	Values
Number of lines	Programmable to 32 / 64 / 128 / 256 / 512 / 1024 lines per revolution
Connection level	24 V single ended / 24V (8V...30V) active high, following DIN EN 61131-2
Max. input frequency	F_{Limit} = 50 kHz (lines/s); f_{Limit} depending on input filter, data measured with R_{Input} = 13,3 kΩ and C_{Input} = 470 pF

The output provides incremental encoder signals that can be processed in superordinate control systems.

The signals are generated based on the angle of rotation of the encoder with a freely programmable line count.

The emulation provides one single-ended track signal A and one single-ended track signal B.

Table 19:   Technical data: Incremental encoder output [X1] (DOUT1, DOUT2):

Parameter	Values
Number of lines	Programmable to 32 / 64 / 128 / 256 / 512 / 1024 lines per revolution
Connection level	24V / max. 20 mA
Output impedance	$R_a \approx 300 \ \Omega$
Limit frequency	F_{Limit} > 100 kHz (lines/s); f_{Limit} depending on cable length, data measured with R_{Load} = 1 kΩ and C_{Load} = 1 nF (which corresponds to a cable length of 5m)

4.6   STO interface

Table 20:   Technical data: Control ports [X40] (STO1, STO2):

Parameter	Values		
Nominal voltage	24 V (related to GND)		
Voltage range	19,2 ... 28,8V		
Permissible residual ripple	2 % (related to nominal voltage 24 V)		
Input current STO1	0,5 mA (typical; maximum 1 mA)		
Input current STO2	25 mA (typical; maximum 30 mA)		
Input voltage threshold Switching on Switching off	 approx. 17 V approx. 15,5 V		
Switch-on time STO1 from Low to High ($t_{STO1-ON}$)	5 ms (typical; maximum 10 ms)		
Switch-on time STO2 from Low to High ($t_{STO1-ON}$)	10 ms (typical; maximum 15 ms)		
Switch-off time STO1 from High to Low ($t_{STO1-OFF}$)	5 ms (typical; maximum 10 ms)		
Switch-off time STO2 from High to Low ($t_{STO2-OFF}$)	70 ms (typical; maximum 75 ms)		
Maximum test impulse length STO1/2 for OSSD signals	19,2 V	24 V	28,8 V
	max. 2,5 ms	max. 4 ms	max. 4 ms

Table 21:   Technical data: Feedback contact [X40] (REL1, REL2):

Parameter	Values
Version	Floating relay contact, normally open
Voltage range contacts	< 30 V (overvoltage-proof up to 60 V DC)
Nominal current	< 200 mA (not short circuit proof)
Voltage drop	< 200 mV
Residual current (contact opened)	< 1µA
Switching time closing	< 1ms
Switching time opening	< 0,5 ms

4.7   Fieldbus interfaces

One of the following technology modules can be integrated in the DIS-2 48/10 FB FS STO basic device. The modules will be integrated into the servo drive at the factory depending on what has been ordered.

4.7.1   CAN-Bus [X401] / [402]

Table 22:   Technical data: CAN-Bus [X401] / [X402]

Communication interface	Values
CAN controller	TJA 1050, Full-CAN-Controller, 1MBit/s; adjustable max. 500kBit/s
CANopen protocol	as per DS301 and DSP402
Current consumption of the activated CAN technology module	5 mA

4.7.2   PROFIBUS [X401] / [402]

Table 23:   Technical data: PROFIBUS [X401] / [X402]

Communication interface	Values
Controller	PROFIBUS-controller VPC3+C, max. 12 MBaud
Protocol	PROFIBUS DP, 32 byte telegrams with mode-dependent structure
Current consumption of the activated PROFIBUS technology module	20 mA

4.7.3   EtherCAT [X401] / [402]

Table 24:   Technical data: EtherCAT [X401] / [X402]

Communication interface	Values
Controller	ESC10, slave
EtherCAT protocol	CoE, CANopen over EtherCAT
Signal level	0 ... 2,5 VDC
Differential voltage	1,9 ... 2,1 VDC
Current consumption of the activated EtherCAT technology module	35 mA

5   Function overview

5.1   Motors

5.1.1   Synchronous servomotors

In a typical application, permanent-magnet synchronous machines with a sinusoidal EMF are used. The DIS-2 48/10 FB FS STO is a universal servo drive that can be used in conjunction with standard servomotors. An automatic motor identification system can be used for the determination and parameterisation of the motor data.

5.2   Current and speed control

The current and speed control system is a cascaded control structure with an internal current control circuit and a superimposed speed control circuit. These controllers are PI controllers. The setpoint selectors are used to transfer setpoints from various sources to the corresponding controllers.

The following setpoint sources are available:

❖ 2 analogue inputs:

  ➢ AIN 0, AIN 1

❖ RS232

❖ Fieldbus

  ➢ CANopen interface or

  ➢ PROFIBUS-DP interface or

  ➢ EtherCAT interface

❖ Synchronisation input

The block diagram *Figure 2* shows the fundamental set-up.

In the case of a rotor-oriented control, two phase currents and the rotor position are measured. First, the currents are transformed into an imaginary part and a real part with the help of a Clark transformation. Then, they are transformed back into the rotor coordinates by way of a Park transformation. This allows the rotor currents to be controlled to corresponding rotor voltages using PI-controllers and to transform them back into the stator system. The driver signal generation system uses a symmetrical pulse width modulation for the power output stage and a sine commutation with the third harmonic.

An integrator monitors the current^2-time-integral of the controller. If a maximum value (maximum current for 1s) is exceeded, a warning will be issued and the current will be limited to the nominal current.

In the torque-controlled mode, a current setpoint **i_set** is specified for the active current controller. In this operating mode, only the current controller is active in the servo drive. Since the torque that is generated on the motor shaft is approximately proportional to the active current in the motor, it is legitimate to use the term torque-controlled mode.

> The accuracy of the torque control depends mainly on the motor and also on the sensor system that is used to measure the rotor position.
>
> With a good synchronous machine, a high-resolution rotary encoder (SINCOS encoder), and good controller adjustment, the DIS-2 can reach a torque ripple in the range of 1% to 3% referred to the maximum current or to the associated maximum torque of the motor.

In the speed-controlled mode, a certain speed setpoint is specified. The DIS-2 servo drive determines the current actual speed **n_actual** by way of the encoder evaluation. In order to ensure compliance with the speed setpoint, the current setpoint **i_set** is determined.
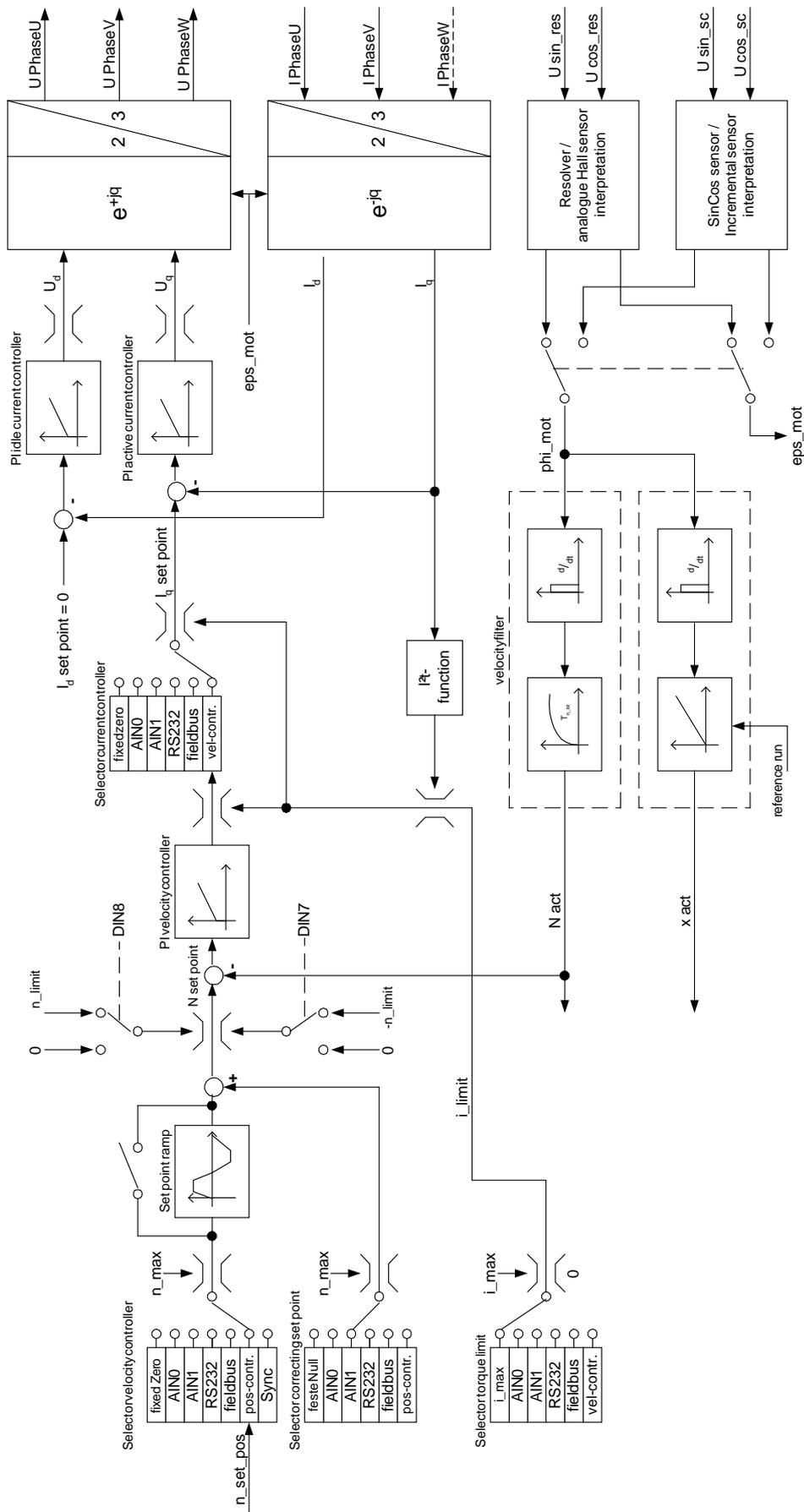
Figure 2:   Controller cascade block diagram

5.3   Positioning mode

In the positioning mode, a positioning control is superimposed on the speed control. In the positioning mode, a certain position is specified. The motor has to move to this position automatically, i.e. without help from an external control system. In this operating mode, the controller cascade in the DIS-2 48/10 FB FS STO is extended as shown in *Figure 3*:

❖ The position controller is a proportional controller (short: P controller). The current position is determined based on the information that is provided by the internal encoder evaluation. The position deviation is processed in the position controller and passed on to the speed controller as a speed setpoint.

❖ The trajectory generator calculates the motion profile that is needed to reach the target based on the current position and speed. It provides the position setpoint for the position controller and a pilot speed for the speed controller in order to improve the control dynamics for rapid positioning processes.

❖ The positioning control provides numerous messages that are required for the external control system, e.g. a target-reached message and a following error message.
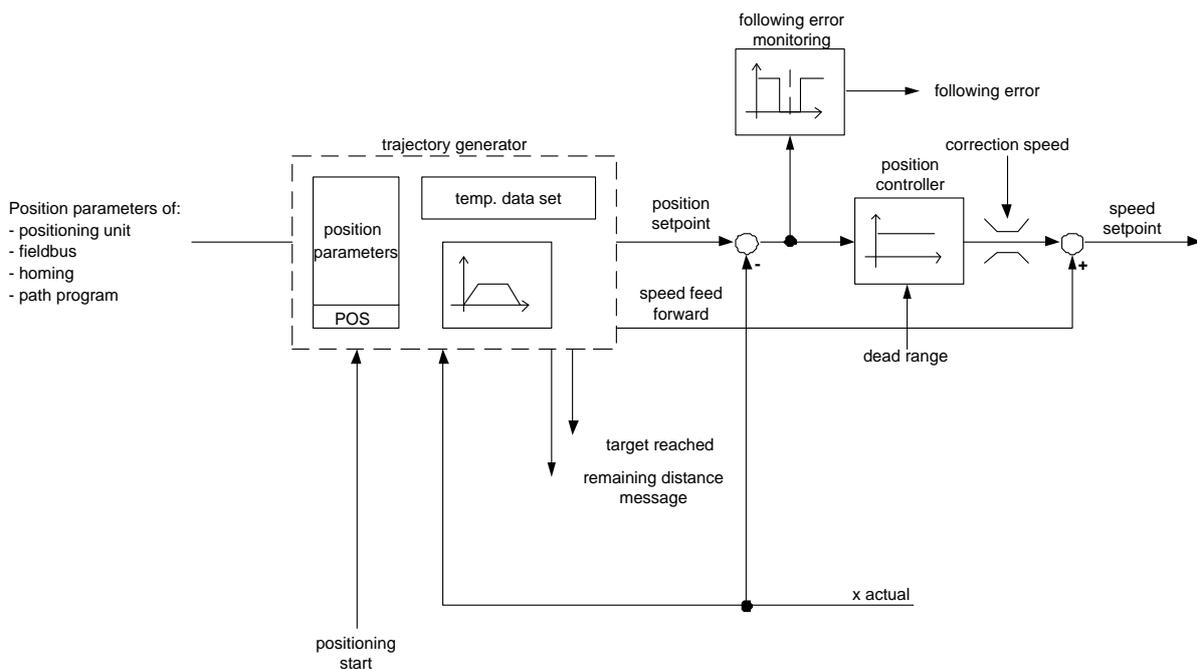
Figure 3:   **Positioning control block diagram**

> Contrary to many competitor products, the DIS-2 48/10 FB FS STO recalculates the entire movement during every control cycle. With this concept, positioning processes can be changed or aborted at any time even during the movement.
> This concept can be realised thanks to the high level of performance of the Motion-Control-DSP that is used for the control process in the DIS-2 48/10 FB FS STO.

The high-performance positioning control system in the DIS-2 48/10 FB FS STO has numerous parameters and position data sets. Up to 64 position sets can be stored in the DIS-2 48/10 FB FS STO in a non-volatile manner and performed by way of the trajectory generator.

Each of the 64 position sets includes a separate target position. The other parameters of the 64 position sets are divided into 4 groups. The following parameters can be set for each of the 4 position groups:

❖ Accelerations

❖ Speed of movement

❖ Selection of the type of acceleration:
   Jerk-limited speed profile or time-optimal (constant acceleration)

❖ Relative or absolute positioning

❖ Waiting for the end of the current positioning process or rejecting it

❖ Start delay

The target position can be parameterised individually for every position set. A remaining distance message can be set for all of the 64 positions sets as a whole.

As an alternative, the DIS-2 48/10 FB FS STO offers the option to save all of the parameters of a position set individually for every position set. This enables a higher level of flexibility for the various motion profiles. As a result, the maximum number of available position sets is reduced to 16. In this case, too, a remaining distance message can be set for all of the 16 positions sets as a whole.

The maximum number of available position sets, i.e. 16 or 64, can be set via the DIS-2 ServoCommander™ software.

In addition, there are position data sets for fieldbus-based positioning processes and for homing. The positioning control thus supports point-to-point movements with zero final speed (standstill at target). Positioning processes can be aborted during the movement and the next position can be approached directly.

The groups and positions are selected via the digital inputs. Alternatively, this selection can also be performed via the RS232 interface or partly also via a fieldbus.

For homing, or if positioning via a fieldbus is desired, the corresponding position data sets are fed directly into the trajectory generator.

5.3.1   Homing

For most applications, every positioning control needs a defined zero point for start-up. This zero point is determined by way of a homing process. The DIS-2 48/10 FB FS STO servo drive can perform this homing process autonomously. It evaluates several inputs, e.g. the limit switch inputs, as the reference signal.

Homing can be started by way of a command via the communication interface or automatically when the servo drive is enabled. Optionally, it is also possible to configure the start via a digital input by way of the parameterisation software DIS-2 ServoCommander™ in order to perform a homing process in a targeted manner regardless of whether the servo drive has been enabled or not. The servo drive

enabling acknowledges error messages, for example, and can be switched off depending on the application, without requiring another homing process when the servo drive is enabled again.

For homing, several different methods have been implemented following the DSP 402 CANopen protocol. For most methods, the system starts by searching for an initiator at search speed. The subsequent movement depends on the method and type of communication. If a homing process is activated via an existing fieldbus, there will be no follow-up positioning to the zero position. However, if the homing process is started via a digital input, follow-up positioning to zero can be selected as an option.

The ramps and speeds for homing can be parameterised via the DIS-2 ServoCommander™. Homing can also be performed in a time-optimal or jerk-free manner.

A detailed description of the homing methods can be found in the DIS-2 ServoCommander™ software manual.

5.3.2 Relative positioning

In the case of relative positioning, the target position is added to the current position. As this does not require a fixed zero point, homing is not compulsory. However, it is often useful in order to bring the drive to a defined position.

When several relative positioning sequences are added to one another, e.g. for a trimming unit or a conveyor belt, endless positioning in one direction is possible (chain dimension).

In order to add a follow-up positioning run to the current target position while a positioning run is in progress, the option *relative, referred to last target* can be used.

In addition, a positioning run in progress can be aborted by a new positioning run without the drive having to stop for this purpose.

5.3.3 Absolute positioning

In this case, the position target is approached independently of the current position. In order to be able to perform an absolute positioning process, we recommend referencing (homing) the drive beforehand. However, this is not compulsory and it is usually not performed if absolute encoders are used. In the case of absolute positioning, the target position is a fixed (absolute) position with regard to the zero point or reference point.

An absolute positioning run in progress can be aborted by a new positioning run without the drive having to stop for this purpose.

5.3.4 Motion profile generator

In terms of the motion profiles, time-optimal and jerk-limited positioning can be distinguished. In the case of time-optimal positioning, the maximum set acceleration is used for starting and braking. The drive reaches the target as quickly as possible. The speed profile is trapezoidal while the acceleration profile is block-shaped. In the case of jerk-limited positioning, the acceleration profile is trapezoidal and the speed profile is of third order.

Since the acceleration changes steadily, the drive movement is particularly gentle with regard to the mechanical system.
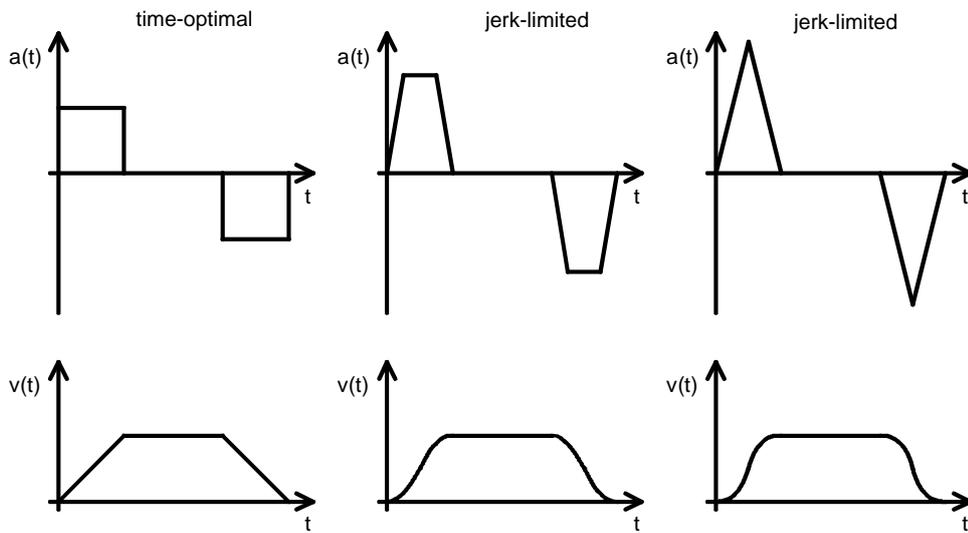
Figure 4:   **Motion profiles of the DIS-2 48/10 FB FS STO**

5.3.5   Positioning sequences

Positioning sequences consist of a series of position sets. These are completed one after the other. A standard position set can become part of a path program. The result is an interlinked list of positions:
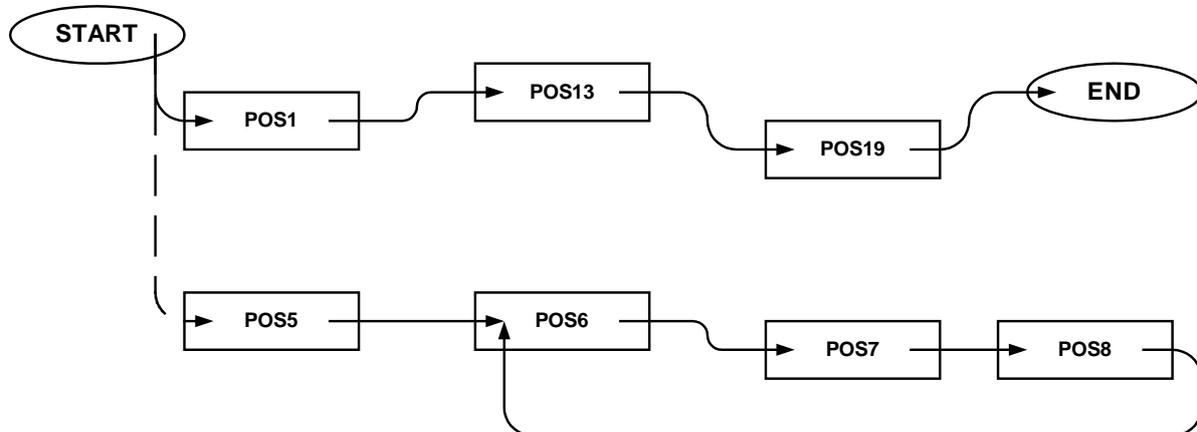
Figure 5:   **Path program**

The DIS-2 48/10 FB FS STO servo drive supports this type of linking of position sets to form a path program. A detailed description concerning the creation of a path program can be found in the DIS-2 48/10 FB FS STO software manual.

5.3.6   Software limit switches

The positioning range of the DIS-2 48/10 FB FS STO can be limited by way of software limit switches that are parameterised via the DIS-2 ServoCommander™.

5.3.7   Brake management

The DIS-2 48/10 FB FS STO servo drive can directly control a holding brake. The holding brake is operated with programmable delays via the DIS-2 ServoCommander™. A start and stop delay can be adjusted separately.

In the positioning mode, an additional automatic braking function can be activated. This automatic braking function switches the power stage of the DIS-2 48/10 FB FS STO servo drive off after a parameterised idle time and engages the brake.

5.4   Synchronisation, electronic gear unit

The DIS-2 48/10 FB FS STO servo drive can be used in a master-slave configuration (hereinafter referred to as "synchronisation"). The servo drive can be a master or a slave.

If the DIS-2 48/10 FB FS STO servo drive is a master, it provides the slave with an encoder signal (A and B single-ended signal) on the 24 V level.

If the DIS-2 48/10 FB FS STO servo drive is used as a slave, A, B, and N single-ended signals can be processed on the 24 V level.

This applies to the speed control and positioning modes. The synchronisation input can be weighted with a gear factor. In addition, the line count of the incremental encoder emulation and of the incremental encoder input can be configured.

5.4.1   Pulse-direction interface

As an alternative to the synchronisation, the A and B track signals can be interpreted as pulse-direction signals so that the servo drive can be controlled by way of a stepper motor card.

5.5   Use of digital and analogue inputs and outputs

In the case of the DIS-2 48/10 FB FS STO, the two differential analogue inputs AIN0 and AIN1 can be used as digital inputs. This means that four additional digital inputs are available. The parameterisation is realised via the DIS-2 ServoCommander™.

5.6   Jogging and teaching

This function offers the option to approach random target positions via the digital inputs and to save them in the internal position sets of the DIS-2 48/10 FB FS STO. The speed of movement, acceleration, and jerk-free part of the jogging mode can be parameterised via the DIS-2 ServoCommander™.

6   Functional safety technology

6.1   General, intended use

The DIS-2 48/10 FB FS STO servo drives support the integrated safety function "Safe Torque Off" (STO) according to the requirements of the standard EN ISO 13849-1.

Furthermore, the principles for testing "Additional requirements for electrical power drive systems according to EN 61800-5-2" have been considered.

Safety indices:

❖ Category / Performance level: Category 3, Performance level e

❖ PFH value
   (probability of dangerous failure per hour): $PFH = 4,29 \cdot 10^{-8}$ /h

	Note
ℹ	The indicated values are only reached under the following condition: Regular testing of the STO function by a superordinated control system (at least once a week), if such process-related testing is not provided anyway, and test at every switch-on of the machine / system (see the note in *section 6.2.2*).

The machine stop must be initiated and ensured by the control system of the machine. This applies particularly to vertical axes without a self-locking mechanism or weight compensation. Vertical axes require further safety measures.

Following a hazard analysis/risk assessment in accordance with the machinery directive 2006/42/EC, the machine manufacturer must plan the safety system for the entire machine whilst taking into account all of the integrated components. This also includes the electric drives. The requirements that must be fulfilled by the control system, i.e. the performance level that must be selected, depend on the actual risk.

The "Safe Torque Off (STO)" function is not the same as an electrical isolation. As a result, it cannot protect against an electric shock. This is why, in the sense of the standard, an EMERGENCY-OFF device cannot be realised with the "Safe Torque Off (STO)" function, since an EMERGENCY OFF requires the disconnection of the entire system from the mains power supply via the mains power disconnection system (main switch or mains contactor).

For stopping, the standard EN 60204-1 describes three stop categories that can be used based on a risk analysis.

Table 25:   **Stop categories**

Stop category 0	Uncontrolled stop by an immediate removal of power.	EMERGENCY OFF or EMERGENCY STOP
Stop category 1	Controlled stop and removal of power supply when the machine has come to a standstill.	EMERGENCY STOP
Stop category 2	Controlled stop without the removal of power when the machine is at a standstill.	Not suitable for EMERGENCY OFF or EMERGENCY STOP

6.2   Integrated "Safe Torque Off (STO)" function

> **DANGER!**
> The "Safe Torque Off" function does **not** protect against electric shock! It only protects against dangerous rotary movements!

6.2.1   General information concerning the STO function

Performance characteristics:

❖ Realisation of the "Safe Torque Off" (STO) function

❖ Floating feedback contact for the operating status and diagnosis

❖ The STO function is integrated in the basic device

❖ The "Safe Stop 1" (SS1) function can be realised with a suitable external safety switching device and a suitable wiring of the DIS-2 48/10 FB FS STO basic device.

There are three suitable measures for realising the "STO" function:

❖ Contactor between the mains power supply and drive system (mains contactor)

❖ Contactor between the power unit and drive motor (motor contactor)

❖ Safe pulse inhibitor (blocking of the pulses of the power semiconductors, integrated in the DIS-2 48/10 FB FS STO)

The integrated solution (safe pulse inhibitor) offers several advantages:

❖ fewer external components, e.g. contactors

❖ reduced wiring and space required in the control cabinet

❖ and, thereby, lower costs.

Another advantage is the availability of the system. In the case of the integrated solution, the intermediate circuit of the servo drive can remain charged. As a result, there are no significant waiting times when the system is restarted.

6.2.2   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 disconnects the driver supply for the power semiconductors and the PMW signals, thereby preventing the power output stage from supplying the voltage that is required by the motor (see *Figure* 6).
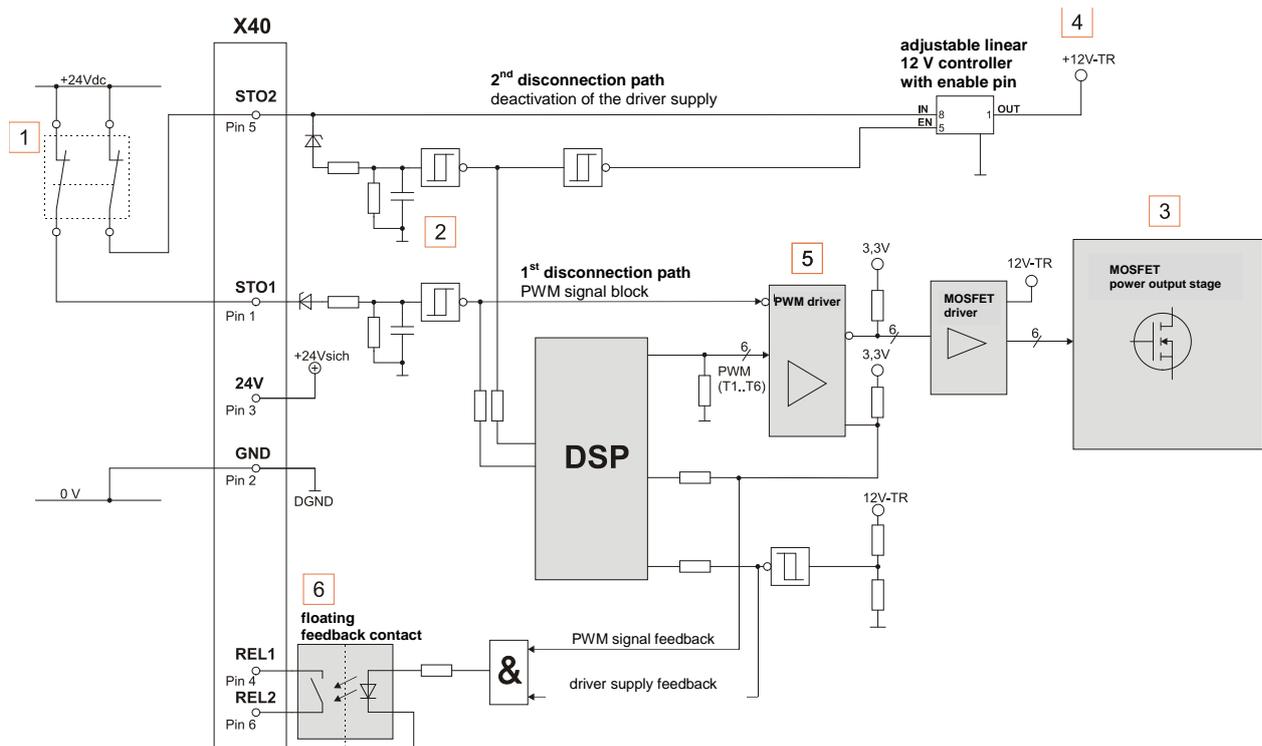
1   Safety circuit (switch, relay, safety circuit)

2   Disconnection paths 1 and 2 (control inputs STO1 and STO2)

3   Power output stage

4   Supply for the output stage drivers

5   PWM signal block

6   Feedback contact

Figure 6:   Mode of operation in the case of the DIS-2 48/10 FB FS STO

When the "Safe Torque Off" (STO) function is active, the energy supply to the drive is interrupted in a safe manner. The drive cannot generate any torque and, thereby, neither any dangerous movements. In the case of suspended loads or other external forces, additional measures must be taken in order to prevent them from sagging (e.g. mechanical holding brakes). In the "Safe Torque Off" (STO) state, the standstill position will not be monitored.

The machine must be stopped in a safe manner, e.g. via a safety switching device. This applies particularly to vertical axes without a self-locking mechanism, arresting device, or weight compensation.

The "Safe Torque Off" (STO) function requires a configuration with two channels, i.e. a restart must be safely prevented via two, completely independent, separate channels. These two channels for interrupting the energy supply to the drive with the safe pulse inhibitor are called disconnection paths:

1st disconnection path: Via STO1 (X40.1), the PWM signals from the DSP are inhibited by setting the enabling pin of the 8-pin line driver to "high". As a result, the output stage drivers will no longer be actuated by pulse patterns.

2nd disconnection path: Via STO2 (X40.5), the +12 V TR supply voltage for the MOSFET power output stage will be switched off directly.

There are so-called feedback paths for both channels:

Feedback for the STO1 disconnection path is realised via the eighth channel of the PWM line driver. When the signals are blocked, the channel will assume a high resistance at the output so that the "PMW signal feedback" signal assumes the logic state 1.

Feedback for disconnection path 2 is realised by way of a voltage divider at +12V-TR via an inverter. When the driver supply is disconnected via STO2, the "driver supply feedback" signal assumes the logic state 1.

For self-diagnosis, the enable signals STO1 and STO2 and the associated feedback signals will be checked for plausibility in the DSP.

The plausibility check or the test of the safety function will be performed in accordance with the following truth table:

Table 26:   STO signal plausibility table

24 V	STO1	STO2	PWM signal feedback (STO1)	Driver supply feedback (STO2)	Normally open contact REL 1/2
OFF	X	X	X	X	open
ON	0 V	0 V	1	1	closed (safe state STO)
ON	24 V	0 V	0	1	open
ON	0 V	24 V	1	0	open
ON	24 V	24 V	0	0	open

Note

Floating feedback contact: If an external diagnosis is required, the semiconductor relay transfers the "safe" or "unsafe" state to a superordinate control system. The PLC must perform a plausibility check in accordance with *Table 26* (contact closed = STO state achieved) at regular, suitable intervals (see the note in *section 6.1*). If an error occurs during the plausibility check, the further operation of the system must be prevented by the control system, e.g. by blocking the enable signal or by switching the mains contactor off.

> **DANGER!**
>
> The drive may start with a jerk in the event of multiple errors in the DIS-2 48/10 FB FS STO.
>
> 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 a pole pitch. Examples:
>
> ❖ Rotary axis, synchronous machine, 8-pole ➔ movement < 45° at the motor shaft.
>
> ❖ Linear motor, pole pitch 20 mm ➔ movement < 20 mm at the moved part.

> **Note**
>
> **[X40] is not connected in the delivery state!**
>
> The scope of supply includes an STO connecting cable (pre-assembled on both ends) with the M12 device interface (circular connector) for STO wiring.
>
> If the STO function is not required, the scope of supply includes an alternative mating connector for [X40] that can be used for bridging the pins 1, 3, and 5 in order to deactivate the STO function.

6.2.3   Control inputs STO1, STO2 [X40]

The control inputs STO1 and STO2 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 switching devices, active safety sensors, e.g. light curtains with OSSD signals) and switching contacts (safety switching devices with relay outputs, passive safety sensors, e.g. positively driven position switches) ➔ see for example *section 6.5*.

In order to request the STO safety function ("Safe Torque Off"), the 24 V control voltage is switched off at both control inputs STO1 and STO2 (0 V).
If both control inputs are switched off simultaneously or within a predefined discrepancy time and if the feedback signals have the state "1" (see *Table 26*), the STO function is active.

> *Section 4.6* describes the technical data for the control inputs in the specified operating range.
>
> The requirements concerning the time behaviour result from the technical data in *section 4.6*. The time behaviour itself is described in *section 6.4*.

6.2.3.1   Discrepancy time

The transition between the safe and unsafe state is initiated by level changes at the control inputs STO1 and STO2. In accordance with the specification of the safety function, both levels must be identical. Otherwise, an error message will be generated. 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 STO1 and STO2 simultaneously.

6.2.3.2   Test pulses

Temporary test pulses from safety control systems are tolerated, i.e. they do not trigger a request of the STO function.

The tolerance with regard to test pulses of sensors with OSSD signals is configured for the operating range in accordance with the technical data in *section 4.6*. The permissible test pulse duration is slightly dependent on the control voltage level at the inputs STO1 and STO2.

Example: Input voltage for STO1 and STO2 = 24 V
                  ➔ OSSD signals with a test pulse duration of 4 ms will be tolerated.

6.2.4   Feedback contacts REL1, REL2 [X40]

If the **STO function is not active**, the feedback contact is open. This is the case, for example, if only one of the two control voltages STO1 or STO2 is applied, if the 24 V logic supply voltage is switched off or in the event of a failure of the supply voltage.
If the **STO function is active** (safe state), the relay contact is closed.

> The feedback contact is realised by way of one single channel. It may be used for diagnostic purposes but not in the safety circuit.
>
> *Section 4.6* describes the technical data for the feedback contact.
>
> When the 24 V supply of the basic device is switched on or off, the switching state of the relay may briefly (< 20 ms) deviate from the state of the control inputs STO1 and STO2 due to the fact that the internal supply voltages ramp up with different speeds.

6.2.5   Auxiliary supply +24V, GND [X40]

The DIS-2 48/10 FB FS STO servo drive provides an auxiliary +24 V supply via [X40]. This auxiliary supply is intended **solely** for applying +24 V to the inputs STO1 and STO2 if the STO function is not used.

6.3   Functionalities in the DIS-2 48/10 FB FS STO basic device

The following functions in the basic device are not certified in accordance with the EN safety standards. They are functional extensions and offer additional diagnostic options.
Error messages that are generated by the basic device, e.g. when the discrepancy time is exceeded, are registered and evaluated by the non-safety-relevant state machine of the servo drive. If the conditions for an error state are recognised, an error message will be generated. In this case, it cannot be absolutely guaranteed that the power output stage has been switched off safely.

> **Note**
>
> When error messages are acknowledged, all of the acknowledgeable errors concerning the functional safety will be acknowledged as well ➔ see *section 10.2.*

The servo drive monitors the status of the control inputs STO1 and STO2.
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 PWM signal block by STO1

❖ Detection of the disconnection of the driver supply for the power semiconductors by STO2

❖ Deactivation of the drive control and also of the actuation of the power semiconductors (PWM)

❖ Deactivation of the actuation of the holding brake

❖ Evaluation of the actuation of the STO inputs (discrepancy time)

❖ Detection of application-related error states

❖ Diagnosis of the hardware by way of a plausibility check of the disconnection paths

❖ Status and error indication via digital outputs, fieldbuses, etc.

> **Note**
>
> The brake is actuated via the non-safety-oriented firmware of the servo drive.

> **DANGER!**
>
> If one of the control inputs STO1 or STO2 is deactivated while the power output stage is active, the drive will coast down without being braked if the holding brake is not connected.
> This may damage the machine. This is why we recommend connecting a holding brake to the servo drive.

It is possible to request the safe state while the actuation of the power semiconductors (PWM) is active.
The safety function requires both signals to have the same status. It is only during a certain transition period, the so-called "discrepancy time", that unequal signals will be tolerated. If this time is exceeded, an error message will be triggered, see *section 6.2.3.1.*

6.4   Time behaviour

> **Note**
>
> The switching order of STO1/STO2 can be exchanged in all of the diagrams. However, the switching times of the various channels differ from each other due to the underlying principle.

6.4.1   STO basic time behaviour

Figure 7 shows the basic time behaviour of the safety module. You can find the time data in *Table 27*.
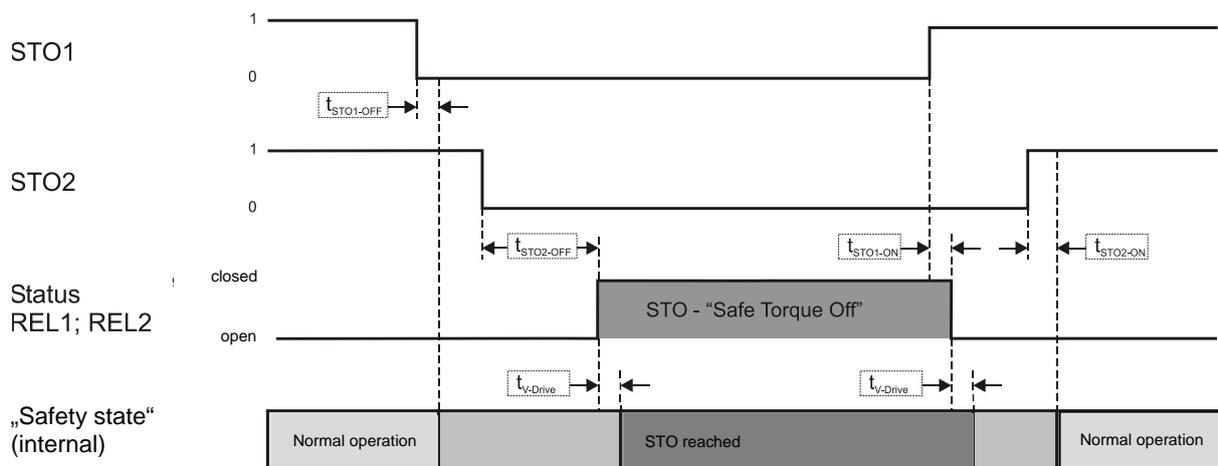
Figure 7:   **Basic time behaviour during the activation and deactivation of the STO safety function**

Table 27:   **Time data concerning Figure 7**

Time	Description	Value
$t_{STO1-ON}$	STO1 – switching time from low to high STO1 switch-on time from low to high until the blocking of the PWM signal is deactivated	➔ *section 4.6*
$t_{STO2-ON}$	STO2 – switching time from low to high STO2 switch-on time from low to high until the supply of the output stage drivers is available	➔ *section 4.6*
$t_{STO1-OFF}$	STO1 – switching time from high to low STO1 switch-off time from high to low until the blocking of the PWM signal is activated	➔ *section 4.6*
$t_{STO2-OFF}$	STO2 – switching time from high to low STO2 switch-off time from high to low until the supply of the output stage drivers is no longer available	➔ *section 4.6*
$t_{V-Drive}$	Internal delay due to the firmware	0...5 ms

6.4.2   Time behaviour for activating STO during operation with restart

Figure 8 shows the time behaviour starting with the disconnection of the control voltage at STO1/2 and the sequence that is necessary for restarting the device. You can find the time data in *Table 28*.

Notes:

❖ The actuation of the holding brake is realised via the basic device and not in a safety-oriented manner. The holding brake will not be engaged until the speed is at 0.

❖ 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 $t_{V\text{-Brake-OFF}}$ has elapsed.
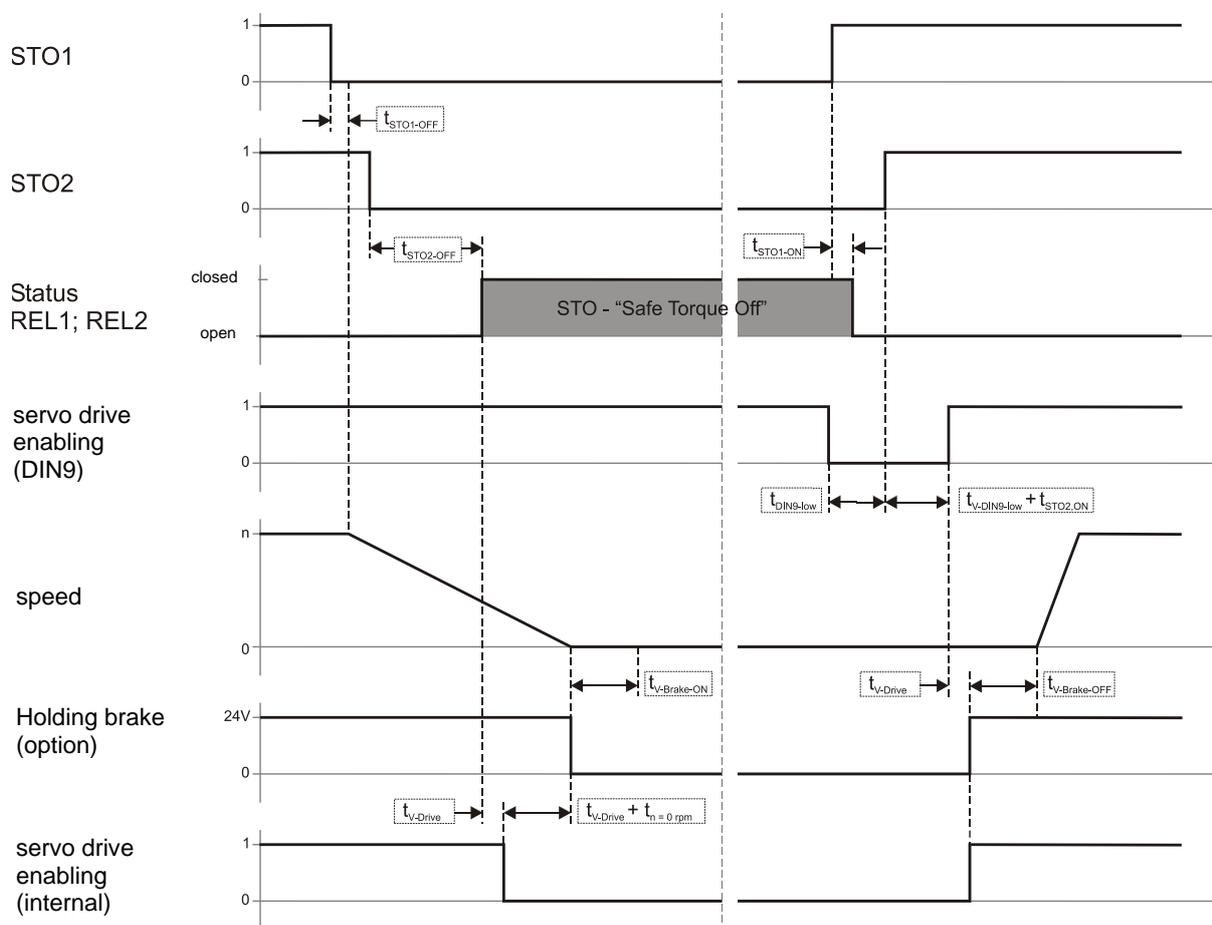
Figure 8:   **Time behaviour when activating the safety function STO with restart**

Table 28:   Time data concerning Figure 8

Time	Description	Value
$t_{STO1-ON}$	STO1 – switching time from low to high STO1 switch-on time from low to high until the blocking of the PWM signal is deactivated	➔ *section 4.6*
$t_{STO2-ON}$	STO2 – switching time from low to high STO2 switch-on time from low to high until the supply of the output stage drivers is available	➔ *section 4.6*
$t_{STO1-OFF}$	STO1 – switching time from high to low STO1 switch-off time from high to low until the blocking of the PWM signal is activated	➔ *section 4.6*
$t_{STO2-OFF}$	STO2 – switching time from high to low STO2 switch-off time from high to low until the supply of the output stage drivers is no longer available	➔ *section 4.6*
$t_{DIN9-low}$	Time during which DIN9 must be low before STO1/2 will be switched on again	0 ms
$t_{V-DIN9-low}$	Delay during which DIN9 must still be low after STO1/2 have been switched on again and the status of the STO function has changed	> 5 ms
$t_{V-Drive}$	Internal delay due to the firmware	0...5 ms
$t_{V-Brake-ON}$	Switch-off delay of the holding brake (time until the brake is engaged)	Depending on the brake [1]
$t_{V-Brake-OFF}$	Switch-on delay of the holding brake (time until the brake is released)	Depending on the brake [2]

[1]   Physical delay until the brake is closed. As far as this example is concerned, this time does not need to be parameterised in the servo drive since, at this point of time, the internal servo drive enabling is no longer set due to the STO selection.

[2]   Minimum time: Physical delay until the brake is open. This time can be parameterised by way of a higher value in the servo drive.

6.4.3   Time behaviour for activating SS1 during operation with restart

The time behaviour in *Figure 9* is based on the SS1 example circuit in *section 6.5.2* and on the control signal S1 for K1. You can find the time data in *Table 29.*
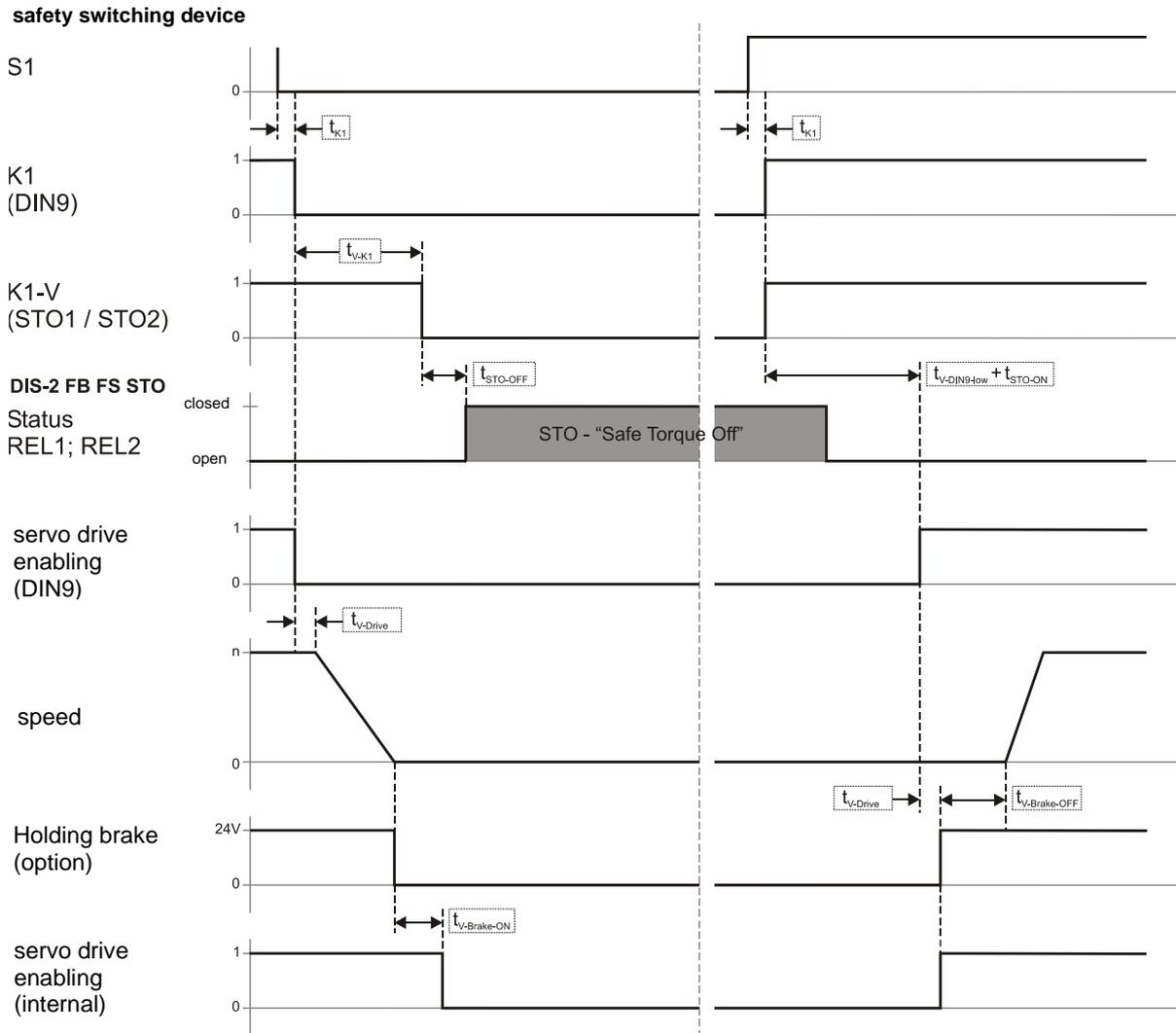
Figure 9:   Time behaviour when activating the safety function SS1 (external switching) with restart

Table 29:   **Time data concerning Figure 9**

Time	Description	Value
t_{K1}	Delay between the switching of S1 and the closing of the undelayed contact K1	➔ data sheet of the safety switching device
t_{V-K1}	Delay between S1 and the opening of the off-delayed contacts K1	Can be adjusted on the safety switching device
t_{STO-ON}	STO1 switch-on time from low to high until the blocking of the PWM signal is deactivated <u>or</u> STO2 switch-on time from low to high until the supply of the output stage drivers is available (At this point of time, both STO signals are high, depending on the switching sequence and switching time.)	➔ *section 4.6*
$t_{STO-OFF}$	STO1 switch-off time from high to low until the blocking of the PWM signal is activated <u>or</u> STO2 switch-off time from high to low until the supply of the output stage drivers is no longer available (At this point of time, both signals are low, depending on the switching sequence and switching time.)	➔ *section 4.6*
$t_{V-DIN9-low}$	Delay during which DIN9 must still be low after STO1/2 have been switched on again and the status of the STO function has changed	> 5 ms
$t_{V-Drive}$	Internal delay due to the firmware	0...5 ms
$t_{V-Brake-ON}$	Switch-off delay of the holding brake (time until the brake is engaged)	Depending on the brake [1]
$T_{V-Brake-OFF}$	Switch-on delay of the holding brake (time until the brake is released)	Depending on the brake [2]

[1] Physical delay until the brake is closed. This time should be parameterised at minimum in the servo drive in order to keep the internal servo drive enabling set until the brake has really engaged, e.g. in order to prevent any suspended loads from slipping.

[2] Minimum time: Physical delay until the brake is open. This time can be parameterised by way of a higher value in the servo drive.

6.5 Circuit examples

6.5.1 "Safe Torque Off" (STO)
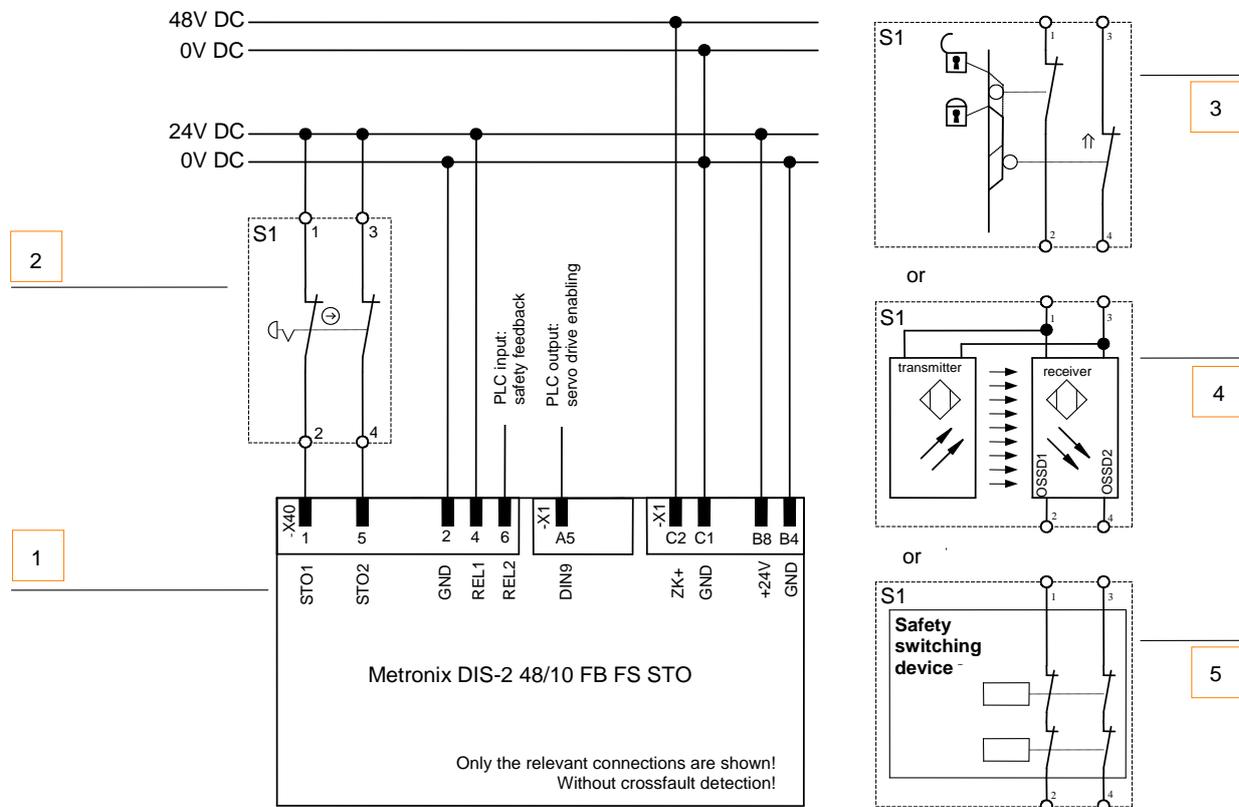
1 Servo drive with a safety module
   (only the relevant connections are shown)

2 Emergency-stop switch

3 Protective door

4 Light curtain

5 Safety switching device

Figure 10:   Circuit example "Safe Torque Off" (STO)

The "Safe Torque Off" (STO) safety function can be requested by various devices. The switch S1 can be, for example, an emergency-stop switch, a switch of a protective door, a light curtain, or a safety switching device. 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. Once the output stage has been switched off, this is output by the floating contact REL1/REL2.

Notes concerning the circuit example

❖ The servo drive with a safety module does not include any crossfault detection.
  In the case of a direct wiring of light grids, the crossfault detection will be performed by the light
  grid provided that it is suitable for this purpose.

❖ If safety switching devices are used, the contacts REL1 and REL2 can be integrated in the
  feedback loop of the safety switching device.

❖ The illustration shows the pin assignment of the STO connector X40 directly on the board and not
  the pin assignment of the circular connector in the mounting plate.

6.5.2   Delays and safe torque switch-off (SS1, "Safe Stop 1")
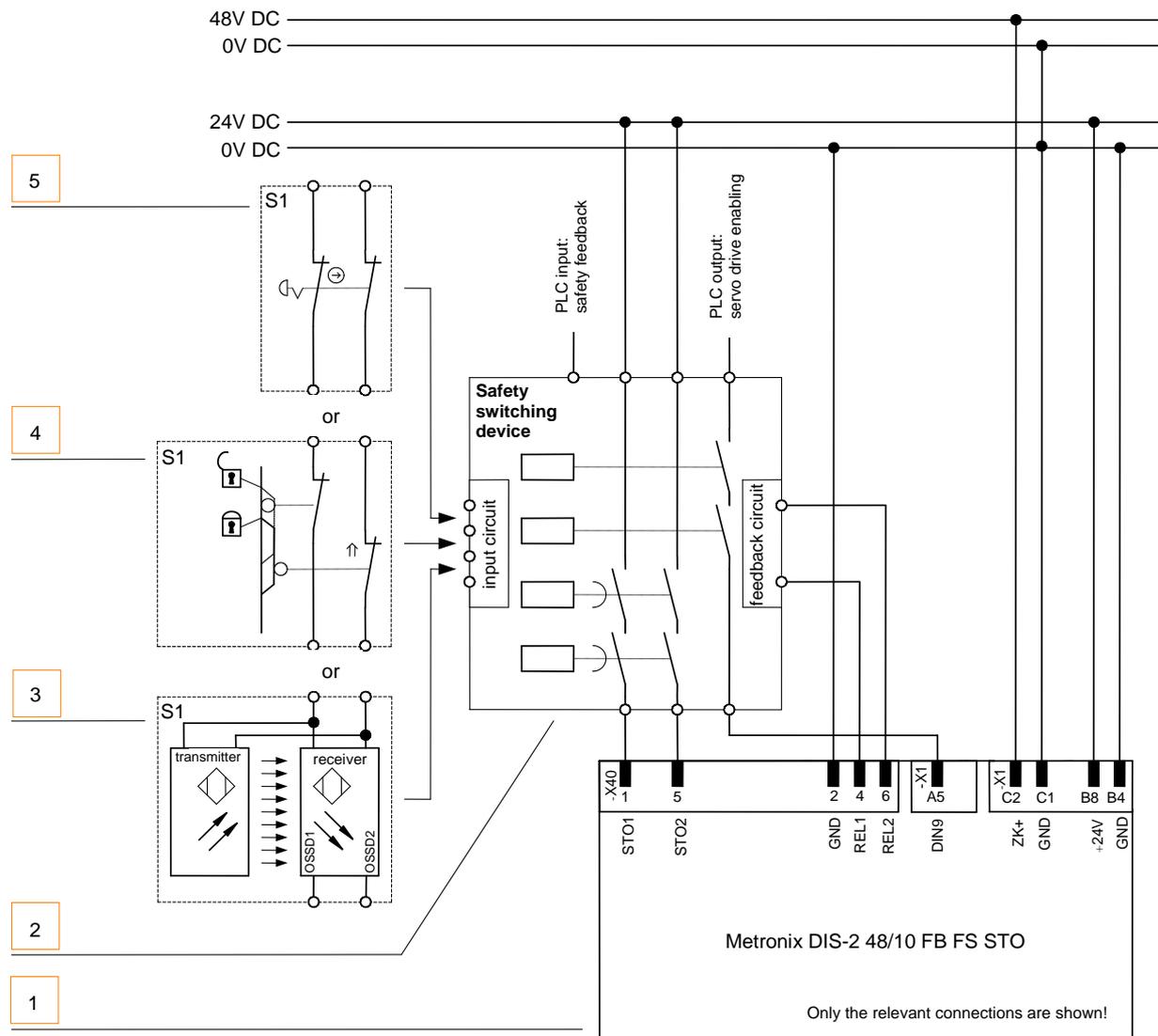
1   Servo drive with a safety module
     (only the relevant connections are shown)

2   Safety switching device

3   Light curtain

4   Protective door

5   Emergency-stop switch

Figure 11:   Circuit example "Delays and safe torque switch-off" (SS1, "Safe Stop 1")

The safety function "Safe Stop 1" (SS1, type C) can be requested by various devices ➔ *Figure 11*.

The switch S1 in *Figure 11* can be, for example, an emergency-stop switch, a switch of a protective door, or a light curtain. The safety request is realised via two channels and via the switch S1 towards the safety switching device. The safety switching device switches the servo drive enabling off. When the servo drive enabling is switched off, 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 set in the safety switching device, the output stage will be switched off via two channels via STO1/2. Once the output stage has been switched off, this is output by the floating contact REL1-REL2.

Notes concerning the circuit example

❖ The safety switching device that is used must switch the servo drive enabling (X1-A5, DIN9) off without delay and the inputs STO1 and STO2 (X40-1, X40-5) 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 in the DIS-2 FB FS STO before STO1/2 are switched off.

❖ The illustration shows the pin assignment of the STO connector X40 directly on the board and not the pin assignment of the circular connector in the mounting plate.

6.6 Parameterisation with the DIS-2 ServoCommander™

The DIS-2 ServoCommander™ (DSC) parameterisation software has been expanded for the use of DIS-2 FB FS STO servo drives with an integrated "Safe Torque Off" (STO) function.

A complete description of the parameterisation software can be found in the DIS-2 user manual.

The main additions are:

❖ Status indication of the state machine of the firmware of the DIS-2 FB FS STO basic device

❖ Status indication of the STO input signals and the associated feedback signals

❖ Option to parameterise the discrepancy time between STO1 and STO2

❖ Support of the specified warnings and error messages
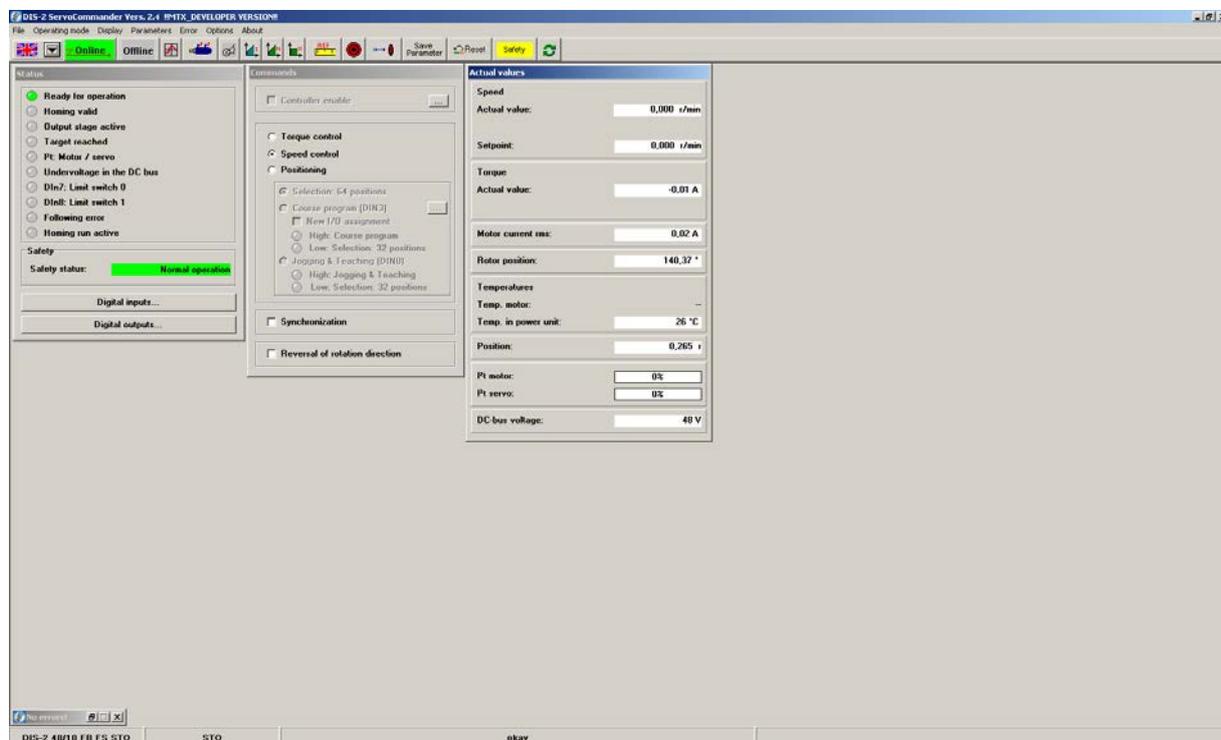
Figure 12: Indication of the type of servo drive and extended status window

6.6.1 Servo drive type indication

At the lower edge of the DSC main screen, there is a **status bar**. It shows the type of servo drive, see *Figure 12*.

6.6.2 Status indication of the state machine

The **status window** (i.e. the window that is permanently displayed in the online mode) has been extended by the **status indication of the state machine**. It shows the status of the functional safety in the firmware of the DIS-2 FB FS STO basic device, see *Figure 12.*

In addition, the status of the internal state machine is indicated in the **Safety module** window, see *section 6.6.3 "Safety module – Status" window.*

6.6.3 "Safety module – Status" window

In order to use the DIS-2 FB FS STO servo drive with the integrated STO safety function, the **Safety module – Status** window has been added to the DSC parameterisation software.

It shows the status of the state machine in the DIS-2 FB FS STO. The status results from an evaluation of the STO input signals and their respective feedbacks.

This window can be opened either via the menu **Parameters – Functional safety – Status** or via the **Safety** button in the quick-access toolbar below menu bar, see *Figure 12*.

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

The following shows the three states "normal operation", "error", and "safe state reached".
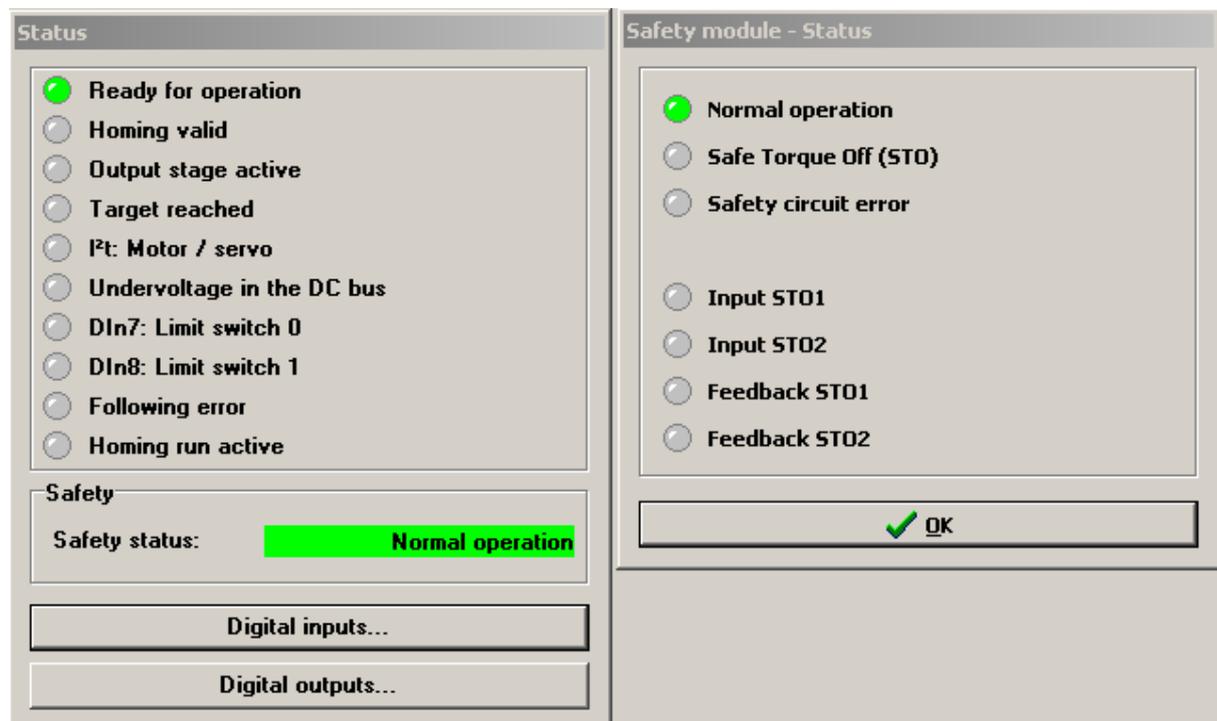
Figure 13: General "Status" window and "Safety module – Status" window with the state "Normal operation"
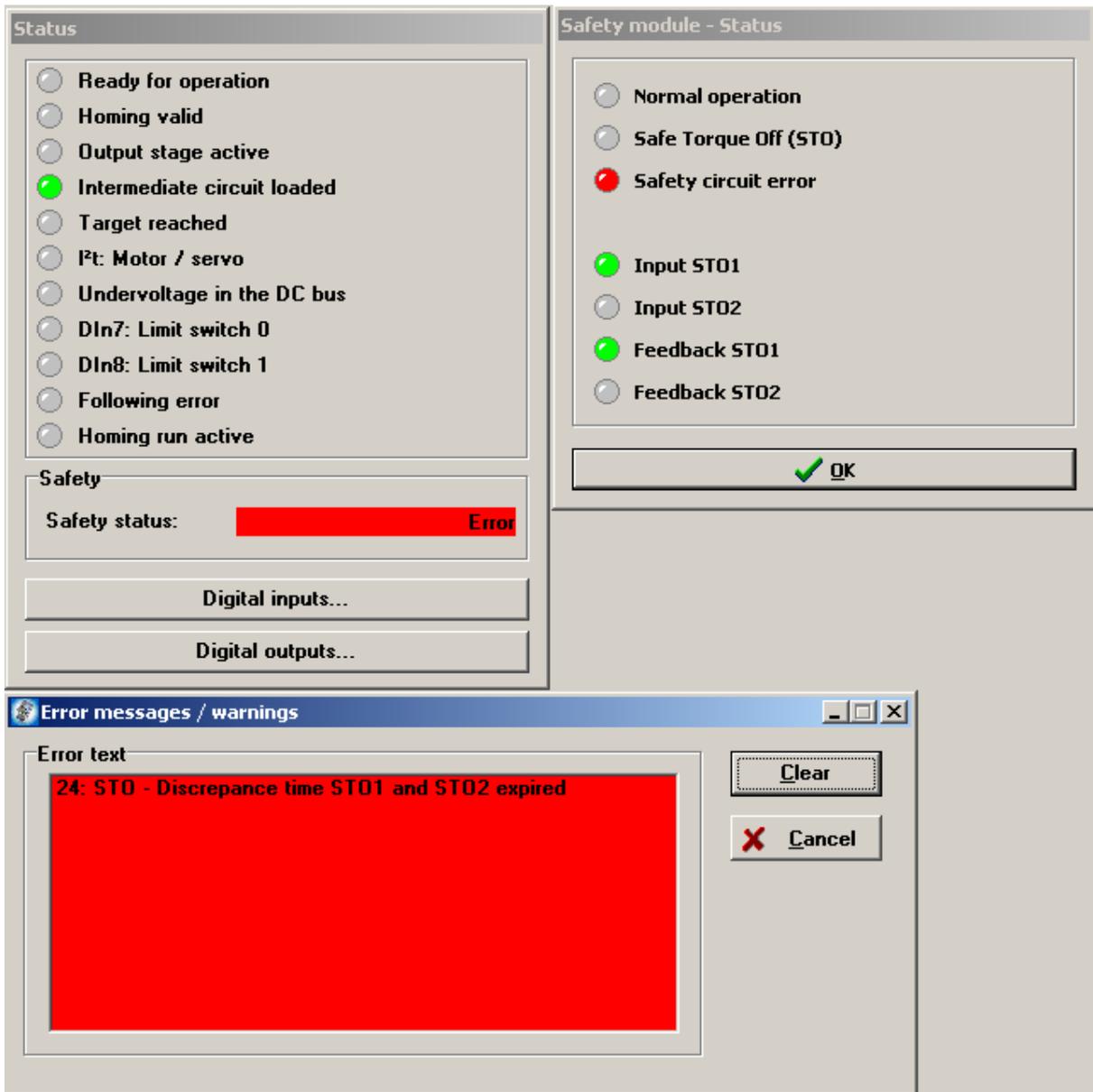
Figure 14: General "Status" window, "Safety module – Status" window, and "Error messages / warnings" window with the state "Error"
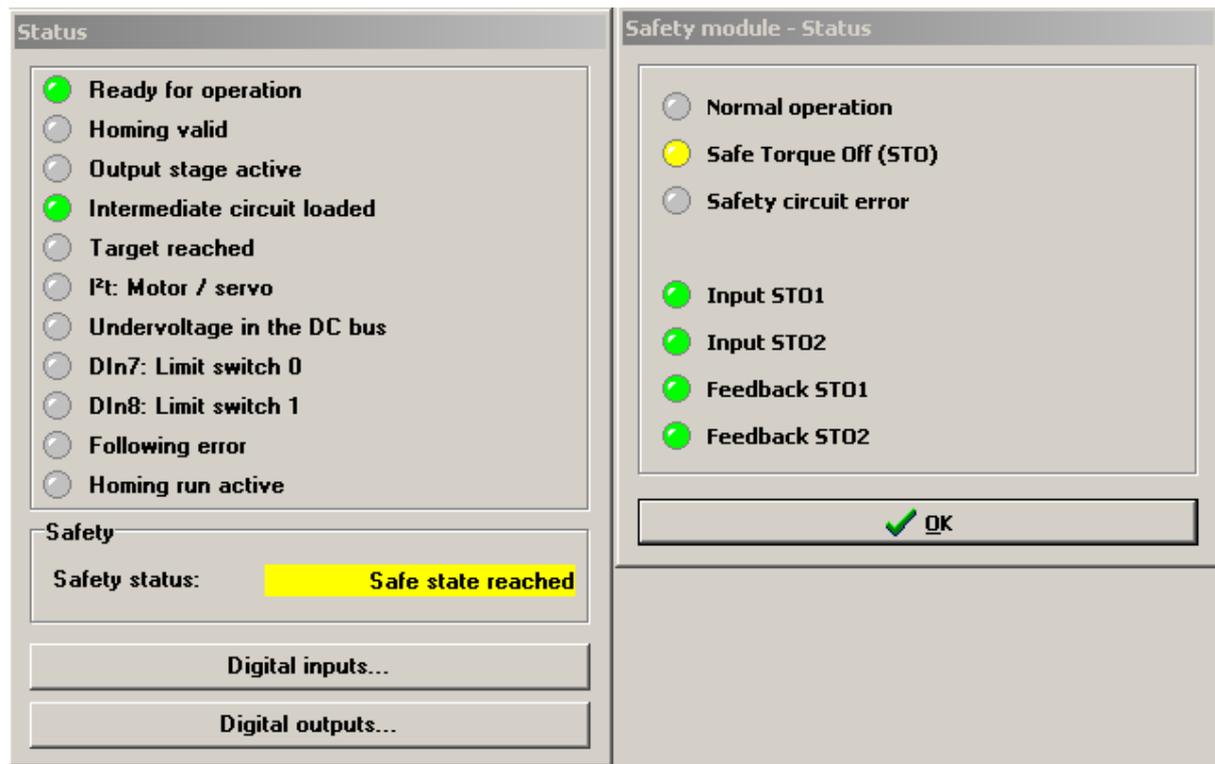
Figure 15: General "Status" window and "Safety module – Status" window with the state "Safe state reached"

6.6.4 "Safety module – Parameters" window

In order to use the DIS-2 FB FS STO servo drive with the integrated STO safety function, the **Safety module – Parameters** window has been added to the DSC parameterisation software.

This window can be opened via the menu **Parameters – Functional safety – Parameters** and it is used to parameterise the discrepancy time.

This value is preset to 100 ms and should be fine for the usual applications. If necessary, the discrepancy time (see *section 6.2.3.1*) between STO1 and STO2 can be prolonged to up to 1 s.
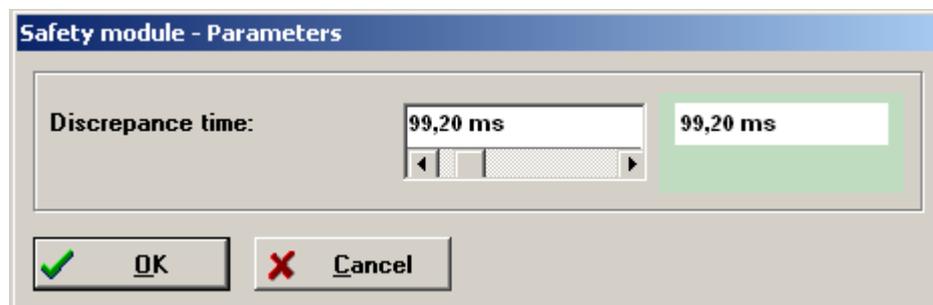
Figure 16: "Safety module – Parameters" window

6.7 Functional test, validation

	Note
□	The STO function must be validated after the installation or after the installation has been changed.
	This validation must be documented by the machine or system manufacturer. As assistance for the commissioning process, the following checklist example includes several questions for minimising the risk.
	This checklist does not replace an education in safety matters.
	We cannot accept any liability for the completeness of the checklist.

Table 30:   **Questions for a validation in accordance with EN ISO 13849-1 and -2 (example)**

No.	Questions	Yes/No		Done
1.	Has a risk assessment been performed?	Yes □	No □	□
2.	Have an error list and validation plan been created?	Yes □	No □	□
3.	Have the steps of the validation plan, including an analysis and test, been performed and has a validation report been created? At least the following tests must be performed for a validation:	Yes □	No □	□
	a) Check of the components: Is the DIS-2 48/10 FB FS STO being used (check against the type plates)?	Yes □	No □	□
	b) Is the wiring correct (check against the circuit diagram)?	Yes □	No □	□
	− Have any jumpers been removed?	Yes □	No □	□
	− Has a safety switching device been connected to X40?	Yes □	No □	□
	− Has the safety switching device been certified and wired in accordance with the requirements of the application?	Yes □	No □	□
	c) Functional tests:	Yes □	No □	□
	− Actuation of the emergency-stop of the system. Is the drive being stopped?	Yes □	No □	□
	− If only STO1 is activated, is the drive being stopped immediately and is the error "Discrepancy time STO1 and STO2 exceeded" being signalled (display 24) in the DIS-2 FB FS STO after the discrepancy time has elapsed?	Yes □	No □	□

No.	Questions	Yes/No		Done
	– If only STO2 is activated, is the drive being stopped immediately and is the error "Discrepancy time STO1 and STO2 exceeded" being signalled (display 24) in the DIS-2 FB FS STO after the discrepancy time has elapsed?	Yes ☐	No ☐	☐
	– Does the system detect a short circuit between STO1 and STO2 or has a suitable fault exclusion been defined?	Yes ☐	No ☐	☐
	– Only if a safety switching device with an evaluation of the REL1/REL2 feedback contact is used: Is the drive being stopped in the event of a short circuit of REL1 and REL2?	Yes ☐	No ☐	☐
	– Is the restart being prevented? This means that if the emergency stop 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 ☐	☐

7 Mechanical installation

7.1 Important notes

❖ The DIS-2 48/10 FB FS STO servo drive was designed for direct installation on the motor.

❖ Optionally, it is possible to use it separately from the motor. In this case, additional connecting cables between the motor and the DIS-2 servo drive are required. These cables should be as short as possible. The maximum length is 1 m.

❖ Optimum cooling can be ensured when the DIS-2 48/10 FB FS STO servo drive is mounted in a vertical position. This means that connector [X1] is located on top or at the bottom.

❖ The maximum permissible temperature of the housing is 70°C to guarantee the specified service life of the electronic system.

❖ Connect the connecting cable for [X1] as closely as possible to the DIS-2 48/10 FB FS STO servo drive to increase the reliability of the cabling.

❖ Installation spaces:
Keep a minimum distance of 100 mm to other components each underneath and above the device to ensure sufficient venting.
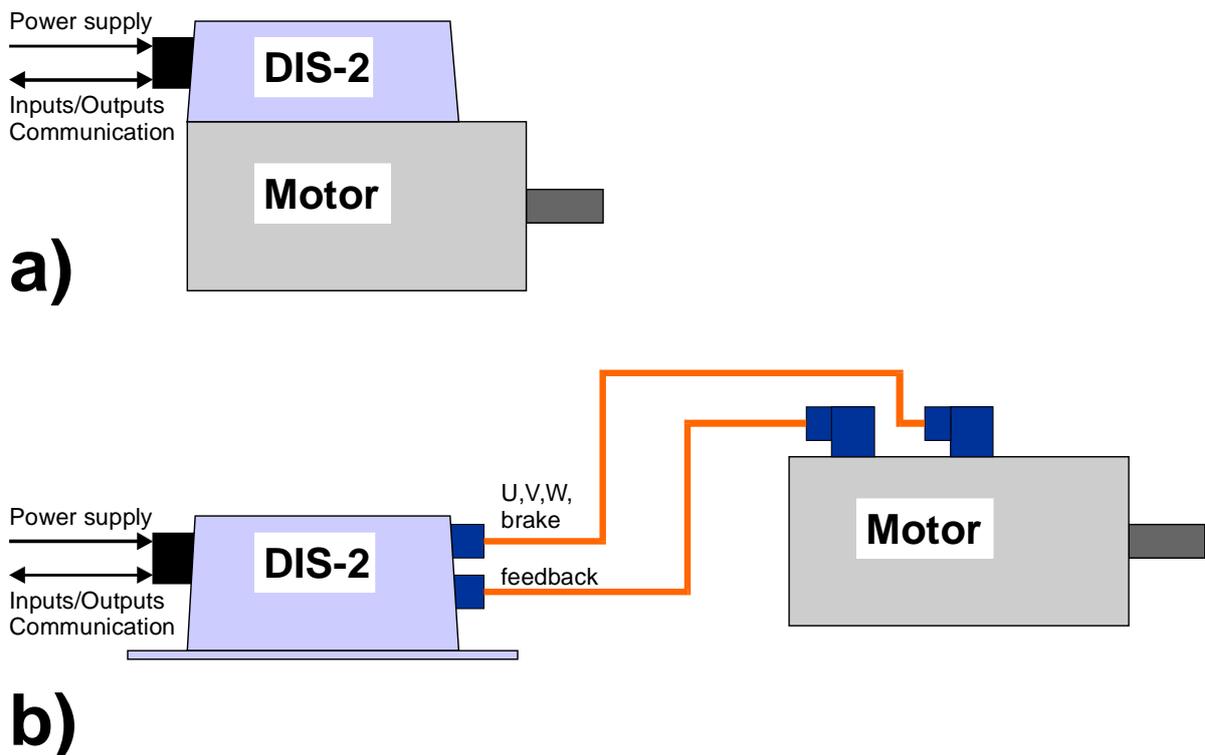
Figure 17: **a) Mounted directly on the motor – standard,**
b) Separated from the motor – Please contact your local distributor to check whether this option is available.

7.2   Position and alignment of the connectors

The DIS-2 48/10 FB FS STO has the following connections:
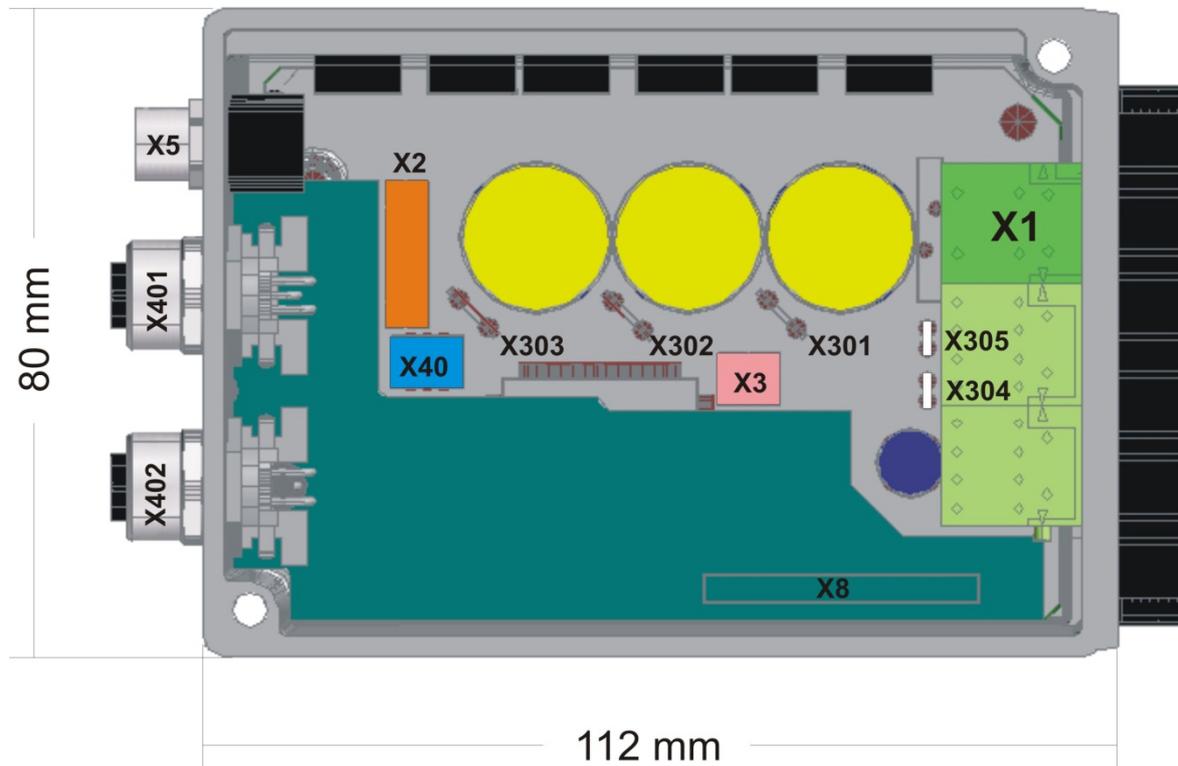
Figure 18:   **Arrangement of the connectors DIS-2 48/10 FB FS STO – Top view of the device**

7.2.1   Connectors on the main board

❖ **[X1]:** The only connector on the main board that is led to the outside. It includes digital and analogue inputs and outputs and the power supply.

❖ **[X2]:** Connector of the angle encoder.

❖ **[X3]:** Connector of the holding brake.

❖ **[X304, X305]:** Connector for the brake resistor that is mounted on the mounting plate.

❖ **[X301, X302, X303]:** Connectors for the three motor phases U, V and W.

❖ **[X8]:** Expansion interface for technology modules (fieldbuses).

❖ **[X40]:** Connector of the STO interface. This interface is led to the outside via a 5-pole M12 circular connector. The circular connector normally is fixed on the mounting plate.

7.2.2   Connectors for the fieldbus interfaces and RS232 interface (CANopen, PROFIBUS or EtherCAT)

❖ **[X5]:** Connector for the RS232 communication, for example to parameterise the DIS-2 48/10 FB FS STO

❖ **[X401]:** Fieldbus connector for bus IN or bus OUT

❖ **[X402]:** Second fieldbus connector for bus IN or bus OUT

7.3   Dimensions of the housing
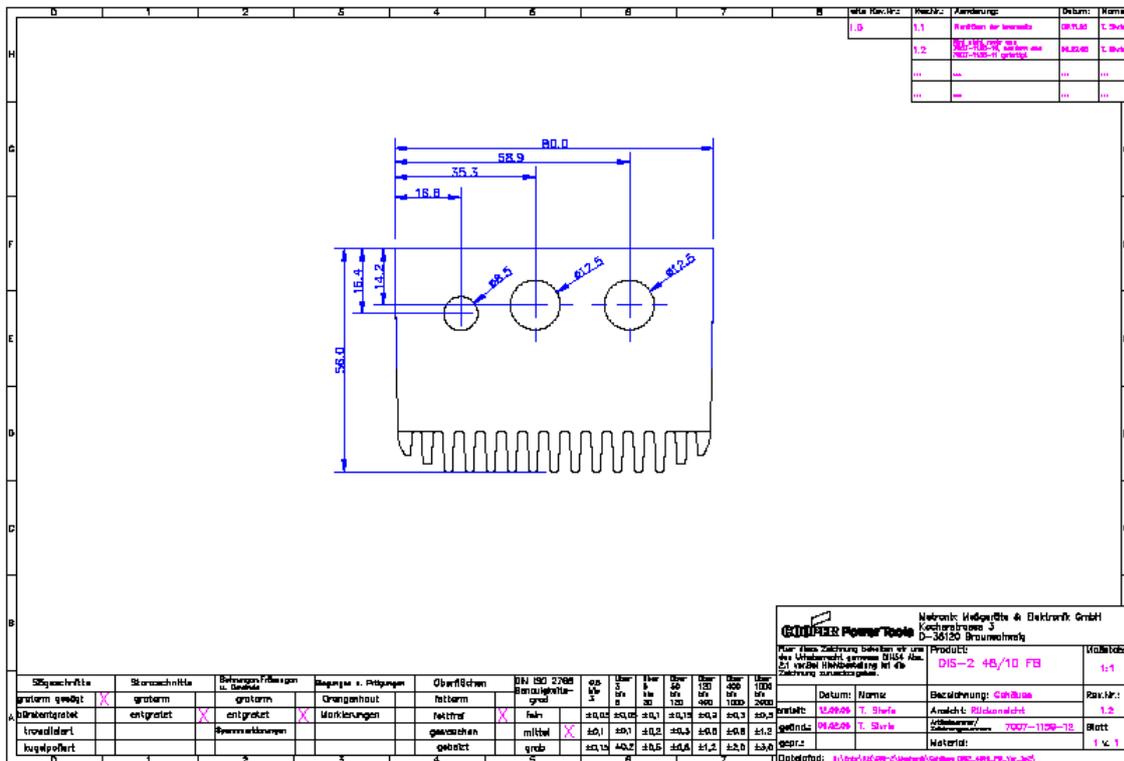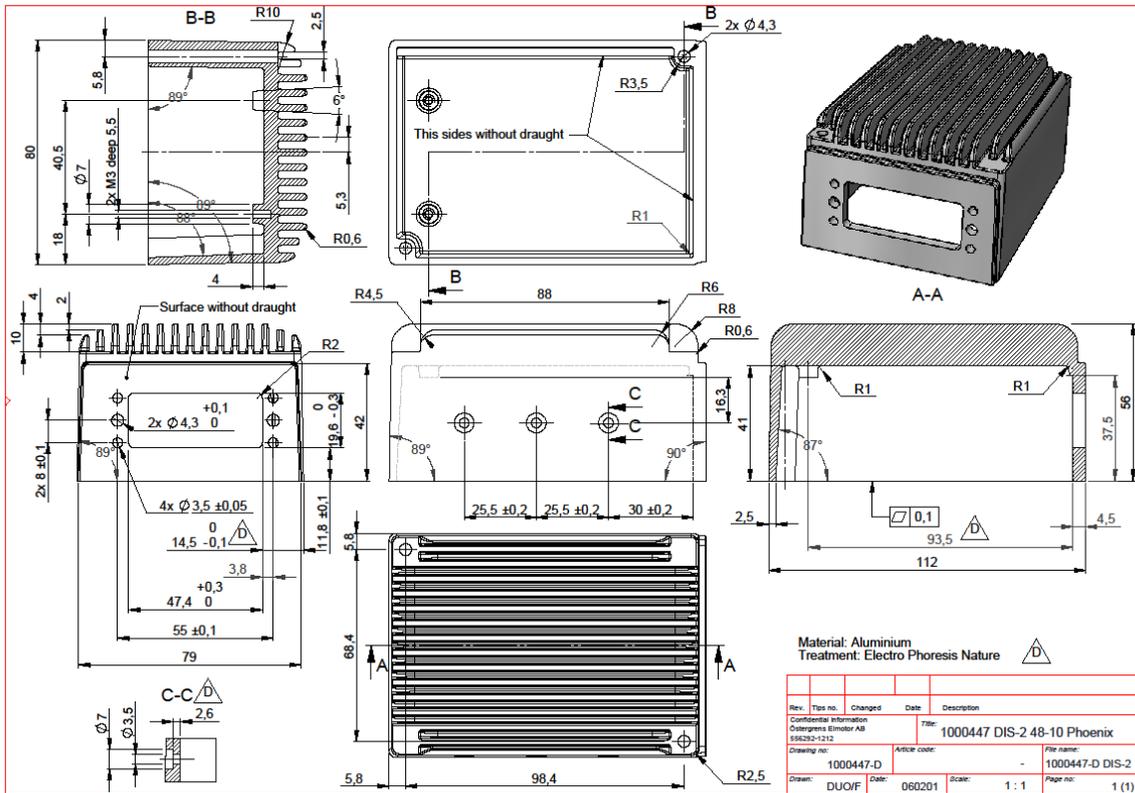
Figure 19:   Dimensions of the housing

7.4   Mounting

The servo drive DIS-2 48/10 FB FS STO will be mounted directly to the motor using a seal. The mounting flange at the motor should have a smooth surface with a circular slot to achieve the highest protection against water. Achieving the protection degree of IP67 is possible by using a good mechanical construction.
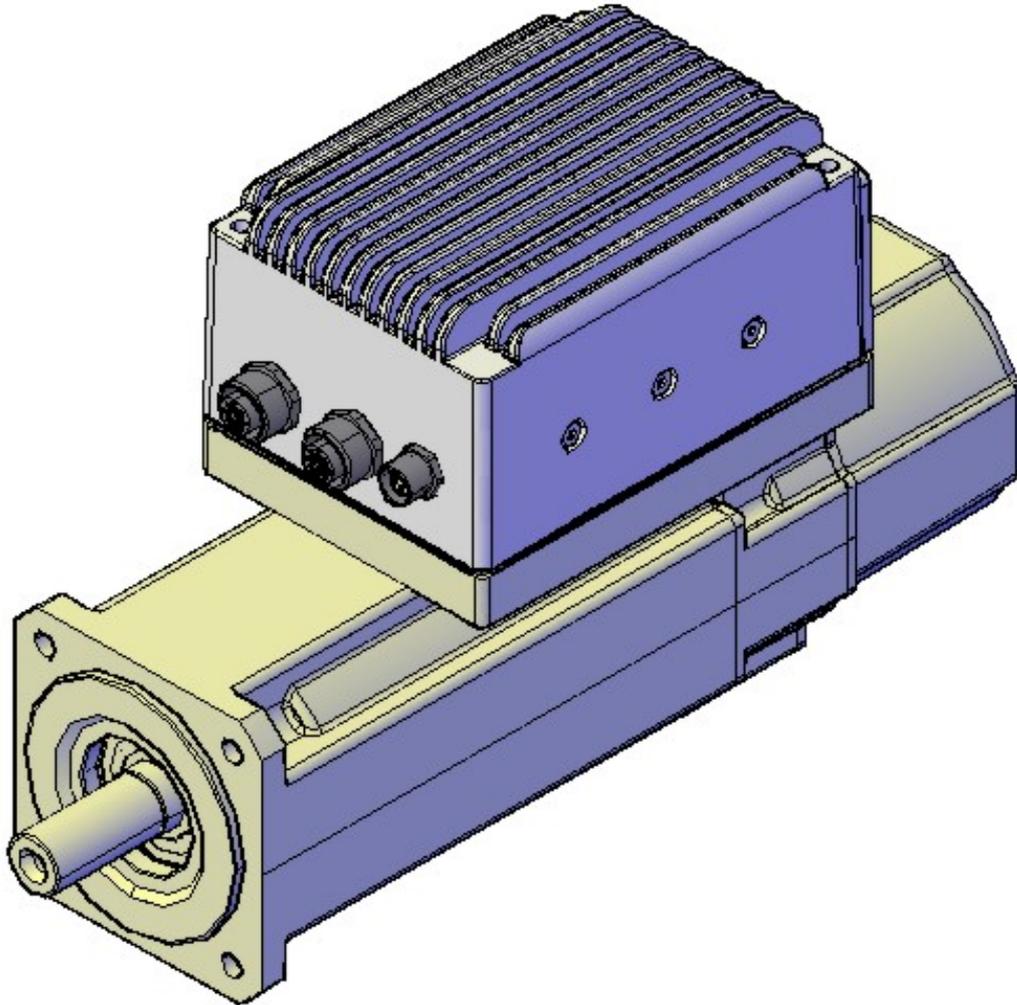
Figure 20:   DIS-2 mounting example without STO

The following two figures show a mounting example of an STO application. In this case, the mounting plate must be milled deeper so that the M12 circular connector [X40A] can be integrated.
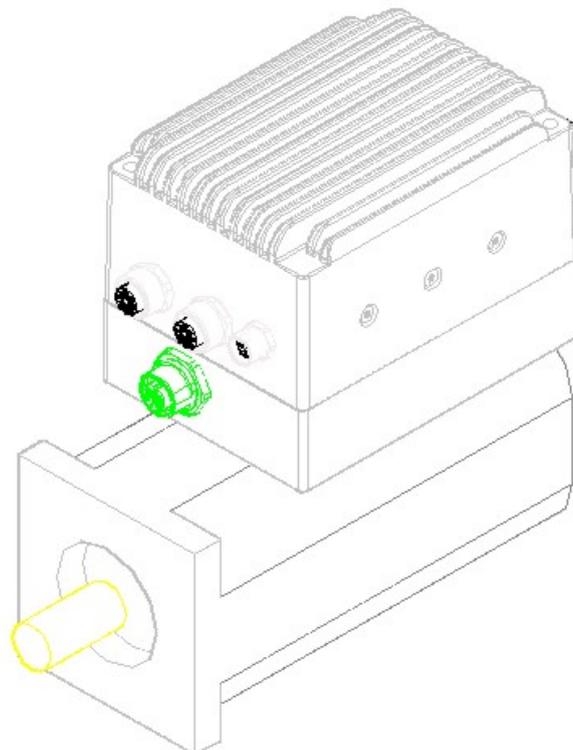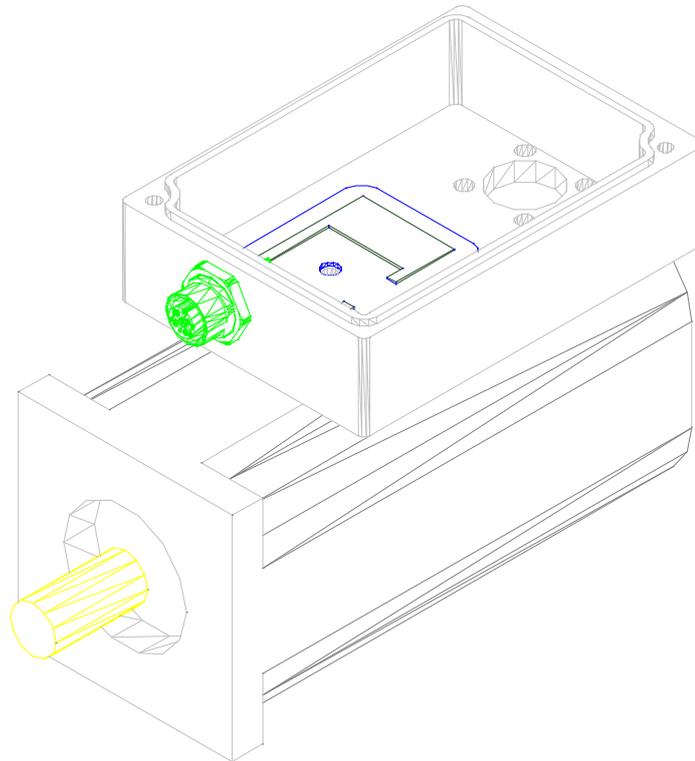
Figure 21:   DIS-2 48/10 FB FS STO mounting example <u>with</u> STO – synchronous servo motor, mounting plate with brake resistor and servo drive

Figure 22: **DIS-2-FB FS STO Example of a mounting plate universal**

Figure 23:   DIS-2-FB FS STO Example of a realised mounting plate

8   Electrical installation

8.1   Connection to power supply, control and motor

The following figure shows a typical application with two or more DIS-2 servo drives with a connection to an 48V intermediate circuit supply, to a 24 V DC logic supply and to a control or to a PLC without STO functionality.

The connector [X40] for the integrated safety function "Safe Torque Off (STO)" is not shown in this figure. The STO applications are described in *section 6.5.*
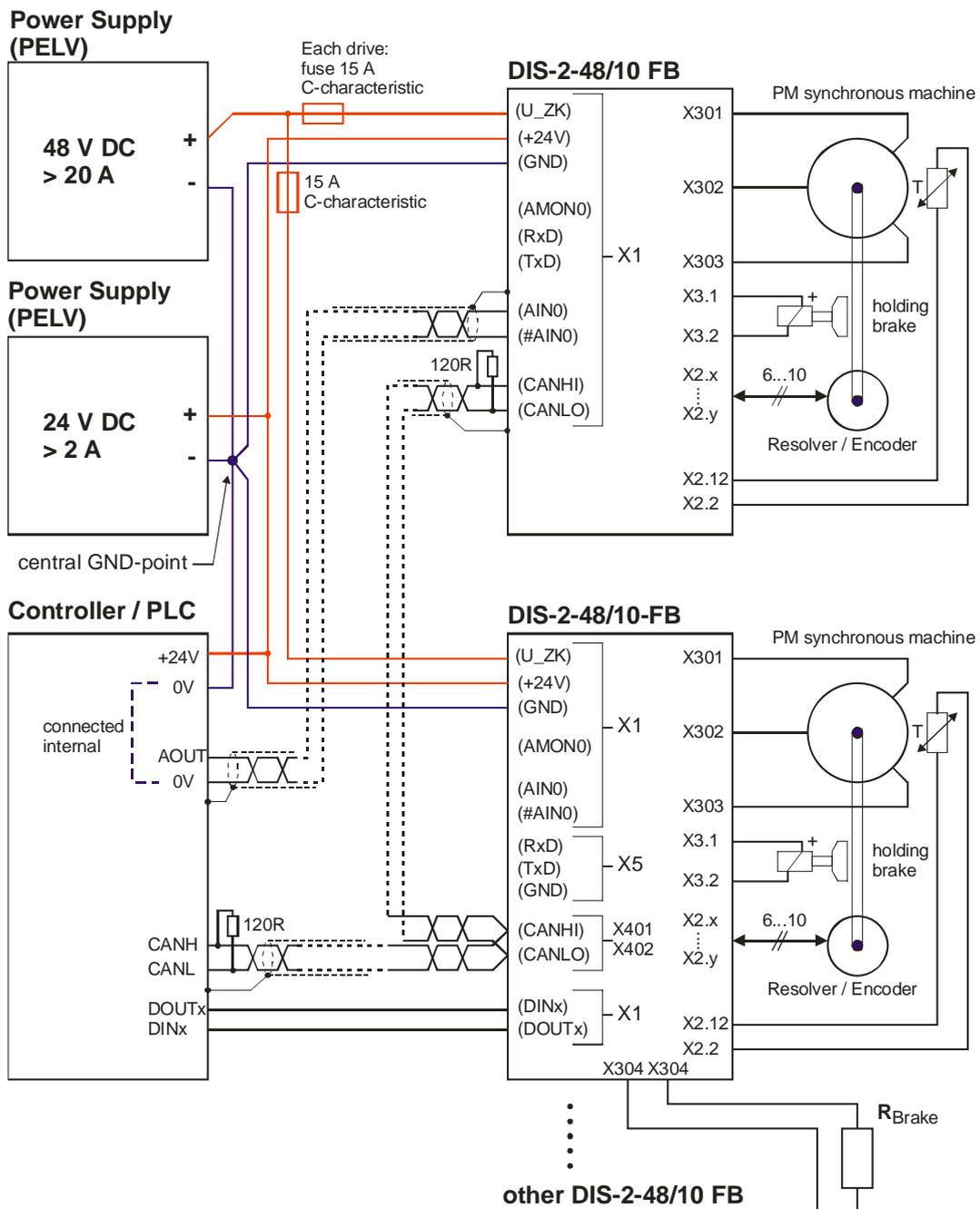
Figure 24:   **Connection to power supply, control and motor**

The servo drive is connected to the 48 V intermediate circuit supply and to the 24 V logic supply. A shared reference potential (GND) is used. A central star point near the power supply units for all GND connections reduces the "ground bouncing" effects between the servo drives.

The motor has to be connected through the FASTONs [X301] to [X303] on the circuit board of the DIS-2. The DIS-2 controls an optional holding brake through connector [X3]. The encoder and the temperature sensor have to be connected through the recessed connector [X2] on the circuit board.

The DIS-2-48/10 FB FS STO has an additional integrated brake chopper. It is therefore possible to connect the braking resistor through the FASTONs [X304] and [X305] on the circuit board as shown in *Figure 24* on the bottom right. Normally, the braking resistor is installed on the mounting plate for the electronics housing.

⚠	**DANGER!**
	Only use the brake resistor that is approved by the manufacturer. The used brake resistor must have a high pulse loading capacity to be able to permanently withstand the short peak loads. Unsuitable brake resistors will fail prematurely; they can cause fires and even electrical hazards! Consecutively, the user is at risk of being harmed, too.

If the analogue inputs are used to assign setpoints, we recommend using shielded and twisted cables for AINx / #AINx, even if the control does not provide any differential signal. Connection of #AINx to the 0V reference potential at the control system prevents common-mode interferences which are caused by high currents flowing through the power stage and the external cables. The shield prevents the penetration of interferences and should be connected on both ends (to the housing of the DIS-2 48/10 FB FS STO servo drive and to the housing of the control system).

The wiring of the fieldbus should be done in the same way as the wiring of the analogue inputs. At both ends of the network, for example for the CAN bus (120 Ω / 1%), a termination resistor is needed. The fieldbus is looped through the DIS-2 48/10 FB FS STO via the fieldbus connectors [X401] und [X402].

The DIS-2 48/10 FB FS STO has a separate connector, [X5], for the serial service interface to be connected to a PC. This enables the parameterisation and analysis using the DIS-2 ServoCommander^{TM} or the control of the servo drive. [X5] is part of the fieldbus module and is looped through to the basic device.

The signals for the digital IOs, DINx and DOUTx, do not need a shield to protect them against interferences, but a shielded cable between the DIS-2 servo drive and the control system improves the EMC behaviour throughout the entire system, particularly in view of radiated interferences. At least the control signals DIN9 (servo drive enable) and DOUT0 (ready for operation) have to be connected between the PLC and the servo drive.

For synchronization, DIN4, 5 and 6 are used as incremental encoder inputs and DOUT1 and DOUT2 are used as incremental encoder outputs.

Make sure that the servo drive is completely wired prior to switching on the power supply for the intermediate circuit (DC bus) and the logic system. If the 24 V DC power supply connections are reversed, if the power supply is too high or if the connections of the intermediate supply and the logic supply are mixed up, the DIS-2 48/10 FB FS STO servo drive may be permanently damaged.

Verify that the power supply used for the power and for the logic part fulfil the specifications for the DIS-2 48/10 FB FS STO and are correspondingly resistant:

see *Table 7:   Technical data: Performance data power supply [X1]*

All power supply units must have PELV (Protective Extra Low Voltage).

Intermediate supply: 48 V DC (PELV)

Logic supply: :   24 V DC (PELV)

DANGER!

Wrong connections around the power supply can destroy the servo drive DIS-2 48/10 FB FS STO when the power is switched on. This is particularly true for the connection of the mains, the protection earth, the motor phases and the brake resistor.

Also high voltages lead to the destruction of the device. A high power can occur if the neutral conductor is not loadable, or a neutral conductor interruption occurs in the wiring cabinet or externally!

8.2   Connectors on the basic device
         DIS-2 48/10 FB FS STO

8.2.1   Connection: Power supply and I/O [X1]

Configuration on the device [X1]:   Phoenix PLUSCON – VARIOCON with a total of 18 contacts

Counterplug [X1]:   Phoenix PLUSCON – VARIOCON kit,
                                         consisting of: 1x VC-TFS2
                                                             2x VC-TFS8
                                                             1x VC-TR2/3M
                                                             1x VC-MEMV-T2-Z
                                                             1x VC-EMV-KV-PG21-(11,5-15,5/13,5)

                                                         Dimensions approximately
                                                         H x W x DH = 86 mm x 80 mm x 32 mm
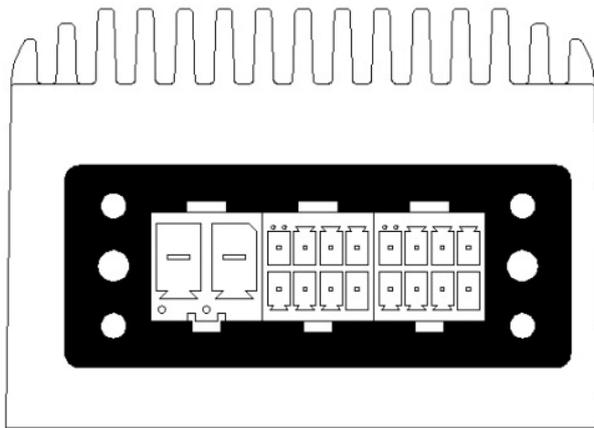
C		B				A			
2	1	8	7	6	5	8	7	6	5
		4	3	2	1	4	3	2	1

Figure 25:   **Connection and pin numbering [X1]**

Table 31:   Pin assignment [X1]

Pin No.	Denomination	Values	Specification
A1	DOUT0 / READY	0 V / 24 V	Ready for operation
A2	DIN8	0 V...24 V	Digital input: Limit switch 1 (blocks n > 0)
A3	DIN5	0 V...24 V	Digital input: Positioning group selector Bit 1 / Incremental encoder input track B
A4	#AIN1(DIN3)	-10 V...10 V (0 V...24 V)	Inverted analogue input 1: Differential analogue input with AIN1 or (Digital input: Positioning destination selector Bit 3)
A5	DIN9	0 V...24 V	Digital input: Power stage activation
A6	DIN7	0 V...24 V	Digital input: Limit switch 0 (blocks n < 0)
A7	DIN4	0 V...24 V	Digital input: Positioning group selector Bit 0 / Incremental encoder input track A
A8	AIN1 (DIN2)	-10 V...10 V (0 V...24 V)	Analogue input 1: Differential analogue input with #AIN1 or (Digital input: Positioning destination selector Bit 2)
B1	#AIN0 (DIN1)	-10 V...10 V	Inverted analogue input 0: Differential analogue input with AIN0 or (Digital input: Positioning destination selector Bit 1)
B2	DOUT2	0 V...24 V	Digital output programmable / encoder output track B
B3	AMON0	0 V...10 V; 2 mA	Analogue output 0
B4	GND	0 V	Reference potential for the control signals
B5	AIN0 (DIN0)	-10 V...10 V	Analogue input 0: Differential analogue input with #AIN0 or (Digital input: Positioning destination selector Bit 0)
B6	DOUT1	0 V...24 V	Digital output programmable / encoder output track A#
B7	DIN6	0 V...24 V	Digital input: Positioning start / Incremental encoder track N
B8	+24V logic	+24 V / I_{logic} = 200 mA...1000 mA	24 V power supply for the internal logic and the IOs.
C1	**GND**	**0 V**	**Shared ground potential for the intermediate circuit voltage (DC bus voltage) and the 24V logic supply.**
C2	ZK+	+48 V / 15 $A_{nom.}$	Intermediate circuit supply (DC bus)

8.2.2   Connection: Motor [X301-X303]

Configuration on the device [X301 – X303]:   6.3 mm FAST-ON male

Counterplug [X301 – X303]:   6.3 mm FAST-ON female (insulated externally)
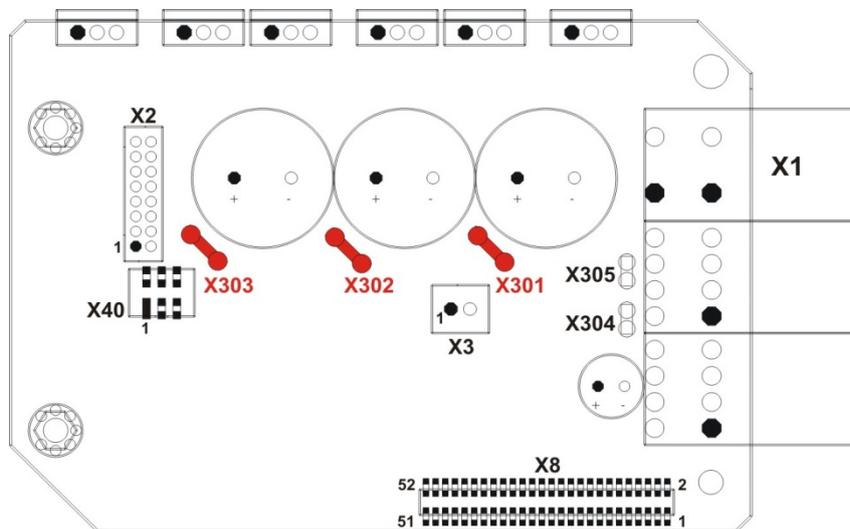
Figure 26:   **Position and connection motor cable**

Table 32:   **Pin assignment [X301 – X303]**

[X30x]	Denomination	Values	Specification
[X301]	PHASE_U	3 x 0 V...48 V	
[X302]	PHASE_V	15 $A_{RMS,nom}$ 40 $A_{RMS,max}$	Connection of the three motor phases
[X303]	PHASE_W	0 Hz...200 Hz	

8.2.3   Connection: Angle encoder [X2]

Configuration on the device [X2]:   JST No. B16B-PHDSS
Counterplug [X2]:   JST No. PHDR-16VS / contacts: JST No. SPHD-002T-P0.5
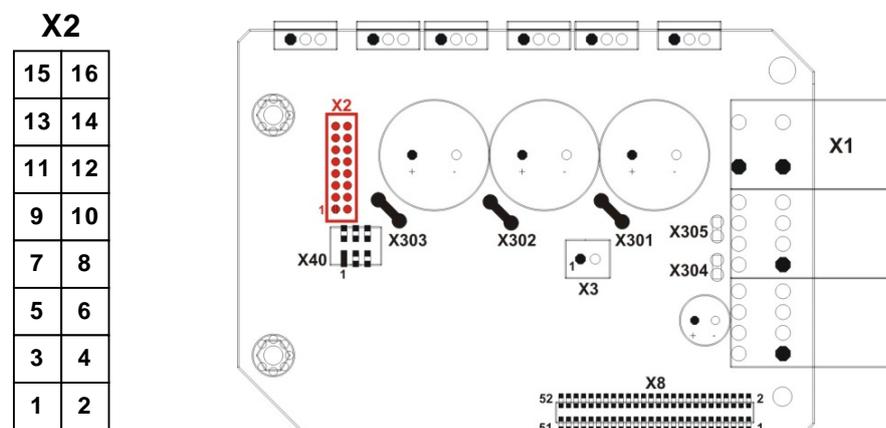
Figure 27:   **Position and connection angle encoder**

Table 33:   Pin assignment [X2]

Pin No.	Denomination		Values	Specification
1	GND		0 V	Reference potential for incremental encoder / analogue Hall sensors / Stegmann HIPERFACE® encoder
	2	GND		0 V	Reference potential for Hall sensors and / or motor temperature sensor
3	+5V		+5 V / 100 mA	+5 V supply for linear Hall sensors or incremental encoder
	4	+5V		+5 V / 100 mA	+5 V supply for Hall sensors
5	COS	A	1.5 $V_{RMS,diff}$ / $R_i > 10$ kΩ	Connection to resolver signal S1 or connection to incremental encoder track A
	6	HALL_U		0 V / 5 V $R_i = 5$ kΩ	Phase U Hall sensor for commutation Input with 4,7 kΩ pull-up at +5 V
7	#COS	#A	1.5 $V_{RMS,diff}$ / $R_i > 10$ kΩ	Connection to resolver signal S3 or connection to incremental encoder track #A
	8	HALL_V		0 V / 5 V $R_i = 5$ kΩ	Phase V Hall sensor for commutation Input with 4,7 kΩ pull-up at +5 V
9	SIN	B	1.5 $V_{RMS,diff}$ / $R_i > 10$ kΩ	Connection to resolver signal S2 or connection to incremental encoder track B
	10	HALL_W		0 V / 5 V $R_i = 5$ kΩ	Phase W Hall sensor for the commutation Input with 4,7 kΩ pull-up at +5 V
11	#SIN	#B	1.5 $V_{RMS,diff}$ / $R_i > 10$ kΩ	Connection to resolver signal S4 or connection to incremental encoder track #B
	12	MTEMP		0 V / 3.3 V $R_i = 2$ kΩ	Motor temperature sensor, normally-closed contact, PTC, or analogue sensor of KTY series; connected to GND
13	REF	N	3 $V_{RMS,diff.}$ max. 50 mA$_{RMS}$	Connection to resolver signal R1 or connection to incremental encoder track N / DATA
	14	+12V		+12 V / 100 mA	+12 V power supply for Stegmann HIPERFACE® encoder
15	#REF	#N	3 $V_{RMS,diff.}$ max. 50 mA$_{RMS}$	Connection to resolver signal R2 or connection to incremental encoder track #N / #DATA
	16	n.c.		-	-

8.2.4   Connection: Holding brake [X3]

Configuration on the device [X3]:   JST No. BH02B-XASK-BN (High Box Type)

Counterplug [X3]:   JST No. XAP-02V-1 with 2 contacts

JST No. SXA-001T-P0.6
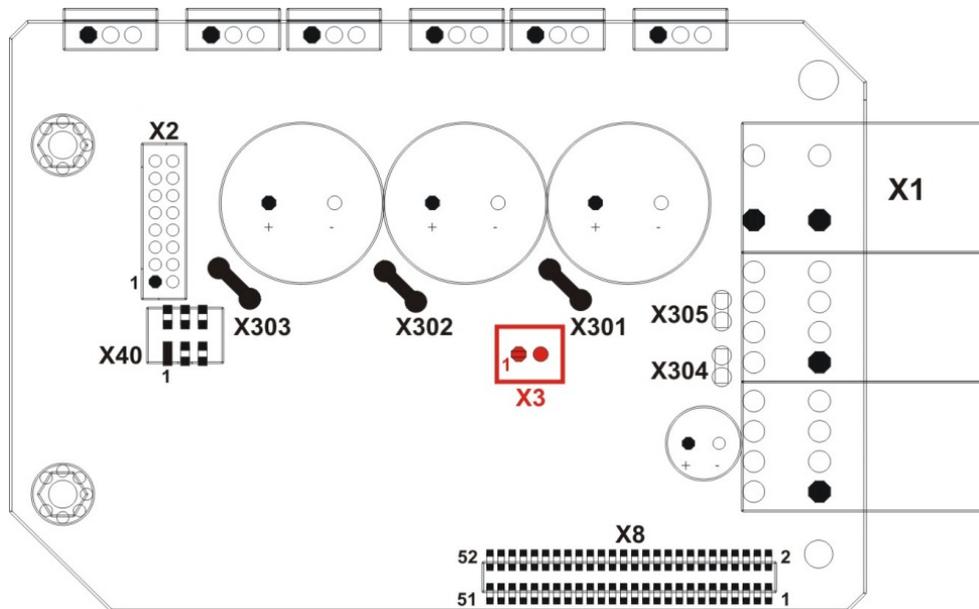
Figure 28:   **Position and connection holding brake**

Table 34:   **Pin assignment [X3]**

Pin No.	Denomination	Values	Specification
1	DOUT3	0 V / 24 V max. 500 mA	Digital output: (high active) for the holding brake, internal supply via the 24 V logic supply.
2	GND	0 V	Reference potential for the holding brake

8.2.5   Connection: Brake resistor [X304, X305]

Configuration on the device [X304, X305]:   2.8 mm FAST-ON male

Counterplug [X304, X305]:   2.8 mm FAST-ON female (insulated externally)

Configuration brake resistor: see accessories in *section 1.2, Table 4*
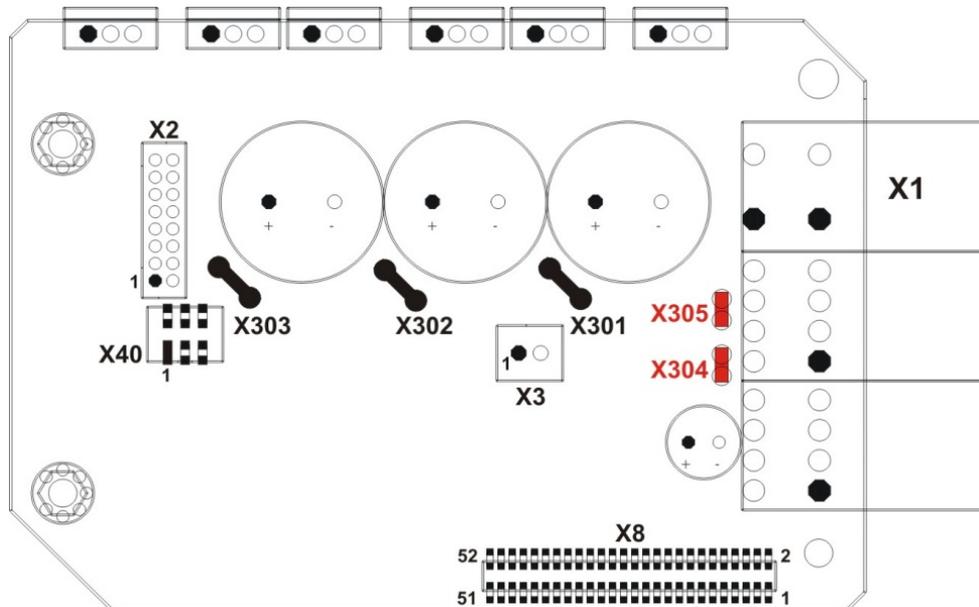
Figure 29:   **Position and connection brake resistor**

Table 35:   **Pin assignment [X304, X305]**

[X30x[	Denomination	Values	Specification
[X304[	ZK+	+48 V / 10 A$_{nom.}$	Intermediate circuit supply (DC bus)
[X305]	BR-CHOP	0 V / 48 V	Connection to brake resistance transistor

8.2.6   Connection: Extension port [X8]

Configuration on the device [X8]:   2 x 26 RM 1.27 mm pin row with protective collar
Counterplug [X8]:   2 x 26 RM 1.27 mm socket row
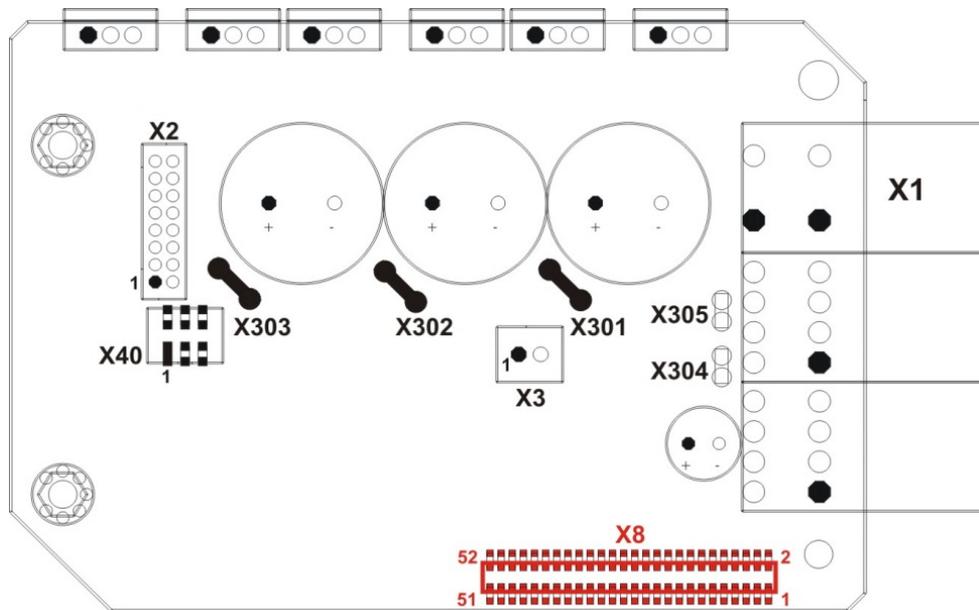
Figure 30:   Position and connection technology module interface

Table 36:   Pin assignment [X8]

Pin No.		Denomination	Values	Specification
1		n.b.	All signals with 3,3 V CMOS logic level	Not used
	2	+24 V	+ 24 V / max. 100 mA	Withdrawal of the protected logic supply of + 24 V for future applications / device variants
3		DIN8	0 V / 24 V	Digital 24 V input for limit switches, parallel to [X1]
	4	DIN7	0 V / 24 V	Digital 24 V input for limit switches, parallel to [X1]
5		GND	0 V	Reference potential
	6	GND	0 V	Reference potential
7		RxD	+/- 10 V	Serial interface signal RxD
	8	TxD	+/- 10 V	Serial interface signal TxD
9		CANHI_NDR	0 V / 5 V	Field bus signal CAN_H before „filter"
	10	CANLO_NDR	0 V / 5 V	Field bus signal CAN_L before „filter"
11		+3.3 V	3,3 V +/- 2%	Technology module power supply 100 mA max. (together with 5 V)
	12	+5 V	5,0 V +/- 5%	Technology module power supply 100 mA max. (together with mit 3.3 V)

Continuation of the table: Pin assignment [X8]

Pin No.		Denomination	Values	Specification
13		D14		
	14	D15		
15		D12		
	16	D13		
17		D10		
	18	D11		
19		D8		
	20	D9	All signals with 3,3 V CMOS logic level	16-bit parallel interface data bus
21		D6		
	22	D7		
23		D4		
	24	D5		
25		D2		
	26	D3		
27		D0		
	28	D1		
29		A11		
	30	A12		
31		A9		
	32	A10		
33		A7		
	34	A8	All signals with 3,3 V CMOS logic level	16-bit parallel interface – address bus
35		A5		
	36	A6		
37		A3		
	38	A4		
39		A1		
	40	A2		
41		#DS		
	42	A0		
43		#RD		Bus control signals for access to technology modules via the data and address bus, and synchronous-serial interface for access to technology modules with an SSIO interface
	44	#WR		
45		#IRQB (SYNC)	All signals with 3,3 V CMOS logic level	
	46	#IRQA		
47		MOSI		
	48	SCLK		
49		MISO		
	50	#SS		
51		GND	0 V	Reference potential
	52	GND	0 V	Reference potential

8.2.7   Connection: Safe Torque Off (STO) [X40] and [X40A]

For further information concerning the safety function please refer to *chapter 6*.

Configuration on the device [X40]:   Molex No. 87832-0614

Counterplug [X40]:   Molex No. 51110-0660 with up to 6 contacts

                                                                    Molex No. 50394-8051

Configuration on the mounting plate [X40A]:   for example: PhoenixContact M12 socket

                                                                    (SACC-DSI-FS-5P-PG 9/0,5 SCO 0,25), rear panel
                                                                    5-pin-type A-coded

Counterplug [X40A]:   for example: M12 plug with xx m cable length:
                                                                    SAC-5P-MS/xx-PUR SAC

Length in metres	Order number
1,5	1518960
5,0	1518986
10.0	1518999

Example for [X40A]:

The counterplug Molex No. 51110-0660 mentioned above is attached to the free cable ends.
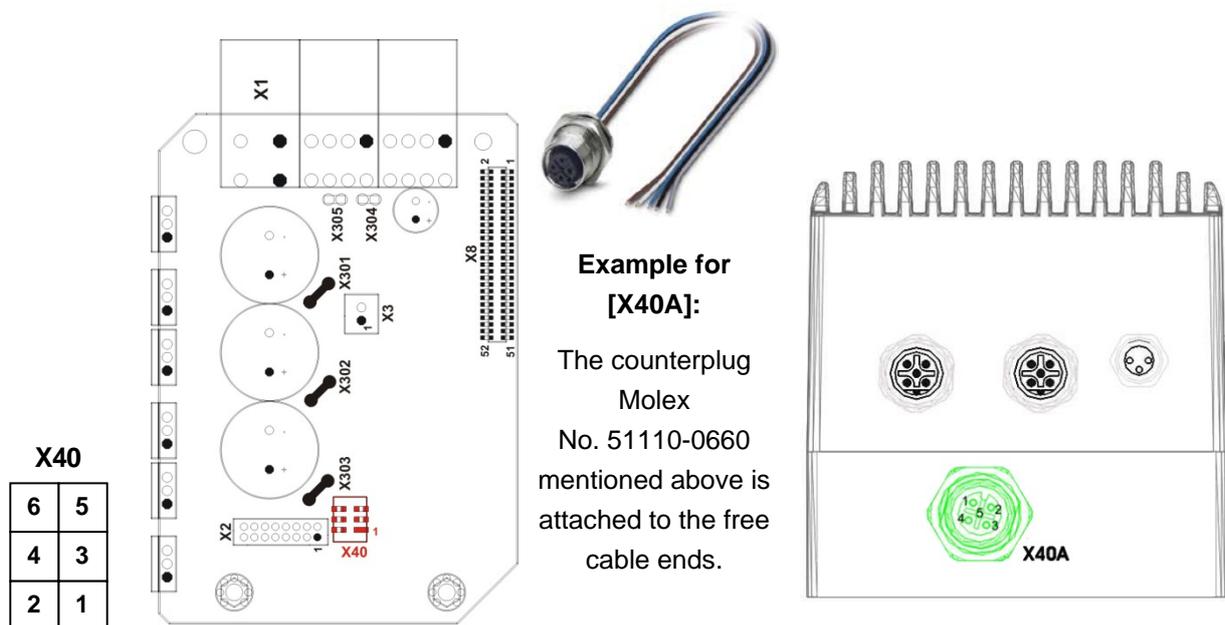
Figure 31:   Position and connection STO signals [X40] and [X40A]

Table 37:   Pin assignment [X40]

Pin No.		Denomination	Values	Specification
1		STO1	0 V / 24 V	Control input 1 for STO function
	2	GND		Corresponding GND for STO1 and STO2
3		+24V	+24 V / +/-20%	Internal logic supply +24V
	4	REL1		Normally open contact for feedback STO to an external control system
5		STO2	0 V / 24 V	Control input 2 for STO function
	6	REL2		Normally open contact for feedback STO to an external control system

Table 38:   Pin assignment [X40A]

Pin No.		Denomination	Values	Specification
1		STO1	0 V / 24 V	Control input 1 for STO function
	2	STO2	0 V / 24 V	Control input 2 for STO function
3		REL1		Normally open contact for feedback STO
	4	REL2		Normally open contact for feedback STO
5		GND		Corresponding GND for STO1 and STO2

8.3 Connectors field bus modules DIS-2 48/10 FB FS STO

The following types of technology modules can be integrated into the basic device DIS-2 48/10 FB FS STO. The modules are factory assembled according to the order. The RS232 interface is integrated in each technology module.

8.3.1 Connection: Serial interface [X5]

Configuration on the device: M8 flush-type socket, 3-pin type

Counterplug [X5]:   M8 counterplug for free configuration, for example
                                      Phoenix, order number 1506901 or
                                      see accessories *section 1.2, Table 4*
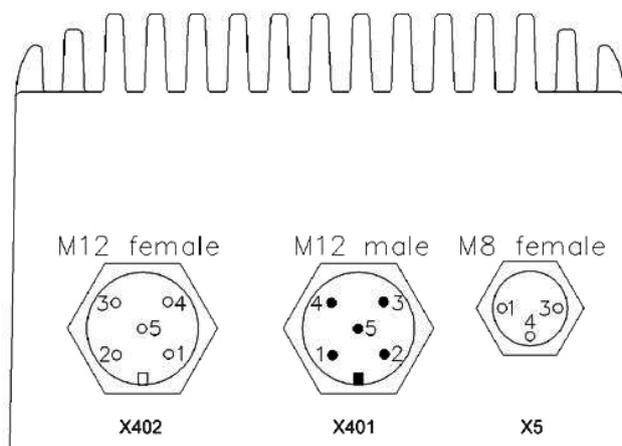
Figure 32:   **Position and connection RS232 interface**

Table 39:   Pin assignment [X5]

Pin No.	Denomination	Values	Specification
1	RxD	+/-10 V	Receive signal, RS232 specification
3	TxD	+/-10 V	Transmit signal, RS232 specification
4	GND	0 V	Reference potential for the serial interface, internally connected with the common reference potential for the logic system

Table 40:   **Pin assignment to set up an RS232 adapter cable for connection to a PC/notebook**

[X5] pin assignment at DIS-2 48/10-FB		D-SUB 9 connector (pin) for connection to a PC		Specification
Pin No.	Denomination	Pin No.	Denomination	Specification
1	RxD	3	TxD_PC	Transmit signal, RS232 specification
3	TxD	2	RxD_PC	Receive signal, RS232 specification
4	GND	5	GND	Reference potential for the serial interface, internally connected with the common reference potential for the logic system
-	Shield		Shield	Connect the cable shield on both sides of the connector housing

8.3.2   Connection: CANopen [X401] and [X402]

Configuration on the device: [X401]   M12 flush-type plug, 5-pin type, A-coded

                                       [X402]   M12 flush-type socket, 5-pin type, A-coded

Counterplug: Assembled M12 bus cable, for example made by Phoenix, one end male connector, one end female connector, pre-fabricated lengths, order name: SAC-5P-MS/xxx-920/FS SCO

                                       xxx defines the length in [m]. The following lengths are available:

                                       xxx = 0,3 / 0,5 / 1,0 / 2,0 / 5,0 / 10,0 / 15,0

Length in metres	Order number	Length in metres	Order number
0,3	1518258	5	1518290
0,5	1518261	10	1518300
1,0	1518274	15	1518813
2,0	1518287		

Terminating resistor CANopen M12:   Order number: 1507816
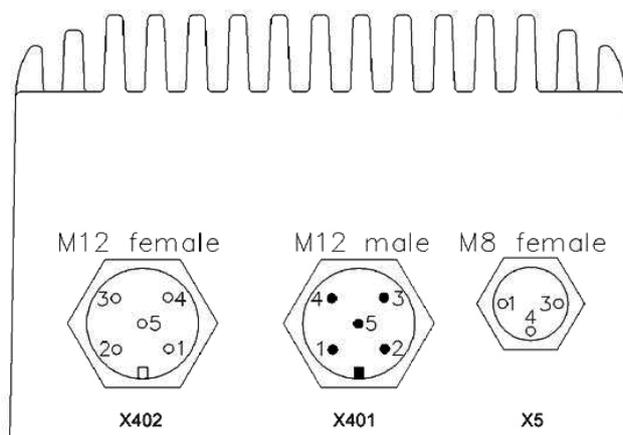
Figure 33:   **Position and connection CAN interface**

Table 41:   **Pin assignment [X401] and [X402]**

Pin No.	Denomination	Values	Specification
1	Shield	PE	Contact for cable shield, in the DIS-2 48/10 FB FS STO connected with the housing
2	--	-	Not used
3	CAN_GND	0 V	Reference potential for the CAN bus, internally connected with the common reference potential for the logic system
4	CANHI	0 V 5 V	Signal CAN_H according to CAN-Bus specification
5	CANLO	0 V 5 V	Signal CAN_L according to CAN-Bus specification

8.3.3   Connection: PROFIBUS [X401] and [X402]

The PROFIBUS interface at the servo drive DIS-2 48/10 FB FS STO is configured according to EN 50170 as a 5-pole M12 plug, B-coded at the technology module as plug and socket.

Configuration on the device: [X401] M12 flush-type plug, 5-pin type, B-coded

                                       [X402] M12 flush-type plug, 5-pin type, B-coded

Counterplug: Assembled M12 bus cable, for example made by Phoenix, one end female connector straight, shielded M12-B-coded, 2-pin type, other end male connector straight, shielded M12-B-coded, 2-pin type, pre-fabricated lengths, order name: SAC-5P-MS/xxx-920/FS SCO

                                       xxx defines the length in [m]. The following lengths are available:

                                       xxx = 0.3 / 0.5 / 1.0 / 2.0 / 5.0 / 10.0 / 15.0

Length in metres	Order number
0,3	1518106
0,5	1518119
1,0	1518122
2,0	1518135

Length in metres	Order number
5	1518148
10	1518151
15	1518164

Terminating resistor PROFIBUS M12:   1507803
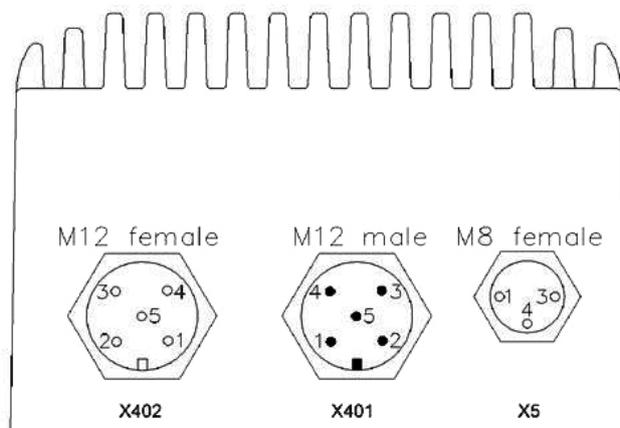
Figure 34:   Position and connection PROFIBUS interface

Table 42:   Pin assignment [X401] and [X402]

Pin No.	Denomination	Values	Specification
1	+5V	+5V	
2	A-line	green	Signal A according to the PROFIBUS specification
3	0V	0 V	Internally connected with the common reference potential for the logic system
4	B-line	red	Signal B according to the PROFIBUS specification
5	Shield	PE	Contact for cable shield, in the DIS-2 48/10 FB FS STO connected with the housing

8.3.4   Connection: EtherCAT [X401] and [X402]

The EtherCAT interface at the servo drive DIS-2 48/10 FB FS STO is configured according to IEC 61076-2-101 as a 4-pole M12 socket, shielded and D-coded at the technology module.

Configuration on the device: [X401]   M12 flush-type plug, 4-pin type, D-coded

                                      [X402]   M12 flush-type plug, 4-pin type, D-coded

Position: [X401]   front – middle

                                      [X402]   front – left

Counterplug: Assembled M12 Bus cable for example made by Phoenix Contact, shielded M12, D-coded, 4-pin type cable pre-fabricated lengths, order number:

Length in metres	Order number
0,3	1523065
0,5	1523078
1,0	1523081
2,0	1521533

| Length in metres	Order number
5	1524051
10	1524064
15	1524077
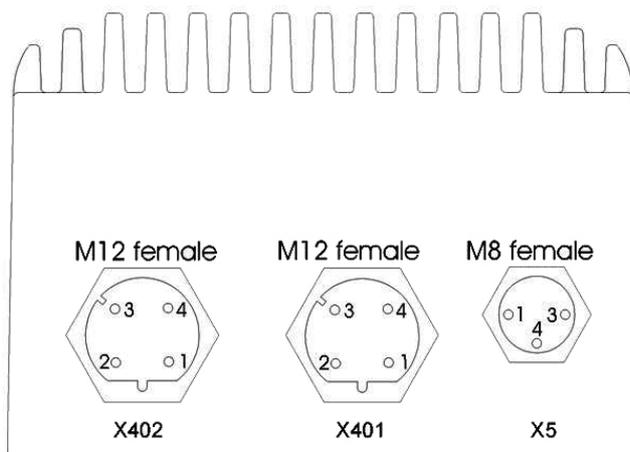
Figure 35:   **Position and connection EtherCAT interface**

Table 43:   **Pin assignment [X401] and [X402]**

Pin No.	Denomination	Values	Specification
1	TX+	0 ... 2,5 VDC	Transmission Data +
2	RX+	0 ... 2,5 VDC	Receive Data +
3	TX-	0 ... 2,5 VDC	Transmission Data -
4	RX-	0 ... 2,5 VDC	Receive Data -

8.4   Notes concerning the safe and EMC-compliant installation

8.4.1   Explanations and terminology

Electromagnetic compatibility (EMC) or electromagnetic interference (EMI) includes the following requirements:

❖ Sufficient **immunity** of an electrical installation or electrical device against external electrical, magnetic, or electromagnetic interferences via cables or the environment.

❖ Sufficiently small **emission** of electrical, magnetic, or electromagnetic interference of an electrical installation or electrical device to other devices in the vicinity via cables or through the environment.

8.4.2   General information concerning EMC

The interference emission and interference immunity of a servo drive always depends on the overall drive concept that includes the following components:

❖ Power supply

❖ Servo drive

❖ Motor

❖ Electromechanical system

❖ Configuration and type of wiring

❖ Superordinated control system

DIS-2 servo drives have been qualified in accordance with the product standard EN 61800-3 for electrical drives.

In most cases, no external filter measures are required (see below).

The declaration of conformity for the EMC directive 2004/108/EC is available from the manufacturer.

Caution!

In a residential (i.e. non-industrial) environment, this product can cause high-frequency interferences that may require interference suppression measures.

8.4.3   EMC ranges: First and second environment

The DIS-2 48/10 FB FS STO servo drive fulfils the requirements of the applicable product standard EN 61800-3 if the servo drive is installed in a suitable manner and if all of the connecting lines are wired in an equally suitable manner. This standard no longer refers to "limit value classes", but to so-called environments. The first environment includes mains supply networks that supply residential buildings. The second environment includes mains supply networks that supply only industrial buildings. In addition, these environments have been divided into interference emission categories:

First environment, restricted availability   → category C2 (rated voltage < 1000 V)

Second environment   → category C3 (rated voltage < 1000 V)

8.4.4   EMC-compliant cabling

8.4.4.1   Connection between the DIS-2 and the motor

If the DIS-2 servo drive is mounted directly on the motor, the cables are located inside the housing. They are only a few cm long. In this case, shielding is not necessary.

If you want to mount the motor and the DIS-2 separately, please observe the following wiring instructions:

❖   Use shielded cables only. The encoder cables should have an internal and an external shield.

❖   Use separate cables for the motor phases and the angle encoder.
     Alternative: Use a combined cable for the motor and the angle encoder, but with separate shields.

❖   Connect all (external) shields with the housing of the DIS-2 servo drive.

❖   Connect the shield of the motor cable with the motor housing.

❖   Connect the internal shield of the encoder cable to PIN 1 of [X2].

❖   Make sure to set up a "good" PE connection between the motor and the DIS-2 servo drive.

> A "good" PE connection only has a low impedance even in the case of very high interference frequencies. An optimum PE connection can be obtained by mounting the DIS-2 servo drive directly on the motor. If you want to mount the DIS-2 servo drive and the motor separately, make sure to mount them on the same (metal) part of the machine. In this case, the surface of the machine part should be made of uncoated aluminium or galvanized sheet metal!

8.4.4.2   Connection between DIS-2 and power supply

❖ Use cable with a sufficient cross-section to reduce "ground bouncing" effects on the DC bus supply (intermediate circuit supply):
2.5 mm² (AWG13) should be sufficient for a cable length of up to 5 m between the power supply unit and the DIS-2 servo drive.

❖ Use a star-shaped cable layout (see *section 8.1 Connection to power supply, control and motor)* if you want to connect several DIS-2 servo drives to one power supply unit. The star point of the reference potential should be as close as possible to the power supply unit.

❖ The power supply unit should have Y-capacitors of at least 100 nF between the DC bus voltage (intermediate circuit voltage) and PE as well as between GND and PE.

❖ Make sure to set up a "good" PE connection between the DIS-2 servo drive and the power supply unit. It is important to ensure a good feedback of the high-frequency leakage currents generated by the clocked power stage in the DIS-2 servo drive combined with the winding capacity between the motor phase and PE in the motor.

❖ To make sure that the radiation limits are complied with, use a shielded cable.

The device variants DIS-2 48/10 FB use Pluscon Variocon connectors made by Phoenix for [X1]. If the recommended metal connector housings (see also *section 8.2.1*) are used, a good PE connection is ensured by the design of the housing. It is sufficient to connect the shield to the connector housing of the counterplug.

> A "good" PE connection only has a low impedance even in the case of very high interference frequencies. Mounting the DIS-2 servo drive and the power supply unit to the same (metal) part of the machine is sufficient for most cases. If not, use a flexible copper strip (width approx. 10 mm) or a connecting cable with a Cu cross-section of at least 6 mm^2 to set up a PE connection.

> **DANGER!**
> For safety reasons, all PE ground conductors must be connected prior to initial operation.
> The regulations of EN 61800-5-1 concerning protective grounding must be complied with during installation!

9   Start-up

9.1   General connection notes

> ℹ️ Since the way the connecting cables are laid is highly important for EMC considerations, ensure to comply with the information that is given in *section 8.4 Notes concerning the safe and EMC-compliant installation*!

> ⚠️ **DANGER!**
>
> Non-compliance with the safety instructions that are stated in *chapter 2 Safety notes for electrical drives and controllers* may result in damage to property, injuries, electric shock or, in extreme cases, in death.

9.2   Tools/material

❖ PC with the parameterisation software DIS-2 ServoCommander™

❖ Serial interface cable

❖ DIS-2 48/10 FB FS STO control panel or control unit

❖ Power supply cable

❖ Screwdriver or Allen key, depending on the screws with which the DIS-2 48/10 FB FS STO is fastened on the motor

9.3   Connecting the DIS-2 48/10 FB FS STO servo drive to the motor

❖ Connect the connector (see the connector set in *section 1.2 Scope of supply*) to the motor cable and connect it to the corresponding interface [X301-X303] on the DIS-2 48/10 FB FS STO.

❖ Connect the connector (see the connector set *1.2 Scope of supply*) to the encoder cable and, if included, also to the motor temperature sensor. Then, connect it to the corresponding interface [X2] on the DIS-2 48/10 FB FS STO and let it lock into place.

❖ Connect the connector (see the connector set *1.2 Scope of supply*) to the cable of the holding brake (if necessary). Then, connect it to the corresponding interface [X3] on the DIS-2 48/10 FB FS STO and let it lock into place.

❖ Screw the braking resistor (see the accessories *1.2 Scope of supply*) (if necessary) onto the mounting plate. Connect it to the corresponding interface [X304, X305] on the DIS-2 48/10 FB FS STO and let it lock into place.

❖ Check all of the plug-in connections.

9.4   Connecting the DIS-2 48/10 FB FS STO servo drive to the power supply and to the control panel or control unit

❖   Ensure that the power supply is switched off.

❖   Connect the connector [X1] to the DIS-2 48/10 FB FS STO servo drive. Alternatively, the control panels can also be connected via [X1].

❖   If applicable, connect the superordinate control system to the fieldbus interface [X401] / [X402].

❖   If applicable, connect the connector of the integrated "Safe Torque Off" (STO) system [X40] or [X40A]. See also the note in *section 6.2.2*.

❖   Connect the 24 V connectors to a suitable power supply unit.

❖   Make the mains supply connections.

❖   Check all of the plug-in connections.

9.5   Connecting the PC

❖   Plug the connector of the serial interface cable (see the accessories *1.2 Scope of supply*) into the port for the serial interface [X5] of the DIS-2 48/10 FB FS STO.

❖   Plug the D-Sub connector of the serial interface cable into an RS232 port of the PC.

❖   Check all of the plug-in connections.

The rest of the procedure is described in the software manual.

9.6   Checking whether the system is ready for operation

1.   Ensure that the servo drive enabling (DIN9) is inactive (LOW).

2.   Switch the power supply of all of the devices on.

3.   Start the DIS-2 ServoCommander™.

4.   The communication with the servo drive will be started.

5.   Parameterise the servo drive depending on the application.

If the communication with the servo drive could not be started, there is a malfunction. Perform the following steps:

1.   Switch the power supply off.

2.   Check all of the connecting cables.

3.   Check whether the 24 V power supply operates correctly.

4.   Switch the power supply on.

10   Service functions and error messages

10.1   Protection and service functions

10.1.1   Overview

The DIS-2 48/10 FB FS STO servo drive has an extensive sensor system that monitors the controller unit, power output stage, motor, and the communication with the outside world. Errors that occur will be stored in the internal error memory. Most errors will cause the controller unit to shut down the servo drive and power output stage. The servo drive can only be switched on again after the error memory has been erased by an acknowledgement and after the error has been eliminated or ceased to exist.

Operational safety is ensured by an extensive sensor system and numerous monitoring functions:

❖ Measurement of the motor temperature

❖ Measurement of the power unit temperature

❖ Measurement of the temperature inside the housing

❖ Detection of earth faults (PE)

❖ Detection of connections between two motor phases

❖ Detection of a short circuit of the braking resistor

❖ Detection of undervoltage/overvoltage in the intermediate circuit

❖ Detection of errors concerning the internal voltage supply

❖ Measurement of the average power loss (I²t monitoring) of the servo drive and motor

❖ Detection of errors during the current measurement process

❖ Detection of errors of the rotary encoder

❖ Detection of errors during the motor identification process

❖ Monitoring of the motion sequence

❖ Detection of internal errors

❖ Monitoring of the STO functionality

10.1.2   Overcurrent and short-circuit monitoring

❖ **Overcurrent and short-circuit monitoring:** The overcurrent and short-circuit monitoring system responds as soon as the current in the intermediate circuit exceeds two times the maximum current of the servo drive. It detects short circuits between two motor phases and short circuits at the motor output terminals against the positive and negative reference potential of the intermediate circuit and against PE. If the error monitoring system detects an overcurrent, the power output stage will be shut down immediately to guarantee resistance against short circuits. In addition, a short circuit of the braking resistor while the brake chopper is active will also be detected.

❖ **I²t current monitoring with a warning of the servo drive:** The DIS-2 48/10 FB FS STO servo drive has an I²t monitoring system to limit the average power loss in the power output stage. Since the power loss in the electronic power system and in the motor increases in a square manner with the current in the worst case, the squared current value is taken as the measure for the power loss. When 80% of the maximum integrated value is reached, a warning (parameterisable) will be issued. When 100% is reached, the maximum current will be limited to the rated current.

❖ **Check of the current measurement and offset calibration when the power stage is turned on:** When the power stage is switched on, an automatic offset calibration of the current measurement will be performed. If the offset is beyond the permissible tolerances, an error will be generated.

10.1.3   Monitoring of the intermediate circuit voltage

❖ **Overvoltage monitoring:** The overvoltage monitoring system of the intermediate circuit responds as soon as the intermediate circuit voltage exceeds the operating voltage range. As a result, the power output stage will be switched off.

❖ **Undervoltage monitoring:** The system checks whether the intermediate circuit voltage is above a certain minimum limit (parameterisable). For applications requiring the intermediate circuit to be run "empty" or a set-up process with a reduced intermediate circuit voltage, the response to this error can be configured accordingly.

10.1.4   Logic supply monitoring

❖ **24 V overvoltage/undervoltage monitoring:** The supply of the logic component of the DIS-2 48/10 FB FS STO servo drive is monitored. If the power supply of the logic component is too high or too low, an error message will be issued.

❖ **Internal operating voltages:** All of the operating voltages that are generated internally, e.g. the 3.3 V supply of the processor, are monitored.

10.1.5   Monitoring of the heat sink/housing temperature

❖ **Temperature derating:** The permissible maximum current will be reduced at high temperature levels in order to ensure a long service life of the servo drive.

❖ **Shut-down at overtemperature:** The heat sink temperature of the power output stage is measured with a linear temperature sensor. When the temperature limit is reached, an error message will be issued. In addition, a temperature warning will be issued when the temperature is approximately 5°C below the limit value.

10.1.6   Motor monitoring

❖ **Monitoring of the rotary encoder:** An error of the rotary encoder leads to the shut-down of the power output stage. In the case of a resolver, the track signal is monitored, for example. In the case of incremental encoders, the commutation signals are checked. Other "intelligent" encoders have other error detection features.

❖ **Motor temperature measurement and monitoring:** The DIS-2 48/10 FB FS STO servo drive has an analogue input for measuring and monitoring the motor temperature. Thanks to the analogue signal detection method, also non-linear sensors are supported. The shut-down temperature can be parameterised. Alternatively, the motor temperature can also be monitored by way of a normally closed contact or PTC. In this case, however, the shut-down threshold cannot be parameterised.

❖ **I²t current monitoring with warning for the motor:** The DIS-2 48/10 FB FS STO servo drive has an I²t monitoring system to limit the average power loss in the motor. Since the power loss in the electronic power system and in the motor increases in a square manner with the current in the worst case, the squared current value is taken as the measure for the power loss. When 80% of the maximum integrated value is reached, a warning (parameterisable) will be issued. When 100% is reached, the maximum current will be limited to the rated current.

❖ **Monitoring of the automatic motor identification process:** The system monitors whether the automatic identification of the phase sequence, number of pairs of poles, and angle encoder offset have been performed successfully.

10.1.7   Monitoring of the motion sequence

❖ **Following error:** The deviation between the position setpoint and the actual position is monitored.

❖ **Positioning range:** A running positioning process is monitored to see whether the positions are within the adjustable positioning range.

❖ **Limit switches:** If both limit switches are active at the same time, an error will be generated.

❖ **Path program:** The path program is monitored in order to detect invalid commands.

10.1.8   Additional internal monitoring functions

❖ **Memory test/checksums:** The internal FLASH memory (program and data flash memory) is monitored by way of a checksum test and the processor stack is also monitored.

❖ **Operating mode:** Depending on the operating mode, certain specific monitoring functions will be activated.

❖ **Communication:** The communication via the serial interface and fieldbus is monitored.

10.1.9   Monitoring of the STO functionality

❖ **Plausibility check:** The system checks whether the STO feedback signals are in line with the associated STO input signals.

❖ **Discrepancy time monitoring:** The system checks whether the STO channels are activated within the set discrepancy time.

10.1.10   Operating hour meter

The DIS-2 48/10 FB FS STO servo drive has an integrated operating hour meter. It is displayed via the DIS-2 ServoCommander^{TM} parameterisation software in the menu **Info/Info** on the **Times** tab.

The current count of the operating hour meter will be saved in the internal flash memory once per minute. As a result, there may be deviations of up to 60 seconds after a reset or power-on.

10.2   Error messages

The following table provides an overview of all the errors that may occur.

In the **Reaction** column, reactions that can be parameterised by the user are marked with an "**X**".

> The parameterisation of the errors is described in the software manual!

The abbreviations **C**, **E**, and **W** have the following meaning:

❖ **C** = critical error: The controlled operation of the motor cannot be guaranteed.
  The power output stage will be switched off immediately. The motor will coast down.

❖ **E** = error: The motor will be decelerated based on the safety ramp.
  Then, the output stage will be switched off.

❖ **W** = warning: The operation of the motor is still possible, although perhaps only for a limited time.
  The user can parameterise whether warnings will be displayed or not:

  ➢ Display: The error will be displayed but no other measures will be taken.

  ➢ No display: The error will be ignored completely.

Table 44:   Error overview

Error no.	CAN error code	Meaning	Possible causes/measures	Response time	Reaction C	E	W
3	4310	Motor overtemperature	Check the configuration of the temperature monitoring system. Is the temperature sensor wired correctly? Is the movement of the mechanical system impaired or is the motor too hot?	< 100 ms	X	X	X
4	4210	Undertemperature/ overtemperature of the electronic system	Temperature of the electronic power system < -40°C or > 85°C. Has the DIS-2 been heated up by the motor? If necessary, decouple the DIS-2 thermally. Check/improve the installation and cooling conditions.	< 100 ms	X	X	
5	7392	SINCOS supply 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.	< 5 ms	X		
6	7391	SINCOS RS485 communication 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. Is a new or unknown SINCOS encoder being used?	< 5 ms	X		
7	7390	SINCOS track signal 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.	< 5 ms	X		
8	7380	Resolver track signal error or carrier failure	Is the resolver connected? Is the angle encoder cable defective? Is the angle encoder defective? Check the configuration of the angle encoder interface.	< 5 ms	X		

Error no.	CAN error code	Meaning	Possible causes/measures	Response time	Reaction C	E	W
9	5113	5 V electronic system supply error	The error may be due to a defective angle encoder or Hall sensors or due to a wiring error of X2. Possible error on technology module X8 Electronic error in the DIS-2 device. The error cannot be eliminated by the user. Return the servo drive to the distributor.	< 5 ms	X		
10	5114	12 V electronic system supply error	The error may be due to a defective angle encoder or SINCOS encoder or due to a wiring error of X2. Electronic error in the DIS-2 device. The error cannot be eliminated by the user. Return the servo drive to the distributor.	< 5 ms	X		
11	5112	24 V logic supply error	Is the 24 V logic supply too high or too low? Is it impossible to load the 24 V logic supply, e.g. when the holding brake is actuated? Error in the holding brake or in the wiring to X3 or overload of the brake output due to a brake with a too high current consumption. Electronic error in the DIS-2 device. The error cannot be eliminated by the user. Return the servo drive to the distributor.	< 5 ms	X		
12	--	HW-FW conflict	The firmware that has been loaded is not suitable for the device (e.g. DIS-2 48/10 firmware in a DIS-2 48/10 FB FS STO).	< 5 ms	X		
13	5210	Current measurement offset error	The error cannot be eliminated by the user. Return the servo drive to the distributor.	< 5 ms	X		

Error no.	CAN error code	Meaning	Possible causes/measures	Response time	Reaction		
					C	E	W
14	2320	Overcurrent in the intermediate circuit/output stage	Is the motor defective? Is, for example, the winding overloaded and burnt? Is there a short circuit between the winding and housing? Is there a short circuit in the cable between two phases or between a phase and the shield? Insulation of the motor phase connections? Defect inside the DIS-2 (output stage defective or insulation fault – insulating foil)	< 10 µs	X		
15	3220	Undervoltage in the intermediate circuit	Is the intermediate circuit supply too low? Is it impossible to load the intermediate supply sufficiently, e.g. during an acceleration with full current? Check the configuration of the intermediate circuit monitoring system. If necessary, set it to 50% to 70% of the rated voltage.	< 1 ms	X	X	X
16	3210	Overvoltage in the intermediate circuit	Intermediate circuit voltage > 440 V. Is the intermediate circuit supply too high during idling? Check the rating. The braking energy is too high when the axes are decelerated. The capacity in the intermediate circuit is too low. Install an additional capacitor (approx. 10,000 uF for every 10 A of motor current).	< 1 ms	X		
17	7385	Hall encoder 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.	< 5 ms	X		

Error no.	CAN error code	Meaning	Possible causes/measures	Response time	Reaction		
					C	E	W
19	2312	I^2t error of the motor (I^2t at 100%)	Have the angle encoder, number of pairs of poles, and direction been adjusted correctly? Has an automatic motor identification been performed? Is the motor blocked? Check the power rating of the drive package.	< 100 ms	X	X	X
20	2311	I^2t error of the servo drive (I^2t at 100%)	See error 19.	< 100 ms	X	X	X
22	---	Faulty internal STO1 plausibility check	The low time of the OSSD input signals is not in the permissible range. Please contact the technical support team. Electronic error in the DIS-2 device. The error cannot be eliminated by the user. Return the servo drive to the distributor.	< 100 ms	X		
23	---	Faulty internal STO2 plausibility check	The low time of the OSSD input signals is not in the permissible range. Please contact the technical support team. Electronic error in the DIS-2 device. The error cannot be eliminated by the user. Return the servo drive to the distributor.	< 100 ms	X		
24	---	The discrepancy time of STO1 and STO2 has been exceeded.	The control inputs STO1 and STO2 are not actuated simultaneously. The control inputs STO1 and STO2 are not wired in the same way. Check the discrepancy time that has been parameterised with the ServoCommander™.	Can be adjusted in the DSC.	X		
26	2380	I^2t at 80%	Is the motor blocked? Check the power rating of the drive package.	< 100 ms	X	X	X
27	4380	Motor temperature 5°C below maximum	Check the power rating of the drive package.	< 100 ms	X	X	X

Error no.	CAN error code	Meaning	Possible causes/measures	Response time	Reaction C	E	W
28	4280	Output stage temperature 5°C below maximum	Check the power rating of the drive package. Has the DIS-2 been heated up by the motor? If necessary, decouple the DIS-2 thermally. Check/improve the installation and cooling conditions.	< 100 ms	X	X	X
29	8611	Following error	Is the motor blocked? Is the controller adjusted optimally, in particular the internal control circuits for current and speed? Is the parameterised acceleration too high? The error window is too small. Increase the window.	< 5 ms	X	X	X
31	8612	Limit switch error	Have the limit switches been wired correctly? Are the limit switches defective? Check the configuration of the limit switches.	< 1 ms	X	X	X
35	6199	Timeout at quick stop	Has an angle encoder error occurred? Has the motor identification not been successful? Is the parameterised acceleration too high?	< 5 ms	X		
36	8A80	Homing error	The homing run could not be completed successfully. Check the configuration of the homing run. Is the parameterisation of the controllers, including the angle encoder setting, OK?	< 5 ms	X	X	X
37	--	Error: EtherCAT bus monitoring	There is no signal on the bus.	< 5 ms	X		
38	--	Error: EtherCAT piggy	Has the correct FW been loaded? Please contact the technical support team.	< 5 ms	X		

Error no.	CAN error code	Meaning	Possible causes/measures	Response time	Reaction C	E	W
40	6197	Error: Motor and angle encoder identification	Is the angle encoder connected? Is the angle encoder cable defective? Is the angle encoder defective? Check the configuration of the angle encoder interface.	< 5 ms	X		
43	6193	Path program: unknown command	Please contact the technical support team.	< 5 ms	X	X	
44	6192	Path program: invalid jump destination	The digital inputs for START1 and START2 are set simultaneously. An invalid jump destination/an invalid target position will be addressed.	< 5 ms	X	X	
46	8120	Node guarding timeout	A remote frame has not been received within the set "nodeguarding" time.	< 5 ms	X	X	X
47	--	Error: PROFIBUS piggy	Has the correct FW been loaded? Please contact the technical support team.	< 5 ms	X		
48	--	Error: PROFIBUS initialisation	Please contact the technical support team.	< 5 ms	X		
53	--	EtherCAT communication error	The communication is disturbed: Check the installation under EMC aspects.	< 5 ms	X	X	X
54	--	PROFIBUS communication error	The communication is disturbed: Check the installation under EMC aspects.	< 5 ms	X	X	X
55	8100	CAN communication error	The communication is disturbed: Check the installation under EMC aspects. Check the baud rate setting. Check the node number setting. Is the node used more than once in the network?	< 5 ms	X	X	X
56	7510	RS232 communication error	The communication is disturbed: Check the installation under EMC aspects.	< 5 ms	X	X	X

Error no.	CAN error code	Meaning	Possible causes/measures	Response time	Reaction		
					C	E	W
57	6191	Position data set error	There is a conflict between the acceleration and the set travel speed. Please contact the technical support team.	< 5 ms	X		
58	6380	Incorrect operating mode	The operating mode has been changed while the power stage is on.	< 5 ms	X	X	X
59	6195	General arithmetic error	Internal error. Please contact the technical support team.	< 5 ms	X		
60	6190	Error during the pre-calculation of the positioning	Internal error. Please contact the technical support team.	< 5 ms	X		
61	8762	SYNC message timeout	A SYNC message has not been received within the set SYNC time	< 5 ms	X	X	X
62	6180	Stack overflow	Internal error. Please contact the technical support team.	< 5 ms	X		
63	5581	Checksum error	Internal error. Please contact the technical support team.	< 5 ms	X		
64	6187	Initialisation error	Internal error. Please contact the technical support team.	< 5 ms	X		

The servo drives manages error no. 1 to 64 internally.

If your device displays an error number that is not described in the error table or that is marked as an "unknown error", contact your local distributor.

It is possible that these error numbers have been assigned during firmware extensions or to customised firmware versions with additional monitoring functions.