ILS1U, ILS1V, ILS1W

Lexium Integrated Drive

Product manual

V2.00, 09.2008

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Schneider Electric

Important information

This manual is part of the product.

Carefully read this manual and observe all instructions.

Keep this manual for future reference.

Hand this manual and all other pertinent product documentation over to all users of the product.

Carefully read and observe all safety instructions and the chapter "Before you begin - safety information".

Some products are not available in all countries.
For information on the availability of products, please consult the catalog.

Subject to technical modifications without notice.

All details provided are technical data which do not constitute warranted qualities.

Most of the product designations are registered trademarks of their respective owners, even if this is not explicitly indicated.

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Writing conventions and symbols

Work steps

If work steps must be performed consecutively, this sequence of steps is represented as follows:

- ■ Special prerequisites for the following work steps
- ▶ Step 1
- ◁ Specific response to this work step
- ▶ Step 2

If a response to a work step is indicated, this allows you to verify that the work step has been performed correctly.

Unless otherwise stated, the individual steps must be performed in the specified sequence.

Bulleted lists

The items in bulleted lists are sorted alphanumerically or by priority. Bulleted lists are structured as follows:

- Item 1 of bulleted list
- Item 2 of bulleted list
  - Subitem for 2
  - Subitem for 2
- Item 3 of bulleted list

Making work easier

Information on making work easier is highlighted by this symbol:

Sections highlighted this way provide supplementary information on making work easier.

Parameters

Parameters are shown as follows:

`Gruppe.Name Index:Subindex`

SI units

SI units are the original values. Converted units are shown in brackets behind the original value; they may be rounded.

Example:
Minimum conductor cross section: 1.5 mm^2 (AWG 14)

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1 Introduction

1.1 About this manual

This manual is valid for all ILS1U, ILS1V, ILS1W standard products. This chapter lists the type code for this product. The type code can be used to identify whether your product is a standard product or a customized model.

1.2 Unit overview

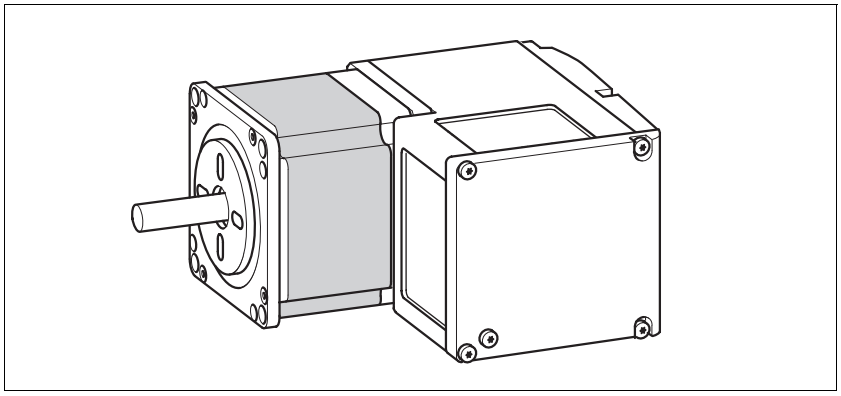

Figure 1.1 Device overview

The "Lexium Integrated Drive" consists of a stepper motor and integrated electronics. The product integrates interfaces, control electronics, a holding brake (optional) and the power stage.

Reference value supply

The "Lexium Integrated Drive" moves the stepper motor as specified by a reference value. The setpoint signal is generated by a positioning or NC controller and fed to the multifunction interface as a pulse signal.

The resolution can be set via the number of steps.

Safety function

The integrated safety function STO (IEC 61800-5-2) meets the requirements of Safety Integrity Level SIL2. The safety function allows for a category 0 stop as per EN 60204-1 without external power contactors. It is not necessary to interrupt the supply voltage. This reduces the system costs and the response times.

The STO safety function is available as of device revision RS10 (see nameplate).

Using the library considerably facilitates controlling the device. The library is available for download from the Internet.
http://www.schneider-electric.com

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1.3 Components and interfaces

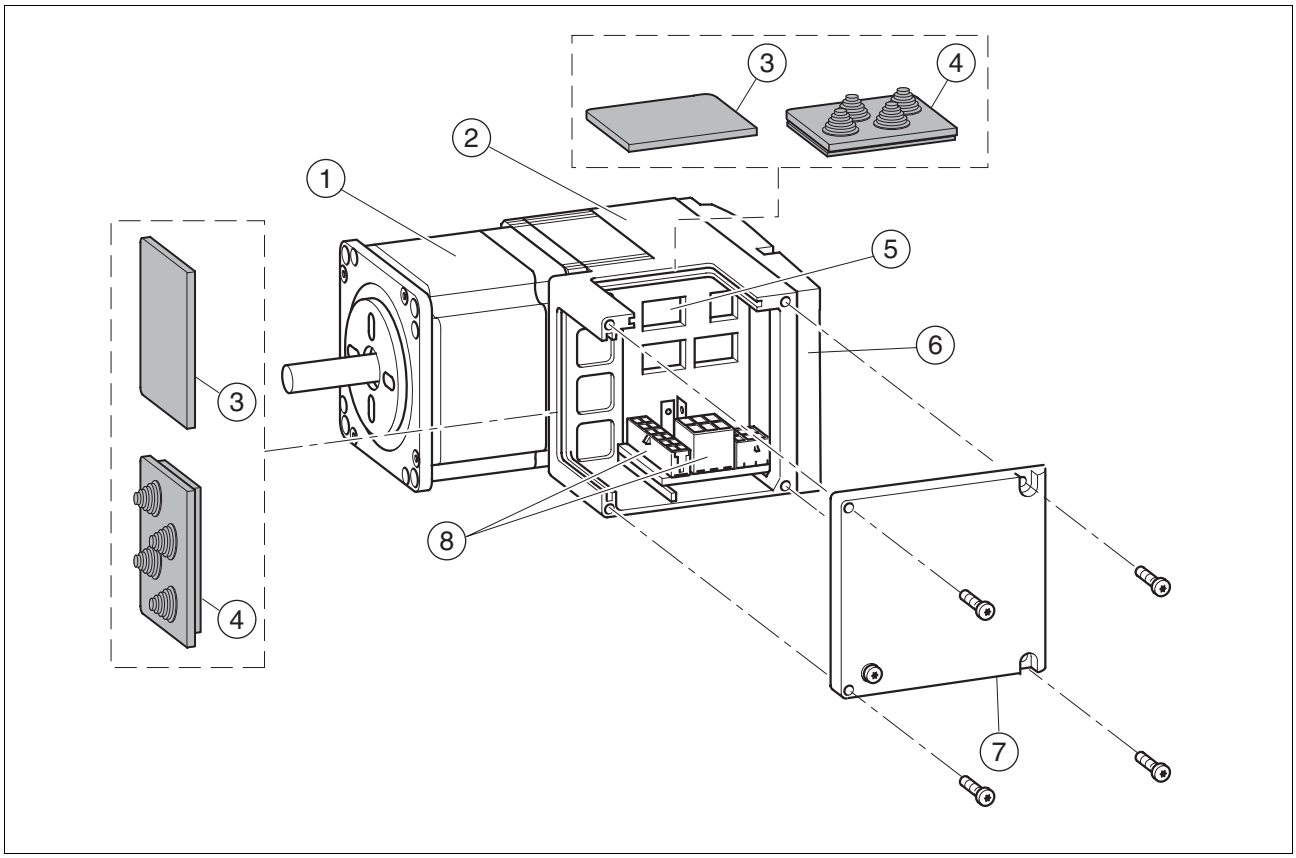

Figure 1.2 Components and interfaces

(1) 3-phase stepper motor
(2) Electronics housing
(3) Insert for sealing (accessory)
(4) Insert with cable entry (accessory)
(5) Switches for settings
(6) Cover of electronics housing, must not be removed
(7) Cover of connector housing, to be removed for installation
(8) Electrical interfaces

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1.3.1 Components

Motor The motor is a brushless 3-phase stepper motor. The motor has a high power density due to the use of the latest magnetic materials and an optimized design.

Electronics The electronic system comprises control electronics and power stage. They have a common power supply and are not galvanically isolated.

The drive system can be controlled by external reference signals via the multifunction interface.

4 different 24V signals are also available. The function of the inputs and outputs can be set with parameter switches.

Holding brake The drive can optionally be equipped with an integrated holding brake. The holding brake is controlled automatically.

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1.3.2 Interfaces

Standard available interfaces:

Supply voltage VDC

The supply voltage VDC supplies the control electronics and the power stage.

The ground connections of all interfaces are galvanically connected. For more information see chapter 5.2 "Ground design". This chapter also provides information on protection against reverse polarity.

Multifunction interface

Depending on the device version, this interface operates at one of the following signal levels:

- 24V signals opto-isolated
- 5V signals opto-isolated
- 5V differential signals without galvanic isolation

The reference pulses are supplied via two of the inputs, either as pulse/direction signals or as AB signals. The other inputs have the functions "power stage enable / pulse blocking" and "step size switching / PWM motor current control".

24 V signal interface

2 inputs and 2 outputs are available. The inputs are used for "step size switching" and "power stage enable / pulse blocking". The outputs have the functions "power stage ready" and "error output / index pulse".

Communication interface

Function:

- Connection of the RS485 bus for service purposes

A PC can be connected to the interface via an RS485-RS232 converter so that the communication interface can be used for service purposes. The commissioning software can then be used for tasks such as reading the error memory or monitoring the temperature.

The RS485 interface can be used for firmware updates.

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1.4 Name plate

The nameplate contains the following data:

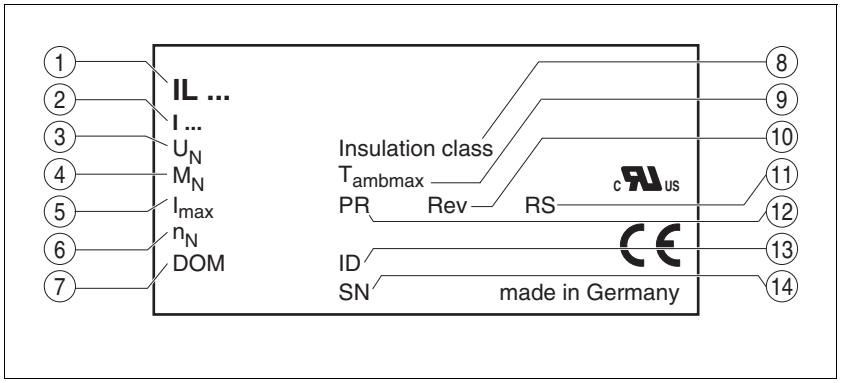

Figure 1.3 Nameplate

(1) Type code
(2) Type code (old designation)
(3) Nominal voltage
(4) Nominal torque
(5) Maximum input current
(6) Nominal speed
(7) Date of manufacture
(8) Thermal class
(9) Maximum ambient air temperature
(10) Software revision
(11) Hardware revision
(12) Firmware number
(13) Material number
(14) Serial Number

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1.5 Type code

ILS	1	U	57	1	P	B	1	A	0	--

Motor
ILS = Stepper motor

Supply voltage
1 = 24 ... 36 V_{DC}

Communication interface
U = Pulse/direction 24V_{DC} optocoupler
V = Pulse/direction 5V_{DC} optocoupler
W = Pulse/direction 5 V_{DC} RS422

Size
57 = 57 mm [1)]
85 = 85 mm

Length
1 = 1 stack
2 = 2 stacks
3 = 3 stacks

Winding
P = Medium speed of rotation/medium torque
T = High speed of rotation/low torque

Connection version
B = Printed circuit board connector

Position capture
1 = Stepper motor with index pulse

Holding brake
A = Without holding brake
F = With holding brake [2)]

Gearbox
0 = Without gearbox

Reserved

1) Not available in combination with the holding brake option.
2) Not available for size 57 mm.

Customized product In the case of a customized product, position 9 is an "S".
Positions 10 ... 13 are the number of the customized product.

Example: IL••••••S1234--

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1.6 Documentation and literature references

Source product manuals

The current product manuals are available for download from the Internet.
http://www.schneider-electric.com

Source EPLAN Macros

For easier engineering, macro files and product master data are available for download from the Internet at:

http://www.schneider-electric.com

Additional literature

We recommend the following literature for more in-depth information:

- Ellis, George: Control System Design Guide. Academic Press
- Kuo, Benjamin; Golnaraghi, Farid: Automatic Control Systems. John Wiley & Sons

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1.7 Declaration of conformity

SCHNEIDER ELECTRIC MOTION DEUTSCHLAND GmbH & Co. KG
Breslauer Str. 7 D-77933 Lahr

EC DECLARATION OF CONFORMITY
YEAR 2008

☒ according to EC Directive Machinery 98/37/EC
☒ according to EC Directive EMC 2004/108/EC
☐ according to EC Directive Low Voltage 2006/95/EC

We declare that the products listed below meet the requirements of the mentioned EC Directives with respect to design, construction and version distributed by us. This declaration becomes invalid with any modification on the products not authorized by us.

Designation:	Motors with integrated control electronics
Type:	ILA, ILE, ILS
Product number:	0x6600xxxxxxx, 0x6610xxxxxxx, 0x66206xxxxxx, 0x66307xxxxxx 0x6640xxxxxxx, 0x66606xxxxxx, 0x66707xxxxxx
Applied harmonized standards, especially:	EN ISO 13849-1:2006, Performance Level "d" (category 3) EN 61800-3:2004, second environment EN 62061:2005, SILcl 2 EN 61508:2001, SIL 2
Applied national standards and technical specifications, especially:	UL 508C Product documentation
Company stamp:	Schneider Electric Motion Deutschland GmbH & Co. KG Postfach 11 80 • D-77901 Lahr Breslauer Str. 7 • D-77933 Lahr
Date/ Signature:	10 July 2008
Name/ Department:	Wolfgang Brandstätter/Development

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1.8 TÜV certificate for functional safety

TÜV NORD

Certificate

TÜV NORD SysTec GmbH & Co. KG hereby certifies

Schneider Electric Motion GmbH
Breslauerstr.7
77933 Lahr

for the realisation of the functions "Safe Torque Off" (STO)
and "Emergency Stop" in the drive

IclA Ixx

meets the requirements listed in the below mentioned standards

- IEC61508:2000; SIL 2
- ISO 13849-1:2006; PL d (category 3)
- IEC 62061:2005; SILcl2

based on report Nr. SAS-127/2007TB and the version releases procedure list in the appendix in the valid version.
This certificate entitles the holder to use the mark

TÜV NORD Certification
Safety Approved

IclA Ixx
IEC 61508:2000
SIL 2
ISO 13849-1:2006
PL d (category 3)
IEC 62061:2005
SILcl2

SAS1728/08
Voluntary Certification

Valid until: 2013-01-09
Certificate No.: SAS1728/08, Vers. 1.2
File Reference: M.IB5.03.141.01.SLA

Augsburg, 2008-04-01

TÜV NORD SysTec GmbH & Co. KG
Branch South
Halderstraße 27
86150 Augsburg
Germany

Dr. Immanuel Höfer

08

BA51-10

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2 Before you begin - safety information

2.1 Qualification of personnel

Only appropriately trained persons who are familiar with and understand the contents of this manual and all other pertinent product documentation are authorized to work on and with this product. In addition, these persons must have received safety training to recognize and avoid hazards involved. These persons must have sufficient technical training, knowledge and experience and be able to foresee and detect potential hazards that may be caused by using the product, by changing the settings and by the mechanical, electrical and electronic equipment of the entire system in which the product is used.

All persons working on and with the product must be fully familiar with all applicable standards, directives, and accident prevention regulations when performing such work.

2.2 Intended use

This product is a motor with an integrated drive and intended for industrial use according to this manual.

The product may only be used in compliance with all applicable safety regulations and directives, the specified requirements and the technical data.

Prior to using the product, you must perform a risk assessment in view of the planned application. Based on the results, the appropriate safety measures must be implemented.

Since the product is used as a component in an entire system, you must ensure the safety of persons by means of the design of this entire system (e.g. machine design).

Operate the product only with the specified cables and accessories. Use only genuine accessories and spare parts.

The product must NEVER be operated in explosive atmospheres (hazardous locations, Ex areas).

Any use other than the use explicitly permitted is prohibited and can result in hazards.

Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel.

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2.3 Hazard categories

Safety instructions to the user are highlighted by safety alert symbols in the manual. In addition, labels with symbols and/or instructions are attached to the product that alert you to potential hazards.

Depending on the seriousness of the hazard, the safety instructions are divided into 4 hazard categories.

⚠ DANGER

DANGER indicates an imminently hazardous situation, which, if not avoided, **will result** in death or serious injury.

⚠ WARNING

WARNING indicates a potentially hazardous situation, which, if not avoided, **can result** in death, serious injury, or equipment damage.

⚠ CAUTION

CAUTION indicates a potentially hazardous situation, which, if not avoided, **can result** in injury or equipment damage.

CAUTION

CAUTION used without the safety alert symbol, is used to address practices not related to personal injury (e.g. **can result** in equipment damage).

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2.4 Basic information

⚠ DANGER

UNINTENDED CONSEQUENCES OF EQUIPMENT OPERATION

When the system is started, the drives are usually out of the operator's view and cannot be visually monitored.

- Only start the system if there are no persons in the hazardous area.

Failure to follow these instructions will result in death or serious injury.

⚠ WARNING

UNEXPECTED MOVEMENT

Drives may perform unexpected movements because of incorrect wiring, incorrect settings, incorrect data or other errors.

Interference (EMC) may cause unpredictable responses in the system.

- Carefully install the wiring in accordance with the EMC requirements.
- Switch off the voltage at the inputs $\overline{\text{STO\_A}}$ ($\overline{\text{PWRR\_A}}$) and $\overline{\text{STO\_B}}$ ($\overline{\text{PWRR\_B}}$) to avoid an unexpected restart of the motor before switching on and configuring the drive system.
- Do NOT operate the drive system with unknown settings or data.
- Perform a comprehensive commissioning test.

Failure to follow these instructions can result in death or serious injury.

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⚠ WARNING

LOSS OF CONTROL

- The designer of any control scheme must consider the potential failure modes of control paths and, for certain critical functions, provide a means to achieve a safe state during and after a path failure. Examples of critical control functions are EMERGENCY STOP, overtravel stop, power outage and restart.
- Separate or redundant control paths must be provided for critical functions.
- System control paths may include communication links. Consideration must be given to the implication of unanticipated transmission delays or failures of the link.
- Observe the accident prevention regulations and local safety guidelines. [1)]
- Each implementation of the product must be individually and thoroughly tested for proper operation before being placed into service.

Failure to follow these instructions can result in death or serious injury.

1) For USA: Additional information, refer to NEMA ICS 1.1 (latest edition), Safety Guidelines for the Application, Installation, and Maintenance of Solid State Control and to NEMA ICS 7.1 (latest edition), Safety Standards for Construction and Guide for Selection, Installation for Construction and Operation of Adjustable-Speed Drive Systems.

⚠ CAUTION

UNEXPECTED BEHAVIOR AND DESTRUCTION OF SYSTEM COMPONENTS

When you work on the wiring and when you unplug or plug in connectors, this may cause unexpected behavior and destruction of system components.

- Switch the power supply off before working on the wiring.

Failure to follow these instructions can result in injury or equipment damage.

2.5 Functional safety

Using the safety functions integrated in this product requires careful planning. For more information see chapter5.3 "Safety function STO ("Safe Torque Off")" on page 40.

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2.6 Standards and terminology

Technical terms, terminology and the corresponding descriptions in this manual are intended to use the terms or definitions of the pertinent standards.

In the area of drive systems, this includes, but is not limited to, terms such as "safety function", "safe state", "fault", "fault reset", "failure", "error", "error message", "warning", "warning message", "alarm", etc.

Among others, these standards include:

- IEC 61800 series: "Adjustable speed electrical power drive systems"
- IEC 61800-7 series: "Adjustable speed electrical power drive systems - Part 7-1: Generic interface and use of profiles for power drive systems - Interface definition"
- IEC 61158 series: "Industrial communication networks - Fieldbus specifications"
- IEC 61784 series: "Industrial communication networks - Profiles"
- IEC 61508 series: "Functional safety of electrical/electronic/programmable electronic safety-related systems"

Also see the glossary at the end of this manual.

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3 Technical Data

This chapter contains information on the ambient conditions and on the mechanical and electrical properties of the device family and the accessories.

3.1 Certifications

Product certifications:

Certified by	Assigned number	Validity
TÜV Nord	SAS-1728/08	2013-01-09
UL	File E 153659	

Certified safety function

This product has the following certified safety function:

- Safety function STO "Safe Torque Off" (IEC 61800-5-2)

3.2 Ambient conditions

Ambient temperature during operation

The maximum permissible ambient temperature during operation depends on the distance between the devices and the required power. Observe the pertinent instructions in the chapter Installation.

Operating temperature [1) 2)]	[°C]	0 ... 50
Operating temperature with current reduction of 2% per Kelvin [1)]	[°C]	50 ... 65

1) Limit values with flanged motor (steel plate 300x300x10 mm)
2) If the product is to be used in compliance with UL 508C, note the information provided in chapter 3.5 "Conditions for UL 508C".

Ambient conditions transportation and storage

The environment during transport and storage must be dry and free from dust. The maximum vibration and shock load must be within the specified limits.

Temperature	[°C]	-25 ... +70

Temperature

Max. temperature of power stage [1)]	[°C]	105
Max. temperature of motor [2)]	[°C]	110

1) Can be read via parameter
2) Measured on the surface

Relative humidity

The following relative humidity is permissible during operation:

Relative humidity (non-condensing)	[%]	15 ... 85

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Installation altitude

The installation altitude is defined as height above sea level.

Installation altitude	[m]	≤1000

Vibration and shock

Vibartion, sinusoidal	As per IEC/EN 60068-2-6 0.15 mm (from 10 Hz ... 60 Hz) 20 m/s^2 (from 10 Hz ... 500 Hz)
Shock, semi-sinusoidal	As per IEC/EN 60068-2-27: 150 m/s^2 (11 ms)

EMC

Emission	IEC/EN 61800-3: Class C2 EN 61000-6-4 EN 55022: Class A
Noise immunity	IEC/EN 61800-3: Second environment

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3.3 Mechanical data

3.3.1 Degree of protection

IP degree of protection

The product has the following IP degree of protection as per EN 60529.

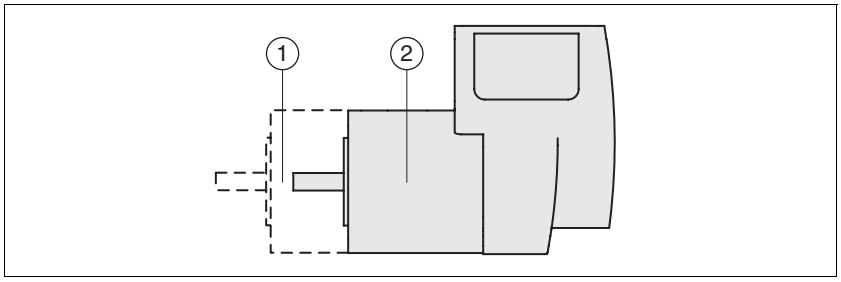

Figure 3.1 IP degree of protection

Item		Degree of protection
1	Shaft bushing	IP41
	Shaft bushing with GBX gear (accessory)	IP54
2	Housing, except shaft bushing	IP54

The total degree of protection is determined by the component with the lowest degree of protection.

Overview of IP degrees of protection

First digit		Second digit	
Protection against intrusion of objects		**Protection against intrusion of water**	
0	No protection	0	No protection
1	External objects >50 mm	1	Vertically falling dripping water
2	External objects >12 mm	2	Dripping water falling at an angle (75 ° ... 90 °)
3	External objects >2.5 mm	3	Spraying water
4	External objects >1 mm	4	Splashing water
5	Dust-protected	5	Water jets
6	Dust-tight	6	Heavy sea
		7	Immersion
		8	Submersion

Degree of protection if STO is used

You must ensure that conductive substances cannot get into the product (pollution degree 2). If you use the safety function and conductive substances get into the product, the safety function may become inoperative.

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3.3.2 Mounting position

Mounting position

The following mounting positions are defined and approved as per EN 60034-7:

- IM B5 drive shaft horizontal
- IM V1 drive shaft vertical, shaft end down
- IM V3 drive shaft vertical, shaft end up

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3.3.3 Dimensions

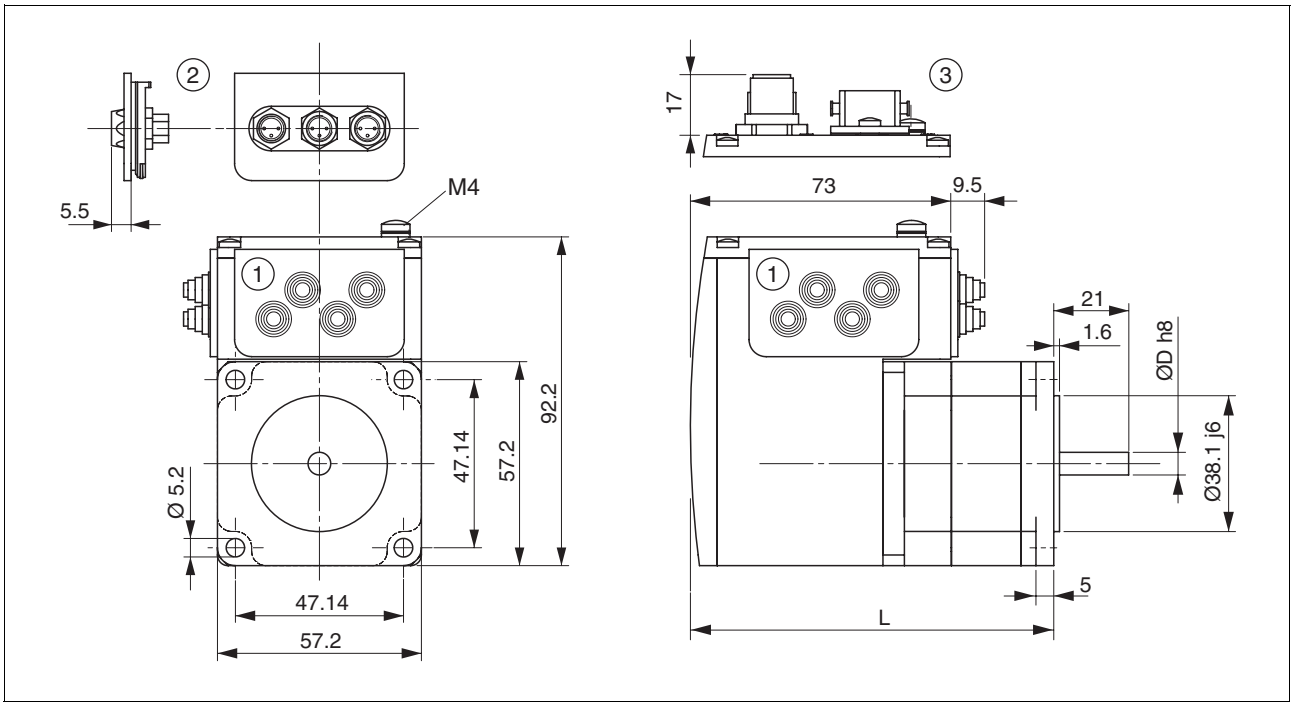

Figure 3.2 Dimensions

(1) Insert with cable entry (accessory)
(2) Insert kit (accessory)
(3) Industrial connector (option)

Total length L

ILS••571...		**P•1A0**
Length	[mm]	101.9

ILS••572...		**2P•1A0**
Length	[mm]	115.9

ILS••573...		**3P•1A0**
Length	[mm]	138.9

Shaft diameter D

ILS••571...		**P•1A0**
D	[mm]	6.35

ILS••572...		**2P•1A0**
D	[mm]	6.35

ILS••573...		**3P•1A0**
D	[mm]	8

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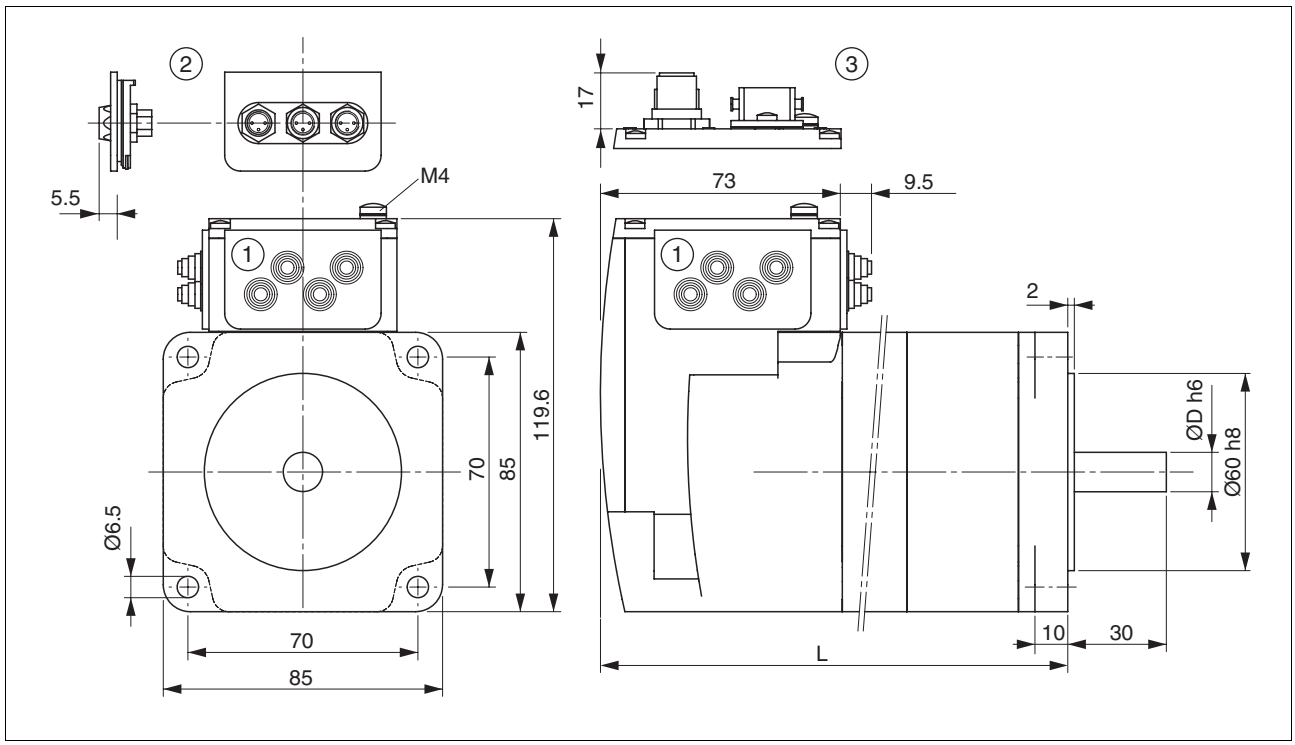

Figure 3.3 Dimensions

(1) Insert with cable entry (accessory)
(2) Insert kit (accessory)
(3) Industrial connector (option)

Total length L

ILS••851...		**••1A0**	**••1F0**
L	[mm]	140.6	187.3

ILS••852...		**••1A0**	**••1F0**
L	[mm]	170.6	217.3

ILS••853...		**••1A0**	**••1F0**
L	[mm]	200.6	247.3

Shaft diameter D

ILS••851...	**mm**	**••1•0**
D	[mm]	12

ILS••852...		**••1•0**
D	[mm]	12

ILS••853...		**••1•0**
D	[mm]	14

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3.4 Electrical Data

Overview of printed circuit board connectors

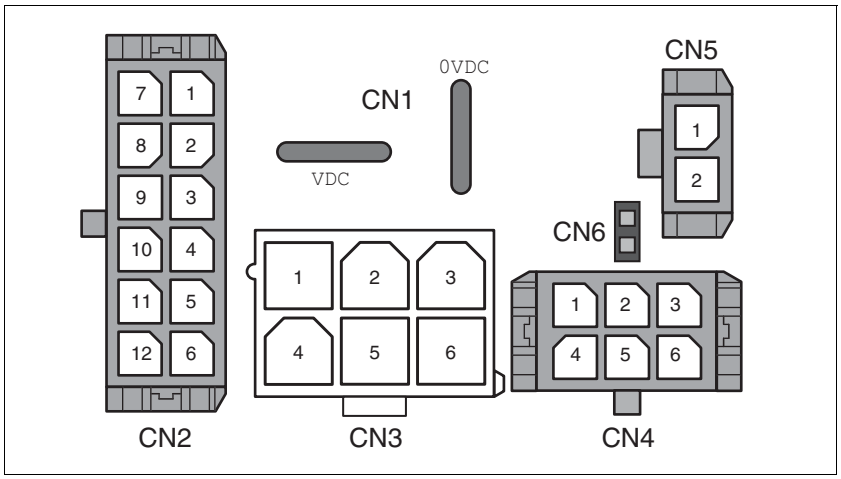

Figure 3.4 Overview of printed circuit board connectors

3.4.1 Supply Voltage VDC at CN1

		ILS1•57•	ILS1•851 ILS1•852	ILS1•853
Nominal voltage	[V_{dc}]	24 / 36	24 / 36	24 / 36
Limit values	[V_{dc}]	18 ... 40	18 ... 40	18 ... 40
Ripple at nominal voltage	[V_{pp}]	≤3.6	≤3.6	≤3.6
Max. current input [1)] Winding type P Winding type T	[A]	 3.5 -	 5 -	 5 6
Fuse to be connected upstream [2)]	[A]	≤16	≤16	≤16

1) The actual power requirement is often significantly lower, because the maximum possible motor torque is usually not required for operation of a system.
2) See chapter 5.1.1 "Supply voltage"

Inrush current current Charging current for capacitor C=1500 µF

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3.4.2 Multifunction interface at CN2

Signal inputs

		ILS1U	ILS1V	ILS1W
Logic 0 (U_{low})	[V]	-3 ... +3	-5.25 ... +0.4	RS422
Logic 1 (U_{high})	[V]	+20 ... +30	+2.5 ... +5.25	RS422
Permissible voltage range	[V]	-3 ... +30	-5.25 ... +5.25	-2 ... +26
Input resistance	[Ω]	2000	140	5000
Galvanic isolation		Yes	Yes	No

Signal outputs

		ILS1U	ILS1V	ILS1W
Max. switching voltage	[V]	30	30	30
Max. switching current	[mA]	100	100	100
Voltage drop at 10 mA 100 mA	[V]	 ≤1.6 ≤1.9	 ≤1.6 ≤1.9	 ≤0.2 ≤0.2
Galvanic isolation		Yes	Yes	No

3.4.3 24V signals to CN4

Signal inputs

The signal inputs are galvanically connected to 0VDC and not protected against reverse polarity.

Logic 0 (U_{low})	[V]	-3 ... +3
Logic 1 (U_{high})	[V]	+20 ... +30
Permissible voltage range	[V]	-3 ... +30
Input resistance	[Ω]	2000

Signal outputs

The signal outputs are galvanically connected to 0VDC and short-circuit protected.

Nominal voltage	[V]	24
Voltage range	[V]	23 ... 25
Maximum current (total)	[mA]	200
Maximum current per output	[mA]	100
Suitable for inductive loads	[mH]	1000

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3.4.4 STO safety function at CN5 and CN6

The signal inputs are galvanically connected to 0VDC.

Logic 0 (U_{low})	[V]	-3 ... +4.5
Logic 1 (U_{high})	[V]	+15 ... +30
Input current $\overline{\text{STO\_A}}$ ($\overline{\text{PWRR\_A}}$) (typical at 24V)	[mA]	≤10
Input current $\overline{\text{STO\_B}}$ ($\overline{\text{PWRR\_B}}$) (typical at 24V)	[mA]	≤3
Debounce time	[ms]	1
Detection of signal difference between $\overline{\text{STO\_A}}$ ($\overline{\text{PWRR\_A}}$) and $\overline{\text{STO\_B}}$ ($\overline{\text{PWRR\_B}}$)	[s]	≥1
Response time (until shutdown of power stage)	[ms]	<50
Permitted test pulse width of upstream devices	[ms]	<1

Data for maintenance plan and safety calculations

Use the following data of the STO safety function for your maintenance plan and the safety calculations:

Lifetime (IEC 61508)		20 years
SFF (IEC 61508) Safe Failure Fraction	[%]	66
HFT (IEC 61508) Hardware Fault Tolerance Type A subsystem		1
Safety integrity level IEC 61508 IEC 62061		 SIL2 SILCL2
PFH (IEC 61508) Probability of Dangerous Hardware Failure per Hour	[1/h]	$1.84*10^{-9}$
PL (ISO 13849-1) Performance Level		d (Category 3)
$MTTF_d$ (EN 13849-1) Mean Time to Dangerous Failure		4566 years
DC (EN 13849-1) Diagnostic Coverage	[%]	90

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3.5 Conditions for UL 508C

If the product is used to comply with UL 508C, the following conditions must be met:

Ambient temperature during operation

Surrounding air temperature	[°C]	0 ... +50
Surrounding air temperature with current reduction of 2% per Kelvin	[°C]	50 ... 65

Pollution degree Use in an environment with pollution degree 2.

Power supply Use only power supply units that are approved for overvoltage category III.

Wiring Use only 60/75 °C copper conductors.

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4 Basics

4.1 Functional safety

Automation and safety engineering are two areas that were completely separated in the past but recently have become more and more integrated. Engineering and installation of complex automation solutions are greatly simplified by integrated safety functions.

Usually, the safety engineering requirements depend on the application. The level of the requirements results from the risk and the hazard potential arising from the specific application.

Working with IEC 61508

IEC 61508 standard

The standard IEC 61508 "Functional safety of electrical/electronic/programmable electronic safety-related systems" covers the safety-related function. It is not only one single component but the entire function chain (e.g. from the sensor through the logical processing unit to the actuator) that is considered as one single unit. This function chain must meet the requirements of the specific safety integrity level as a whole. Systems and components that can be used in various applications for safety tasks with comparable risk levels can be developed on this basis.

SIL, Safety Integrity Level

The standard IEC 61508 defines 4 safety integrity levels (SIL) for safety functions. SIL1 is the lowest level and SIL4 is the highest level. A hazard and risk analysis serves as a basis for determining the required safety integrity level. This is used to decide whether the relevant function chain is to be considered as a safety function and which hazard potential it must cover.

PFH, Probability of a dangerous hardware failure per hour

To maintain the safety function, the IEC 61508 standard requires various levels of measures for avoiding and controlling faults, depending on the required SIL. All components of a safety function must be subjected to a probability assessment to evaluate the effectiveness of the measures implemented for controlling faults. This assessment determines the PFH (probability of a dangerous failure per hour) for a safety system. This is the probability per hour that a safety system fails in a hazardous manner and the safety function cannot be correctly executed. Depending on the SIL, the PFH must not exceed certain values for the entire safety system. The individual PFH values of a function chain are added; the total PFH value must not exceed the maximum value specified in the standard.

SIL	PFH at high demand or continuous demand
4	$\geq 10^{-9}$ ... $<10^{-8}$
3	$\geq 10^{-8}$ ... $<10^{-7}$
2	$\geq 10^{-7}$ ... $<10^{-6}$
1	$\geq 10^{-6}$ ... $<10^{-5}$

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HFT and SFF

Depending on the SIL for the safety system, the IEC 61508 standard requires a specific hardware fault tolerance HFT in connection with a specific proportion of safe failures SFF (safe failure fraction). The hardware fault tolerance is the ability of a system to execute the required safety function in spite of the presence of one or more hardware faults. The SFF of a system is defined as the ratio of the rate of safe failures to the total failure rate of the system. According to IEC 61508, the maximum achievable SIL of a system is partly determined by the hardware fault tolerance HFT and the safe failure fraction SFF of the system.

SFF	**HFT type A subsystem**			**HFT type B subsystem**		
	0	**1**	**2**	**0**	**1**	**2**
< 60%	SIL1	SIL2	SIL3	---	SIL1	SIL2
60% ... <90%	SIL2	SIL3	SIL4	SIL1	SIL2	SIL3
90% ... < 99%	SIL3	SIL4	SIL4	SIL2	SIL3	SIL4
≥99%	SIL3	SIL4	SIL4	SIL3	SIL4	SIL4

Fault avoidance measures

Systematic errors in the specifications, in the hardware and the software, usage faults and maintenance faults of the safety system must be avoided to the maximum degree possible. To meet these requirements, IEC 61508 specifies a number of measures for fault avoidance that must be implemented depending on the required SIL. These measures for fault avoidance must cover the entire life cycle of the safety system, i.e. from design to decommissioning of the system.

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5 Engineering

This chapter contains information on the application of the product that is vital in the design phase.

5.1 External power supply units

⚠ DANGER

ELECTRIC SHOCK CAUSED BY INCORRECT POWER SUPPLY UNIT

The VDC and +24VDC supply voltages are connected with many exposed signal connections in the drive system.

- Use a power supply unit that meets the PELV (Protective Extra Low Voltage) requirements.
- Connect the negative output of the power supply unit to PE (ground).

Failure to follow these instructions will result in death or serious injury.

5.1.1 Supply voltage

General

The power supply unit must be rated for the power requirements of the drive. The input current can be found in the technical data.

The actual power requirements are often significantly lower because the maximum possible motor torque is usually not required for normal operation of a system.

When designing the system, note that the input current of the drive is higher during the motor acceleration phase than during constant movement.

Protection against reverse polarity

In the case of reverse polarity, the supply voltage is short-circuited. The drive is continuous short circuit-proof up to a short-circuit current of a maximum of 15 A. If the power is supplied by a transformer power supply unit, several hundred amperes may flow for a short period of time in the event of reverse polarity; the drive is rated for this and will not be damaged.

Fuse: a circuit-breaker (16 A, trip characteristic B) or a blade fuse (FKS, max. 15 A) or a fuse (5 mm x 20 mm, 10 A slow-blow).

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Regeneration condition

Note the following for drives with large external mass moments of inertia or for highly dynamic applications:

Motors return regeneration energy during deceleration. The DC bus can store a limited amount of energy in the capacitors. Connecting additional capacitors to the DC bus increases the amount of energy that can be stored.

If the capacity of the capacitors is exceeded, the excess energy must be discharged via internal or external braking resistors. If the energy is not discharged, an overvoltage monitor will shut off the power stage.

Overvoltages can be limited by adding a braking resistor with a corresponding braking resistor controller. This converts the regenerated energy to heat energy during deceleration.

Braking resistor controllers can be found in chapter 10 "Accessories and spare parts". See the product manual for a description of the braking resistor controller.

⚠ CAUTION

LOSS OF CONTROL DUE TO REGENERATION CONDITION

Regeneration conditions resulting from braking or external driving forces may increase the VDC supply voltage to an unexpected level. Components not rated for this voltage may be destroyed or cause misoperation.

- Verify that all VDC consumers are rated for the voltage occurring during regeneration conditions (for example limit switches).
- Use only power supply units that will not be damaged by regeneration conditions.
- Use a braking resistor controller, if necessary.

Failure to follow these instructions can result in injury or equipment damage.

24V signal power supply

A constant 24V signal power supply is available for the sensor system.

It must not be connected in parallel with the 24V signal power supply of a different drive.

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5.2 Ground design

The ground connections of all interfaces are galvanically connected, including the ground for the VDC supply voltage.

The multifunction interface is an exception to this in the case of devices with galvanic isolation.

The following points must be considered when you wire the drives in a system:

- The voltage drop in the VDC power supply lines must be kept as low as possible (less than 1 V). At higher ground potential differences between different drives, the communication / control signals may be affected.
- If the distance between the system components is greater, it is recommended to use decentralized power supply units close to the individual drives to supply the VDC voltage. However, the ground connections of the individual power supply units must be connected with the largest possible conductor cross section.
- The internal 24V signal power supply must not be connected in parallel with the internal 24V signal power supply of a different drive.
- If the master controller (e.g. PLC, IPC etc.) does not have galvanically isolated outputs for the drives, you must verify that the current of the VDC supply voltage has no path back to the power supply unit via the master controller. Therefore, the master controller ground may be connected to the VDC supply voltage ground at a single point only. This is usually the case in the control cabinet. The ground contacts of the various signal connectors in the drive are therefore not connected; there is already a connection via the VDC supply voltage ground.
- If the controller has a galvanically isolated interface for communication with the drives, the ground of this interface must be connected to the signal ground of the first drive. This ground may be connected to a single drive only to avoid ground loops. This also applies to a galvanically isolated CAN connection.

Equipotential bonding conductors

Potential differences can result in excessive currents on the cable shields. Use equipotential bonding conductors to reduce currents on the cable shields.

The equipotential bonding conductor must be rated for the maximum current flowing. Practical experience has shown that the following conductor cross sections can be used:

- 16 mm^2 (AWG 4) for equipotential bonding conductors up to a length of 200 m
- 20 mm^2 (AWG 4) for equipotential bonding conductors with a length of more than 200 m

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5.3 Safety function STO ("Safe Torque Off")

See page 35 for information on using the IEC 61508 standard..

5.3.1 Definitions

Safety function STO (IEC 61800-5-2)

The safety function STO ("Safe Torque Off", "Safe Torque Off") shuts off the motor torque safely. It is not necessary to interrupt the supply voltage. There is no monitoring for standstill.

"Power Removal"

The STO safety function ("Safe Torque Off") is also known as "Power Removal".

Category 0 stop (EN 60204-1)

Stopping by immediate removal of power to the machine actuators (i.e. an uncontrolled stop).

Category 1 stop (EN 60204-1)

Controlled stop with power available to the machine actuators to achieve the stop. Power is not interrupted until the stop is achieved.

5.3.2 Function

The STO safety function integrated into the product can be used to implement an "EMERGENCY STOP" (EN 60204-1) for category 0 stops. With an additional, approved EMERGENCY STOP module, it is also possible to implement category 1 stops.

Function principle

The STO safety function is triggered via 2 redundant inputs. The circuits of the two inputs must be separate so that there are always two channels.

The switching process must be simultaneous for both inputs (skew <1s). The power stage is disabled and an error message is generated. The motor can no longer generate torque and coasts down without braking. A restart is possible after resetting the error message with a "Fault Reset".

The power stage is disabled and an error message is generated if only one of the two inputs is switched off or if the skew is too great. This error message can only be reset by switching off the product.

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5.3.3 Requirements for using the safety function

⚠ WARNING

LOSS OF SAFETY FUNCTION

Incorrect usage may cause a hazard due to the loss of the safety function.

- Observe the requirements for using the safety function.

Failure to follow these instructions can result in death or serious injury.

Category 0 stop

During a category 0 stop, the motor coasts down in an uncontrolled way. If access to the machine coasting down involves a hazard (results of the hazard and risk analysis), you must take appropriate measures.

Category 1 stop

A controlled stop must be triggered with a category 1 stop. The controlled stop is not monitored by the drive system; in the case of a power outage or an error, the stop may not be performed correctly. Final shutoff of the motor is achieved by switching off the two inputs of the STO safety function. The shutoff is usually controlled by a standard EMERGENCY STOP module with a safe time delay.

Behavior of holding brake

Triggering the STO safety function means that the delay time for motors with holding brake is not effective. The motor cannot generate holding torque to bridge the time to application of the holding brake. Especially in the case of vertical axes it is important to verify whether additional measures are required to avoid lowering of the load.

Vertical axes, external forces

If external forces act on the motor (vertical axis) and an unwanted movement, for example caused by gravity, could cause a hazard, the motor must not be operated without additional measures for fall protection, corresponding to the required safety.

Unintended restart

To avoid an unexpected restart after restoration of power (e.g. after power outage), jumper CN6 jumper must be removed. This causes the signal inputs ENABLE and GATE to respond in an edge-controlled way and no longer statically. Note that a master controller (profile generator) must not trigger an unintended restart.

Degree of protection if STO is used

You must ensure that conductive substances cannot get into the product (pollution degree 2). If you use the safety function and conductive substances get into the product, the safety function may become inoperative.

Protected cable installation

If short circuits or cross circuits can be expected in connection with the two signals of the STO safety function and if they are not detected by upstream devices, protected cable installation is required.

In the case of an unprotected cable installation, the two signals of the STO safety function may be connected to external voltage if a cable is damaged. If the two signals are connected to external voltage, the STO safety function is no longer operative.

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Protected cable installation possibilities:

- Use separate cables for two signals. Any additional wires in these cables may only carry voltages according to PELV.
- Use a shielded cable. The grounded shield is designed to dissipate the external voltage in the case of damages and to trip the fuse in this way.
- Use a separately grounded shield. If there are other wires in the cable, the two signals must be isolated from these wires by a grounded, separate shield.

Data for maintenance plan and safety calculations

Use the following data of the STO safety function for your maintenance plan and the safety calculations:

Lifetime (IEC 61508)		20 years
SFF (IEC 61508) Safe Failure Fraction	[%]	66
HFT (IEC 61508) Hardware Fault Tolerance Type A subsystem		1
Safety integrity level IEC 61508 IEC 62061		 SIL2 SILCL2
PFH (IEC 61508) Probability of Dangerous Hardware Failure per Hour	[1/h]	$1.84*10^{-9}$
PL (ISO 13849-1) Performance Level		d (Category 3)
$MTTF_d$ (EN 13849-1) Mean Time to Dangerous Failure		4566 years
DC (EN 13849-1) Diagnostic Coverage	[%]	90

Hazard and risk analysis

As a system manufacturer you must conduct a hazard and risk analysis of the entire system. The results must be taken into account in the application of the STO safety function.

The type of circuit resulting from the analysis may differ from the following application examples. Additional safety components may be required. The results of the hazard and risk analysis always have priority.

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5.3.4 Application examples STO

Example of category 0 stop Application without EMERGENCY STOP module, category 0 stop.

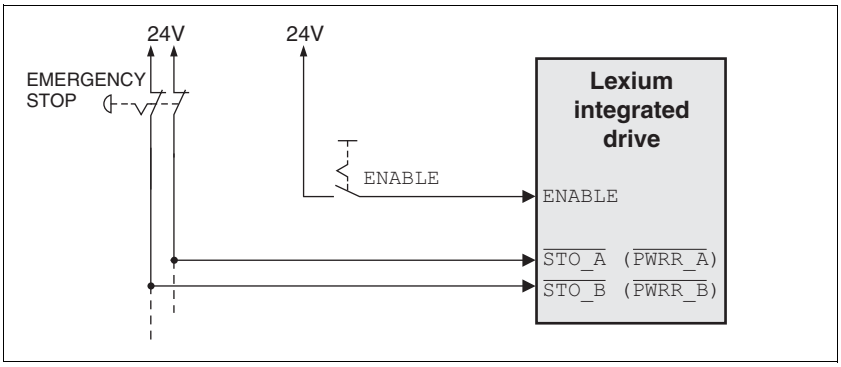

Figure 5.1 Example of category 0 stop

Please note:

- When the EMERGENCY STOP switch is tripped, this initiates a category 0 stop

Example of category 1 stop Application with EMERGENCY STOP module, category 1 stop.

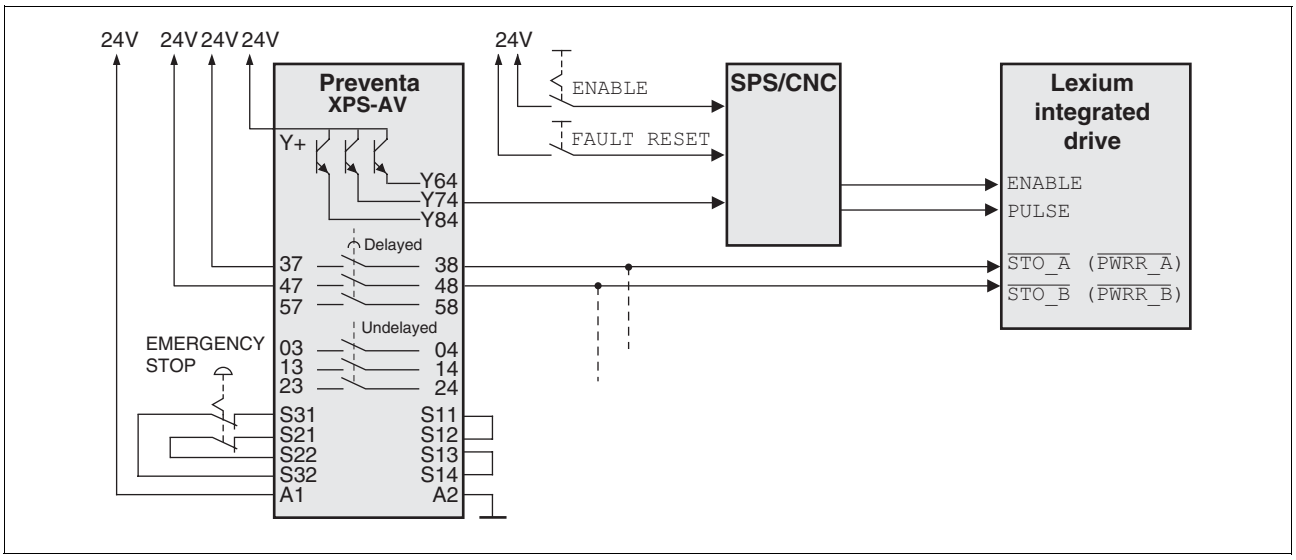

Figure 5.2 Example of category 1 stop

Please note:

- The master controller (profile generator) receives an undelayed stop signal from the EMERGENCY STOP module and must bring the drive to a controlled stop.
- The inputs STO_A (PWRR_A) and STO_B (PWRR_B) must be switched off with a time delay. The delay is set at the EMERGENCY STOP safety module. If the motor has not yet stopped when the delay time has elapsed, it coasts down in an uncontrolled way (uncontrolled stop).
- The specified minimum current and the permissible maximum current of the relay must be observed if the relay outputs of the EMERGENCY STOP module are used.

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5.4 Monitoring functions

The monitoring functions in the product can help to guard the system and reduce the risks involved in a system misoperation. These monitoring functions may not be used to protect persons.

The following monitoring functions are available:

Monitoring	Task
Stall detection	Checks the motor movement using the index pulse
Overvoltage and undervoltage	Monitors for overvoltage and undervoltage of the supply voltage
Motor overload	Monitors for excessively high current in the motor phases
Overtemperature	Monitors the device for overtemperature

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6 Installation

⚠ WARNING

LOSS OF CONTROL

- The designer of any control scheme must consider the potential failure modes of control paths and, for certain critical functions, provide a means to achieve a safe state during and after a path failure. Examples of critical control functions are EMERGENCY STOP, overtravel stop, power outage and restart.
- Separate or redundant control paths must be provided for critical functions.
- System control paths may include communication links. Consideration must be given to the implication of unanticipated transmission delays or failures of the link.
- Observe the accident prevention regulations and local safety guidelines. [1)]
- Each implementation of the product must be individually and thoroughly tested for proper operation before being placed into service.

Failure to follow these instructions can result in death or serious injury.

1) For USA: Additional information, refer to NEMA ICS 1.1 (latest edition), Safety Guidelines for the Application, Installation, and Maintenance of Solid State Control and to NEMA ICS 7.1 (latest edition), Safety Standards for Construction and Guide for Selection, Installation for Construction and Operation of Adjustable-Speed Drive Systems.

⚠ CAUTION

RISK OF INJURY WHEN REMOVING CIRCUIT BOARD PLUGS

- When removing them note that the connectors must be unlocked.
  - Supply voltage VDC:
    Unlock by pulling at the plug housing
  - Miscellaneous:
    Unlock by pressing the locking lever
- Always hold the plug to remove it (not the cable).

Failure to follow these instructions can result in injury or equipment damage.

The chapter Engineering contains basic information that you should know before starting the installation.

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6.1 Electromagnetic compatibility, EMC

⚠ WARNING

SIGNAL AND DEVICE INTERFERENCE

Signal interference can cause unexpected responses of device.

- Install the wiring in accordance with the EMC requirements.
- Verify compliance with the EMC requirements.

Failure to follow these instructions can result in death, serious injury or equipment damage.

This drive system meets the EMC requirements according to the standard IEC 61800-3, if the described measures are implemented during installation. If it is operated outside this scope, note the following:

⚠ WARNING

HIGH-FREQUENCY INTERFERENCE

In a domestic environment this product may cause high-frequency interference that may require action to suppress interference.

EMC measures	Effect
Keep cables as short as possible. Do not install unnecessary cable loops, use short cables from the star point in the control cabinet to the external ground connection.	Reduces capacitive and inductive interference.
Ground the product via the motor flange or with a ground strap to the ground connection at the cover of the connector housing.	Reduces emissions, increases immunity.
Ground shields of digital signal wires at both ends by connecting them to a large surface or via conductive connector housings.	Reduces interference affecting the signal wires, reduces emissions
Connect large surface areas of cable shields, use cable clamps and ground straps	Reduces emissions.

The following cables must be shielded:

- Multifunction interface
- STO safety function,
  see the requirements in chapter 5.3.3 "Requirements for using the safety function".

The following cables do not need to be shielded:

- Supply voltage VDC
- 24 V signal interface

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Equipotential bonding conductors

Potential differences can result in excessive currents on the cable shields. Use equipotential bonding conductors to reduce currents on the cable shields.

The equipotential bonding conductor must be rated for the maximum current flowing. Practical experience has shown that the following conductor cross sections can be used:

- 16 mm^2 (AWG 4) for equipotential bonding conductors up to a length of 200 m
- 20 mm^2 (AWG 4) for equipotential bonding conductors with a length of more than 200 m

6.2 Mechanical installation

⚠ CAUTION

HOT SURFACES

Depending on the operation, the surface may heat up to more than 100°C (212°F).

- Do not allow contact with the hot surfaces.
- Do not allow flammable or heat-sensitive parts in the immediate vicinity.
- Consider the measures for heat dissipation described.
- Check the temperature during test runs.

Failure to follow these instructions can result in injury or equipment damage.

⚠ CAUTION

MOTOR DAMAGE AND LOSS OF CONTROL

Shock or strong pressure applied to the motor shaft may destroy the motor.

- Protect the motor shaft during handling and transportation.
- Avoid shocks to the motor shaft during mounting.
- Do not press parts onto the shaft. Mount parts to the shaft by glueing, clamping, shrink-fitting or screwing.

Failure to follow these instructions can result in injury or equipment damage.

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⚠ WARNING

MOTOR WITHOUT BRAKING EFFECT

If power outage and faults cause the power stage to be switched off, the motor is no longer stopped by the brake and may increase its speed even more until it reaches a mechanical stop.

- Verify the mechanical situation.
- If necessary, use a cushioned mechanical stop or a suitable brake.

Failure to follow these instructions can result in death, serious injury or equipment damage.

⚠ WARNING

LOSS OF BRAKING FORCE DUE TO WEAR OR HIGH TEMPERATURE

Applying the holding brake while the motor is running will cause excessive wear and loss of the braking force. Heat decreases the braking force.

- Do not use the brake as a service brake.
- Note that "EMERGENCY STOPS" may also cause wear
- At operating temperatures of more than 80°C (176°F), do not exceed a maximum of 50% of the specified holding torque when using the brake.

Failure to follow these instructions can result in death, serious injury or equipment damage.

⚠ WARNING

LOAD FALLS DURING SWITCHING ON

When the brake of stepping motor drives is released and external forces are applied (vertical axes), the load may fall if the friction is low.

- In such applications, limit the load to a maximum of 25% of the static holding torque.

Failure to follow these instructions can result in death, serious injury or equipment damage.

To install a drive in locations difficult to access, it may be useful to carry out the electrical installation first and then install the fully wired drive.

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Heat dissipation

The motor may become very hot, e.g. in the case of incorrect arrangement of multiple motor. The surface temperature of the motor must not exceed 110 °C during continuous operation.

- Verify that the maximum temperature is not exceeded.
- Verify that there is sufficient heat dissipation, e.g. by means of good ventilation or heat dissipation via the motor flange.

Mounting

The motor is designed to be mounted using four M5 screws. The motor flange must be mounted on a flat surface to avoid mechanical tension from being transmitted to the housing.

Painted surfaces have an insulating effect. During mounting verify that the motor flange is mounted in such a way as to allow for good conductivity (electrical and thermal).

Mounting distances

No minimum clearances are required for installation. However, note that the motor can become very hot.

Observe the bending radii of the cables used.

Ambient conditions

Observe the permissible ambient conditions.

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6.3 Electrical installation

⚠ WARNING

UNEXPECTED BEHAVIOR CAUSED BY FOREIGN OBJECTS

Foreign objects, deposits or humidity can cause unexpected behavior.

- Keep foreign objects from getting into the product.
- Do not remove the cover of the electronics housing. Only remove the connector housing cover.
- Verify correct seat of seals and cable entries.

Failure to follow these instructions can result in death, serious injury or equipment damage.

⚠ WARNING

LOSS OF SAFETY FUNCTION CAUSED BY FOREIGN OBJECTS

Conductive foreign objects, dust or liquids may cause the STO safety function to become inoperative.

- You may not use the STO safety function unless you have protected the system against contamination by conductive substances.

Failure to follow these instructions can result in death or serious injury.

⚠ CAUTION

DAMAGE TO SYSTEM COMPONENTS AND LOSS OF CONTROL

Interruptions of the negative connection of the controller supply voltage can cause excessively high voltages at the signal connections.

- Do not interrupt the negative connection between the power supply unit and load with a fuse or switch.
- Verify correct connection before switching on.
- Do not connect the controller supply voltage or change its wiring while the is supply voltage present.

Failure to follow these instructions can result in injury or equipment damage.

The chapter Engineering contains basic information that you should know before starting the installation.

The drive is equipped with parameter switches in the connector housing. Set the parameter switches before connecting the cables, because after connection they are difficult to access.

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6.3.1 Overview of all connections

Overview of printed circuit board connectors

The following figure shows the pin assignment of the interfaces with the connector housing cover open.

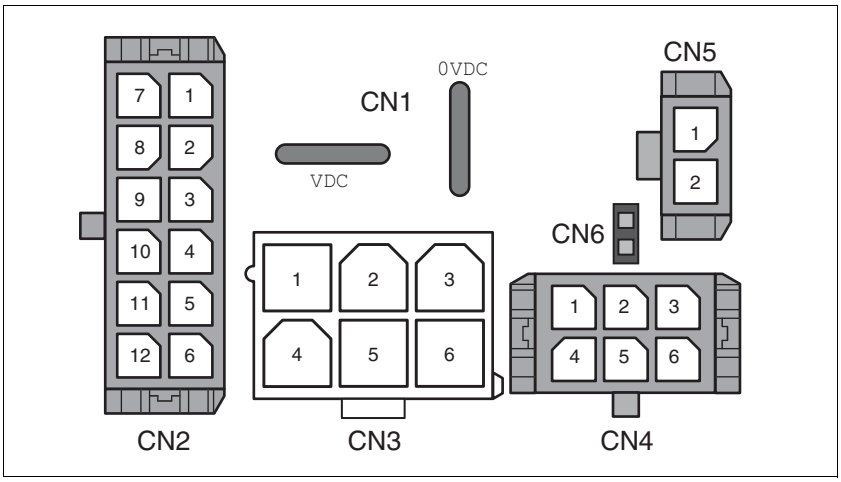

Figure 6.1 Overview of all connections

Connection	Assignment
CN1	Supply voltage VDC
CN2	Multifunction interface
CN3	Service interface
CN4	24 V signal interface
CN5	Interface for STO safety function
CN6	Jumper for disabling STO safety function

6.3.2 Input and output signals

The various functions of the drive are available at two different interfaces. The inputs and outputs of the two different interfaces differ in terms of the signal level.

Overview

Function	Connection CN2	Connection CN4	I/O
PULSE/DIR	CN2.6/12 / CN2.5/11	-	I
A/B	CN2.5/11 / CN2.6/12	-	I
ENABLE	CN2.4/10	CN4.2	I
GATE	CN2.4/10	CN4.2	I
STEP2_INV	CN2.3/9	CN4.5	I
PWM	CN2.3/9	-	I
ACTIVE	CN2.2/8	CN4.6	O
FAULT	-	CN4.3	O
INDEXPULSE	-	CN4.3	O

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6.3.3 Setting the parameter switches

The figure below provides an overview of the available parameter switches. The switches are shown as you see them when the connector housing cover is open.

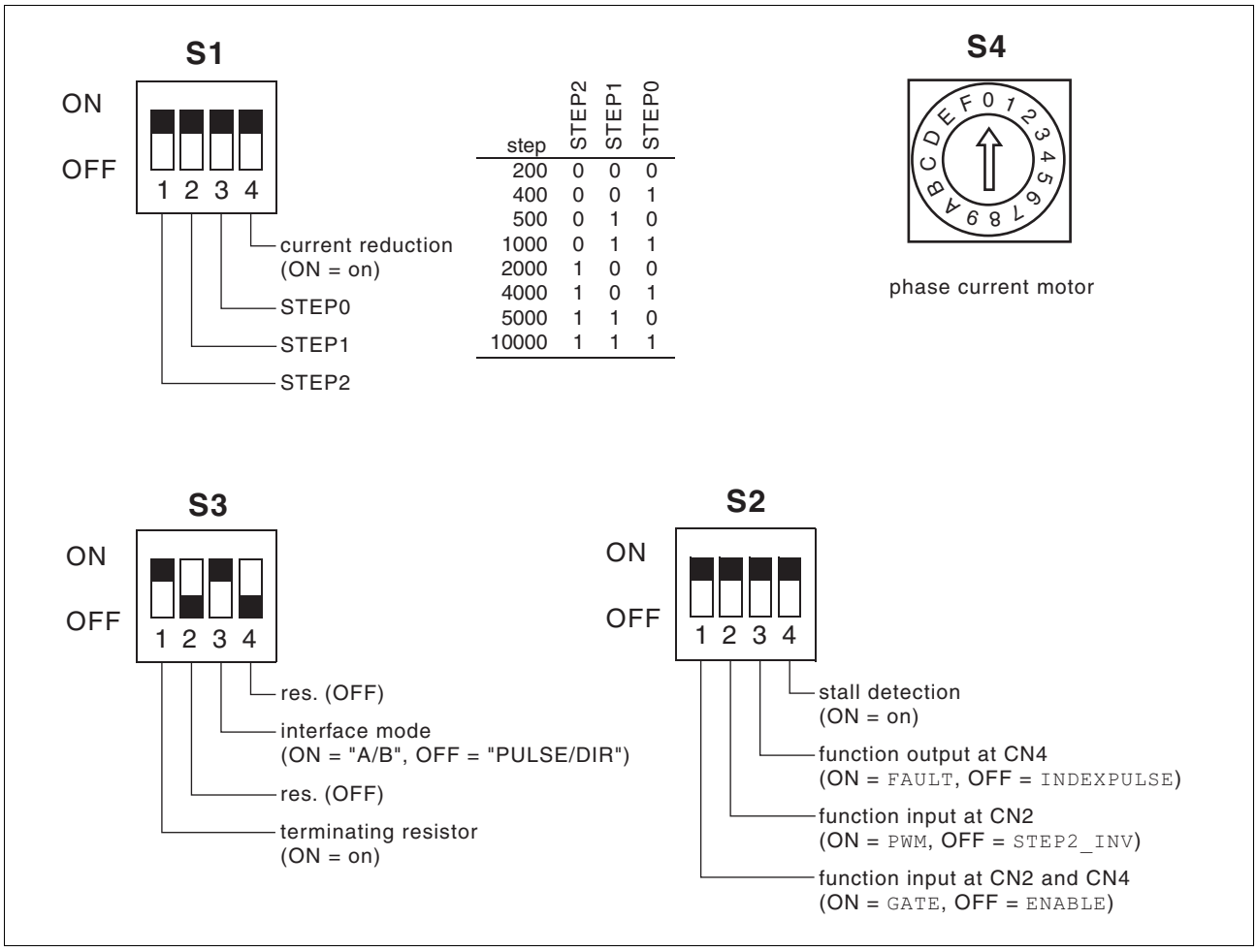

Figure 6.2 Parameter switches

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6.3.3.1 Switch S1

Setting the number of steps

The resolution of the drive can be adjusted via the number of steps.

Example: At a number of steps of 1000, the drive executes exactly one complete motor revolution at 1000 pulses.

At a pulse frequency of 1 kHz this corresponds to a speed of rotation of 60 1/min.

- ▶ Switch off all supply voltages. Verify that no voltages are present (safety instructions).
- ▶ Use parameter switches S3.1 to S3.3 to set the number of steps.

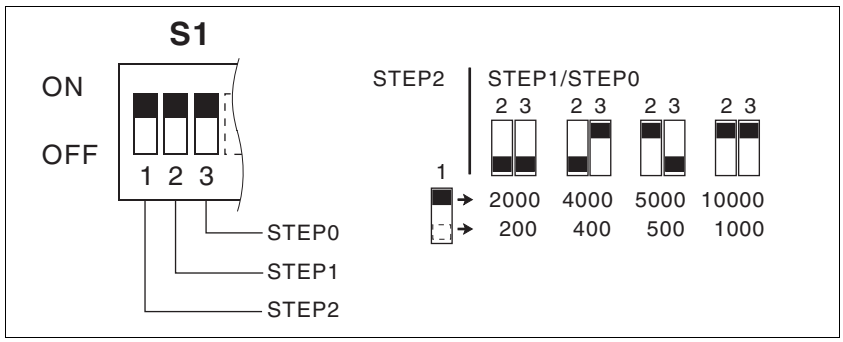

Figure 6.3 Setting the number of steps

The "STEP2" setting can be inverted with the `STEP2_INV` input signal.

Setting the "current reduction"

If the full holding torque is not required at standstill, the "current reduction" function can be used to reduce the holding torque.

⚠ WARNING

FALLING LOAD AT STANDSTILL

If the current reduction is enabled, the motor torque at standstill is reduced; if external forces act on the drive (vertical axes), this may cause the load to fall.

- Verify that the load conditions allow for operation with current reduction.
- If necessary, switch on the current reduction.

Failure to follow these instructions can result in death, serious injury or equipment damage.

Motor and electronics heat up less and efficiency is improved.

The motor phase current is reduced to approximately 70% of the set motor phase current value 100 ms after the rising edge of a pulse.

- ▶ Switch off all supply voltages. Verify that no voltages are present (safety instructions).
- ▶ Activate or deactivate current reduction with parameter switch S1.4.

Switch setting S1.4	Meaning
ON (factory setting)	Function "Current reduction" activated
OFF	Function "Current reduction" deactivated

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6.3.3.2 Switch S2

Setting the "ENABLE/GATE" signal input

The "ENABLE/GATE" signal can have 2 functions:

Switch setting S2.1	Meaning
ON	Function "GATE"
	Enable/block power stage
OFF	Function "ENABLE"
	Enable/block pulse input

The "ENABLE/GATE" signal is available at the following interfaces:

- 24 V signal interface
- Multifunction interface

Setting the "STEP2_INV/PWM" signal input

The "STEP2_INV/PWM" signal can have 2 functions:

Switch setting S2.2	Meaning
ON	Function "PWM"
	Control of the motor phase current or current set to zero by pulse width modulation at signal input.
OFF	Function "STEP2_INV"
	Inverting the setting of parameter switch 1.1 "STEP2" (increase or reduce number of steps by a factor of 10)

The "STEP2_INV/PWM" signal is available at the following interfaces:

- Multifunction interface
- STEP2_INV also at 24V signal interface

Setting the "FAULT/INDEXPULSE" signal output

The "FAULT/INDEXPULSE" signal can have two functions:

Switch setting S2.3	Meaning
ON	Function "FAULT"
OFF	Function "INDEXPULSE"

The "FAULT/INDEXPULSE" signal is available at the following interfaces:

- 24V signal interface, pin 3

Setting the stall detection

Switch setting S2.4	Meaning
ON	Stall detection enabled
OFF	Stall detection disabled

The drive is fitted with stall detection. The stall detection responds if the actual position of the motor deviates from the reference position by more than one revolution.

If the stall detection responds, the current to the drive is disabled and the signal output FAULT is set.

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6.3.3.3 Switch S3

Setting the terminating resistor

Switch setting S3.1	Meaning
ON	125Ω terminating resistor enabled
OFF	125Ω terminating resistor disabled

Setting the interface mode

Switch setting S3.3	Meaning
ON	Interface mode "A/B"
OFF	Interface mode "PULSE/DIR"

The reference position values can be supplied to the multifunction interface as pulse/direction signals or as A/B encoder signals. The compact drive converts the input signals to a motor movement, corresponding to the switch setting.

Reserved parameter switches are provided for future extensions and must be set to OFF.

6.3.3.4 Switch S4

The motor phase current is set with a rotary switch S4. A high motor phase current generates a high motor torque.

Switch setting S4	Motor phase current [1)]
0	25
1	30
2	35
3	40
4	45
5	50
6	55
7	60
8	65
9	70
A	75
B	80
C	85
D	90
E	95
F	100

1) In percent of nominal current

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6.3.4 Connection via cable entry

The cable specifications and pin assignments can be found in the chapters that describe the connections.

Preparing and fastening cables

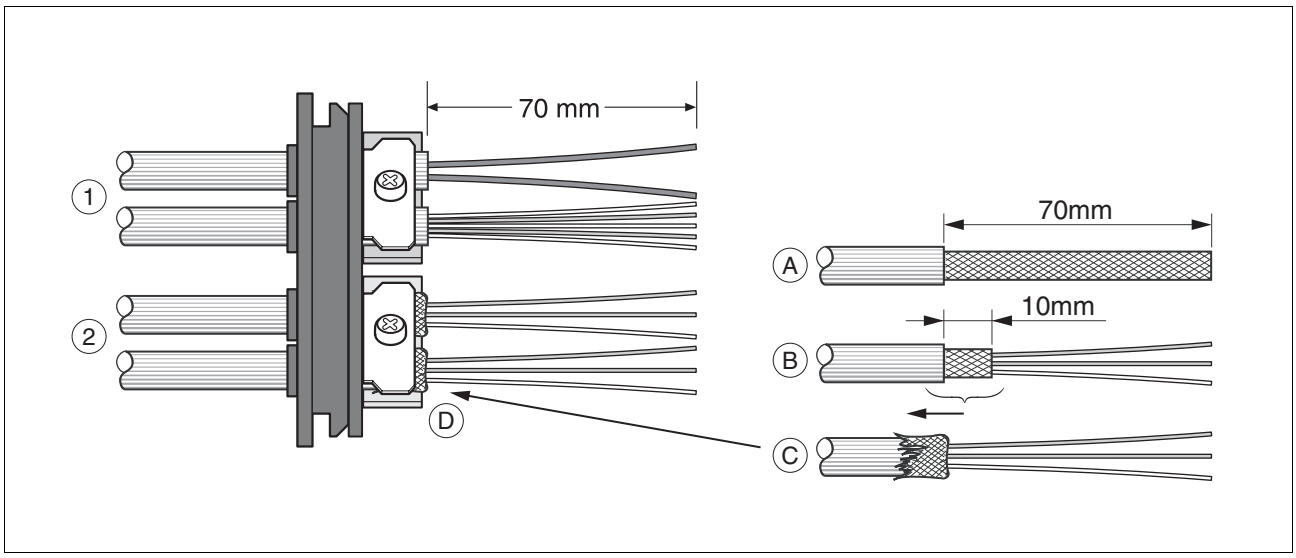

Figure 6.4 Fastening the cable in the cable entry

(1) Unshielded cable
(2) Shielded cable

- ▶ Trim the cable bushings to fit the cable.

  NOTE: The specified degree of protection IP54 can only be achieved with properly trimmed cable bushings.
- ▶ (A) Strip the jacket of all cables; length 70 mm.
- ▶ (B) Shorten the shield to a rest of 10 mm.
- ▶ (C) Slide the shield braiding back over the cable jacket.
- ▶ (D) Loosen the strain relief.
- ▶ Push the cables though the strain relief.
- ▶ Glue EMC shielding foil around the shield.
- ▶ Pull the cable back to the strain relief.
- ▶ Fasten the strain relief.

Mounting connectors

The table below lists the parts and data required for assembly. Connector housings and crimp contacts are included in the accessories kit. See also chapter 10 "Accessories and spare parts".

Only use the special tool listed in the Accessories chapter to release single crimp contacts from the connector housing.

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Connection	Conductor cross section of the crimp contact [mm²]	Stripping length [mm]	Manufacturer's crimp contact no.	Crimping tool	Connector manufacturer	Connector type
CN1	0.75 ... 1.5 (AWG 18 ... 16) 2.5 ... 4.0 (AWG 12)	5 ... 65 ... 6	160773-6 341001-6	654174-1	Tyco Electronics	Positive Lock 1-926 522-1
CN2	0.14 ... 0.6 (AWG 24 ... 20)	2.5 ... 3.0	43030-0007	69008-0982	Molex	Micro-Fit 3.0 43025-1200
CN3	0.25 ... 1.0 (AWG 24 ... 18)	3.0 ... 3.5	39-00-0060	69008-0724	Molex	Mini-Fit Jr. 39-01-2065
CN4	0.14 ... 0.6 (AWG 24 ... 20)	2.5 ... 3.0	43030-0007	69008-0982	Molex	Micro-Fit 3.0 43025-0600
CN5	0.14 ... 0.6 (AWG 24 ... 20)	2.5 ... 3.0	43030-0007	69008-0982	Molex	Micro-Fit 3.0 43645-0200

Prepare the cable for connection as follows:

- ▶ Strip the ends of the cable.
- ▶ Attach cable lugs and crimp contacts. Verify that you have the correct crimp contacts and the matching crimping tool.
- ▶ Slide the cable lugs and crimp contacts straight into the connector until they snap in place.

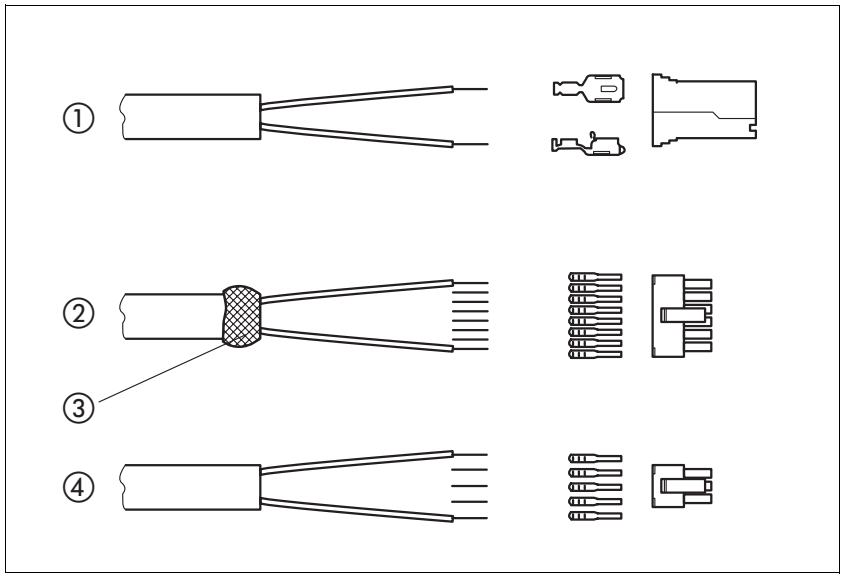

Figure 6.5 Connectors, cable lugs and crimp contacts

(1) Supply voltage VDC
(2) Multifunction interface
(3) Shield wire with EMC shield foil
(4) 24 V signal interface

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Mounting the cable entry

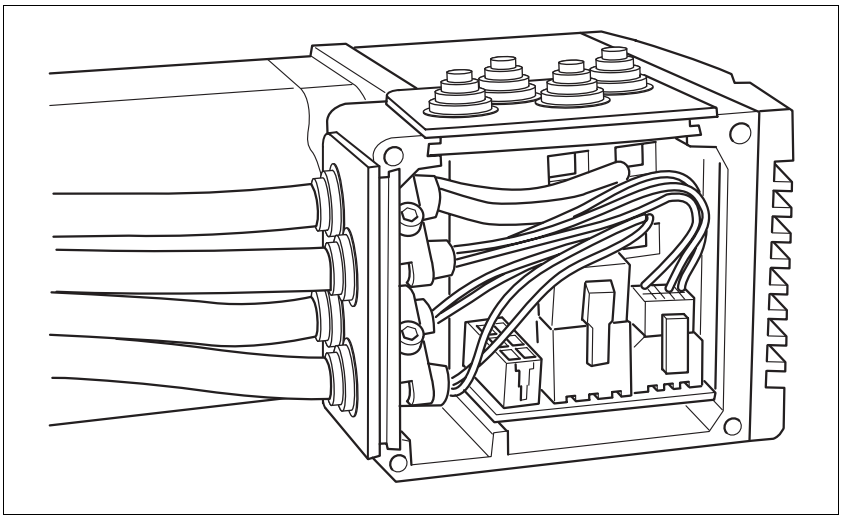


Figure 6.6 Inserting the cable entries

- ▶ Unscrew the connector housing cover.

  NOTE: Shipping locks made of cardboard must not be used for operating the drive. Replace all shipping locks by cable entries or signal inserts.

- ▶ First adjust the parameter switches as these are difficult to access once the cables are connected.

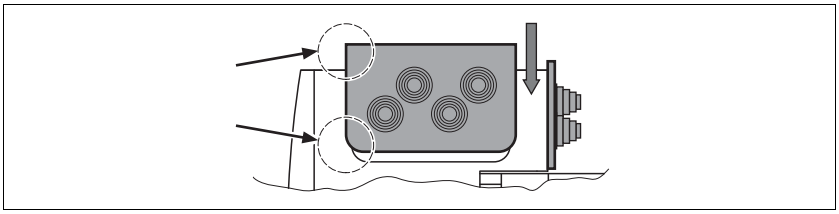
  For a description of the parameter switches, see the chapters describing the connections.

- ▶ Connect the plug of the assembled cable to the matching socket. The plugs cannot be turned out of position and must click into place when being plugged in.

  Only pull the connector housing (not the cable).

- ▶ Plug the cable entry in one of the two cutouts provided. The side to be used for the cable entry depends on the space available in your system.

  NOTE: The pointed corners of the cable entry must point in the direction of the connector housing cover. Degree of protection IP54 is not reached if the cable entry is mounted the other way round.



- ▶ Close the cutout that is not used with a sealing insert for cutouts.
- ▶ Finally, screw the connector housing cover back into place.

  If screws are lost use M3x12 only.

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6.3.5 Connection of VDC supply voltage

⚠ DANGER

ELECTRIC SHOCK CAUSED BY INCORRECT POWER SUPPLY UNIT

The VDC and +24VDC supply voltages are connected with many exposed signal connections in the drive system.

- Use a power supply unit that meets the PELV (Protective Extra Low Voltage) requirements.
- Connect the negative output of the power supply unit to PE (ground).

Failure to follow these instructions will result in death or serious injury.

⚠ CAUTION

LOSS OF CONTROL DUE TO REGENERATION CONDITION

Regeneration conditions resulting from braking or external driving forces may increase the VDC supply voltage to an unexpected level. Components not rated for this voltage may be destroyed or cause misoperation.

- Verify that all VDC consumers are rated for the voltage occurring during regeneration conditions (for example limit switches).
- Use only power supply units that will not be damaged by regeneration conditions.
- Use a braking resistor controller, if necessary.

Failure to follow these instructions can result in injury or equipment damage.

CAUTION

DAMAGE TO CONTACTS

The connection for the controller supply voltage at the product does not have an inrush current limitation. If the voltage is switched on by means of switching of contacts, damage to the contacts or contact welding may result.

- Use a power supply unit that limits the peak value of the output current to a value permissible for the contact.
- Switch the power input of the power supply unit instead of the output voltage.

Failure to follow these instructions can result in equipment damage.

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⚠ CAUTION

DAMAGE TO SYSTEM COMPONENTS AND LOSS OF CONTROL

Interruptions of the negative connection of the controller supply voltage can cause excessively high voltages at the signal connections.

- Do not interrupt the negative connection between the power supply unit and load with a fuse or switch.
- Verify correct connection before switching on.
- Do not connect the controller supply voltage or change its wiring while the is supply voltage present.

Failure to follow these instructions can result in injury or equipment damage.

Cable specifications and terminal

Two different crimp contacts are available for different conductor cross sections, see chapter 6.3.4 "Connection via cable entry".

Minimum conductor cross section	[mm^2]	0.75 (AWG 18)
Maximum connection cross section	[mm^2]	4.0 (AWG 12)
Stripping length	[mm]	5 ... 65 ... 6

Crimp contact 1607736-6	[mm^2]	
Minimum connection cross section		0.75 (AWG 18)
Maximum connection cross section		1.5 (AWG 16)
Crimp contact 341001-6	[mm^2]	
Minimum connection cross section		2.5 (AWG 12)
Maximum connection cross section		4.0 (AWG 12)

Unshielded cables may be used for the VDC supply voltage. Twisted pair is not required.

- ▶ Use pre-assembled cables to reduce the risk of wiring errors.
- ▶ Verify that wiring, cables and connected interfaces meet the PELV requirements.

Connecting the cables

- ▶ Note the specified technical data.
- ▶ Note the information provided in chapters 5.1 "External power supply units" and 5.2 "Ground design".
- ▶ Install fuses for the power supply cable accordance with the selected conductor cross section / wire gauge (note the inrush currents).

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Pin assignment printed circuit board connector

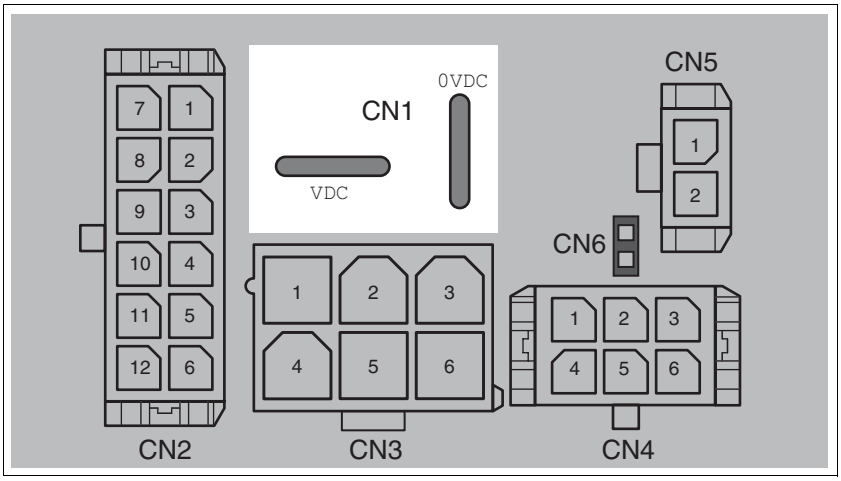

Figure 6.7 Pin assignment supply voltage

Signal	Meaning	Number [1)]
VDC	Supply voltage	1
0VDC	Reference potential to VDC	2

1) Information relates to pre-assembled cables

You can crimp together two wires to supply multiple drives via one DC bus. Two different crimp contacts are available for different conductor cross sections, see chapter 6.3.4 "Connection via cable entry".

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6.3.6 Connection of multifunction interface

Circuit of the signal inputs

The signal input circuits depend on the type of device used.

Drives with galvanic isolation are isolated by means of optocouplers.

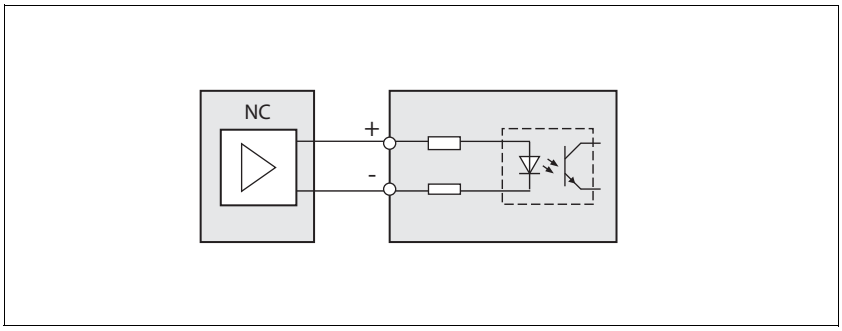

Figure 6.8 Signal input circuits with galvanic isolation

Drives without galvanic isolation operate at the RS422 level.

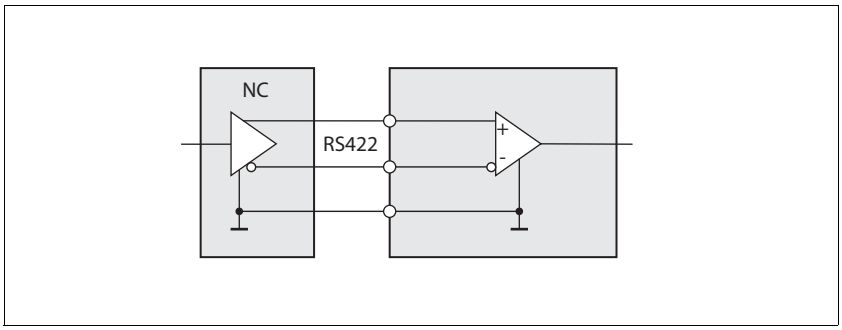

Figure 6.9 Signal input circuits without galvanic isolation

- Logic 0
  - 0 level at input "+"
  - 1 level at input "-"
- Logic 1
  - 1 level at input "+"
  - 0 level at input "-"

Open inputs are logic 0.

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Signal output circuits

The ACTIVE signal output provides the operating readiness signal for the drive.

Drives with galvanic isolation are isolated by means of optocouplers. The signal output switches through if the power stage is enabled.

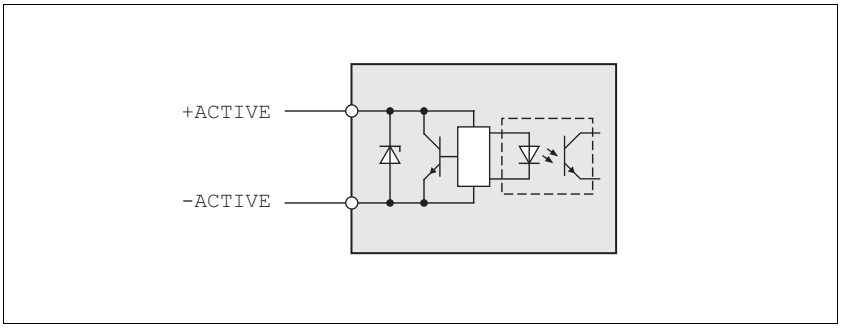

Figure 6.10 Signal output circuits with galvanic isolation

In the case of drives without galvanic isolation, the signal output is an open collector output. -ACTIVE and 0VDC are connected internally. When the power stage is enabled, the signal output +ACTIVE switches through to 0VDC.

The signal output ACTIVE of a product versions is short-circuit protected.

Pin	Signal	Signal value	Meaning
2, 8	ACTIVE	0	Power stage is enabled
		High resistance	Power stage is disabled

Cable specifications and terminal

- Shielded cable
- Twisted-pair cables
- Grounding of the shield at both ends

Maximum cable length [1]	[m]	100
Minimum conductor cross section	[mm^2]	0.14 (AWG 24)
Maximum connection cross section	[mm^2]	0.6 (AWG 20)
Stripping length	[mm]	2.5 ... 3.0

1) The length depends on the conductor cross section and the driver circuit used

▶ Use equipotential bonding conductors, see page 47.

▶ Use pre-assembled cables to reduce the risk of wiring errors.

▶ Verify that wiring, cables and connected interfaces meet the PELV requirements.

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Pin assignment printed circuit board connector

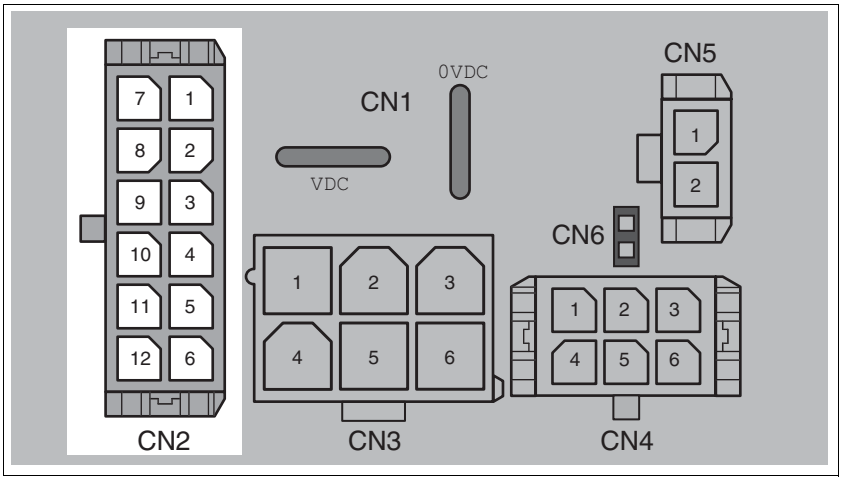

Figure 6.11 Pin assignment multifunction interface

Pin	Signal	Meaning	Color [1)]	I/O
1	+5V	220Ω resistance against internal +5V	-	
7	0V	Internally connected to CN1.0VDC	Blue	
2	+ACTIVE	Drive ready	Red/blue	O
8	-ACTIVE	Drive ready	Gray/pink	O
3	+STEP2_INV or +PWM	Angular resolution or control of phase currents	Black	I
9	-STEP2_INV or -PWM	Angular resolution or control of phase currents	Violet	I
4	+ENABLE or +GATE	Enable signal	Gray	I
10	-ENABLE or -GATE	Enable signal	Pink	I
5	+DIR or +A	Direction of rotation "DIR" or "A" channel of AB encoder signals	Green	I
11	-DIR or -A	Direction of rotation "DIR" or "A" channel of AB encoder signals	Yellow	I
6	+PULSE or +B	Motor step "PULSE" or "B" channel of AB encoder signals	White	I
12	-PULSE or -B	Motor step "PULSE" or "B" channel of AB encoder signals	Brown	I

1) Information relates to pre-assembled cables

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6.3.7 24V signal interface connection

24V signal power supply

The 24V signal power supply provided for constant supply of the sensor system.

It must not be connected in parallel with the 24V signal power supply of a different drive.

Cable specifications and terminal

Minimum conductor cross section	[mm^2]	0.2 (AWG 24)
Maximum connection cross section	[mm^2]	0.6 (AWG 20)
Stripping length	[mm]	2.5 ... 3.0

- ▶ Use pre-assembled cables to reduce the risk of wiring errors.
- ▶ Verify that wiring, cables and connected interfaces meet the PELV requirements.

Pin assignment printed circuit board connector

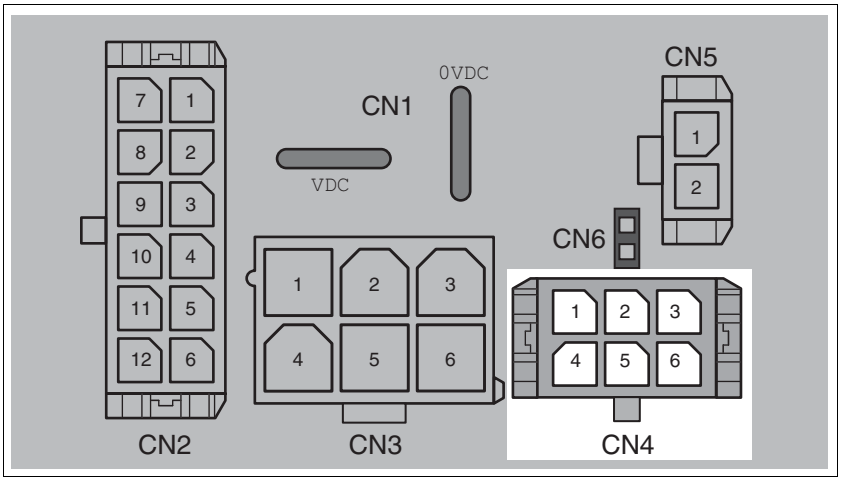

Figure 6.12 Pin assignment of the 24V signal interface

Pin	Signal	Meaning	I/O
1	+24VDC_OUT	24V signal power supply	O
2	ENABLE or GATE	Enable signal	I
3	FAULT or INDEXPULSE	Error detection or Index pulse	O
4	0VDC	Internally connected to CN1.0VDC	
5	STEP2_INV	Angular resolution	I
6	ACTIVE	Drive ready	O

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6.3.8 Connection of STO safety function

⚠ WARNING

LOSS OF SAFETY FUNCTION

Incorrect usage may cause a hazard due to the loss of the safety function.

- Observe the requirements for using the safety function.

Failure to follow these instructions can result in death or serious injury.

Requirements

For information and requirements relating to the STO safety function, see chapter 5.3 "Safety function STO ("Safe Torque Off")".

Cable specifications and terminal

- Shielded cable corresponding to the requirements for protected layout of wires

Minimum conductor cross section	[mm^2]	0.34 (AWG 20)
Maximum connection cross section	[mm^2]	0.6 (AWG 20)
Stripping length	[mm]	2.5 ... 3.0

▶ Use equipotential bonding conductors, see page 47.

▶ Use pre-assembled cables to reduce the risk of wiring errors.

▶ Verify that wiring, cables and connected interfaces meet the PELV requirements.

The cable available as an accessory is a special cable that is only available with a connector. The shield of the cable is connected to the grounded housing of the drive via the metal connector. It is sufficient to connect one end of the cable to the grounded housing.

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Pin assignment printed circuit board connector

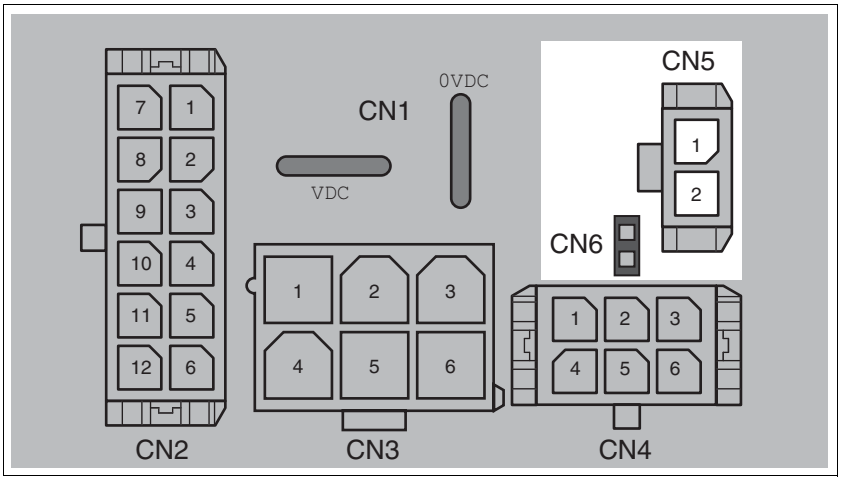
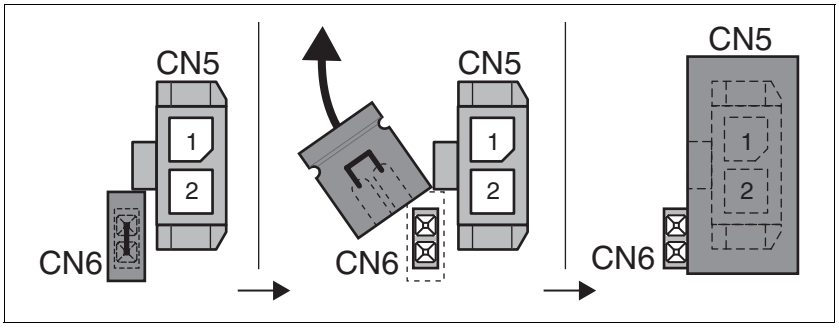


Figure 6.13 Pin assignment of safety function

Pin	Signal	Meaning
CN5.1	$\overline{\text{STO\_A}}$ ($\overline{\text{PWRR\_A}}$)	Safety function STO "Safe Torque Off" (IEC/ EN 61800-5-2)
CN5.2	$\overline{\text{STO\_B}}$ ($\overline{\text{PWRR\_B}}$)	Safety function STO "Safe Torque Off" (IEC/ EN 61800-5-2)
CN6		Jumper plugged in: STO disabled Jumper removed: STO enabled

NOTE: Jumper CN5 cannot be plugged in as long as jumper CN6 is still plugged in (mechanical lock).

Connecting the safety function



- ▶ Remove jumper CN6.
- ▶ Connect the connector to CN5.

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6.4 Checking wiring

Check the following:

- ▶ Did you properly install and connect all cables and connectors?
- ▶ Are there any live, exposed cables?
- ▶ Did you properly connect the signal wires?
- ▶ Did you properly install all seals (degree of protection IP54)?

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7 Commissioning

⚠ WARNING

UNEXPECTED MOVEMENT

When the drive is operated for the first time, there is a risk of unexpected movements caused by possible wiring errors or unsuitable parameters.

- Perform the first test run without coupled loads.
- Verify that a functioning button for EMERGENCY STOP is within reach.
- Anticipate movements in the incorrect direction or oscillation of the drive.
- Only start the system if there are no persons or obstructions in the hazardous area.

Failure to follow these instructions can result in death, serious injury or equipment damage.

⚠ WARNING

UNINTENDED BEHAVIOR

The behavior of the drive system is governed by numerous stored data or settings. Unsuitable settings or data may trigger unexpected movements or responses to signals and disable monitoring functions.

- Do NOT operate the drive system with unknown settings or data.
- Verify that the stored data and settings are correct.
- When commissioning, carefully run tests for all operating states and potential fault situations.
- Verify the functions after replacing the product and also after making changes to the settings or data.
- Only start the system if there are no persons or obstructions in the hazardous area.

Failure to follow these instructions can result in death, serious injury or equipment damage.

⚠ WARNING

ROTATING PARTS

Rotating parts may cause injuries and may catch clothing or hair. Loose parts or parts that are unbalanced may be flung.

- Verify correct mounting and installation of all rotating parts.
- Use a cover to help protect against rotating parts.

Failure to follow these instructions can result in death, serious injury or equipment damage.

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⚠ WARNING

MOTOR WITHOUT BRAKING EFFECT

If power outage and faults cause the power stage to be switched off, the motor is no longer stopped by the brake and may increase its speed even more until it reaches a mechanical stop.

- Verify the mechanical situation.
- If necessary, use a cushioned mechanical stop or a suitable brake.

Failure to follow these instructions can result in death, serious injury or equipment damage.

⚠ WARNING

FALLING PARTS

The motor may move as a result of the reaction torque; it may yyyyy tip and fall.

- Mount the motor securely so it will not break loose during strong acceleration.

Failure to follow these instructions can result in death, serious injury or equipment damage.

⚠ CAUTION

HOT SURFACES

Depending on the operation, the surface may heat up to more than 100°C (212°F).

- Do not allow contact with the hot surfaces.
- Do not allow flammable or heat-sensitive parts in the immediate vicinity.
- Consider the measures for heat dissipation described.
- Check the temperature during test runs.

Failure to follow these instructions can result in injury or equipment damage.

7.1 Preparing for commissioning

The following tests are required before commissioning:

▶ Wiring and connection of all cables and system components

▶ Function of the limit switch, if installed

For commissioning, you need a fieldbus master (e.g. PLC) or an industrial PC

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7.2 Running commissioning

7.2.1 First setup

Prepare a list with the parameters required for the functions used.

Direction of rotation

Rotation of the motor shaft in a clockwise or counterclockwise direction of rotation. Clockwise rotation is when the motor shaft rotates clockwise as you look at the end of the protruding motor shaft.

The direction of rotation can be reversed with the parameter `Motion.invertDir 28:6`.

The new value is only activated when the drive is switched on.

▶ Save the parameter to the EEPROM

▶ Switch the supply voltage off and on.

If you invert the direction of rotation, verify once again that the limit switches are properly wired.

- Connect the positive limit switch to `IO0`
- Connect the negative limit switch to `IO1`

The positive limit switch is the switch that is tripped by the mechanical system if the motor shaft rotates as follows:

- Without inversion of the direction of rotation: Clockwise
- Without inversion of the direction of rotation: Counter-clockwise

Reference speed

The reference speed for the motor depends on the application requirements.

▶ Set the reference speed with the parameter `Motion.v_target0 29:23`.

Acceleration/deceleration

Note that when the drive decelerates, it recovers energy from the system and the voltage may increase depending on the external torque and the deceleration value set.

The drive has two acceleration settings:

- Acceleration/deceleration
  Parameter `Motion.acc, 29:26`
- Deceleration for "Quick Stop"
  Parameter `Motion.dec_Stop, 28:21`

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7.2.2 Starting 24V signal interface

7.2.2.1 Setting the functions of the 24V signals

You can configure the 24V signals as input or output with the parameters `IO.IO0_def 34:1` to `IO.IO3_def 34:4` and assign specific functions to the 24V signals.

For more information see chapter 6 "Installation".

7.2.2.2 Testing 24V signals

The following table shows the readable and writable status of the 24V signals and the possible parameter settings.

Group.Name Index:Subindex dec. (hex.)	Description Bit assgnment	Data type range dec.	Unit Default dec.	R/W per.
I/O.IO0_def 34:1 ($22:01_h$)	Configuration of IO0 Value 0: Input freely usable Value 1: Input LIMP (only with IO0) Value 2: Input LIMN (only with IO1) Value 3: Input STOP Value 4: Input REF Value 5: Input programmable Value 128: Output freely usable Value 130: Output programmable	UINT16 0..255	- 1	R/W per.
I/O.IO1_def 34:2 ($22:02_h$)	Configuration of IO1 See parameter IO0_def	UINT16 0..255	- 2	R/W per.
I/O.IO2_def 34:3 ($22:03_h$)	Configuration of IO2 See parameter IO0_def	UINT16 0..255	-	R/W per.
I/O.IO3_def 34:4 ($22:04_h$)	Configuration of IO3 See parameter IO0_def	UINT16 0..255	-	R/W per.

Testing the signal inputs and limit switches

Proceed as follows for testing:

- ▶ Trigger the limit switch or the sensor manually.

  The corresponding bit in parameter `IO.IO_act 33:1` must be 1 as long as the input is logic 1.

Checking the freely usable signal outputs

Proceed as follows for testing:

- ▶ Write the value required to set the associated output to logic 1 to parameter `IO.IO_act 33:1`.
- ▶ Measure the voltage at the output or check the response of the connected actuator.

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7.2.2.3 Testing the function of limit switches

Monitoring of the $\overline{LIMP}$ / $\overline{LIMN}$ limit switches is activated in the factory settings. In all drives without limit switches, monitoring must be disabled with the parameter `Settings.SignEnabl, 23:13`, value = 0.
The factory setting for the STOP input is "disabled".

Condition: The limit switch signals are monitored.

For more information see chapter 7.2.2.2 "Testing 24V signals".

Group.Name Index:Subindex dec. (hex.)	Description Bit assgnment	Data type range dec.	Unit Default dec.	R/W per.
Settings.SignEnabl 28:13 (1C:0D$_h$)	Activation of monitoring inputs Bit value 0: Monitoring is not active Bit value 1: Monitoring is active Assignment of bits: Bit 0: LIMP (positive limit switch) Bit 1: LIMN (negative limit switch) Bit 2: STOP (STOP switch) Bit 3: REF (reference switch) NOTE: Monitoring is only active if the I/O port is configured as the corresponding function (parameter I/O.IO0_def to IO3_def).	UINT16 0..15	- 	R/W per.
Settings.SignLevel 28:14 (1C:0E$_h$)	Signal level for monitoring inputs Used to define whether errors are triggered at 0 or 1 level. Bit value 0: Response at 0 level Bit value 1: Response at 1 level Assignment of bits: Bit 0: LIMP Bit 1: LIMN Bit 2: STOP Bit 3: REF	UINT16 0..15	- 0	R/W per.
Status.Sign_SR 28:15 (1C:0F$_h$)	Stored signal status of external monitoring signals Bit value 0: not activated Bit value 1: activated Assignment of bits: Bit 0: LIMP Bit 1: LIMN Bit 2: STOP Bit 3: REF Bit 7: SW stop Stored signal status of released external monitoring signals	UINT16 0..15	- -	R/-

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You can change enabling of the external monitoring signals $\overline{\text{LIMP}}$, $\overline{\text{LIMN}}$ and STOP with the parameter `Settings.SignEnabl 28:13`; use the parameter `Settings.SignLevel 28:14` to change evaluation for active LOW or HIGH.

- Connect the limit switch that limits the working range for clockwise rotation to $\overline{\text{LIMP}}$.
- Connect the limit switch that limits the working range for counter-clockwise rotation to $\overline{\text{LIMN}}$.
- Verify the function of the limit switches with the parameter `Status.Sign_SR 28:15`.
- Enable the power stage.
- Run a "Fault Reset".

  After that, no bit may be set in parameter `Status.Sign_SR 28:15`.
- Briefly actuate the limit switch manually.

  After that, the corresponding bit must be set in parameter `Status.Sign_SR 28:15`.
- Run a "Fault Reset".

  After that, no bit may be set in parameter `Status.Sign_SR 28:15`.

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7.2.3 Testing safety functions

Operation with STO

If you wish to use the STO safety function, carry out the following steps. Perform the steps exactly in the sequence described.

- Supply voltage switched off.
- ▶ Verify that the inputs $\overline{\text{STO\_A}}$ ($\overline{\text{PWRR\_A}}$) and $\overline{\text{STO\_B}}$ ($\overline{\text{PWRR\_B}}$) are electrically isolated from each other. The two signals must not be electrically connected.
- ▶ Trigger the safety function. $\overline{\text{STO\_A}}$ ($\overline{\text{PWRR\_A}}$) and $\overline{\text{STO\_B}}$ ($\overline{\text{PWRR\_B}}$) must be switched off.
- ▶ Switch on the VDC supply voltage.
- ▶ Reset the safety function. $\overline{\text{STO\_A}}$ ($\overline{\text{PWRR\_A}}$) and $\overline{\text{STO\_B}}$ ($\overline{\text{PWRR\_B}}$) must be switched on simultaneously (time offset <1s).
- ▶ Enable the power stage.

Input ENABLE/GATE to ENABLE	Input ENABLE/GATE to GATE
Enable the power stage with the input signal ENABLE, see chapter 8.2.2 "Input ENABLE"	Power stage is automatically enabled

- ◁ The power stage is enabled. If the power stage is not enabled, there is a wiring error.
- ▶ Trigger the safety function. $\overline{\text{STO\_A}}$ ($\overline{\text{PWRR\_A}}$) and $\overline{\text{STO\_B}}$ ($\overline{\text{PWRR\_B}}$) must be switched off simultaneously (time offset <1s).
- ◁ The power stage is disabled and the output FAULT is set. If the power stage is not disabled, there is a wiring error.
- ▶ Check the behavior of the drive during fault conditions.
- ▶ Document all tests of the safety function in your acceptance certificate.

Operation without STO

If you do not want to use the STO safety function:

- ▶ Verify that jumper CN6 is connected.

7.2.4 Testing the function of limit switches

You can limit the movement range of the motor with limit switches. The limit switch signals must be monitored by the master controller. When the limit switch is tripped, the master controller must interrupt the reference value pulses to the drive.

- ▶ Verify the function of the limit switches before operating the drive in the system.

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7.2.5 Performing the test run

⚠ WARNING

UNEXPECTED MOVEMENT

- Run the first test movement with no coupled load.
- If the drive is already installed in a system, make sure that unexpected movements will not cause any damage.
- Start the first test movement with low pulse frequency. If the "DIR" signal is disabled, the drive must rotate clockwise.

Failure to follow these instructions can result in death, serious injury or equipment damage.

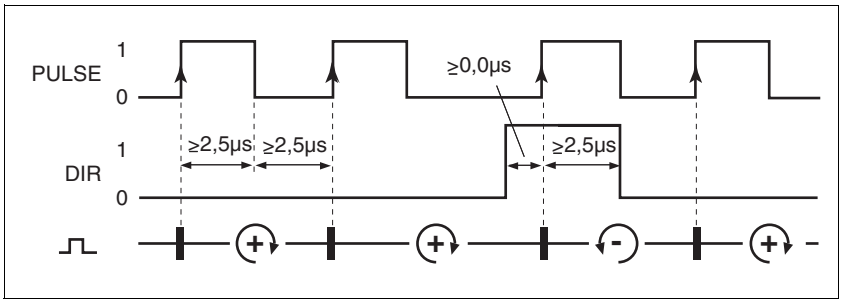

Figure 7.1 Checking the direction of rotation of the motor

If the motor follows the pulses, the motor is correctly controlled.

7.2.6 Optimizing the motor behavior

Selecting the number of steps

Each input pulse is smoothed internally. The number of steps should be set as high as possible for optimum constant velocity.

At an input frequency of 100 Hz and higher, internal switching to continuous movement achieves a smoother constant velocity of the motor.

Calculating and testing cut-off frequencies

The cut-off frequencies for the following operating phases must be set at the NC controller for optimum operation:

- Acceleration phase
- Start-stop phase

The cut-off frequencies of a motor depend on the following quantities:

- Motor torque
- External mass moment of inertia

You can use these moments to derive the cut-off frequencies from the characteristic curves.

Proceed as follows to calculate the cut-off frequencies:

- Calculate the moment of inertia of the system reduced to the axis.
- Calculate the following values based on the motor characteristic and the motor torque:
  - Maximum start-stop frequency
  - Slope of frequency ramp

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Frequency for the start-stop phase

The unloaded motor starts and stops at the start-stop frequency. If external moments of inertia affect the motor, you will need to select a lower frequency for the start-stop phase.

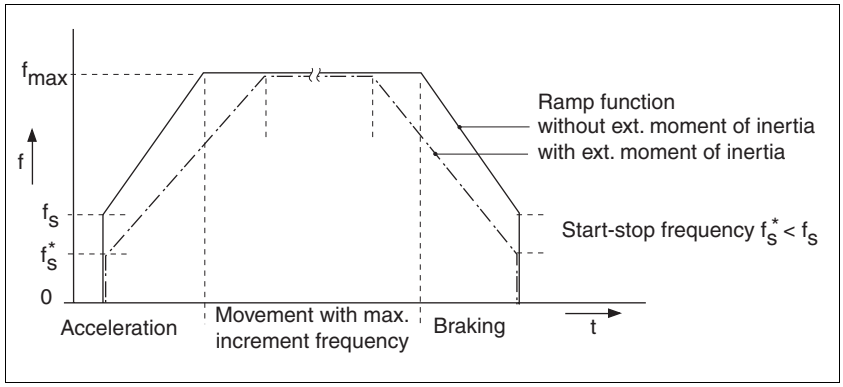

Figure 7.2 Characteristic curves of the linear ramp

Limit the pulse frequency to the start-stop frequency before you change the direction of rotation.

Frequency ramp

In the acceleration and deceleration range above the start-stop frequency the control frequency must be changed continuously corresponding to the frequency ramp.

The rise of the frequency ramp depends on the external mass moment of inertia and depends on the motor type.

- ▶ Program the frequency data into the NC controller.
- ▶ Start the test run under realistic load conditions.

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8 Operation

The chapter "Operation" describes the basic functions of the drive.

8.1 Basics

8.1.1 Overview

Reference value supply

The "Lexium Integrated Drive" moves the stepper motor as specified by a reference value. The setpoint signal is generated by a positioning or NC controller and fed to the multifunction interface as a pulse signal.

The resolution can be set via the number of steps.

Functions

Different functions can be controlled via the inputs.

- Enable and disable power stage and reset errors
- Block pulse input
- Switch step resolution
- Control motor phase current

The following can be polled via the outputs:

- Readiness
- Error
- Index pulse

8.1.2 Overview of motor phase current

The motor phase current of the drive is influenced by several factors.

- Setting of switch S4
- Input signal PWM (S2.2 = OFF)
- Current reduction at standstill (S1.4 = ON)

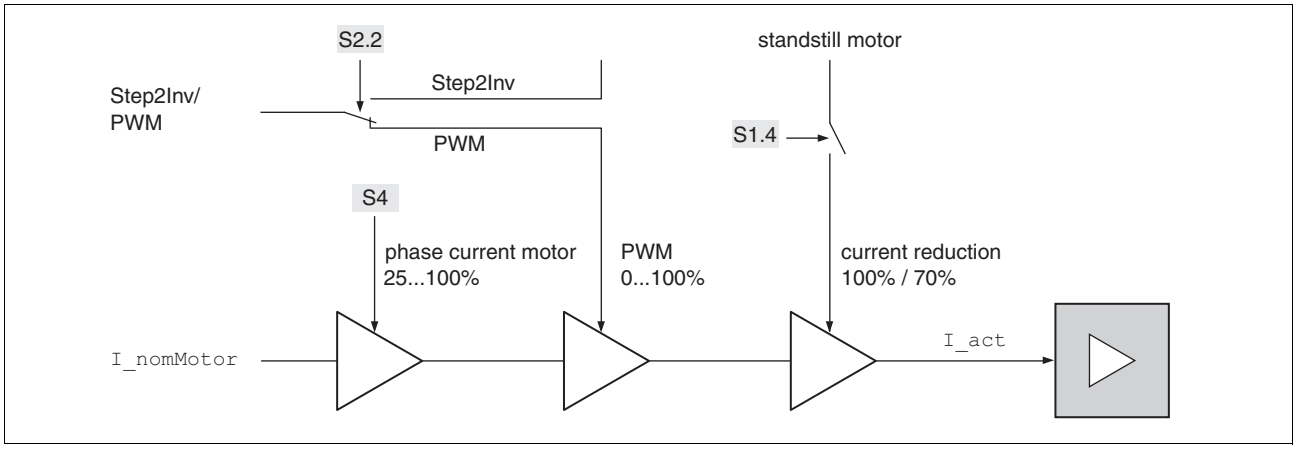

Figure 8.1 Overview of motor phase current

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8.2 Functions

8.2.1 Inputs PULSE/DIR and A/B

The signal inputs PULSE/DIR and A/B are used in combination:

- Interface mode "PULSE/DIR"
  Pulse/direction signals
- Interface mode "A/B"
  AB encoder signals

Interface mode "PULSE/DIR"

The motor executes an angle step with the rising edge of the PULSE signal. The direction of rotation is controlled by the DIR signal.

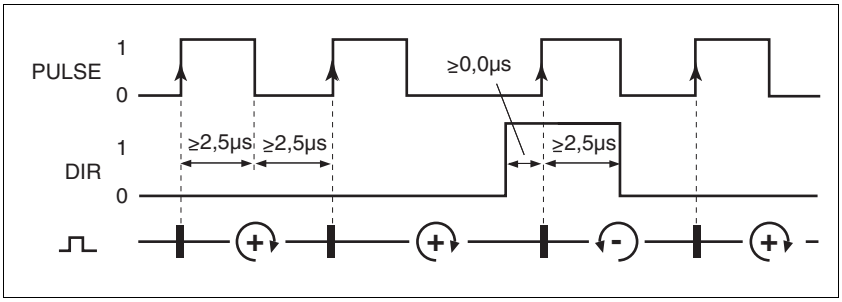

Figure 8.2 Pulse/direction signals

Signal	Signal value	Meaning
PULSE	Rising edge	Angle step
DIR	0 / open 1	Clockwise direction of rotation Counterclockwise direction of rotation

Interface mode "A/B"

In "A/B" interface mode, A/B encoder signals are supplied as reference values.

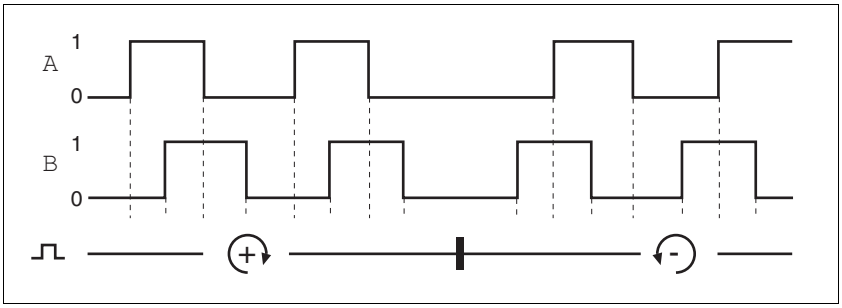

Figure 8.3 AB encoder signals

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8.2.2 Input ENABLE

Function

The input ENABLE enables the power stage so the motor can be controlled.

In the case of a falling edge, an error message is reset.

Signal value	Meaning
Rising edge	Enable power stage
Falling edge	Disable power stage and reset error message

Drives without a holding brake

When the power stage is enabled the signal output ACTIVE signal operating readiness after approximately 20 ms.

It is disabled immediately when the power stage is disabled.

Drives with a holding brake

The holding brake is automatically released when the power stage is enabled. After approximately 170 ms the signal output ACTIVE signals operating readiness.

Before the power stage can be disabled, the motor must be at a standstill to avoid damage to the holding brake. It remains enabled for approximately 50 ms when the power stage is disabled.

Operation with STO

If the drive is operated with the STO safety function, the input responds edge-controlled and no longer statically.

8.2.3 Input GATE

Function

The input GATE blocks the signals at the signal interface without disabling the operating readiness. In a multi-axis system you can select individual axes with GATE.

Signal value	Description
rising edge	blocking signals
falling edge	releasing signals

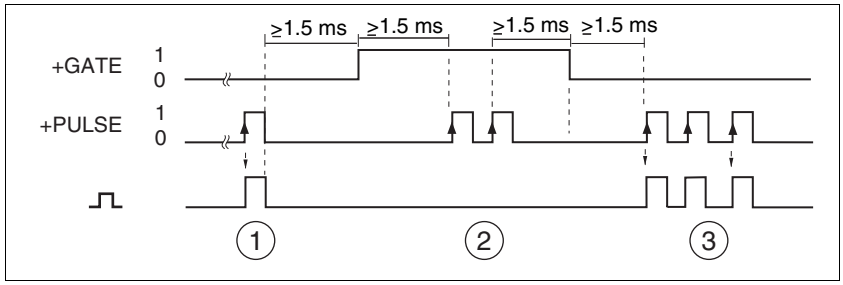

Figure 8.4 Signal sequences during switch-on via GATE

(1) Motor step
(2) no motor steps
(3) motor steps

There must be no pulse pending for 1.5 ms before and after switching the signal GATE to ensure that the drive can follow the pulse preset step by step.

Operation with STO

If the drive is operated with the STO safety function, the input responds edge-controlled and no longer statically.

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8.2.4 Input STEP2_INV

The STEP2INV input can be used if a high positioning accuracy is required but the output frequency of the master is limited.

The number of steps can be increased or reduced by a factor of 10 with the signal input.

The STEP2_INV input inverts the setting of switch S1.1.

The table below shows an example:

Signal value	S1.1	S1.2	S1.3	Number of motor steps	Explanation
0 / open	0	0	1	400	Number of motor steps set as with switches S1.1 .. S1.3
1	0	0	1	4000	Setting of switch S1.1 is inverted

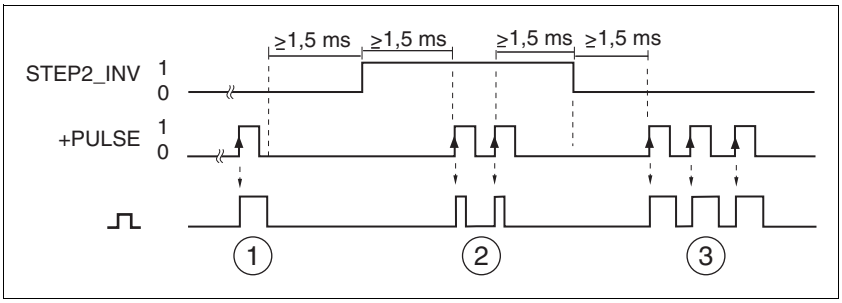

Figure 8.5 Signal sequences when the STEP2_INV changes

(1) Large motor step
(2) Motor steps which are smaller by a factor of 10
(3) Large motor steps

No pulse may be applied for 1.5 ms before and after the STEP2_INV signal changes so that the drive can follow the pulse step by step. If this condition is not satisfied, the LED signals a warning. The warning does not affect the operating readiness of the drive.

8.2.5 Input PWM

The input PWM (**p**ulse **w**idth **m**odulation) allows you to control the motor phase current (and, by implication, the torque). The nominal motor current can be controlled between 0% and 100%.

1 level No motor phase current flows at constant 1 level (current set to zero).

0 level The motor operates with the adjusted nominal motor phase current a constant 0 level.

Square-wave signal The motor phase current can be controlled with a square-wave signal. The pulse-pause ratio determines the value between 0% and 100%. The frequency of the square-wave signal must be between 6 kHz and 25 kHz.

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8.2.6 Output ACTIVE

The ACTIVE output indicates the operating readiness of the drive. As soon as the drive is ready for operation, pulse can be supplied.

Signal value	Meaning
1	Ready (power stage enabled)
0	Not ready (power stage disabled)

8.2.7 Output FAULT

The FAULT output indicates a fault condition. The error is reset by a falling edge at the ENABLE signal input.

Signal value	Meaning
1	Error
0	No error

8.2.8 Output INDEXPULSE

The drive sends the INDEXPULSE signal via the internal Hall sensor at the motor shaft once per revolution.

Signal value	Meaning
1	Index pulse
0	No index pulse

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8.2.9 Function of the holding brake

Motors with integrated holding brakes help to avoid unwanted movements of the motor without current.

The holding brake is not available with all product versions.

⚠ WARNING

LOSS OF BRAKING FORCE DUE TO WEAR OR HIGH TEMPERATURE

Applying the holding brake while the motor is running will cause excessive wear and loss of the braking force. Heat decreases the braking force.

- Do not use the brake as a service brake.
- Note that "EMERGENCY STOPS" may also cause wear
- At operating temperatures of more than 80°C (176°F), do not exceed a maximum of 50% of the specified holding torque when using the brake.

Failure to follow these instructions can result in death, serious injury or equipment damage.

Control The integrated holding brake is controlled automatically.

Releasing the holding brake The holding brake is automatically released when the power stage is enabled. After a delay time the drive switches to operating stats 6 "Operation Enable".

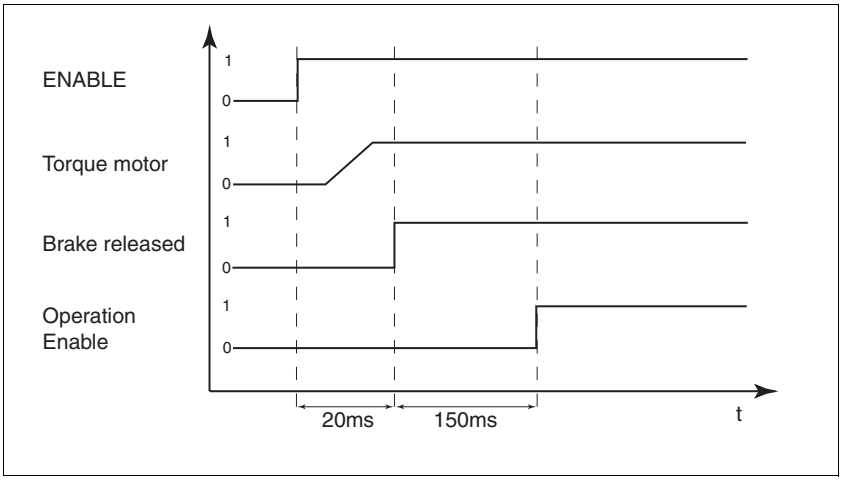

Figure 8.6 Releasing the holding brake

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Applying the holding brake

When the power stage is disabled and in the event of an error of error class 2, the holding brake is automatically applied. However, the motor current is not disconnected until after a delay time. This allows the holding brake to be applied before the motor loses its torque.

In the event of an error of error classes 3 or 4, the holding brake is automatically applied and the motor current is immediately disconnected.

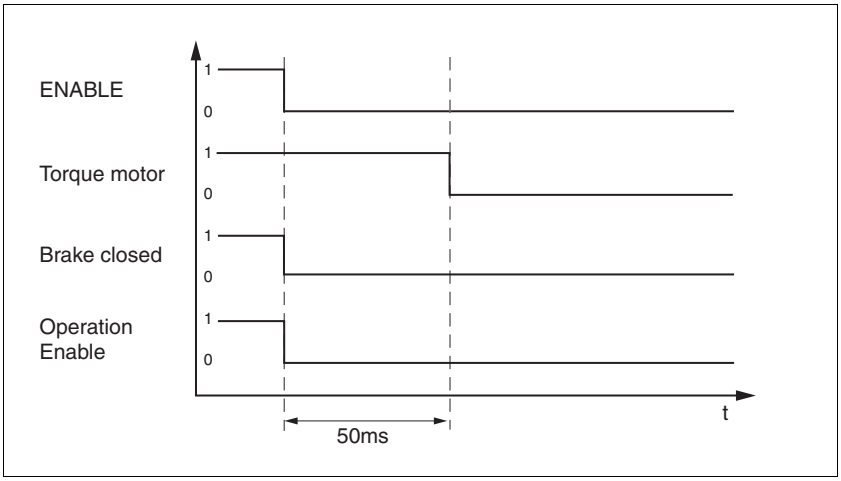

Figure 8.7 Applying the holding brake

The delay time is not effective if the power stage is disabled via the STO safety function. Especially in the case of vertical axes it is important to verify whether additional measures are required to avoid lowering of the load.

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9 Diagnostics and troubleshooting

9.1 Error indication and troubleshooting

9.1.1 Operation state and error indication

Temperature monitoring

Sensors in the drive measure the temperature of the power stage.

If the permissible maximum temperature is exceeded, the power stage switches off and signals a temperature error.

Stall detection

The stall detection system checks whether the index pulse is always triggered at the same angular position of the rotating field during the motor movement. If a stepper motor stalls, the motor shaft is displaced in relation to the rotating field by an angle corresponding to one or more complete pairs of poles. One pair of poles corresponds to 1/50 of a revolution.

Constraints

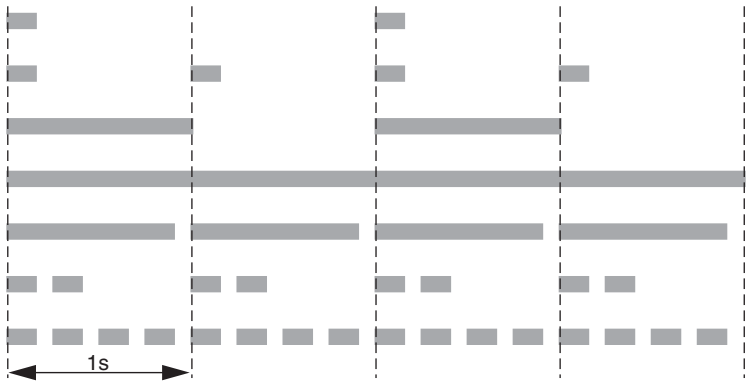
- Stall detection is initially inactive whenever the power stage is enabled. The detection is automatically activated as soon as the index pulse is reached. A stall by one or more pairs of poles is only detected from this point on.
- If the stepper motor stalls during deceleration just before standstill, this will be only detected when the index pulse is reached the next time, i.e. it may only be detected during the next movement.
- If the range of travel of the application is less than one complete motor revolution, the index pulse may be outside of the range of travel. In such a case, stalling of the stepper motor is not detected.
- If the motor shaft is rotated by external forces during standstill, the stall detection does not detect this.

Error message via 24 V signal interface

Errors are sent to a master controller via the signal output "FAULT/INDEXPULSE" (pin 3) of the 24V signal interface. At the same time, the power stage is disabled and the "ACTIVE" signal switches to LOW.

Status indication

The LED shows error messages and warnings. It indicates the operating states in coded form.

Status indication	Meaning
	• Start-up • Undervoltage or STO • Power stage disabled • Power stage enabled • Warning • Error • Internal error

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9.1.2 Reset error message

When the problem is remedied and the parameter switch 2.1 is set to "OFF", the error message can be acknowledged by means of a falling edge at the signal input ENABLE.

If the parameter switch 2.1 is set to "ON", the output signal GATE is active. An error message can then only be acknowledged by switching off the power supply.

9.1.3 Error classes and error response

Error response

The product triggers an error response in the event of a fault. Depending upon the severity of the fault, the device responds in accordance with one of the following error classes:

Error class	Reaction	Meaning
0	Warning	Message only, no interruption.
3	Fatal error	Power stage and controller switch off immediately without stopping the motor first.
4	Uncontrolled operation	Power stage and controller switch off immediately without stopping the motor first. Error response can only be reset by switching off the device.

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9.1.4 Causes of errors and troubleshooting

Errors trigger an error response

Signalling of an error:

- The signal output "FAULT" is set
- The internal LED flashes

Error	Error class	Cause of error	Troubleshooting
LED off	–	No supply voltage	Check supply voltage and fuses
Warning	0	Timing of GATE or STEP2_INV not as required	Check the time response of signals at the multifunction interface
Undervoltage	3	Supply voltage below threshold value for switching off the drive	Check voltage, check connections
Stall detection	3	Drive blocked or stalled Movement frequency too high Acceleration too high	Reduce load torque or motor torque; check settings for motor phase current; Reduce movement frequency Reduce acceleration
Maximum speed of rotation of motor	3	Maximum speed of rotation of motor speed	Reduce pulse frequency
Overvoltage	3	Overvoltage, regeneration condition	See chapter 5.1 "External power supply units"
Overtemperature	3	Power stage or motor overheated Ambient temperature too high Poor heat dissipation	Improve heat dissipation via the motor flange or reduce motor phase current
Timing error	3	Timing of "PULSE" not as required Interfering pulses present	Reduce pulse frequency Check EMC measures Check grounding concept
Watchdog	4	Internal system error	Switch drive off and onReplace drive
Inputs of the STO safety function have 0 level	3	STO safety function was triggered	Check guard door, cabling
Inputs of the STO safety function have different levels	4	Interruption of the signal wires	Check signal cable, check signal connection, replace

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9.1.5 Troubleshooting problems

Problem	Cause of problem	Remedy
Motor does not rotate and has no holding torque	Signal input "PWM" = HIGH	Disable PWM
	Signal input "ENABLE" = LOW	Enable power stage
Motor does not rotate but has holding torque	Signal input "GATE" = HIGH	Disable "GATE" signal to enable pulses.
	Pulse frequency	Check timing and signal voltage level of "PULSE/DIR" input signals
Motor rotates irregularly	Pulse frequency	Check timing and signal voltage level of "PULSE/DIR" input signals
	Overload	Reduce load torque
	Motor defective	Replace product
Motor rotates in the wrong direction	+DIR/-DIR incorrectly connectedAB signals reversed	Check signals, connect correctly
Motor torque too low	Motor phase current not set correctly	Set motor phase current (increase)

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10 Accessories and spare parts

10.1 Accessories

Source commissioning software The latest version of the commissioning software is available for download from the internet:

http://www.schneider-electric.com

Source EPLAN Macros For easier engineering, macro files and product master data are available for download from the Internet at:

http://www.schneider-electric.com

Designation	Order no.
Braking Resistor Controller UBC60	ACC3EA001
Installation kit	VW3L10111
Insert with cable entry (2 pcs)	VW3L10100N2
Insert with cable entry (10 pcs)	VW3L10100N10
Cable entry for commissioning	VW3L10222
Insert for sealing (10 pcs)	VW3L10000N10
Insert for sealing (20 pcs)	VW3L10000N20
Insert for sealing (50 pcs)	VW3L10000N50
Cable for commissioning interface, 3m	VW3L1R000R30
Insert kit for commissioning	VW3L1R000
Cable kit, power supply, P/D (A/B), 3m	VW3L2U001R30
Cable kit, power supply, P/D (A/B), 5m	VW3L2U001R50
Cable kit, power supply (P/D (A/B), 10m	VW3L2U001R100
Cable kit, power supply, P/D (A/B), 15m	VW3L2U001R150
Cable kit, power supply, P/D (A/B), 20m	VW3L2U001R200
Cable kit, STO, 3m	VW3L20010R30
Cable kit, STO, 5m	VW3L20010R50
Cable kit, STO, 10m	VW3L20010R100
Cable kit, STO, 15m	VW3L20010R150
Cable kit, STO, 20m	VW3L20010R200
Cable, power supply, 3m	VW3L30001R30
Cable, power supply, 5m	VW3L30001R50
Cable, power supply, 10m	VW3L30001R100
Cable, power supply, 15m	VW3L30001R150
Cable, power supply, 20m	VW3L30001R200
Cable, STO, 3m	VW3L30010R30
Cable, STO, 5m	VW3L30010R50
Cable, STO, 10m	VW3L30010R100
Cable, STO, 15m	VW3L30010R150
Cable, STO, 20m	VW3L30010R200

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Designation	Order no.
Connector kit, 2 x I/O	VW3L50200
Connector kit, 3 x I/O	VW3L50300
Connector, STO output	VW3L50010
Insert kit, 3 x I/O	VW3L40300
Insert kit, 2 x I/O, 1 x STO input	VW3L40210
Insert kit, 1 x STO input, 1 x STO output	VW3L40020

Tool The tools required for cable assembly must be ordered directly from the manufacturer.

- Crimping tool for CN1: AMP 654174-1
- Crimping tool for CN2, CN4 and CN5: Molex 69008-0982
- Crimping tool for CN3: Molex 69008-0724
- Extraction tool for CN2, CN4 and CN5: Molex 11-03-0043
- Extraction tool for CN3: Molex 11-03-0044

Converter An RS232/USB to RS485 converter is required for service and to upgrade the operating system.

- NuDAM converter RS232-RS485: Acceed ND-6520
- NuDAM converter USB-RS485: Acceed ND-6530

10.2 Gearboxes

Designation	Order no.
Planetary gear for Lexium Integrated Drive ILSxx571, ratio 3/1	GBX060003S571L
Planetary gear for Lexium Integrated Drive ILSxx571, ratio 5/1	GBX060005S571L
Planetary gear for Lexium Integrated Drive ILSxx571, ratio 8/1	GBX060008S571L
Planetary gear for Lexium Integrated Drive ILSxx572, ratio 3/1	GBX060003S572L
Planetary gear for Lexium Integrated Drive ILSxx572, ratio 5/1	GBX060005S572L
Planetary gear for Lexium Integrated Drive ILSxx572, ratio 8/1	GBX060008S572L
Planetary gear for Lexium Integrated Drive ILSxx573, ratio 3/1	GBX060003S573L
Planetary gear for Lexium Integrated Drive ILSxx573, ratio 5/1	GBX060005S573L
Planetary gear for Lexium Integrated Drive ILSxx573, ratio 8/1	GBX060008S573L
Planetary gear for Lexium Integrated Drive ILSxx851, ratio 3/1	GBX080003S851L
Planetary gear for Lexium Integrated Drive ILSxx851, ratio 5/1	GBX080005S851L
Planetary gear for Lexium Integrated Drive ILSxx851, ratio 8/1	GBX080008S851L
Planetary gear for Lexium Integrated Drive ILSxx852, ratio 3/1	GBX080003S852L
Planetary gear for Lexium Integrated Drive ILSxx852, ratio 5/1	GBX080005S852L
Planetary gear for Lexium Integrated Drive ILSxx852, ratio 8/1	GBX080008S852L
Planetary gear for Lexium Integrated Drive ILSxx853, ratio 3/1	GBX080003S853L
Planetary gear for Lexium Integrated Drive ILSxx853, ratio 5/1	GBX080005S853L
Planetary gear for Lexium Integrated Drive ILSxx853, ratio 8/1	GBX080008S853L

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11 Service, maintenance and disposal

⚠ CAUTION

DAMAGE TO SYSTEM COMPONENTS AND LOSS OF CONTROL

Interruptions of the negative connection of the controller supply voltage can cause excessively high voltages at the signal connections.

- Do not interrupt the negative connection between the power supply unit and load with a fuse or switch.
- Verify correct connection before switching on.
- Do not connect the controller supply voltage or change its wiring while the is supply voltage present.

Failure to follow these instructions can result in injury or equipment damage.

⚠ CAUTION

RISK OF INJURY WHEN REMOVING CIRCUIT BOARD PLUGS

- When removing them note that the connectors must be unlocked.
  - Supply voltage VDC:
    Unlock by pulling at the plug housing
  - Miscellaneous:
    Unlock by pressing the locking lever
- Always hold the plug to remove it (not the cable).

Failure to follow these instructions can result in injury or equipment damage.

The product may only be repaired by a certified customer service center. No warranty or liability is accepted for repairs made by unauthorized persons.

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11.1 Service address

If you cannot resolve an error yourself please contact your sales office. Have the following details available:

- Nameplate (type, identification number, serial number, DOM, ...)
- Type of error (such as LED flash code or error number)
- Previous and concomitant circumstances
- Your own assumptions concerning the cause of the error

Also include this information if you return the product for inspection or repair.

If you have any questions please contact your sales office. Your sales office staff will be happy to give you the name of a customer service office in your area.

http://www.schneider-electric.com

11.2 Maintenance

Check the product for pollution or damage at regular intervals, depending on the way you use it.

11.2.1 Lifetime STO safety function

The STO safety function is designed for a lifetime of 20 years. After this period, the data of the safety function are no longer valid. The expiry date is determined by adding 20 years to the DOM shown on the nameplate.

▶ This date must be included in the maintenance plan of the system.

Do not use the safety function after this date.

Example The DOM on the nameplate of the device is shown in the format DD.MM.YY, e.g. 31.12.07. (December 31, 2007). This means: Do not use the safety function after December 31, 2027.

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11.3 Replacing units

⚠ WARNING

UNINTENDED BEHAVIOR

The behavior of the drive system is governed by numerous stored data or settings. Unsuitable settings or data may trigger unexpected movements or responses to signals and disable monitoring functions.

- Do NOT operate the drive system with unknown settings or data.
- Verify that the stored data and settings are correct.
- When commissioning, carefully run tests for all operating states and potential fault situations.
- Verify the functions after replacing the product and also after making changes to the settings or data.
- Only start the system if there are no persons or obstructions in the hazardous area.

Failure to follow these instructions can result in death, serious injury or equipment damage.

Observe the following procedure when replacing devices.

- ▶ Note all switch settings.
- ▶ Switch off all supply voltages. Verify that no voltages are present (safety instructions).
- ▶ Label all connections and uninstall the product.
- ▶ Note the identification number and the serial number shown on the product nameplate for later identification.
- ▶ Install the new product as per chapter 6 "Installation"
- ▶ Commission the product as per chapter 7 "Commissioning".

11.4 Shipping, storage, disposal

Removal Removal procedure:

- ▶ Switch off the power supply.
- ▶ Disconnect the power supply.
- ▶ Pull out all plugs.
- ▶ Remove the product from the system.

Shipping The product must be protected against shocks during transportation. If possible, use the original packaging for shipping.

Storage The product may only be stored in spaces where the specified permissible ambient conditions for room temperature and humidity are met. Protect the product from dust and dirt.

Disposal The product consists of various materials that can be recycled and must be disposed of separately. Dispose of the product in accordance with local regulations.

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12 Glossary

12.1 Units and conversion tables

The value in the specified unit (left column) is calculated for the desired unit (top row) with the formula (in the field).

Example: conversion of 5 meters [m] to yards [yd]
5 m / 0.9144 = 5.468 yd

12.1.1 Length

	in	ft	yd	m	cm	mm
in	-	/ 12	/ 36	* 0.0254	* 2.54	* 25.4
ft	* 12	-	/ 3	* 0.30479	* 30.479	* 304.79
yd	* 36	* 3	-	* 0.9144	* 91.44	* 914.4
m	/ 0.0254	/ 0.30479	/ 0.9144	-	* 100	* 1000
cm	/ 2.54	/ 30.479	/ 91.44	/ 100	-	* 10
mm	/ 25.4	/ 304.79	/ 914.4	/ 1000	/ 10	-

12.1.2 Mass

	lb	oz	slug	kg	g
lb	-	* 16	* 0.03108095	* 0.4535924	* 453.5924
oz	/ 16	-	* $1.942559*10^{-3}$	* 0.02834952	* 28.34952
slug	/ 0.03108095	/ $1.942559*10^{-3}$	-	* 14.5939	* 14593.9
kg	/ 0.453592370	/ 0.02834952	/ 14.5939	-	* 1000
g	/ 453.592370	/ 28.34952	/ 14593.9	/ 1000	-

12.1.3 Force

	lb	oz	p	dyne	N
lb	-	* 16	* 453.55358	* 444822.2	* 4.448222
oz	/ 16	-	* 28.349524	* 27801	* 0.27801
p	/ 453.55358	/ 28.349524	-	* 980.7	* $9.807*10^{-3}$
dyne	/ 444822.2	/ 27801	/ 980.7	-	/ $100*10^{3}$
N	/ 4.448222	/ 0.27801	/ $9.807*10^{-3}$	* $100*10^{3}$	-

12.1.4 Power

	HP	W
HP	-	* 745.72218
W	/ 745.72218	-

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12.1.5 Rotation

	min^{-1} (RPM)	**rad/s**	**deg./s**
min^{-1} (RPM)	-	* π / 30	* 6
rad/s	* 30 / π	-	* 57.295
deg./s	/ 6	/ 57.295	-

12.1.6 Torque

	lb·in	**lb·ft**	**oz·in**	**Nm**	**kp·m**	**kp·cm**	**dyne·cm**
lb·in	-	/ 12	* 16	* 0.112985	* 0.011521	* 1.1521	* $1.129*10^{6}$
lb·ft	* 12	-	* 192	* 1.355822	* 0.138255	* 13.8255	* $13.558*10^{6}$
oz·in	/ 16	/ 192	-	* $7.0616*10^{-3}$	* $720.07*10^{-6}$	* $72.007*10^{-3}$	* 70615.5
Nm	/ 0.112985	/ 1.355822	/ $7.0616*10^{-3}$	-	* 0.101972	* 10.1972	* $10*10^{6}$
kp·m	/ 0.011521	/ 0.138255	/ $720.07*10^{-6}$	/ 0.101972	-	* 100	* $98.066*10^{6}$
kp·cm	/ 1.1521	/ 13.8255	/ $72.007*10^{-3}$	/ 10.1972	/ 100	-	* $0.9806*10^{6}$
dyne·cm	/ $1.129*10^{6}$	/ $13.558*10^{6}$	/ 70615.5	/ $10*10^{6}$	/ $98.066*10^{6}$	/ $0.9806*10^{6}$	-

12.1.7 Moment of inertia

	lb·in^2	**lb·ft^2**	**kg·m^2**	**kg·cm^2**	**kp·cm·s^2**	**oz·in^2**
lb·in^2	-	/ 144	/ 3417.16	/ 0.341716	/ 335.109	* 16
lb·ft^2	* 144	-	* 0.04214	* 421.4	* 0.429711	* 2304
kg·m^2	* 3417.16	/ 0.04214	-	* $10*10^{3}$	* 10.1972	* 54674
kg·cm^2	* 0.341716	/ 421.4	/ $10*10^{3}$	-	/ 980.665	* 5.46
kp·cm·s^2	* 335.109	/ 0.429711	/ 10.1972	* 980.665	-	* 5361.74
oz·in^2	/ 16	/ 2304	/ 54674	/ 5.46	/ 5361.74	-

12.1.8 Temperature

	°F	**°C**	**K**
°F	-	(°F - 32) * 5/9	(°F - 32) * 5/9 + 273.15
°C	°C * 9/5 + 32	-	°C + 273,15
K	(K - 273.15) * 9/5 + 32	K - 273.15	-

12.1.9 Conductor cross section

AWG	1	2	3	4	5	6	7	8	9	10	11	12	13
mm^2	42.4	33.6	26.7	21.2	16.8	13.3	10.5	8.4	6.6	5.3	4.2	3.3	2.6

AWG	14	15	16	17	18	19	20	21	22	23	24	25	26
mm^2	2.1	1.7	1.3	1.0	0.82	0.65	0.52	0.41	0.33	0.26	0.20	0.16	0.13

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12.2 Terms and Abbreviations

AC	Alternating current
ASCII	American Standard Code for Information Interchange. Standard for coding of characters
CAN	(**C**ontroller **A**rea **N**etwork), standardized open fieldbus as per ISO 11898, allows drives and other devices from different manufacturers to communicate.
DC	Direct current
Default value	Factory setting.
Direction of rotation	Rotation of the motor shaft in a clockwise or counterclockwise direction of rotation. Clockwise rotation is when the motor shaft rotates clockwise as you look at the end of the protruding motor shaft.
DOM	The **D**ate **o**f **m**anufacturing on the nameplate of the device is shown in the format DD.MM.YY, e.g. 31.12.06 (December 31, 2006).
EMC	Electromagnetic compatibility
Encoder	Sensor for detection of the angular position of a rotating component. The motor encoder shows the angular position of the rotor.
Error class	Classification of errors into groups. The different error classes allow for specific responses to faults, e.g. by severity.
Fatal error	In the case of fatal error, the drive is not longer able to control the motor, so that an immediate switch-off of the drive is necessary.
Fault	Operating state of the drive caused as a result of a discrepancy between a detected (computed, measured or signaled) value or condition and the specified or theoretically correct value or condition.
Fault reset	A function used to restore the drive to an operational state after a detected fault is cleared by removing the cause of the fault so that the fault is no longer active (transition from state "Fault" to state "Operation Enable").
Forcing	Forcing switching states of inputs/outputs.Forcing switching states of inputs/outputs.
I/O	Inputs/outputs
Inc	Increments
Index pulse	Signal of an encoder to reference the rotor position in the motor. The encoder returns one index pulse per revolution.
Limit switch	Switch that signals overtravel of the permissible range of travel.
Motor phase current	The available torque of a stepper motor is determined by the motor phase current. The higher the motor phase current the higher the torque.
Node guarding	Monitoring of the connection with the slave at an interface for cyclic data traffic.
Parameter	Device data and values that can be set by the user.
Parameter switch	Small switches adjacent to each other

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Persistent	Indicates whether the value of the parameter remains in the memory after the device is switched off.
PLC	Programmable logic controller
Profibus	Standardized open fieldbus as per EN 50254-2 which allows drives and other devices from different manufacturers to communicate.
Power stage	The power stage controls the motor. The power stage generates currents for controlling the motor on the basis of the positioning signals from the controller.
PWM	Pulse width modulation
Quick Stop	Function used to enable fast deceleration of the motor via a command or in the event of a malfunction.
RS485	Fieldbus interface as per EIA-485 which enables serial data transmission with multiple devices.
Stall detection	Stall detection monitors whether the index pulse is always correctly triggered at the same angle position of the motor shaft.
Torque ramp	Deceleration of the motor with the maximum possible deceleration, which is only limited by the maximum permissible current. The higher the permissible braking current, the stronger the deceleration. Because energy is recovered up depending on the coupled load, the voltage may increase to excessively high values. In this case the maximum permissible current must be reduced.
Warning	If not used within the context of safety instructions, a warning alerts to a potential problem detected by a monitoring function. A warning is not a fault and does not cause a transition of the operating state. Warnings belong to error class 0.
Watchdog	Unit that monitors cyclic basic functions in the product. Power stage and outputs are switched off in the event of faults.
Zero voltage window	Voltage range that is interpreted as 0 V.

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