SINAMICS G120

SINAMICS G120C frequency converter

Operating instructions · 03/2012

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SINAMICS G120C
SINAMICS G120C frequency converter

Operating Instructions

Edition 03/2012, Firmware 4.5

Original instructions
03/2012, FW V4.5
A5E02999804B AB

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠DANGER
indicates that death or severe personal injury **will** result if proper precautions are not taken.

⚠WARNING
indicates that death or severe personal injury **may** result if proper precautions are not taken.

⚠CAUTION
with a safety alert symbol, indicates that minor personal injury can result if proper precautions are not taken.

CAUTION
without a safety alert symbol, indicates that property damage can result if proper precautions are not taken.

NOTICE
indicates that an unintended result or situation can occur if the relevant information is not taken into account.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The product/system described in this documentation may be operated only by **personnel qualified** for the specific task in accordance with the relevant documentation, in particular its warning notices and safety instructions. Qualified personnel are those who, based on their training and experience, are capable of identifying risks and avoiding potential hazards when working with these products/systems.

Proper use of Siemens products

Note the following:

⚠WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be complied with. The information in the relevant documentation must be observed.

Trademarks

All names identified by ® are registered trademarks of Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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A5E02999804B AB
Ⓟ 06/2012 Technical data subject to change

Change history

Main changes with respect to the manual, edition 01/2011

New functions in firmware V4.5	In Chapter
PROFINET interface	Communication via PROFINET (Page 86)
Know how protection	Write and know how protection (Page 259)
Switching over the inverter control	Switching over the inverter control (command data set) (Page 171)

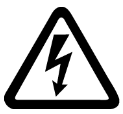
Revised descriptions	In Chapter
EMC-compliant installation	EMC-compliant cabinet design (Page 21)
Function descriptions: • Converter control • Setpoint sources • Setpoint preparation • Motor control • PID technology controller • Fail-safe function Safe Torque Off	Functions (Page 159)
Data backup	Data backup and series commissioning (Page 247)

Table of contents

1 Safety notes

It has to be ensured by the machine manufacturer, that the line-side overcurrent protection equipment interrupts within 5 s (immovable equipment and modules in immovable equipment) in the case of minimum fault current (current on complete insulation failure to accessible conductive parts that are not live during operation and maximum current loop resistance).

General



WARNING

This equipment controls potentially dangerous rotating mechanical parts.

Protection in case of direct contact by means of voltages < 60V (PELV = Protective Extra Low Voltage acc. to EN 61800-5-1) is only permissible in areas with equipotential bonding and in dry indoor rooms. If these conditions are not fulfilled, other protective measures against electric shock are to be taken, e.g., protective insulation.

The converter must always be properly grounded. Since the residual current for this product is greater than 3.5mA AC, a fixed ground connection is required, and the minimum size of the protective conductor must comply with local safety regulations for equipment with a high leakage current.

Install the converter on a metal mounting plate in a control cabinet. The mounting plate must not must be painted and must have good electrical conductivity.

It is strictly prohibited for any mains disconnection to be performed on the motor-side of the system, if the converter is in operation and the output current is not equal to zero.

Take particular notice of the general and regional installation and safety regulations regarding work on dangerous voltage installations (e.g. 61800-5-1) as well as the relevant regulations regarding the correct use of tools and personal protective equipment (PPE).

CAUTION

Static discharges on surfaces or interfaces (e.g. terminal or connector pins) can cause malfunctions or defects. ESD protective measures should therefore be observed when working with converters or converter components.

Transport and storage

⚠ CAUTION
Don't drop the converter or converter components during transport and storage. Protect the equipment from water (rainfall) and excessive temperatures.

Installation and Commissioning

⚠ WARNING
Wherever faults occurring in the control equipment can lead to substantial material damage or even grievous bodily injury (that is, potentially dangerous faults), additional external precautions must be taken or facilities provided to ensure or enforce safe operation, even when a fault occurs (e.g. independent limit switches, mechanical interlocks, etc.).

Operation

⚠ DANGER
Operating the converter outside the scope of the specification given in the technical specifications may cause malfunction or damage to the converter components. In exceptional cases there is the potential to cause overheating, danger of fire, damage to property, personal injury or loss of life.

⚠ WARNING
Emergency stop facilities according to EN 60204, IEC 204 (VDE 0113) must remain operative in all operating modes of the control equipment. Any disengagement of the emergency stop facility must not lead to an uncontrolled or an undefined restart of the equipment.

⚠ WARNING
Use of mobile radio devices (e.g. telephones, walkie-talkies) in the immediate vicinity of the devices (< 1.8 m) can interfere with the functioning of the equipment.

⚠ WARNING
Filtered drives can only be used on power systems with grounded neutral point.

⚠ WARNING

During operation and for a short time after switching-off the converter, the surfaces of the converter can reach a high temperature. Avoid coming into direct contact with the converter surface.

⚠ WARNING

Risk of fire

If an unsuitable braking resistor is used, this could result in a fire and severely damage, people, property and equipment. Use the adequate braking resistor and install it correctly.

The temperature of a braking resistor increases significantly during operation. Avoid coming into direct contact with braking resistors.

Repair

⚠ WARNING

Repairs on equipment may only be carried out by Siemens Service, by repair centers authorized by Siemens or by authorized personnel who are thoroughly acquainted with all the warnings and operating procedures contained in this manual.

Any defective parts or components must be replaced using parts contained in the relevant spare parts list.

Residual risks

The control and drive components of a power drive system (PDS) are approved for industrial and commercial use in industrial supply networks. Their use in public supply networks requires a different configuration and/or additional measures.

These components may only be operated in closed housings or in higher-level control cabinets with protective covers that are closed, and when all of the protective devices are used.

When carrying out a risk assessment of a machine in accordance with the EU Machinery Directive, the machine manufacturer must consider the following residual risks associated with the control and drive components of a PDS.

1. Unintentional movements of driven machine components during commissioning, operation, maintenance, and repairs caused by, for example:
   - Hardware defects and/or software errors in the sensors, controllers, actuators, and connection technology
   - Response times of the controller and drive
   - Operating and/or ambient conditions not within the scope of the specification
   - Condensation / conductive contamination
   - Parameterization, programming, cabling, and installation errors
   - Use of radio devices / cellular phones in the immediate vicinity of the controller
   - External influences / damages
2. Exceptionally high temperatures as well as emissions of noise, particles, or gas caused by, for example:
   - Component malfunctions
   - Software errors
   - Operating and/or ambient conditions not within the scope of the specification
   - External influences / damages
3. Hazardous shock voltages caused by, for example:
   - Component malfunctions
   - Influence of electrostatic charging
   - Induction of voltages in moving motors
   - Operating and/or ambient conditions not within the scope of the specification
   - Condensation / conductive contamination
   - External influences / damages
4. Electrical, magnetic and electromagnetic fields generated in operation that can pose a risk to people with a pacemaker, implants or metal replacement joints, etc. if they are too close.
5. Release of environmental pollutants or emissions as a result of improper operation of the system and/or failure to dispose of components safely and correctly.

Introduction 2

2.1 About this manual

Who requires the operating instructions and what for?

These operating instructions primarily address fitters, commissioning engineers and machine operators. The operating instructions describe the devices and device components and enable the target groups being addressed to install, connect-up, parameterize, and commission the inverters safely and in the correct manner.

What is described in the operating instructions?

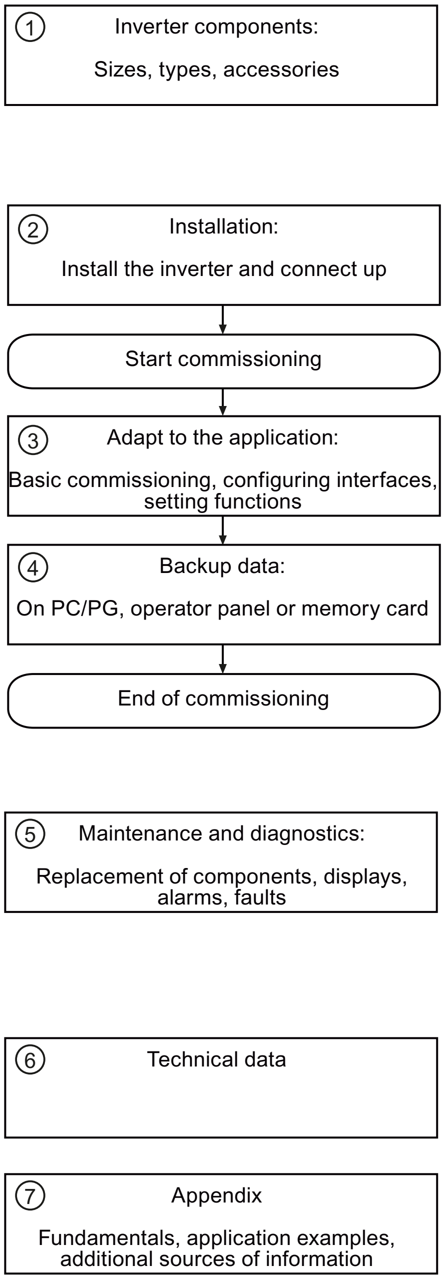
These operating instructions provide a summary of all of the information required to operate the inverter under normal, safe conditions.

The information provided in the operating instructions has been compiled in such a way that it is sufficient for all standard applications and enables drives to be commissioned as efficiently as possible. Where it appears useful, additional information for entry level personnel has been added.

The operating instructions also contain information about special applications. Since it is assumed that readers already have a sound technical knowledge of how to configure and parameterize these applications, the relevant information is summarized accordingly. This relates, e.g. to operation with fieldbus systems and safety-related applications.

2.2 Guide through this manual

In this manual, you will find background information on your inverter, as well as a full description of the commissioning procedure:



① Here you will find information about the hardware of your inverter and the commissioning tools:

- Product overview (Page 17)

② • Installing (Page 21)

All information relating to the commissioning of your inverter is located in the following chapters:

③ • Basic commissioning (Page 51)

- Adapting the terminal strip (Page 73)
- Configuring the fieldbus (Page 85)
- Functions (Page 159)

④ • Data backup and series commissioning (Page 247)

⑤ Information regarding the maintenance and diagnostics of your inverter is located in the following chapters:

- Servicing and maintaining (Page 267)
- Alarms, faults and system messages (Page 277)

⑥ The most important technical data for your inverter is located in this chapter:

- Technical data (Page 295)

⑦ The appendix contains some background information and explanatory examples:

- Appendix (Page 313)

Description

3

3.1 Product overview

The SINAMICS G120C is a range of converters for controlling the speed of three phase motors. The converter is available in three frame sizes.

You find a label with the order number:

- On the front of the converter after removing the blind cover or the operator panel.
- On one side of the converter.

	Rated output power	Rated output current	Order number					
	based on Low Overload		Unfiltered			Filtered		
 Frame Size A	0.55 kW	1.7 A	6SL3210-1KE11-8U		1	6SL3210-1KE11-8A		1
	0.75 kW	2.2 A	6SL3210-1KE12-3U		1	6SL3210-1KE12-3A		1
	1.1 kW	3.1 A	6SL3210-1KE13-2U		1	6SL3210-1KE13-2A		1
	1.5 kW	4.1 A	6SL3210-1KE14-3U		1	6SL3210-1KE14-3A		1
	2.2 kW	5.6 A	6SL3210-1KE15-8U		1	6SL3210-1KE15-8A		1
	3.0 kW	7.3 A	6SL3210-1KE17-5U		1	6SL3210-1KE17-5A		1
	4.0 kW	8.8 A	6SL3210-1KE18-8U		1	6SL3210-1KE18-8A		1
 Frame Size B	5.5 kW	12.5 A	6SL3210-1KE21-3U		1	6SL3210-1KE21-3A		1
	7.5 kW	16.5 A	6SL3210-1KE21-7U		1	6SL3210-1KE21-7A		1
 Frame Size C	11.0 kW	25.0 A	6SL3210-1KE22-6U		1	6SL3210-1KE22-6A		1
	15.0 kW	31.0 A	6SL3210-1KE23-2U		1	6SL3210-1KE23-2A		1
	18.5 kW	37.0 A	6SL3210-1KE23-8U		1	6SL3210-1KE23-8A		1
SINAMICS G120C USS/MB (USS, Modbus RTU)				B			B	
SINAMICS G120C DP (PROFIBUS DP)				P			P	
SINAMICS G120C PN (PROFINET IO)				F			F	
SINAMICS G120C CANopen				C			C	

3.2 Components, which you require depending on your application

Line reactor

A line reactor protects the converter from the rough characteristics of an industrial grid. A line reactor supports the overvoltage protection, smoothes harmonics and bridges commutation notches.

Note

If the relative short-circuit voltage u_k of the line transformer is smaller than 1 %, you have to install a line reactor in order to ensure the optimal lifetime of your converter.

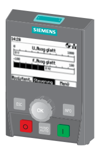
Braking resistor

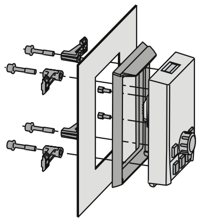
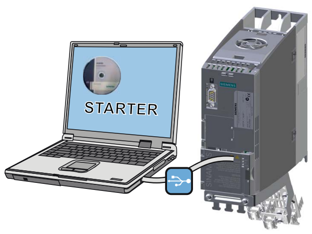
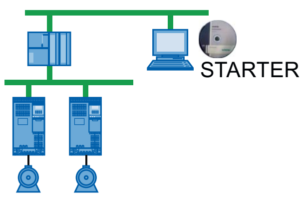
The braking resistor enables loads with a large moment of inertia to be braked quickly.

Converter		Braking resistor	Line reactor
Frame Size A	0.55 kW … 1.1 kW	6SL3201-0BE14-3AA0	6SL3203-0CE13-2AA0
	1.5 kW		6SL3203-0CE21-0AA0
	2.2 kW … 4.0 kW	6SL3201-0BE21-0AA0	
Frame Size B	5.5 kW … 7.5 kW	6SL3201-0BE21-8AA0	6SL3203-0CE21-8AA0
Frame Size C	11.0 kW … 18.5 kW	6SL3201-0BE23-8AA0	6SL3203-0CE23-8AA0

3.3 Commissioning tools

Accessories for commissioning and data backup

Operator Panels for commissioning, diagnostics and controlling converters		Order number
	BOP-2 (Basic Operator Panel) - for snapping onto the frequency converter • Copying of drive parameters • Two-line display • Guided basic commissioning	6SL3255-0AA00-4CA1
	IOP (Intelligent Operator Panel) - for snapping onto the frequency converter • Copying of drive parameters • Plain text display • Menu-based operation and application wizards	6SL3255-0AA00-4JA0

	Door mounting kit for IOP/BOP-2 • For installation of theBOP-2 or IOP in a control cabinet door. • Degree of protection with IOP: IP54 or UL Type 12 • Degree of protection with BOP-2: IP55	6SL3256-0AP00-0JA0
	IOP - with handheld For mobile use of the IOP	6SL3255-0AA00-4HA0
PC tools for commissioning, diagnostics and controlling of the converter		
	PC Connection Kit Includes a STARTER DVD and USB port.	6SL3255-0AA00-2CA0
	STARTER Commissioning tool (PC software) connected to the converter via USB port, PROFIBUS or PROFINET Downloading: STARTER (http://support.automation.siemens.com/WW/view/en/10804985/130000)	STARTER on the DVD: 6SL3072-0AA00-0AG0
	Drive ES Basic As an option to STEP 7 with routing function via network limits for PROFIBUS and PROFINET	6SW1700-5JA00-5AA0
Memory cards: to save and transfer the converter settings		
	MMC card	6SL3254-0AM00-0AA0
	SD card	6ES7954-8LB00-0AA0

Installing 4

4.1 Procedure for installing the converter

Prerequisites for installing the converter

Check that the following prerequisites are fulfilled before you install the converter:

- Are the components, tools and small parts required for installation available?
- Are the ambient conditions permissible? See Technical data (Page 295).

Installation sequence

1. Mount the converter.
2. If required, mount the line reactor.
3. If required, mount the braking resistor.
4. Connect the following components:
   – Converter - motor
   – Converter - line reactor - line
   – Converter - braking resistor
5. Wire the terminal strip of the control unit.
6. When the installation has been complete and checked, power can then be applied to the converter.

You start to commission the converter once installation has been completed.

4.2 EMC-compliant cabinet design

The most cost-effective method of implementing interference suppression measures within the control cabinet is to ensure that interference sources and potentially susceptible equipment are installed separately from each other. This must be taken into account already during the planning phase.

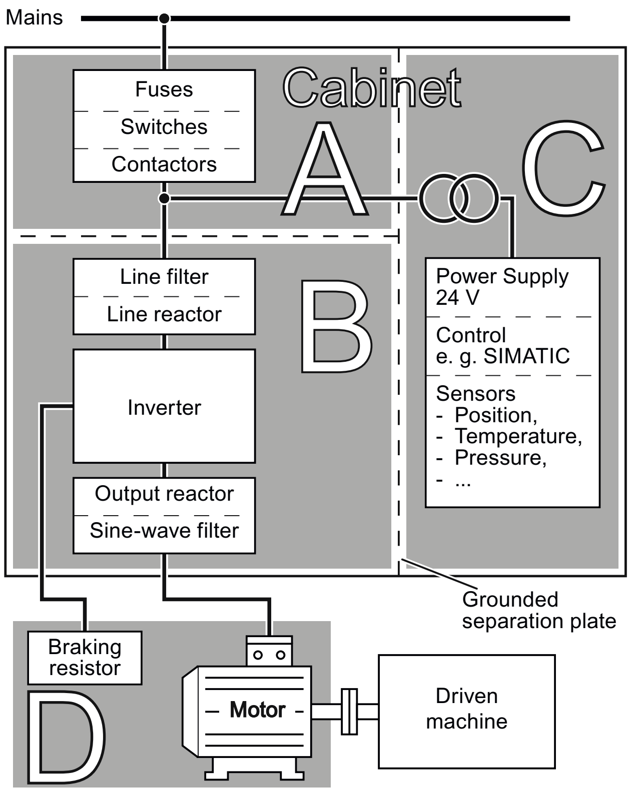
EMC-zone concept within the control cabinet

The control cabinet has to be divided into EMC zones and the devices within the control cabinet have to be assigned to these zones. The example below illustrates this zone concept in greater detail.

The different zones must be electromagnetically decoupled. One method is to ensure that the zones are not positioned directly next to each other (minimum distance app. 25 cm / 9.84 in). A better, more compact method, however, is to use separate metallic housings or separation plates with large surface areas.

Cables within each zone can be unshielded. Cables connecting different zones must be separated and must not be routed within the same cable harness or cable channel. If necessary, filters and/or coupling modules should be used at the interfaces of the zones. Coupling modules with electrical isolation are an effective means of preventing interference from spreading from one zone to another.

All communication and signal cables leaving the cabinet must be shielded. For longer, analog signal cables isolating amplifiers should be used. Sufficient space for bonding the cable shields must be provided, whereby the braided cable shield must be connected to the cabinet ground with excellent electrical conductivity and with a large contact area. Differences in the ground potential between the zones must be avoided to ensure that impermissible, high compensating currents are kept away from the cable shields.



- **Zone A:**
  Supply connection
  Limit values for conducted interference emissions and conducted interference immunity must not be exceeded
- **Zone B:**
  Power electronics
  Sources of interference
- **Zone C:**
  Controller and sensors
  Potentially susceptible equipment

Zone D:
Motor, braking resistor and according cables
Sources of interference

Division of the cabinet and installation into different EMC zones

Control cabinet design

- All metallic components of the cabinet (side panels, back walls, roof plates, and floor plates) must be connected to the cabinet frame with excellent electrical conductivity, ideally with a large contact area or by means of several point-like screwed connections (i.e. to create a Faraday cage).
- The cabinet doors must be connected to the cabinet frame with excellent electrical conductivity by means of short, finely stranded, braided grounding strips, which are ideally placed at the top, in the middle, and at the bottom of the doors.
- The PE busbar and EMC shield busbar must be connected to the cabinet frame with excellent electrical conductivity with a large contact area.
- All metallic housings of devices and additional components integrated in the cabinet (such as converter or line filter) must be connected to the cabinet frame with excellent electrical conductivity and with a large contact area. The best option here is to mount devices and additional components on a bare metal mounting plate (back plane) with excellent electrical conductivity. This mounting plate must be connected to the cabinet frame and, in particular, to the PE and EMC shield busbars with excellent electrical conductivity and a large contact area.
- All connections should be made so that they are permanent. Screwed connections on painted or anodized metal components must be made either by means of special contact washers, which penetrate the isolating surface and establish a metallically conductive contact, or by removing the isolating surface on the contact points.
- Contactor coils, relays, solenoid valves, and motor holding brakes must have interference suppressors to reduce high-frequency radiation when the contacts are opened (RC elements or varistors for AC currentoperated coils, and freewheeling diodes for DC current-operated coils). The interference suppressors must be connected directly on each coil.

4.3 Mounting the inverter

Mounting orientation

Mount the converter in a control cabinet.

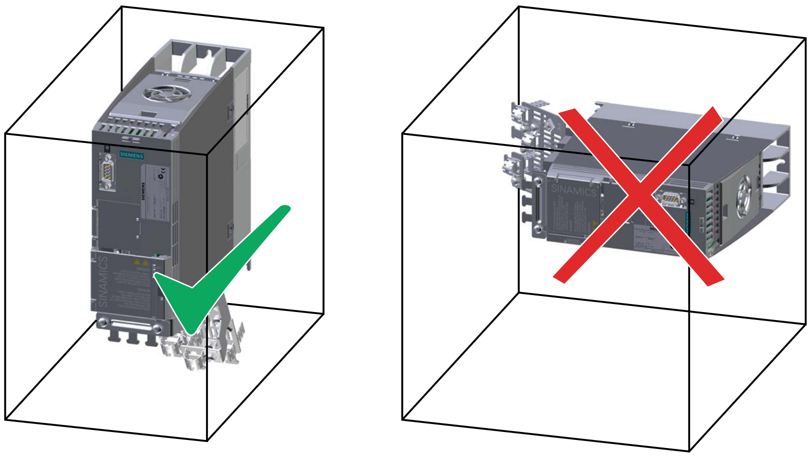
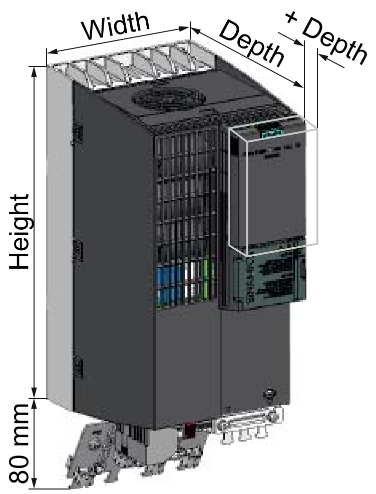
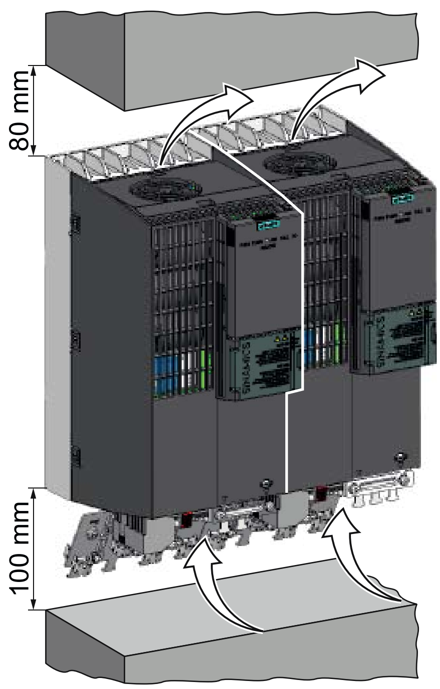
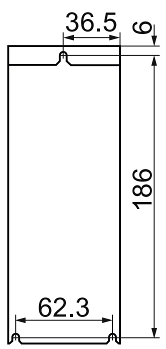
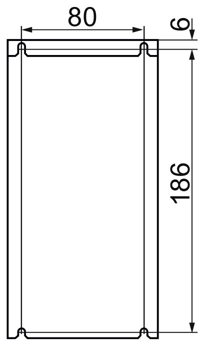
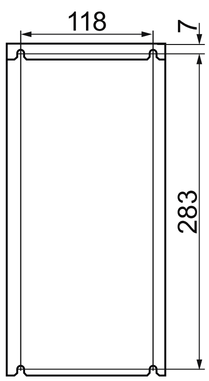


Figure 4-1 The converter must not be installed horizontally.

Devices that could impede the flow of cooling air must not be installed in this area. Make sure that the ventilation openings for the cooling air for the converter are not covered and that the flow of cooling air is not obstructed.

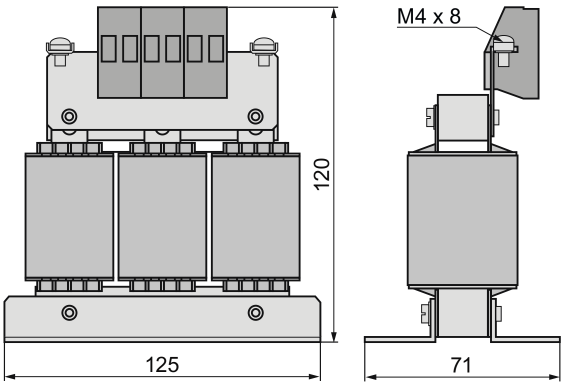
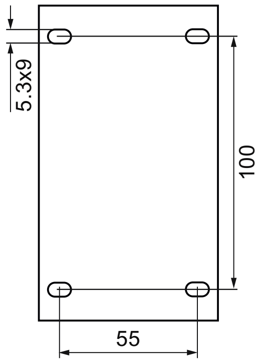
Table 4- 1 Dimensions, drill patterns and minimum distances

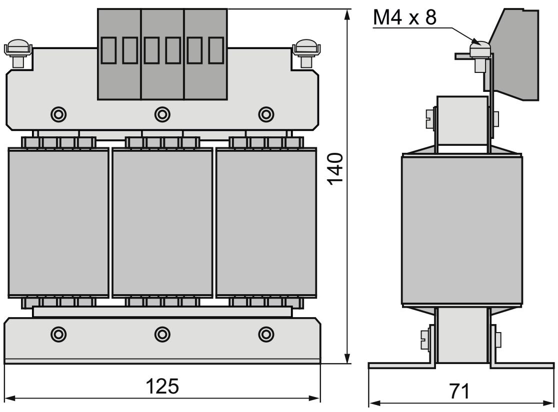
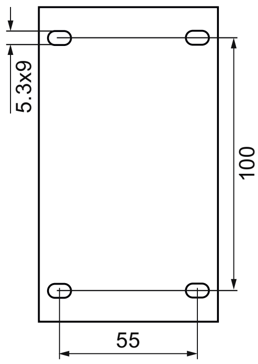
<table>
<tr><th colspan="2"></th><th colspan="2">Frame Size A
0.55 kW … 4.0 kW</th><th>Frame Size B
5.5 kW … 7.5 kW</th><th>Frame Size C
11 kW … 18.5 kW</th></tr>
<tr><td rowspan="9">

Distances to other equipment:

</td><td>Height</td><td colspan="2">196 mm</td><td>196 mm</td><td>295 mm</td></tr>
<tr><td>Width</td><td colspan="2">73 mm</td><td>100 mm</td><td>140 mm</td></tr>
<tr><td>Depth of the converter with PROFINET interface</td><td colspan="2">225.4 mm</td><td>225.4 mm</td><td>225.4 mm</td></tr>
<tr><td>Depth of the converter with USS/MB, CANopen or PROFIBUS interface</td><td colspan="2">203 mm</td><td>203 mm</td><td>203 mm</td></tr>
<tr><td rowspan="2">+ Depth</td><td></td><td colspan="3">+ 21 mm supplementary depth with the operator panel IOP snapped onto the converter.</td></tr>
<tr><td></td><td colspan="3">+ 6 mm supplementary depth with the operator panel BOP-2.</td></tr>
<tr><td>Drill pattern</td><td colspan="2">
</td><td>
</td><td>
</td></tr>
<tr><td>Fixings</td><td colspan="2">3 × M4 bolts
3 × M4 nuts
3 × M4 washers</td><td>4 × M4 bolts
4 × M4 nuts
4 × M4 washers</td><td>4 × M5 bolts
4 × M5 nuts
4 × M5 washers</td></tr>
<tr><td>Tightening torque</td><td colspan="2">2.5 Nm</td><td>2.5 Nm</td><td>2.5 Nm</td></tr>
</table>

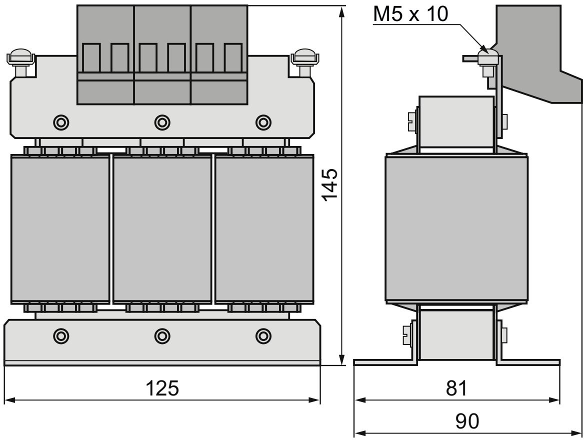
4.4 Mounting the line reactor

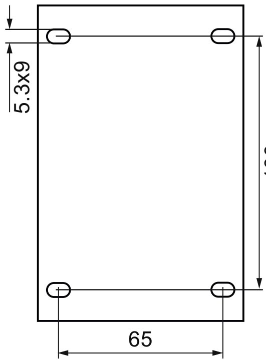
Dimensions and drill patterns

Frame Size A, 0.55 kW … 1.1 kW	
Dimensions [mm]	Drill pattern [mm]
	 Fixings: 4 x M5 bolts 4 x M5 nuts 4 x M5 washers Tightening torque: 6 Nm

Frame Size A, 1.5 kW … 4.0 kW	
Dimensions [mm]	Drill pattern [mm]
	 Fixings: 4 x M5 bolts 4 x M5 nuts 4 x M5 washers Tightening torque: 6 Nm

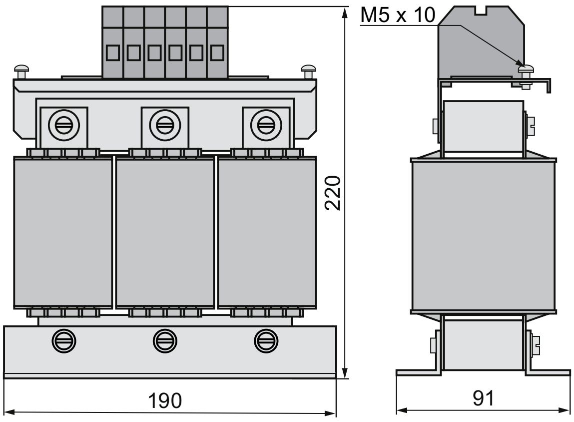
Frame Size B, 5.5 kW … 7.5 kW

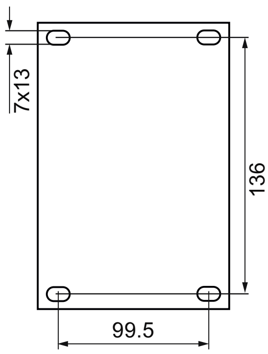




Fixings:
4 x M5 bolts
4 x M5 nuts
4 x M5 washers
Tightening torque: 6 Nm

Frame Size C, 11 kW … 18.5 kW





Fixings:
4 x M6 bolts
4 x M6 nuts
4 x M6 washers
Tightening torque: 10 Nm

Distances to other equipment

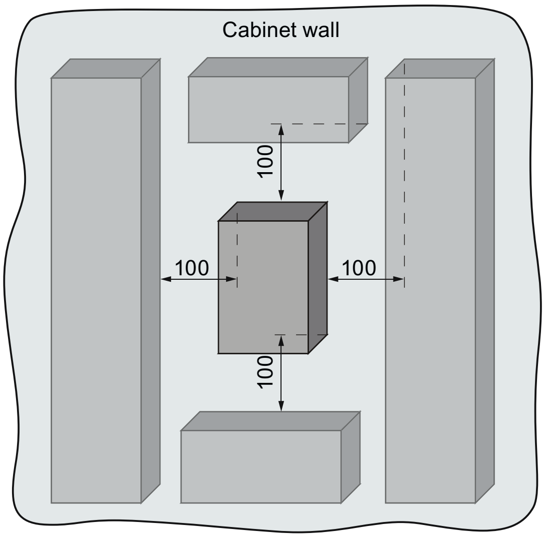


Figure 4-2 Distances of line reactors to other equipment [mm]

4.5 Mounting the braking resistor

Mounting orientation

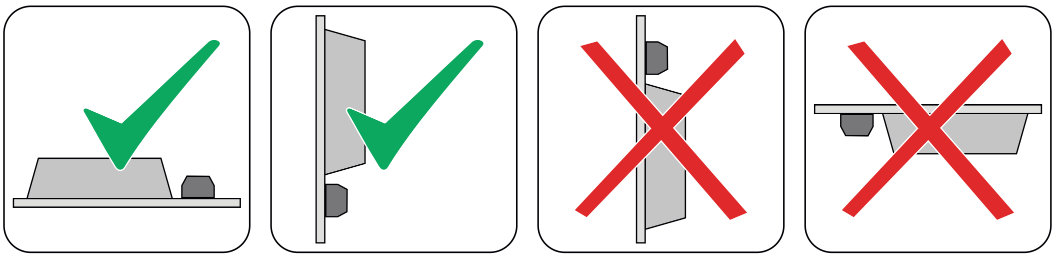
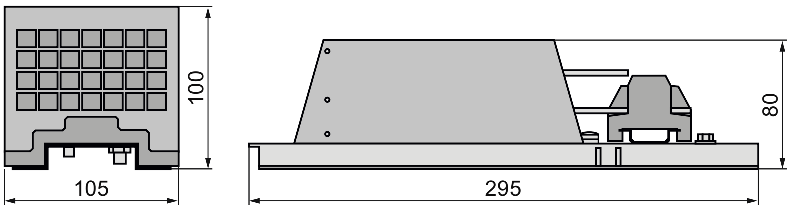
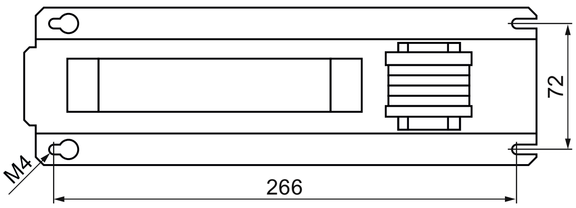
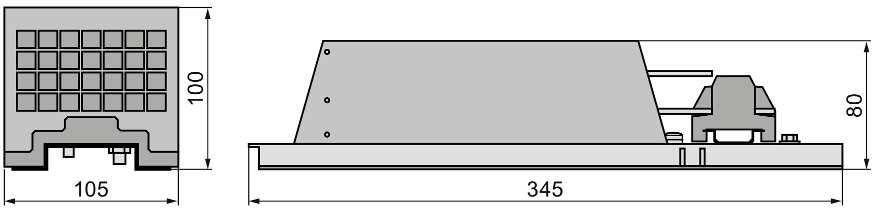
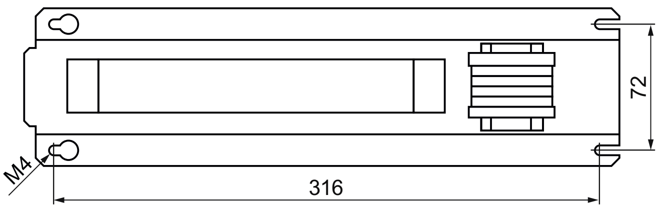


Figure 4-3 Permissible mounting orientation of the braking resistor

⚠ CAUTION
The operation of the braking resistor without housing is not permitted.

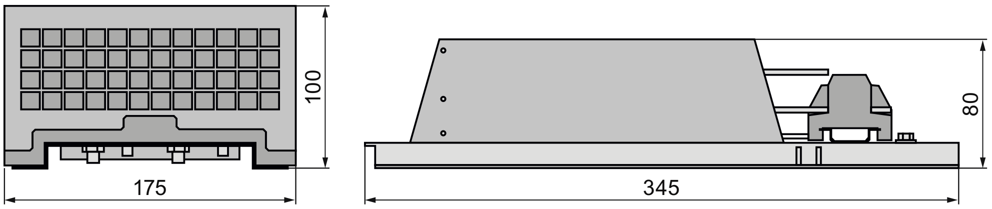
Dimensions and drill patterns

Frame Size A, 0.55 kW … 1.5 kW	
Dimensions [mm]	
	
Drill pattern [mm]	
	Fixing: 4 × M4 bolts 4 × M4 nuts 4 × M4 washers Tightening torque 3 Nm

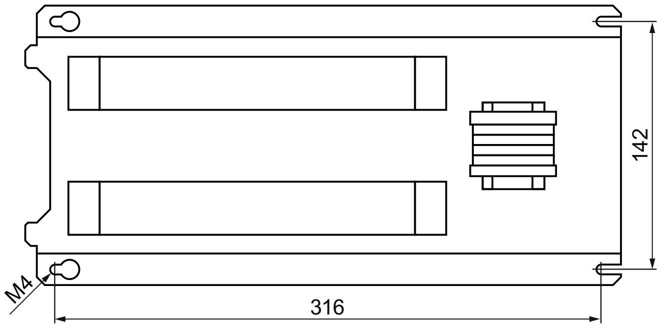
Frame Size A, 2.2 kW … 4.0 kW	
Dimensions [mm]	
	
Drill pattern [mm]	
	Fixing: 4 × M4 bolts 4 × M4 nuts 4 × M4 washers Tightening torque 3 Nm

Frame Size B, 5.5 kW … 7.5 kW

Dimensions [mm]



Drill pattern [mm]

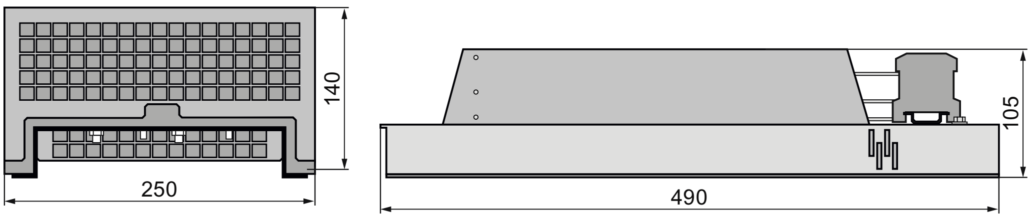


Fixing:

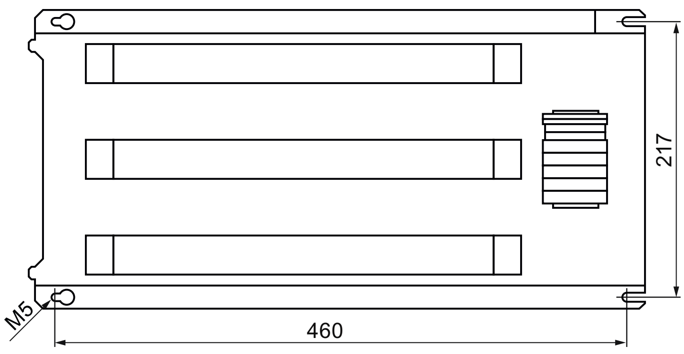
4 × M4 bolts
4 × M4 nuts
4 × M4 washers
Tightening torque 3 Nm

Frame Size C, 11 kW … 18.5 kW

Dimensions [mm]



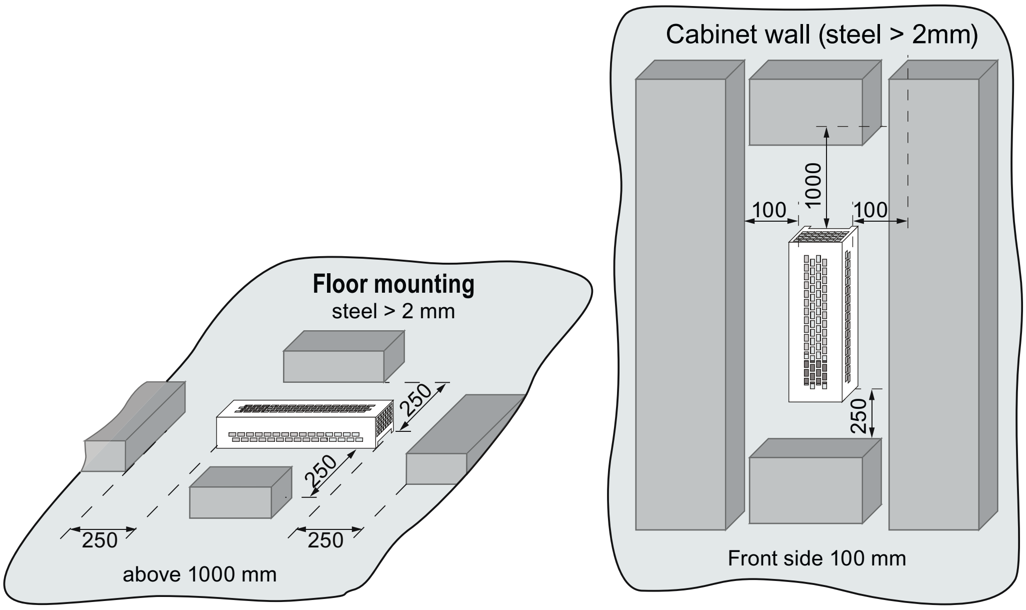
Drill pattern [mm]



Fixing:

4 × M5 bolts
4 × M5 nuts
4 × M5 washers
Tightening torque 6 Nm

Distances to other equipment



Mount the resistor on a heat resistant surface with a high thermal conductivity. Do not install devices that could impede the flow of cooling air in this area. Do not cover the ventilation openings of the braking resistor.

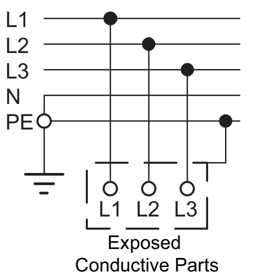
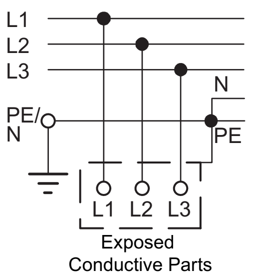
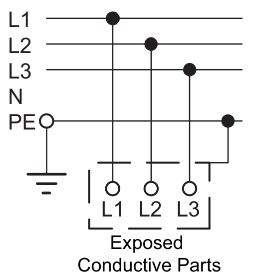
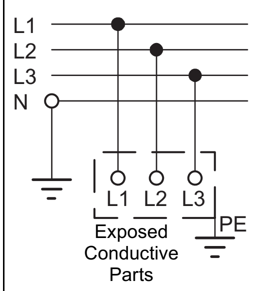
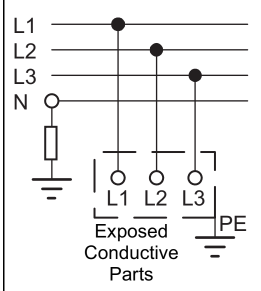
4.6 Connecting the converter

4.6.1 Power distribution systems

Overview of Power Distribution Systems

The power distribution systems described below, as defined in EN 60950 , have been considered in the design of the converter. In the next figures three phase systems are outlined. The three phase converter must be connected to L1, L2 and L3. PE must always be connected. The converter operates with most supply systems.

Table 4- 2 Power distribution systems

TN-S Power System	TN-C-S Power System	TN-C Power System	TT Power System	IT Power System
				
A TN-S power system has separate neutral and protective ground conductors throughout the system.	In a TN-C-S power system, the neutral and protective functions are combined in a single part of the system.	In a TN-C power system, the neutral and protective functions are combined in a single conductor throughout the system.	A TT power system has one point directly grounded, the exposed conductive parts of the installation being connected to a ground, which is electrically independent of the ground of the power system.	An IT power system has no direct connection to ground - instead the exposed parts of the electrical installation are grounded.

IT supplies are fully isolated from the protective earth system, usually by an isolating transformer. It should be noted, however, that a protective earth is still provided.

⚠ WARNING
Converters with built-in filters or external filters must not be used with IT supplies.

If the converter connected to an IT supply is required to remain operational if an output phase is connected to ground, then an output reactor must be fitted to prevent overcurrent tripping. The probability of overcurrent tripping without output reactor increases with the size of the IT supply.

Operation of the converter without a protective earth is not permitted under any circumstances.

4.6.2 Connecting the line supply and motor

Preconditions

Once the inverter has been properly installed, the line and motor connections can now be established. The following warning information must be observed here.

WARNING

Line and motor connections

The inverter must be grounded on the line supply and motor side. If the inverter is not correctly grounded, this can lead to extremely hazardous conditions which, under certain circumstances, can result in death.

The device must be disconnected from the electrical power supply before any connections with the device are established or in any way altered.

The inverter terminals can be at hazardous voltages even after the inverter has been switched off. After disconnecting the line supply, wait at least 5 minutes until the device has discharged itself. Only then, carry out any installation and mounting work.

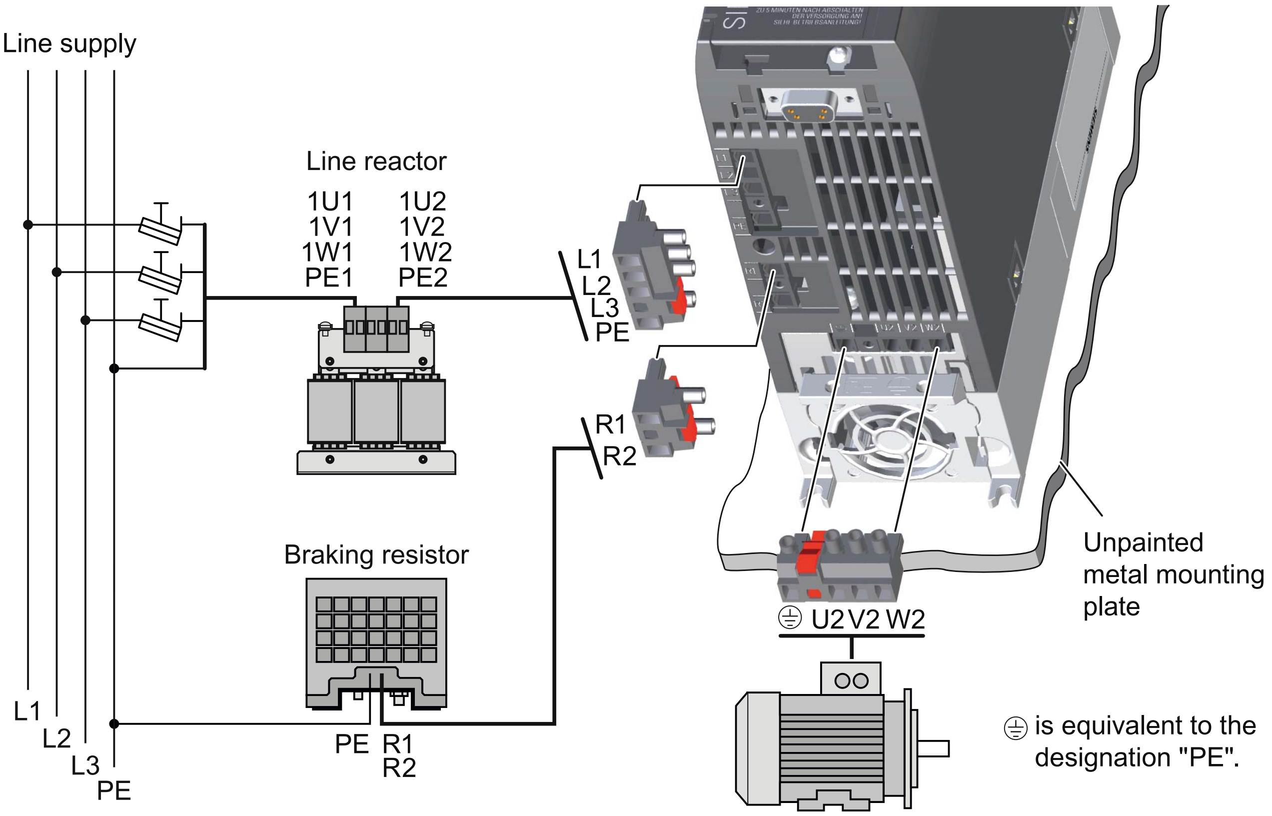
When connecting the inverter to the line supply, ensure that the motor terminal box is closed.

Even if the LED or other indicators do not light up or remain inactive when a function is switched from ON to OFF, this does not necessarily mean that the unit has been switched off or is de-energized.

The short-circuit ratio of the power supply must be at least 100.

Make sure that the inverter is configured for the correct supply voltage (it is not permissible that the inverter is connected to a higher supply voltage).

Connecting line, motor and further components



Converter		Standard fuse	UL/cUL fuse	Braking resistor	Line reactor
FSA	0.55 kW … 1.1 kW	3NA3801 (6 A)	10 A class J	6SL3201-0BE14-3AA0	6SL3203-0CE13-2AA0
	1.5 kW	3NA3803 (10 A)			6SL3203-0CE21-0AA0
	2.2 kW			6SL3201-0BE21-0AA0	
	3.0 kW … 4.0 kW	3NA3805 (16 A)	15 A class J		
FSB	5.5 kW	3NA3807 (20 A)	20 A class J	6SL3201-0BE21-8AA0	6SL3203-0CE21-8AA0
	7.5 kW	3NA3810 (25 A)	25 A class J		
FSC	11 kW	3NA3817 (40 A)	40 A class J	6SL3201-0BE23-8AA0	6SL3203-0CE23-8AA0
	15 kW	3NA3820 (50 A)	50 A class J		
	18.5 kW	3NA3822 (63 A)	60 A class J		

Converter		Cable cross section converter (tightening torque)		Line reactor (tightening torque)			Braking resistor (tightening torque)	
FSA	0.55 kW … 4 kW	2.5 mm^2 (0.5 Nm)	14 AWG (4.5 lbf in)	4 mm^2 (0.8 Nm)	12 AWG (7 lbf in)	PE M4 (3 Nm / 26.5 lbf in)	2.5 mm^2 (0.5 Nm)	14 AWG (4.5 lbf in)
FSB	5.5 kW … 7.5 kW	6 mm^2 (0.6 Nm)	10 AWG (5.5 lbf in)	10 mm^2 (1.8 Nm)	8 AWG (16 lbf in)	PE M5 (5 Nm / 44 lbf in)		
FSC	11 kW … 18.5 kW	16 mm^2 (1.5 Nm)	5 AWG (13.5 lfb in)	16 mm^2 (4 Nm)	5 AWG (35 lbf in)		6 mm^2 (0.6 Nm)	10 AWG (5.5 lbf in)

Components for United States / Canadian installations (UL/CSA)

In order that the system is UL/CSA-compliant, use UL/CSA-certified J-type fuses, overload circuit-breakers or intrinsically safe motor protection devices. For each frame size A to C use class 1 75° C copper wire only.

Install the converter with any external recommended suppressor with the following features:

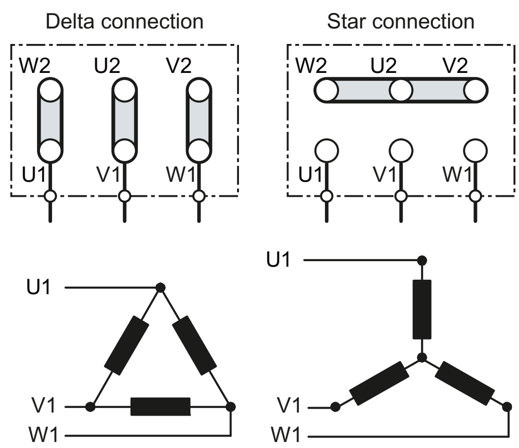
- Surge-protective devices; device shall be a Listed Surge-protective device (Category code VZCA and VZCA7).
- Rated nominal voltage 480/277 V_{AC}, 50/60 Hz, 3-phase.
- Clamping voltage V_{PR} = 2000 V, I_N = 3 kA min, MCOV = 550 V_{AC}, SCCR = 40 kA.
- Suitable for Type 1 or Type 2 SPD application.
- Clamping shall be provided between phases and also between phase and ground.

Star connection and delta connection

With SIEMENS motors, you will see a diagram of both connection types on the inside of the cover of the terminal box:

- Star connection (Y)
- Delta connection (Δ)

The motor rating plate provides information about the correct connection data.



Examples for operating the inverter and motor on a 400 V line supply

Assumption: The motor rating plate states 230/400 V Δ/Y.

Case 1: A motor is normally operated between standstill and its rated speed (i.e. a speed corresponding to the line frequency). In this case, you need to connect the motor in Y. Operating the motor above its rated speed is only possible in field weakening, i.e. the motor torque available is reduced above the rated speed.

Case 2: If you want to operate the motor with the "87 Hz characteristic", you need to connect the motor in Δ.
With the 87 Hz characteristic, the motor's power output increases. The 87 Hz characteristic is mainly used with geared motors.

4.6.3 EMC-compliant installation and connection

EMC-compliant installation of the converter

The EMC-compliant installation of the converter is shown in the following diagram.

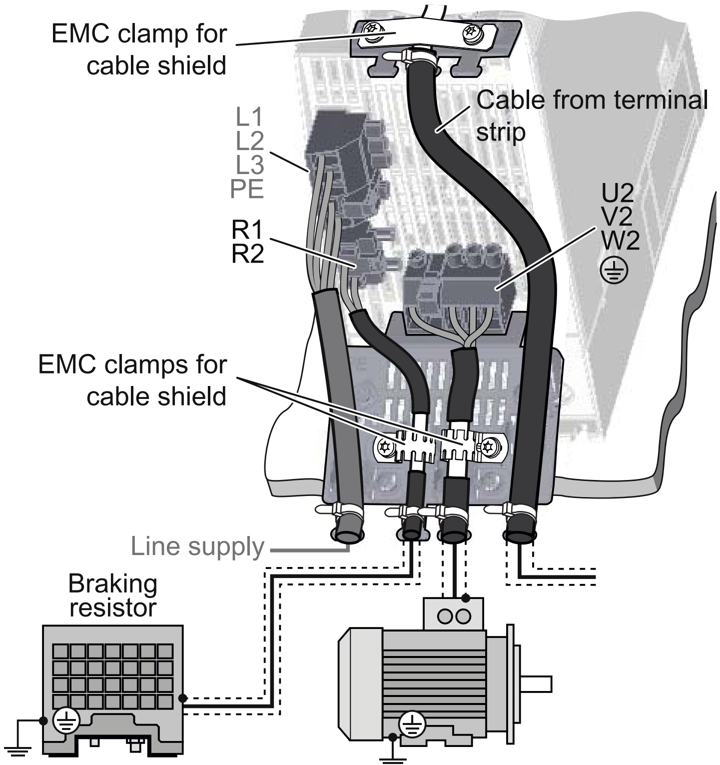


Figure 4-4 Converter shielding

Screening methods

The following illustration shows an example with and without Shielding Plate.

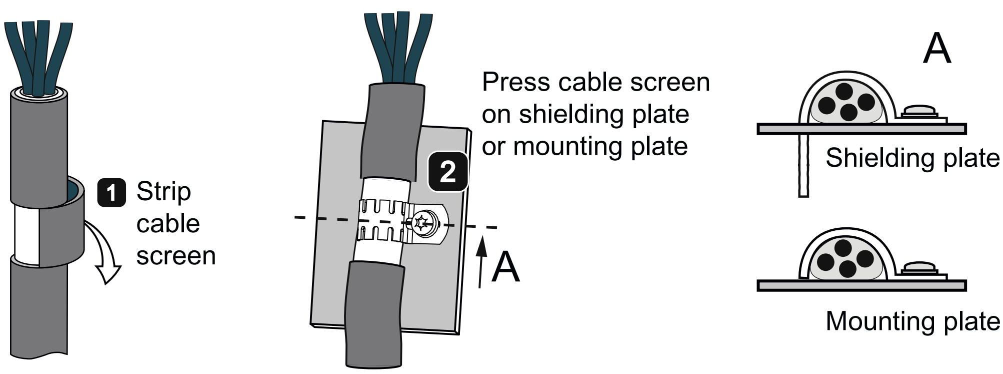


Figure 4-5 Shield

Note

Use an unshielded cable for the mains connection of Power Modules with integrated filter. Power Modules, which are connected to the line supply via an external filter, require a shielded cable between the line filter and Power Module.

Cables inside the cabinet

- All power cables of the drive (line supply cables, cables to braking resistors, as well as motor cables) must be routed separately from signal and data cables. The minimum distance should be approximately 25 cm / 9.84 in. Alternatively decoupling in the cabinet can be implemented by means of separation plates connected to the mounting plate (back plane) with excellent electrical conductivity.
- Line supply cables running between the supply system and the line filter must be routed separately from non-filtered power cables (cables to braking resistors as well as motor cables).
- Signal and data cables, as well as filtered line supply cables, may only cross non-filtered power cables at right angles of 90° to minimize coupled-in interference.
- All cable lengths must be minimized (excessive cable lengths must be avoided).
- All cables must be routed as closely as possible to grounded housing components, such as mounting plates or the cabinet frame. This reduces interference radiation as well as coupled-in interference.
- Signal and data cables, as well as their associated equipotential bonding cables, must always be routed in parallel and with as short a distance as possible.
- When unshielded single-wire cables are used within a zone, the feed and return lines must be either routed in parallel with the minimum possible distance between them, or twisted with one another.
- Spare wires for signal and data cables must be grounded at both ends to create an additional shielding effect.
- Signal and data cables should enter the cabinet only at one point (e.g. from below).

Cables outside the cabinet

- All power cables (line supply cables, cables to braking resistors, as well as motor cables) must be routed seperately from signal and data cables. The minimum distance should be approximately 25 cm / 9.84 in.
- The power cable between converter and motor must be shielded. A symmetrical, 3-wire, three-phase cable should be used here. Shielded cables with symmetrical three-phase conductors (L1, L2, and L3) and an integrated, 3-wire, and symmetrically arranged PE conductor are ideal for this purpose.
- The shielded power cable to the motor must be routed separately from the cables to the motor temperature sensors (PTC/KTY) and the cable to the encoder, since the latter two are treated as signal cables.
- Signal and data cables must be shielded to minimize coupled-in interference with respect to capacitive, inductive, and radiative coupling.
- Particularly sensitive signal cables, such as setpoint and actual value cables and, in particular, encoder cables must be routed with optimum shield bonding at both ends and without any interruptions of the shield.

Cable shields

- Shielded cables must have finely stranded braided shields. Foil shields are not suitable since they are much less effective.
- Shields must be connected to the grounded housings at both ends with excellent electrical conductivity and a large contact area. Only when this method is used coupled-in interference with respect to capacitive, inductive, and radiative coupling can be minimized.
- Bonding connections for the cable shields should be established, where ever possible, directly behind the cable entry into the cabinet. For power cables the EMC shield busbars should be used. For signal and data cables the shield bonding options provided in the cabinet units should be used.
- Cable shields should not be interrupted, wherever possible, by intermediate terminals.
- In the case of both, the power cables and the signal and data cables, the cable shields should be connected by means of suitable EMC shield clips. These must connect the shields to either the EMC shield busbar or the shield bonding options for signal cables with excellent electrical conductivity and a large contact area.
- As plug connectors for shielded data cables (e. g. PROFIBUS cables) only metallic or metallized connector housings should be used.

Equipotential bonding

- Equipotential bonding within a cabinet element has to be established by means of a suitable mounting plate (back plane), to which all metallic housings of the devices and additional components integrated in the cabinet element (e. g. converter or line filter) are connected. The mounting plate has to be connected to the cabinet frame and to the PE or EMC busbar of the cabinet element with excellent electrical conductivity and a large contact area.
- Equipotential bonding between several cabinet elements has to be established by means of a PE busbar which runs through all the cabinet elements. In addition, the frames of the individual cabinet elements must be screwed together multiple times with sufficient electrical conductivity by means of special contact washers. If extremely long rows of cabinets are installed in two groups back to back, the two PE busbars of the cabinet groups must be connected to each other wherever possible.
- Equipotential bonding within the drive system has to be established by connecting all electrical and mechanical drive components (transformer, cabinet, motor, gearbox, and driven machine) to the grounding system. These connections are established by means of standard heavy-power PE cables, which do not need to have any special high-frequency properties. In addition to these connections, the converter (as the source of the high-frequency interference) and all other components in each drive system (motor, gearbox, and driven machine) must be interconnected with respect to the high-frequency point of view. For this purpose cables with good high-frequency properties must be used.

Grounding and high-frequency equipotential bonding measures

The following figure illustrates all grounding and high-frequency equipotential bonding measures using the example of a cabinet with a SINAMICS G120.

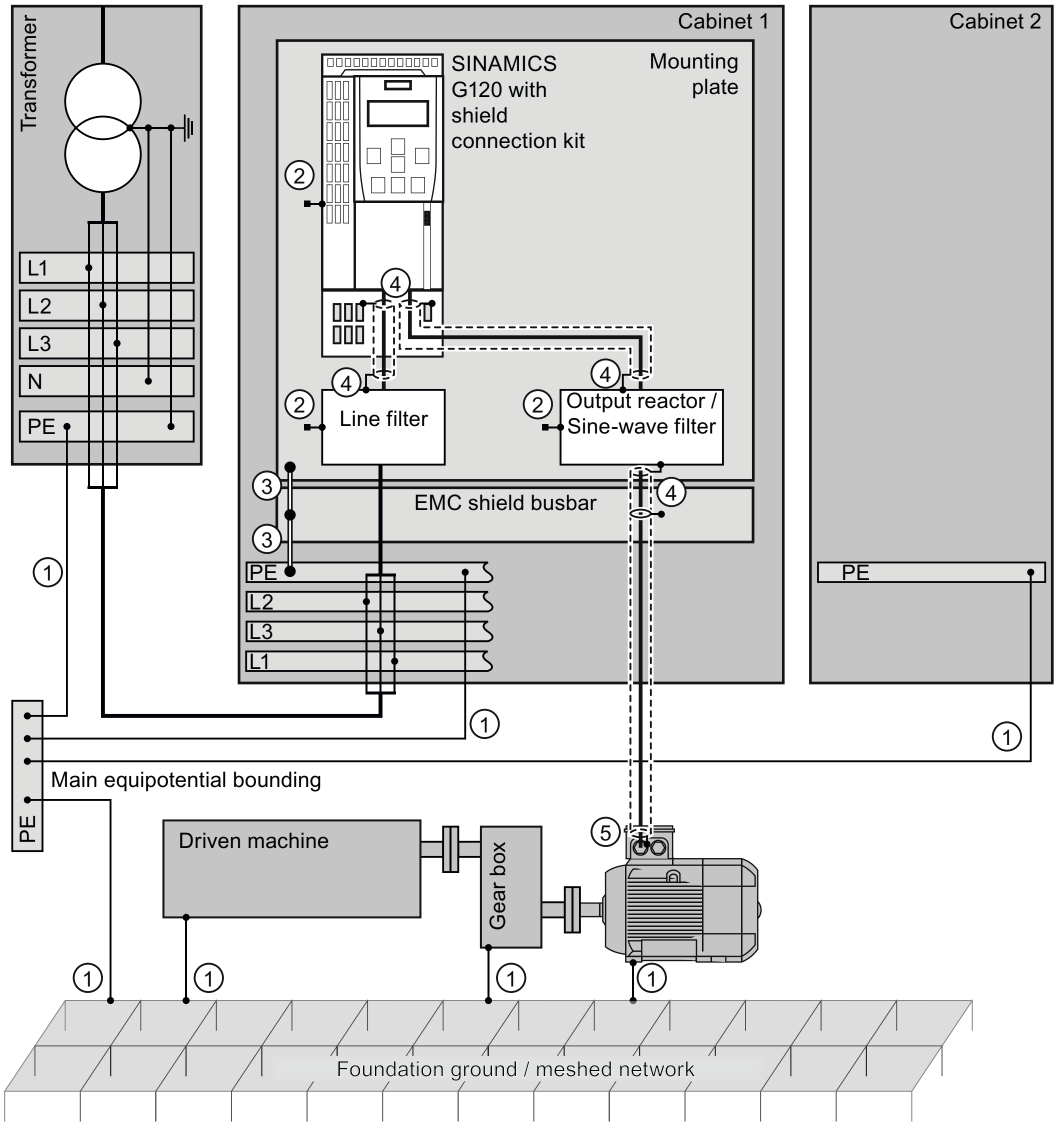
The ground connections ① represent the conventional grounding system for the drive components.

They are made with standard, heavy-power PE conductors without special high-frequency properties and ensure low frequency equipotential bonding as well as protection against injury.

The connections ② inside the cabinet provide solid bonding for high-frequency currents between the metal housings of the integrated components and the EMC shield busbar of the cabinet. These internal connections should be made via a large area using non-isolated metal construction components of the cabinet. In this case, the contact surface must be bare metal and each contact area must have a minimum cross-section of several cm². Alternatively, these connections can be made with short, finely stranded, braided copper wires with a large cross-section (≥ 95 mm² / 000 (3/0) (-2) AWG) between the integrated components and the EMC shield busbar.

The shield and the protective earth conductor of the motor cable provide the high-frequency equipotential bonding between the converter and the motor terminal box.

Therefore connect the protective earth conductor and the cable shield as well to the motor as to the converter.



1. Conventional grounding system without special high-frequency properties
2. Electrically conductive connection to the mounting plate through the largest possible surface area
3. High-frequency equipotential bonding
4. Connect shield with a large contact area and connect protective earth conductor
5. Connect shield via electrically conductive PG gland and connect protective earth conductor

Figure 4-6 Grounding and high-frequency equipotential bonding measures in the drive system and in the plant

Additional measures

Finely stranded, braided copper cables have to be routed in parallel with the cable shields in the following cases:

- Old installations with already existing unscreened cables
- Cables with poor high-frequency properties
- Installations with bad grounding systems

The connections in the figure below provide a solid, high-frequency bonding between the motor housing, the motor terminal box, the gearbox, the driven machine and the EMC busbar.

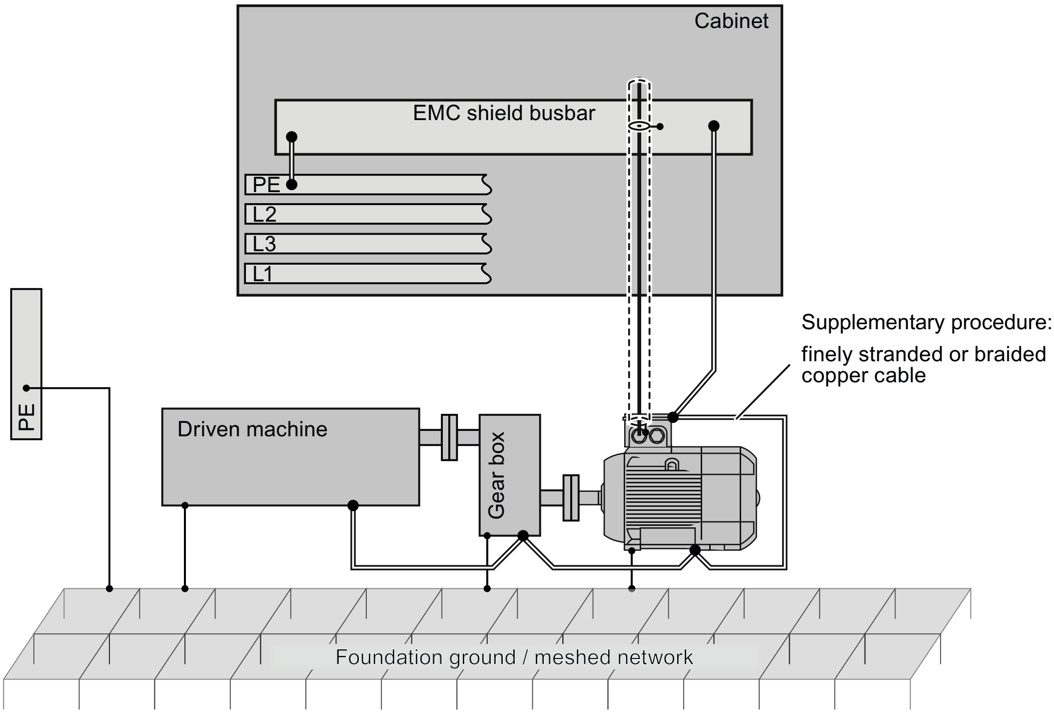
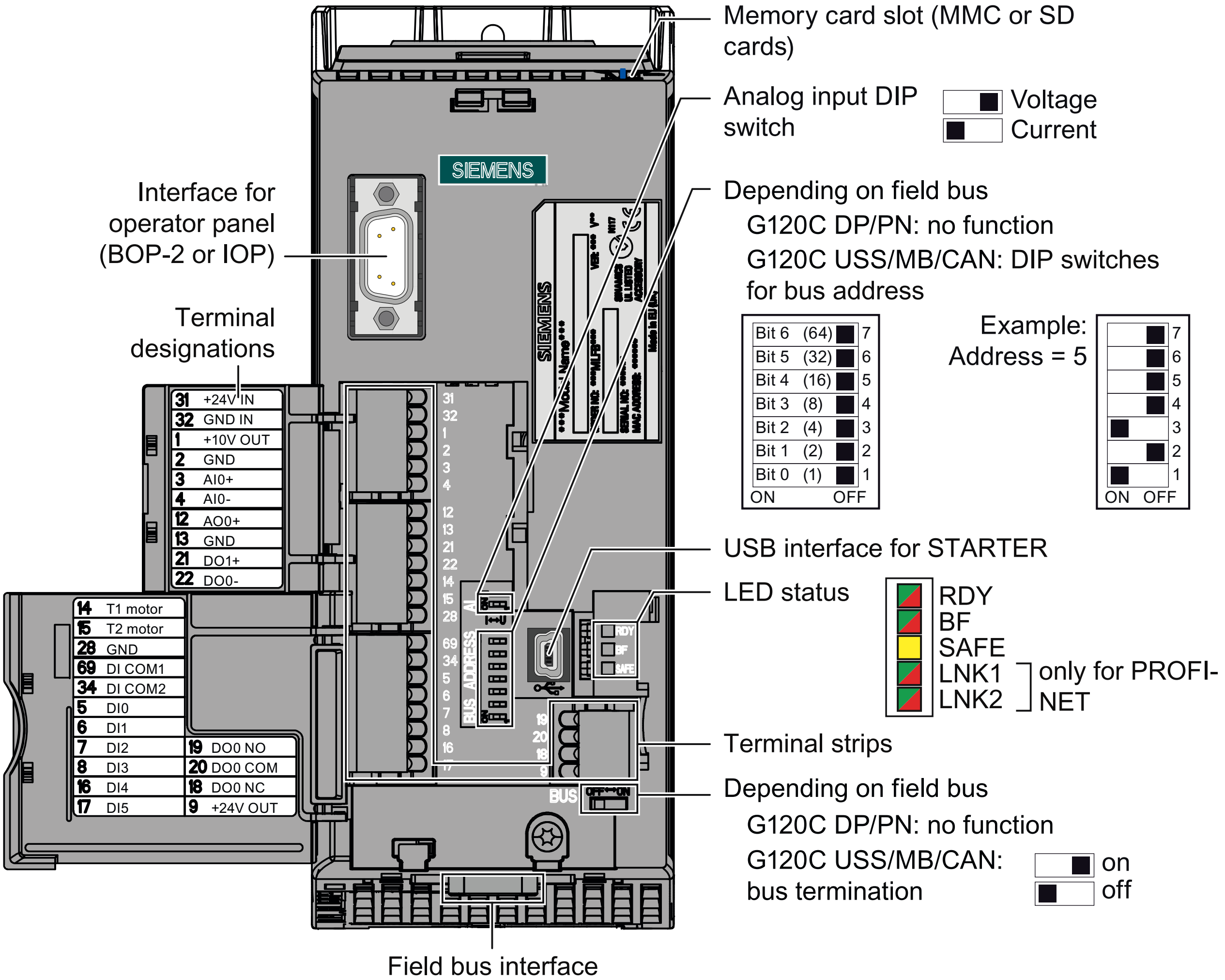


Figure 4-7 Additional high-frequency bonding of the drive system

4.6.4 Interfaces, connectors, switches, terminal blocks and LEDs of the converter

In the diagrams below, the complete breakdown of all user interfaces are explained.



CANopen

1 Not used
2 CAN_L, CAN-signal (dominant low)
3 CAN_GND, CAN-reference
4 Not used
5 (CAN _SHLD), optional cable shield
6 (GND), optional CAN-reference
7 CAN_H, CAN-signal (dominant high)
8 Not used
9 Not used

USS / Modbus RTU

1 0 V, reference potential
2 RS485N, Receive and send (-)
3 RS485P, Receive and send (+)
4 Cable shield
5 Not used

PROFIBUS

1 Shield, ground connection
2 Not used
3 RxD/TxD-P, receive/send data P(B/B')
4 CNTR-P, control signal
5 DGND, data reference potential (C/C')
6 VP, supply voltage positive
7 Not used
8 RxD/TxD-N, receive/send data N(A/A')
9 Not used

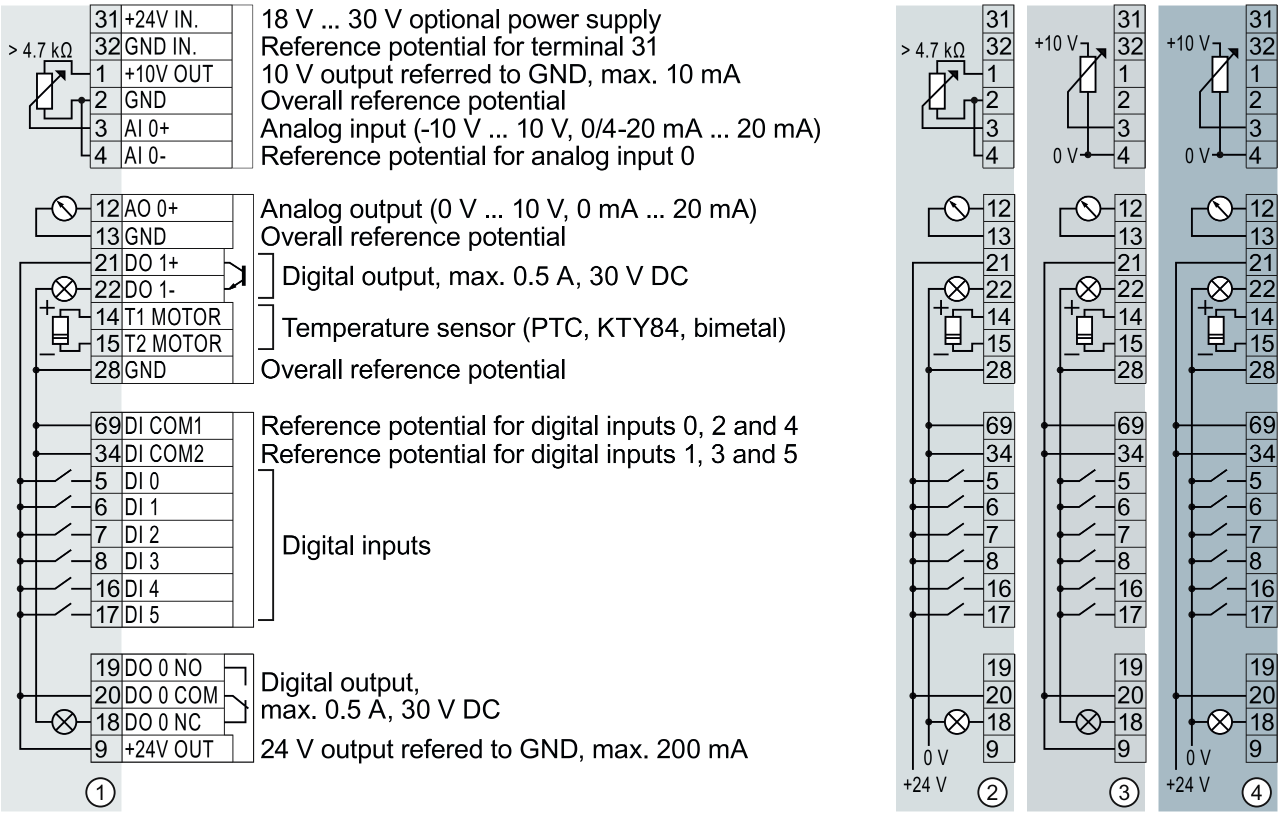
PROFINET

1 RX+, receiver data +
2 RX-, receiver data -
3 TX+, transmission data +
4 Not used
5 Not used
6 TX-, transmission data -
7 Not used
8 Not used

Figure 4-8 Interfaces and connectors

4.6.5 Terminal strips on the converter

Wiring the terminal strip



Wiring variants

①	Wiring using the internal power supply	Digital input = HIGH if switch closed
②	Wiring using an external power supply	Digital input = HIGH if switch closed
③	Wiring using the internal power supply	Digital input = LOW if switch closed
④	Wiring using an external power supply	Digital input = LOW if switch closed

Permissible cable cross-section:	0.5 mm² (21 AWG) … 1.5 mm² (16 AWG)
Recommended cable cross section:	1 mm² (18 AWG)

EMC-compliant installation

- Use shielded cables for connecting the terminal strip to other components.
- Use a clamp for connecting the shielded cable. Connect the shield to the mounting plate or to the shield plate through a good electrical connection and through the largest possible surface area. The handling of shielded cables is shown in section EMC-compliant installation and connection (Page 36).

4.6.6 Wiring terminal strips

Solid or flexible cables are permitted as signal lines. Wire end ferrules must not be used for the spring-loaded terminals.

The permissible cable cross-section ranges between 0.5 mm² (21 AWG) and 1.5 mm² (16 AWG). When completely connecting-up the unit, we recommend cables with a cross-section of 1mm² (18 AWG).

Route the signal lines so that you can again completely close the front doors after connecting-up the terminal strip. If you use shielded cables, then you must connect the shield to the mounting plate of the control cabinet or with the shield support of the inverter through a good electrical connection and a large surface area.

4.6.7 Selecting the interface assignments

Description

The converter offers different predefined assignments (macros) for its inputs and outputs and the fieldbus interface.

Only the inputs and outputs whose functions change by selecting a specific assignment, are shown on the following pages.

Procedure

- Wire up the converter according to the interface assignment most suitable for your application.

Further steps

- In the basic commissioning, select the default settings of the interfaces that best match your particular wiring.
- If necessary, after the basic commissioning, adjust the function of the inputs or outputs and the fieldbus interface.

Fixed speeds

Macro 1

Two fixed speeds

p1003 = Fixed speed 3
p1004 = Fixed speed 4

DI 4 and DI 5 = HIGH:
Inverter adds fixed speed 3 + fixed speed 4

5	DI 0	ON/OFF1 right	Fault	18	DO 0
6	DI 1	ON/OFF1 left		19	
7	DI 2	Acknowledge		20	
8	DI 3	---	Alarm	21	DO 1
16	DI 4	Fixed speed 3		22	
17	DI 5	Fixed speed 4			
3	AI 0	---	Speed	12	AO 0
4			0 V ... 10 V	13	

Macro 2

Two fixed speeds with safety function (STO)

p1001 = Fixed speed 1
p1002 = Fixed speed 2

DI 0 and DI 1 = HIGH:
Motor runs with fixed speed 1 + fixed speed 2

5	DI 0	ON/OFF1 + Fixed speed 1	Fault	18	DO 0
6	DI 1	Fixed speed 2		19	
7	DI 2	Acknowledge		20	
8	DI 3	---	Alarm	21	DO 1
16	DI 4	Reserved for STO		22	
17	DI 5	Reserved for STO			
3	AI 0+	---	Speed	12	AO 0+
4			0 V ... 10 V	13	

See also section: Fail-safe function Safe Torque Off (STO) (Page 228).

Macro 3

Four fixed speeds

p1001 = Fixed speed 1
p1002 = Fixed speed 2
p1003 = Fixed speed 3
p1004 = Fixed speed 4
Several DI = HIGH:
Inverter adds corresponding fixed speeds

5	DI 0	ON/OFF1 + Fixed speed 1	Fault	18	DO 0
6	DI 1	Fixed speed 2		19	
7	DI 2	Acknowledge		20	
8	DI 3	---	Alarm	21	DO 1
16	DI 4	Fixed speed 3		22	
17	DI 5	Fixed speed 4			
3	AI 0+	---	Speed	12	AO 0+
4			0 V ... 10 V	13	

Macro 4

Field bus PROFIBUS DP or PROFINET

5	DI 0	---	Fault	18	DO 0
6	DI 1	---		19	
7	DI 2	Acknowledge		20	
8	DI 3	---	Alarm	21	DO 1
16	DI 4	---		22	
17	DI 5	---			
3	AI 0	---	Speed	12	AO 0
4			0 V ... 10 V	13	

PROFIBUS DP
PROFINET
Telegramm 352

See also section: Configuring communication to the control (Page 91).

Macro 5

Field bus PROFIBUS DP or PROFINET with safety function (STO)

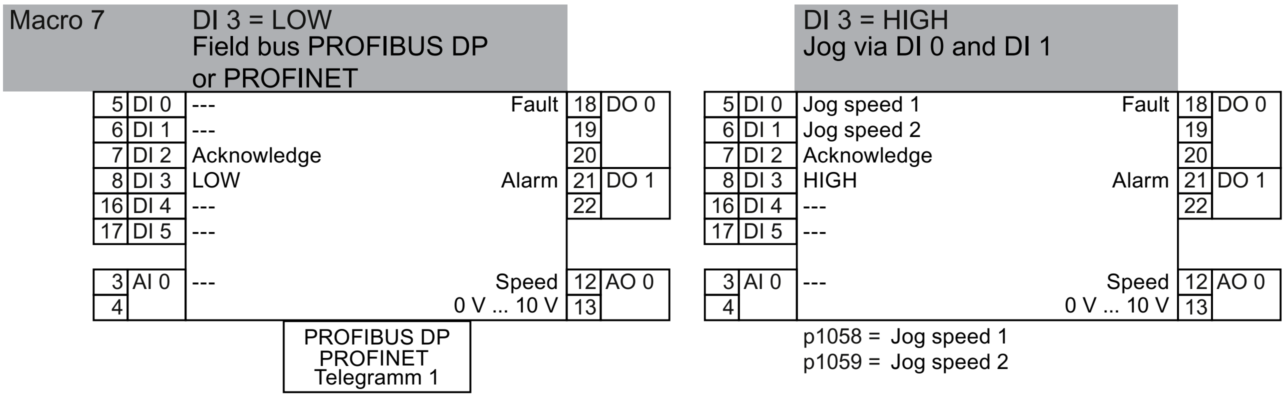
5	DI 0	---	Fault	18	DO 0
6	DI 1	---		19	
7	DI 2	Acknowledge		20	
8	DI 3	---	Alarm	21	DO 1
16	DI 4	Reserved for STO		22	
17	DI 5	Reserved for STO			
3	AI 0	---	Speed	12	AO 0
4			0 V ... 10 V	13	

PROFIBUS DP
PROFINET
Telegramm 352

See also sections: Fail-safe function Safe Torque Off (STO) (Page 228), Configuring communication to the control (Page 91).

Automatic / Manual - change over from field bus to jog

Factory setting with G120C DP and G120C PN:

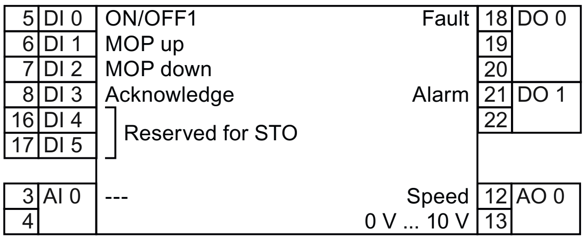


See also section: Configuring communication to the control (Page 91).

Motorized potentiometer

Macro 8

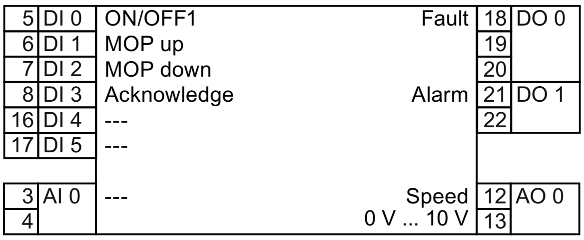
Motorized potentiometer (MOP) with safety function (STO)



See also section: Fail-safe function Safe Torque Off (STO) (Page 228).

Macro 9

Motorized potentiometer (MOP)



Analog setpoint

Macro 13

Safety function (STO)

5	DI 0	ON/OFF1	Fault	18	DO 0
6	DI 1	Reverse		19	
7	DI 2	Acknowledge		20	
8	DI 3	---	Alarm	21	DO 1
16	DI 4	Reserved for STO		22	
17	DI 5				
3	AI 0	Setpoint	Speed	12	AO 0
4		I▭U -10 V ... 10 V	0 V ... 10 V	13	

See also section: Fail-safe function Safe Torque Off (STO) (Page 228).

Process industry

Macro 14

DI 3 = LOW
Field bus PROFIBUS DP or PROFINET

5	DI 0	---	Fault	18	DO 0
6	DI 1	External fault		19	
7	DI 2	Acknowledge		20	
8	DI 3	LOW	Alarm	21	DO 1
16	DI 4	---		22	
17	DI 5	---			
3	AI 0	---	Speed	12	AO 0
4			0 V ... 10 V	13	

PROFIBUS DP
PROFINET
Telegramm 20

DI 3 = HIGH
Motorized potentiometer (MOP)

5	DI 0	ON/OFF1	Fault	18	DO 0
6	DI 1	External fault		19	
7	DI 2	Acknowledge		20	
8	DI 3	HIGH	Alarm	21	DO 1
16	DI 4	MOP up		22	
17	DI 5	MOP down			
3	AI 0	---	Speed	12	AO 0
4			0 V ... 10 V	13	

See also section: Configuring communication to the control (Page 91).

Macro 15

DI 3 = LOW
Analog setpoint

5	DI 0	ON/OFF1	Fault	18	DO 0
6	DI 1	External fault		19	
7	DI 2	Acknowledge		20	
8	DI 3	LOW	Alarm	21	DO 1
16	DI 4	---		22	
17	DI 5	---			
3	AI 0	Setpoint	Speed	12	AO 0
4		I▭U -10 V ... 10 V	0 V ... 10 V	13	

DI 3 = HIGH
Motorized potentiometer (MOP)

5	DI 0	ON/OFF1	Fault	18	DO 0
6	DI 1	External fault		19	
7	DI 2	Acknowledge		20	
8	DI 3	HIGH	Alarm	21	DO 1
16	DI 4	MOP up		22	
17	DI 5	MOP down			
3	AI 0	---	Speed	12	AO 0
4			0 V ... 10 V	13	

Two or three wire control

Macro 12 is factory setting with the G120C USS/MB and G120C CAN.

	Macro 12	Macro 17	Macro 18
Two wire control	Mode 1	Mode 2	Mode 3
Control command 1	ON/OFF1	ON/OFF1 right	ON/OFF1 right
Control command 2	Reverse	ON/OFF1 left	ON/OFF1 left

5	DI 0	Control command 1	Fault	18	DO 0
6	DI 1	Control command 1		19	
7	DI 2	Acknowledge		20	
8	DI 3	---	Alarm	21	DO 1
16	DI 4	---		22	
17	DI 5	---			
3	AI 0	Setpoint	Speed	12	AO 0
4		I U -10 V ... 10 V	0 V ... 10 V	13	

	Macro 19	Macro 20
Three wire control	Mode 1	Mode 2
Control command 1	Release/ OFF1	Release/ OFF1
Control command 2	ON right	ON
Control command 3	ON left	Reverse

5	DI 0	Control command 1	Fault	18	DO 0
6	DI 1	Control command 2		19	
7	DI 2	Control command 3		20	
8	DI 3	Acknowledge	Alarm	21	DO 1
16	DI 4	---		22	
17	DI 5	---			
3	AI 0	Setpoint	Speed	12	AO 0
4		I U -10 V ... 10 V	0 V ... 10 V	13	

Communication with the higher-level control via USS

Macro 21
Field bus USS

p2020 = baud rate
p2022 = Number of PZD
p2023 = Number of PKW

5	DI 0	---	Fault	18	DO 0
6	DI 1	---		19	
7	DI 2	Acknowledge		20	
8	DI 3	---	Alarm	21	DO 1
16	DI 4	---		22	
17	DI 5	---			
3	AI 0	---	Speed	12	AO 0
4			0 V ... 10 V	13	

USS
38400 baud
2 PZD, PKW variable

Communication with the higher-level control via CANopen

Macro 22
Field bus CANopen

p8622 = baud rate

5	DI 0	---	Fault	18	DO 0
6	DI 1	---		19	
7	DI 2	Acknowledge		20	
8	DI 3	---	Alarm	21	DO 1
16	DI 4	---		22	
17	DI 5	---			
3	AI 0	---	Speed	12	AO 0
4			0 V ... 10 V	13	

CANopen
20 kBaud

See also section: CANopen functionality of the inverter (Page 132).

Commissioning guidance 5

Adapting the converter to the drive application

The converter must match the motor and the drive application to be able to optimally operate and protect the motor.

Although the converter can be parameterized for very specific applications, many standard applications function satisfactorily with just a few adaptations.

Use the factory settings ... where possible

In basic applications, the drive already functions with its factory settings. To do this, you must check whether the motor and application match the factory settings of the converter.

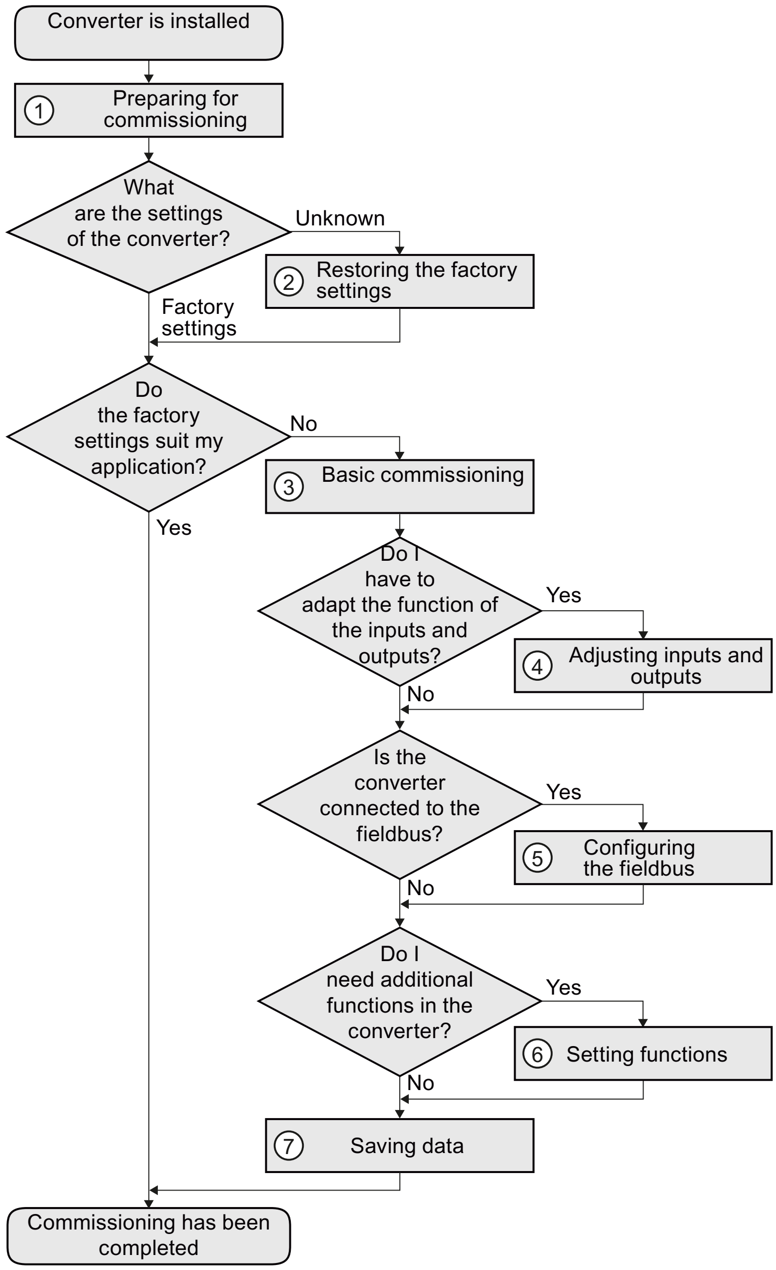
If, when making this check, you identify that you must adapt the factory settings, then you must commission the converter.

Only the basic commissioning is required ... for basic, standard applications

Most standard applications function after just a few adaptations made during the basic commissioning.

Commissioning guidelines

We recommend the following procedure for the commissioning of your converter:



① See (Page 51)

② See (Page 58)

③ Basic commissioning with STARTER (Page 64) or Operator Panel (Page 60)

④ See (Page 73)

⑤ See (Page 85)

⑥ See (Page 159)

⑦ See (Page 247)

Basic commissioning 6

6.1 Preparing basic commissioning

Prerequisites: before you start

Before starting commissioning, you must answer the following questions:

- What data does my converter have?
- What is the data for the connected motor?
- What technological requirements must the drive fulfill?
- Via which converter interfaces does the higher-level control operate the drive?

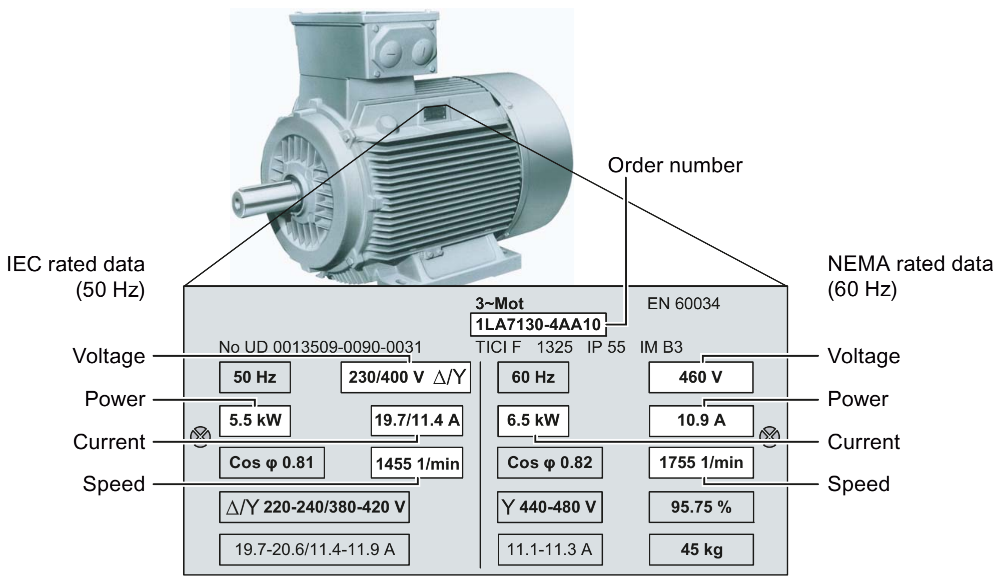
6.1.1 Collecting motor data

In which region of the world is the motor used?

- Europe IEC: 50 Hz [kW]
- North America NEMA: 60 Hz [hp] or 60 Hz [kW]

Motor data of the rating plate

If you use the STARTER commissioning tool and a SIEMENS motor, then you only have to specify the order number of the motor - otherwise you must use the data from the motor rating plate.



NOTICE
Installation note
The rating plate data that you enter must correspond to the connection type of the motor (star connection [Y]/delta connection [Δ]), i.e. for a delta motor connection, the delta rating plate data must be entered.

What is the prevailing temperature where the motor is operated?

- Motor ambient temperature if it differs from the factory setting = 20° C.

6.1.2 Does the motor match the converter?

The converter is preset on a motor at the factory as shown in the figure below.

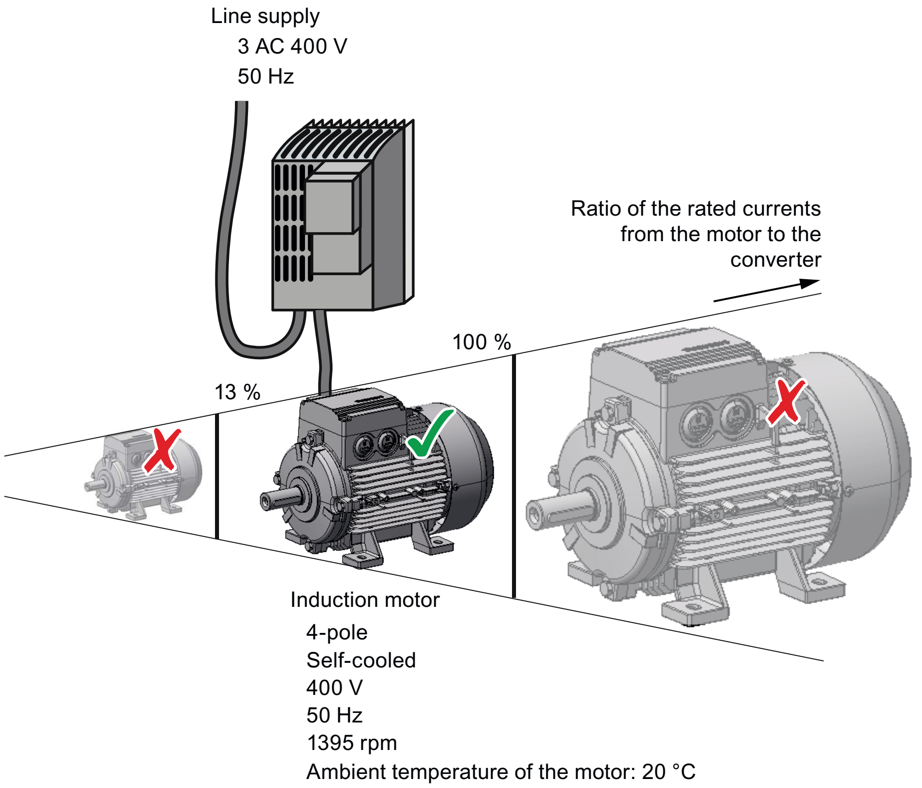


Figure 6-1 Motor data factory settings

The rated current of the motor must be in the range 13% to 100% of the rated converter current.
Example: With a converter with the rated current 10.2 A, you may operate induction motors whose rated currents are in the range 1.3 A to 10.2 A.

6.1.3 Wiring examples for the factory settings

To ensure that the factory setting can be used, you must wire the terminal strip of your converter as shown in the following examples.

Factory pre-assignment of the terminal block at the converter with RS485 field bus interface

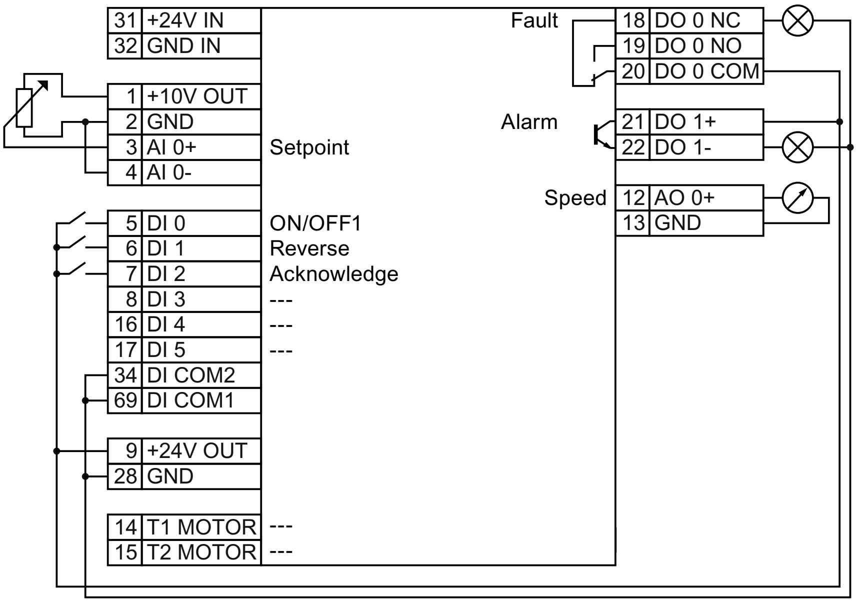


Figure 6-2 Default wiring using RS485 communications

Note

Assignment of terminals following basic commissioning

The assignment of the terminal strip does not change once you have performed the basic commissioning procedure.

Factory pre-assignment of the terminal block at the converter with PROFIBUS interface

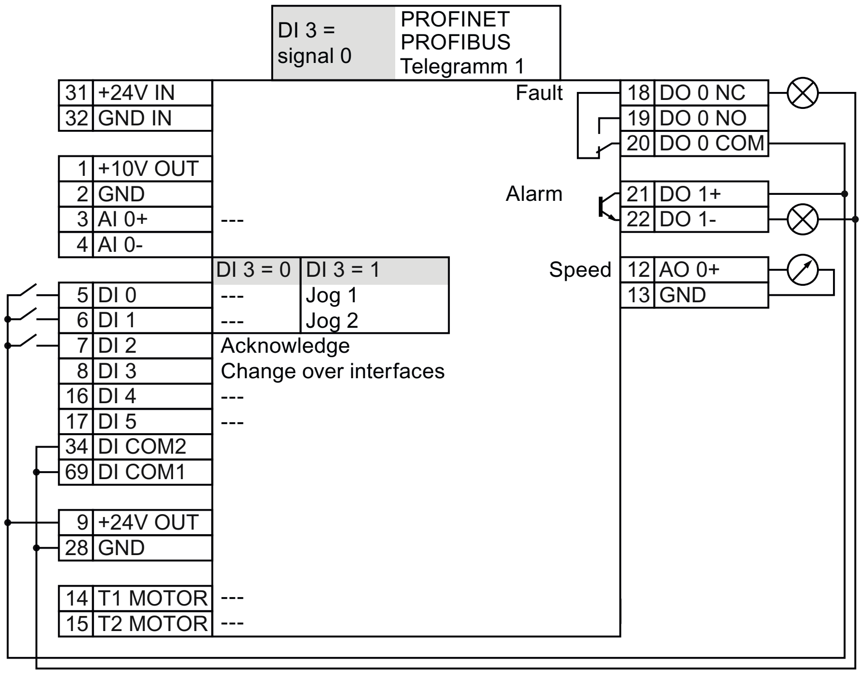


Figure 6-3 Default wiring using PROFIBUS or PROFINET communications

---

Note

Assignment of terminals following basic commissioning

The converter is assigned in the same way as the converter without PROFIBUS or PROFINET interface when you deselect bus communication for both the command sources and the setpoint value specification during basic commissioning of the converter.

6.1.4 Factory setting of the inverter control

Switching the motor on and off

The inverter is set in the factory so that after it has been switched on, the motor accelerates up to its speed setpoint in 10 seconds (referred to 1500 rpm). After it has been switched off, the motor also brakes with a ramp-down time of 10 seconds.

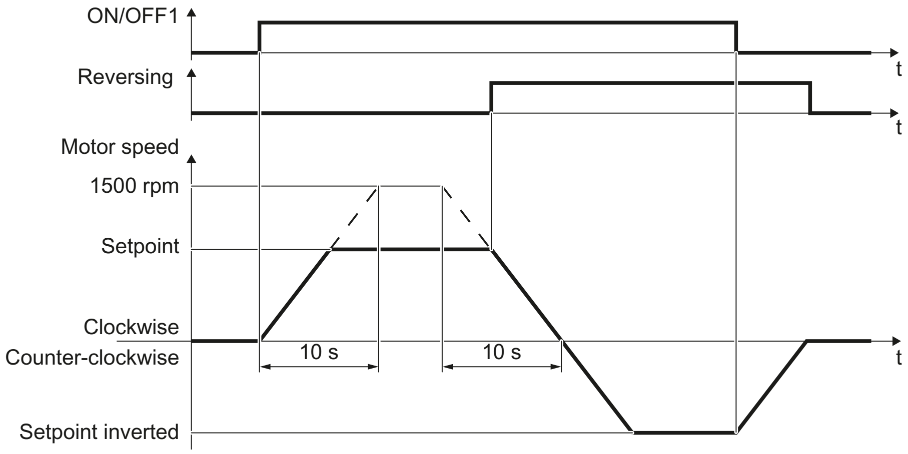


Figure 6-4 Switching on and switching off the motor and reversing in the factory setting

Switching the motor on and off in the jog mode

For inverters with PROFIBUS interface, operation can be switched over using digital input DI 3. The motor is either switched on and off via PROFIBUS – or operated in the jog mode via its digital inputs.

For a control command at the respective digital input, the motor rotates with ±150 rpm. The ramp-up and ramp-down times are also 10 seconds, referred to 1500 rpm.

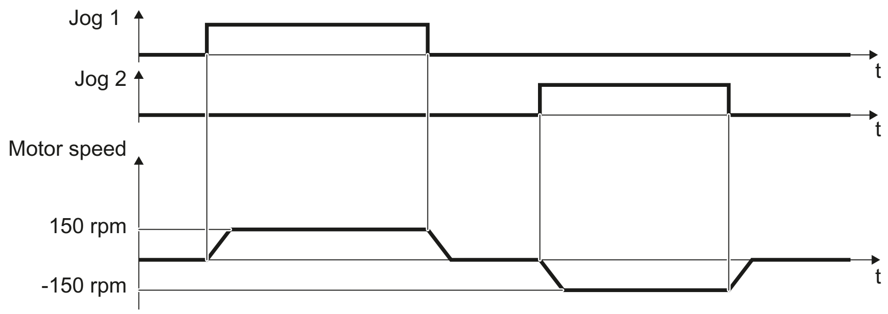


Figure 6-5 Jogging the motor in the factory setting

For induction motors, there are two different open-loop control or closed-loop control techniques:

- U/f control (calculation of the motor voltage using a characteristic curve)
- Closed-loop speed control (also: field-oriented control or vector control)

Criteria for selecting either U/f control or speed control

U/f control is suitable for most applications in which the speed of induction motors is to be changed. Examples of typical applications for U/f control include:

- Pumps
- Fan
- Compressors
- Horizontal conveyors

When compared to U/f control, vector control offers the following advantages:

- The speed is more stable for motor load changes.
- Shorter accelerating times when the setpoint changes.
- Acceleration and braking are possible with an adjustable maximum torque.
- Improved protection of the motor and the driven machine as a result of the adjustable torque limiting.
- The full torque is possible at standstill.
- Torque control is only possible with vector control.

Examples of typical applications in which speed control is used:

- Hoisting gear and vertical conveyors
- Winders
- Extruders

It is not permissible to use speed control in the following cases:

- If the motor is too small in comparison to the inverter (the rated motor power may not be less than one quarter of the rated inverter power)
- If several motors are connected to one inverter
- If a power contactor is used between the inverter and motor and is opened while the motor is powered up
- If the maximum motor speed exceeds the following values:

Inverter pulse frequency	2 kHz			4 kHz and higher		
Pole number of the motor	2-pole	4-pole	6-pole	2-pole	4-pole	6-pole
Maximum motor speed [rpm]	9960	4980	3320	14400	7200	4800

6.1.5 Defining additional requirements for the application

What speed limits should be set? (Minimum and maximum speed)

- Minimum speed - factory setting 0 [rpm]
  The minimum speed is the lowest speed of the motor independent of the speed setpoint. A minimum speed > 0 makes sense in applications, where the motor should be operated with a speed = 0 after it has been switched on. Examples include fans or pumps.
- Maximum speed - factory setting 1500 [rpm]
  The converter limits the motor speed to this value.

What motor ramp-up time and ramp-down time are needed for the application?

The ramp-up and ramp-down time define the maximum motor acceleration when the speed setpoint changes. The ramp-up and ramp-down time is the time between motor standstill and the maximum speed, or between the maximum speed and motor standstill.

- Ramp-up time - factory setting 10 s
- Ramp-down time - factory setting 10 s

6.2 Restoring the factory setting

There are cases where something goes wrong when commissioning a drive system e.g.:

- The line voltage was interrupted during commissioning and you were not able to complete commissioning.
- You got confused when setting the parameters and you can no longer understand the individual settings that you made.
- You don't know whether the inverter was already operational

In cases such as these, reset the inverter to the factory settings.

Reset settings of the safety functions

The settings of the safety functions are protected by a password. In order to reset all settings of the converter to the factory settings, you must begin with the safety functions.

Table 6- 1 Procedure

STARTER	Operator Panel	
1. Go online with STARTER 2. Call the safety functions screen form 3. In the dialog "Safety Integrated" select the button for restoring the factory setting.	Set the following parameters:	
	p0010 = 30	Activate resetting of the settings.
	p9761 = …	Enter the password for the safety functions
	p0970 = 5	Starting resetting. If the converter has reset the settings, p0970 = 5is set.

Final steps:

1. Switch off the converter power supply.
2. Wait until all LEDs on the converter go dark. Now switch on the converter supply voltage again. Your settings only become effective after this power-on reset.

Restoring the factory setting with STARTER or BOP-2

This function resets the settings in the inverter to the factory settings.

Note

The communication settings and the settings of the motor standard (IEC/NEMA) are retained even after restoring the factory setting.

Table 6- 2 Procedure

STARTER	BOP-2
1. Go online with STARTER 2. In STARTER, click on the button .	1. In the "Options" menu, select the "DRVRESET" entry 2. Confirm the reset using the OK key

6.3 Using the factory settings

You only have to do the following, if the factory settings of the converter match your motor and your application.

1. Connect the converter in accordance with the wiring example. See Section: Wiring examples for the factory settings (Page 53)
2. If you operate the drive on a fieldbus, you have to do the following:
   – Configure your central controller according to the settings of the converter.
   – If required by the fieldbus, set the bus address on the converter. See also Section: Interfaces, connectors, switches, terminal blocks and LEDs of the converter (Page 42)

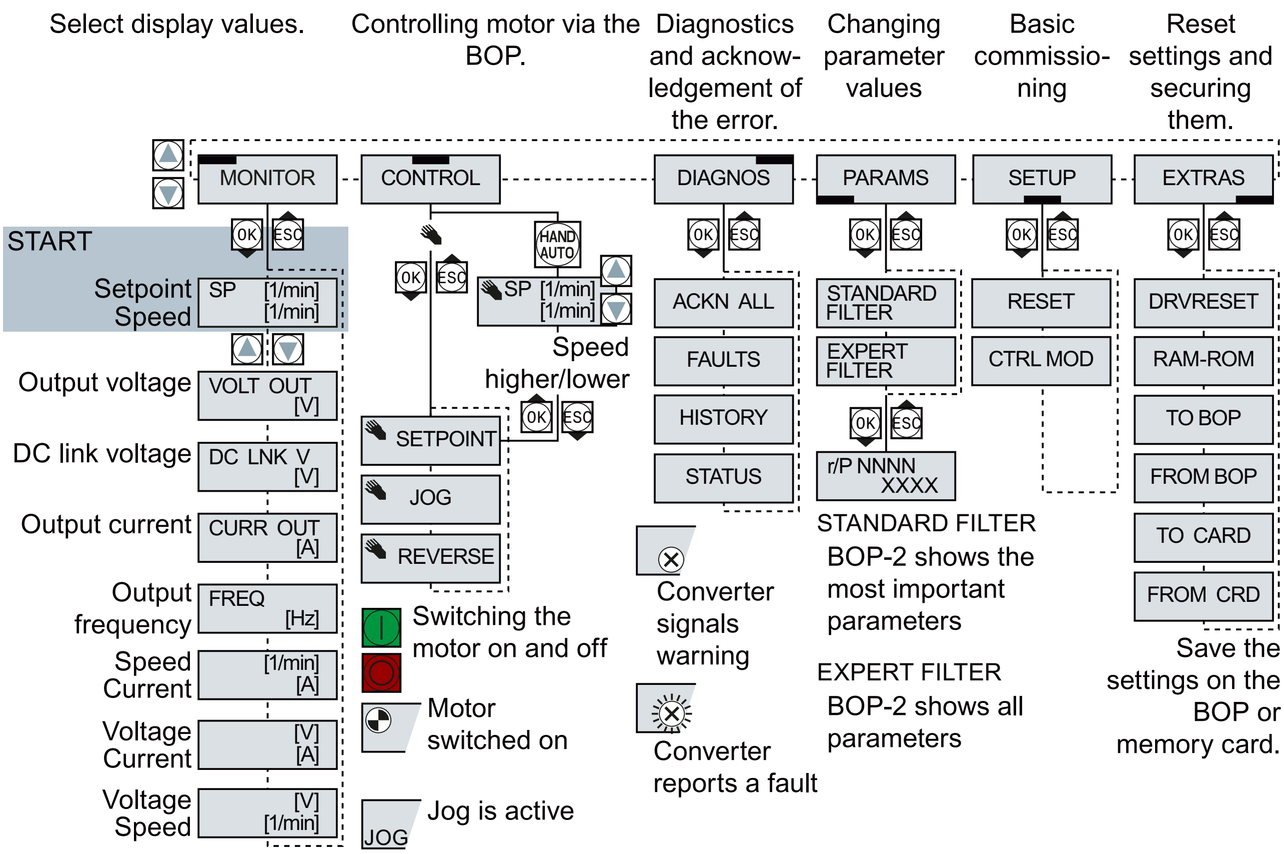
6.4 Basic commissioning with Operator Panel BOP-2

Installing the basic operator panel BOP-2 and selecting basic commissioning

1. Remove the blind cover on the converter.
2. A: Place the bottom edge of the BOP-2 casing into the lower recess of the converter housing.
   B: Push the BOP-2 towards the converter until the release-catch clicks into place on the converter housing.
3. Wait until the operator panel displays setpoint [1/min] and speed [1/min].
4. ESC Press the ESC key.
5. ▲ Press one of the arrow keys until the operator panel displays the SETUP menu.
6. SETUP OK In the SETUP menu press the OK button to start the basic commissioning.

Futher steps see next section (Page 61).

Overview of the BOP-2 menu



6.4.1 Basic commissioning

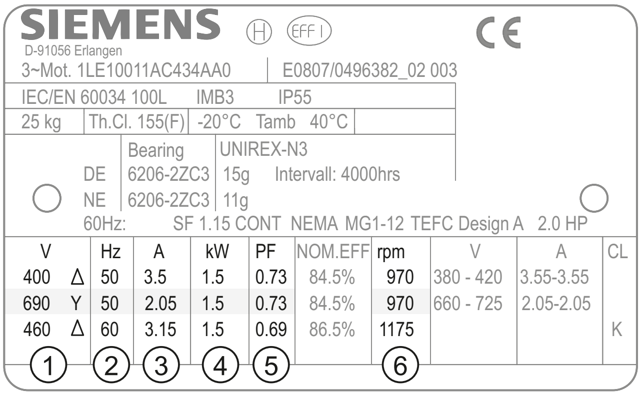
The basic commissioning sets the most important data of the drive.

SETUP [OK] The "SETUP" menu guides you step by step through the basic commissioning of the drive.

1. RESET [OK] Select Reset if you wish to reset all parameters to the factory setting before the basic commissioning: nO → YES → OK
2. CTRL MOD P1300 [OK] Select the motor control mode. The most important control modes are:

VF LIN	V/f control with linear characteristic
VF QUAD	V/f control with square-law characteristic
SPD N EN	Closed loop speed control (vector control)

3. EUR/USA P100 [OK] ② IEC or NEMA standard
4. MOT VOLT P304 [OK] ① Voltage
5. MOT CURR P305 [OK] ③ Current
6. MOT POW P307 [OK] ④ Power IEC (kW) ⑤ Power NEMA (HP)
7. MOT RPM P311 [OK] ⑥ Speed



Set the motor data on the rating plate

8. MOT ID P1900 [OK] We recommend the setting STIL ROT (Identify motor data at standstill and with the motor rotating).

   If one of the following cases applies, select the setting STILL (identify motor data at standstill):

   - You have selected the "Speed control" control mode, but the motor cannot rotate freely, e.g. for mechanically limited traversing sections.
   - You have set "V/f control" as control mode.
9. MAc PAr P15 [OK] Select the configuration for the inputs and outputs, as well as the correct fieldbus for your application. The predefined configurations can be found in the section titled Selecting the interface assignments (Page 44).
10. MIN RPM P1080 [OK] Set the minimum motor speed.
11. RAMP UP P1120 [OK] Set the motor ramp-up time.

12. RAMP DWN P1121 OK — Set the motor ramp-down time.
13. FINISH OK — Confirm that the basic commissioning has been completed:
    nO → YES → OK

Motor data identification and self-optimization

If you select the MOT ID (p1900) during basic commissioning, an alarm will be issued once the basic commissioning has been completed.

For the motor data identification, the motor must be cold. A motor in a warm operational condition supplies unusable measurement results.

> ⚠ **CAUTION**
>
> **Motor data identification for dangerous loads**
>
> Secure dangerous plant and system parts before starting the motor data identification, e.g. by fencing off the dangerous location or lowering a suspended load to the floor.

The converter issues an alarm (alarm A07991).

1. HAND AUTO ⇒ Press the HAND/AUTO botton. The BOP-2 displays the HAND icon.
2. I — Switch on the motor.
3. Wait until the converter switches off the motor after the motor data identification has been completed. This procedure takes several seconds.

If, in addition to the motor data identification, you have also selected a rotating measurement, the converter issues again alarm A07991.

4. I — Switch on again the motor.
5. Wait until the converter switches off the motor after the speed controller has been optimized. This procedure can take up to one minute.
6. HAND AUTO — Switch over from HAND to AUTO.

Now you have finished the basic commissioning and the motor identification.

6.4.2 Changing settings using BOP-2

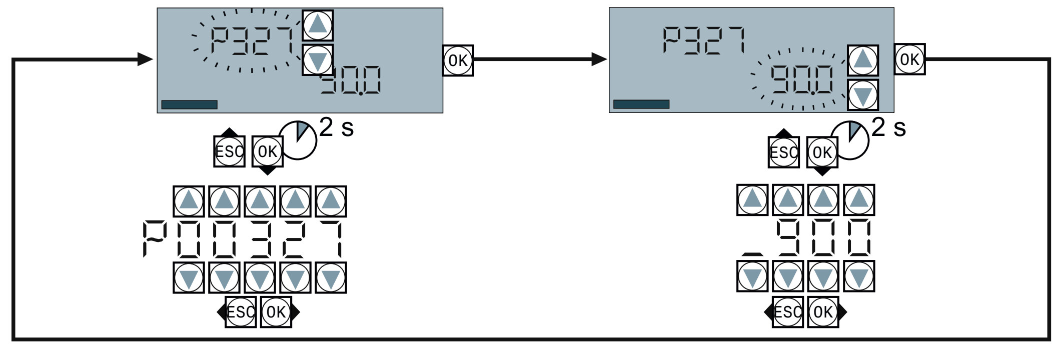
Changing settings using BOP-2

With the BOP-2 you change your converter settings by selecting a parameter via its number (e.g. p0327) and by changing the value of the parameter change.

In the parameters starting with an "r" (for example r0020), the converter will display internal values. You cannot change the value of an r-parameter.

The converter immediately saves all settings which you made using the BOP-2 so that they are protected against power failure.

Procedure

Select the parameters		Changing a parameter value	
			
If the parameter number flashes in the display, you have two options for changing the number:		If the parameter value flashes in the display, you have two options of changing the value:	
1. option:	2. option:	1. option:	2. option:
• Increase or decrease the parameter number using the arrow keys until the number you want is displayed.	• Press and hold the OK key for more than two seconds and change the required parameter number digit by digit.	• Increase or decrease the parameter value using the arrow keys until the value you want is displayed.	• Press and hold the OK key for more than two seconds and enter the required value digit by digit.
• Confirm the parameter number using the OK key.		• Confirm the parameter value using the OK key.	

6.4.3 Additional settings

The Section Commissioning guidance (Page 49) shows you what still has to be set after the basic commissioning in order to adapt the inverter to your application.

6.5 Basic commissioning with STARTER

Preconditions

You require the following to commission the converter using STARTER:

- A pre-installed drive (motor and converter)
- A computer with Windows XP, Vista or Windows 7, on which STARTER V4.3 or higher is installed.

  You can find updates for STARTER in the Internet under: Download STARTER (http://support.automation.siemens.com/WW/view/en/10804985/133100)

Note

The STARTER screens that are depicted show general examples. You may therefore find that a screen contains more or fewer setting options than are shown in these instructions. A commissioning step may also be shown using a converter other than the one you are using.

Going online via USB or fieldbus.

In the following, commissioning is described when the PC and converter are connected with one another via a USB cable.

With STARTER, you can access most converters not only via USB, but also via a fieldbus.

You must proceed as follows when you wish to commission the converter using STARTER via a fieldbus:

1. Configure the communication between the converter and PC.
   An example is provided in the section: Configuring the PROFINET communication with STEP 7 (Page 322).
2. Go online with STARTER via the fieldbus.
3. Start commissioning with the section: Generating a STARTER project (Page 66).

6.5.1 Adapting the USB interface

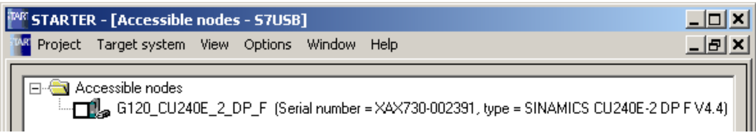
Procedure

- Switch on the converter power supply and connect the converter to the PC via USB.
- You must install the USB driver if you are connecting the converter and PC together for the first time. Windows 7 automatically installs the driver; for older Windows versions, you must confirm the automatic installation.

- Start the STARTER commissioning software.
- If you are using STARTER for the first time, you must check whether the USB interface is correctly set. To do this, click in STARTER on ("Accessible participants").

Case 1: USB interface OK - no setting is required

If the interface is correctly set, the following screen form shows the converter, which is directly connected to your computer via the USB interface.

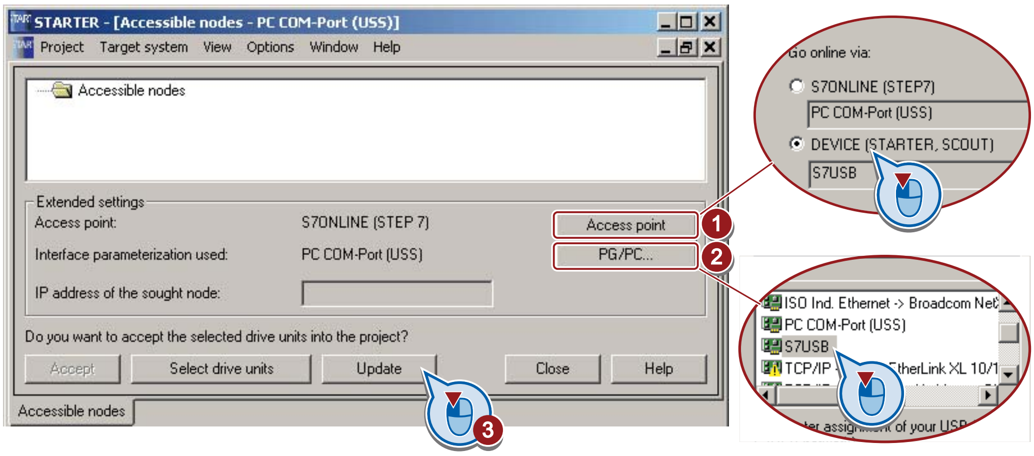


- Close this screen form, without selecting the converter(s) that has/have been found.
- Create your STARTER project.

Case 2: USB interface must be set

In this case, the message box "no other nodes found" is displayed.

- Set the following in the "Accessible participants" screen form:
  - ① Under "Access point activate "DEVICE (STARTER, Scout)"
  - ② Under " PG/PC" select "S7USB"
  - ③ Then click on "Update"

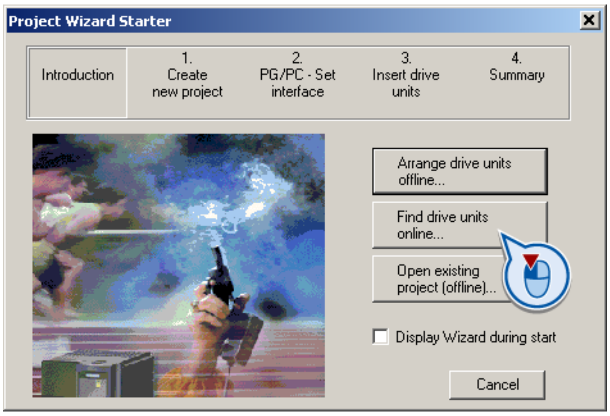


- Close this screen form, without selecting the converter(s) that has/have been found.
- Create your STARTER project.

6.5.2 Generating a STARTER project

Creating a STARTER project using project wizards

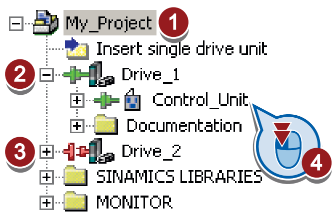
- Using "Project / New with wizard" create a new project.
- To start the wizard, click on "Search online for drive units ...".
- The wizard guides you through all of the settings that you need for your project.



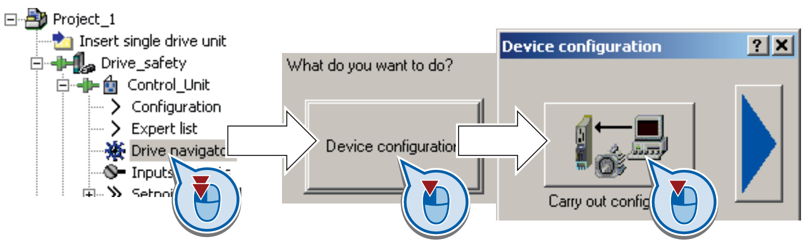
6.5.3 Go online and start wizard for basic commissioning

Procedure

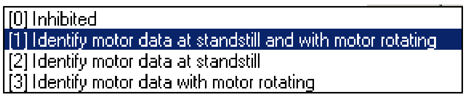
- ① Select your project and go online: .
- In the next screen form, select the device or devices with which you wish to go online.
- In the next screen form, download the hardware configuration that you found online into your project (PG or PC).



- STARTER shows you which converter it is accessing online and which offline:
  ② The converter is online
  ③ The converter is offline
- ④ When you are online, open the screen form of the control unit.
- Start the wizard for basic commissioning.



☑ Control structure	In the first step of the Wizard select the control mode. See also section: Factory setting of the inverter control (Page 55).
☑ Defaults of the setpoin	Select the default setting the interfaces of the converter. See also section: Selecting the interface assignments (Page 44).
☑ Drive setting	Select the application for the converter: Low overload for applications that only require a low dynamic performance, e.g.: Pumps or fans. High overload for applications requiring a high dynamic performance, e.g. conveyor systems.
☑ Motor	Select your motor.
☑ Motor data	Enter the motor data according to the rating plate of your motor. If you have selected a motor based on its order number, the data is already entered.
☑ Drive functions	If you have set the "Speed control" control mode, then we recommend setting "[1] Identify motor data at standstill and with motor rotating".

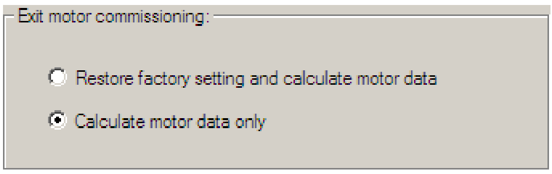


With this setting, the converter optimizes its speed controller.

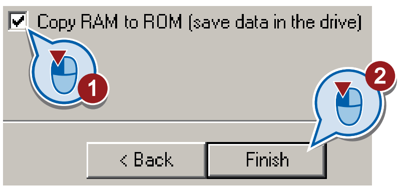
In one of the following cases is applicable, select the setting "[2] Identify motor data at standstill":

- You have selected "Speed control" as control mode, however the motor cannot freely rotate, e.g. for mechanically limited traversing sections.
- You have set "U/f control" as control mode.

☑ Important parameters	Set the most important parameters to suit your application.
☑ Calculation of the motc	We recommend the setting "Calculate motor data only".



① Set the checkmark for "RAM to ROM (save data in the drive)" to save your data in the converter so that it is not lost when the power fails.



② Close basic commissioning.

6.5.4 Switch on the motor via the control panel

After basic commissioning, the converter shows the warning A07791. You must now switch on the motor to start motor data identification.

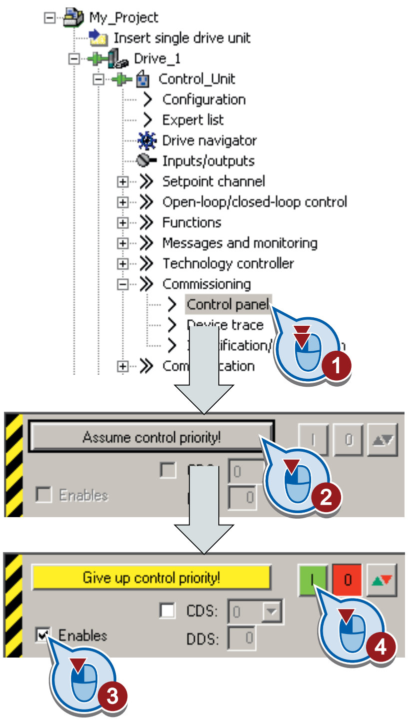
For the motor data identification, the motor must be cold. A motor in the warm operating state provides unusable measurement results.

Procedure

⚠ CAUTION
Motor data identification for dangerous loads
Secure dangerous plant and system parts before starting the motor data identification, e.g. by fencing off the dangerous location or lowering a suspended load to the floor.

- ① Open by double-clicking on the control panel in STARTER.
- ② Fetch the master control for the converter.
- ③ Set the "Enable signals"
- ④ Switch on the motor.

  The converter now starts to identify the motor data. This measurement can take several minutes. After the measurement, the converter switches off the motor.
- Relinquish the master control after the motor data identification.



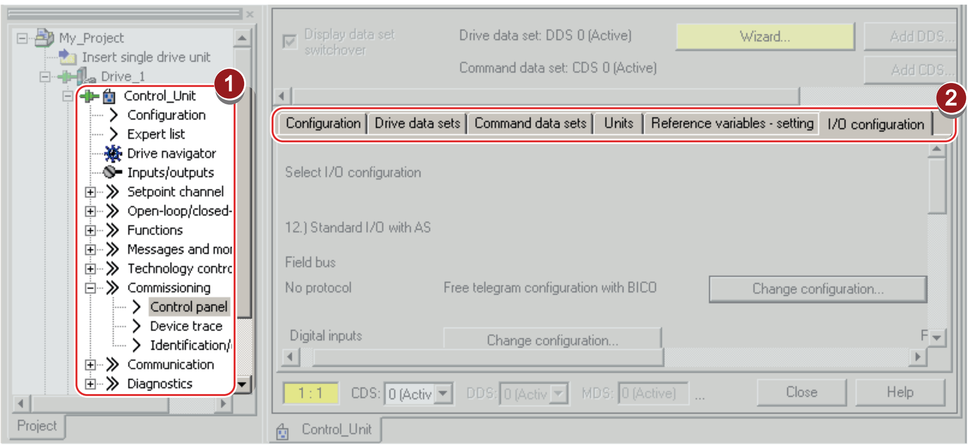
If, in addition to the motor data identification, you have also selected a rotating measurement with self-optimization of the speed control, then you must switch on the converter again as described above and wait for the optimization run to be completed.

6.5.5 Making additional settings

After the basic commissioning, you can adapt the inverter to your application as described in the Commissioning guidance (Page 49).

STARTER offers two options:

1. Change the settings using the appropriate screen forms - **our recommendation**.
   ① Navigation bar: For each inverter function, select the corresponding screen form.
   ② tabs: Switch between screen forms.
   If you change the settings using screen forms you do not need to know the parameter numbers.



2. You change the settings using the parameters in the expert list.
   If you wish to change the settings using the expert list, you need to know the corresponding parameter number and its significance.

Saving settings so that they are not lost when the power fails

All of the changes that you make are temporarily saved in the inverter and are lost the next time the power supply is switched off. For your changes to be permanently saved in the inverter, you must save the changes using the button (RAM to ROM). Before you press the button, you need to mark the appropriate drive in the project navigator.

Go offline

You can now exit the online connection after the data backup (RAM to ROM) with "Disconnect from target system".

6.5.6 Trace function for optimizing the drive

Description

The trace function is used for converter diagnostics and helps to optimize the behavior of the drive. Start the function in the navigation bar using "... Control_Unit/Commissioning/Device trace".

In two settings that are independent of one another, using you can interconnect eight signals each. Each signal that you interconnect is active as standard

You can start a measurement as often as required; the results are temporarily stored (until you exit STARTER) under the "Measurements" tab, together with the date and time. When terminating STARTER or under the "Measurements" tab, you can save the measurement results in the *.trc format.

If you require more than two settings for your measurements, you can either save the individual traces in the project or export them in the *.clg format – and if necessary, load or import.

Recording

Recording is performed in a CU-dependent basic clock cycle. The maximum recording duration depends on the number of recorded signals and the trace clock cycle.

You can extend the recording duration by increasing the trace clock cycle by multiplying with an integer factor and then accepting the displayed maximum duration by . Alternatively, you can also specify the measurement period and then you can calculate the trace clock cycle of STARTER using .

Recording individual bits for bit parameters

You can record individual bits of a parameter (e.g. r0722) by allocating the relevant bit using "bit track" ().

Mathematical function

Using the mathematical function () you can define a curve, for example the difference between the speed setpoint and the speed actual value.

Note

If you use the "record individual bits" or "mathematical functions" option, then this is displayed under signal No. 9.

Trigger

You can create your own start condition (trigger) for the trace. With the factory setting (default setting) the trace starts as soon as you press the button (Start Trace). Using the button , you can define another trigger to start the measurement.

Using pretrigger, set the time for the recording before the trigger is set. As a consequence, the trigger condition traces itself.

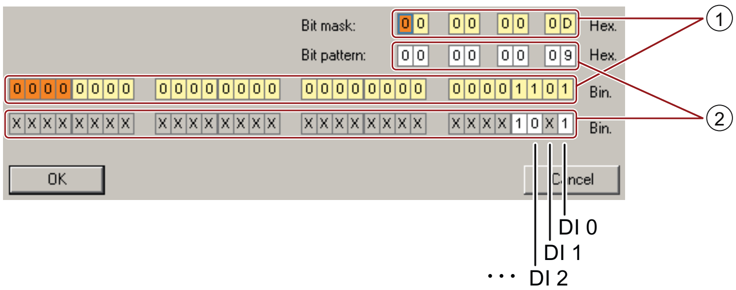
Example of a bit pattern as trigger:

You must define the pattern and value of a bit parameter for the trigger. To do so, proceed as follows:

Using , select "Trigger to variable - bit pattern"

Using , select the bit parameter

Using , open the screen form in which you set the bits and their values for the start condition



① Select the bits for the trace trigger, upper line hex format, lower row binary format

② Define the bits for the trace trigger, upper line hex format, lower row binary format

Figure 6-6 Bit pattern

In the example, the trace starts if DI0 and DI3 are high and DI2 is low. The state of the other digital inputs is not relevant for the start of the trace.

Further, you can either set an alarm or fault as start condition.

Display options

In this area, you can set how the measurement results are displayed.

- Repeat measurement:
  This means that you place the measurements, which you wish to perform at different times, one above one another
- Arrange curves in tracks
  This means that you define as to whether all measured values are to be displayed with a common zero line – or whether each measured value is displayed with its own zero line.
- Measuring cursor on:
  This allows you to analyze the measuring intervals in detail

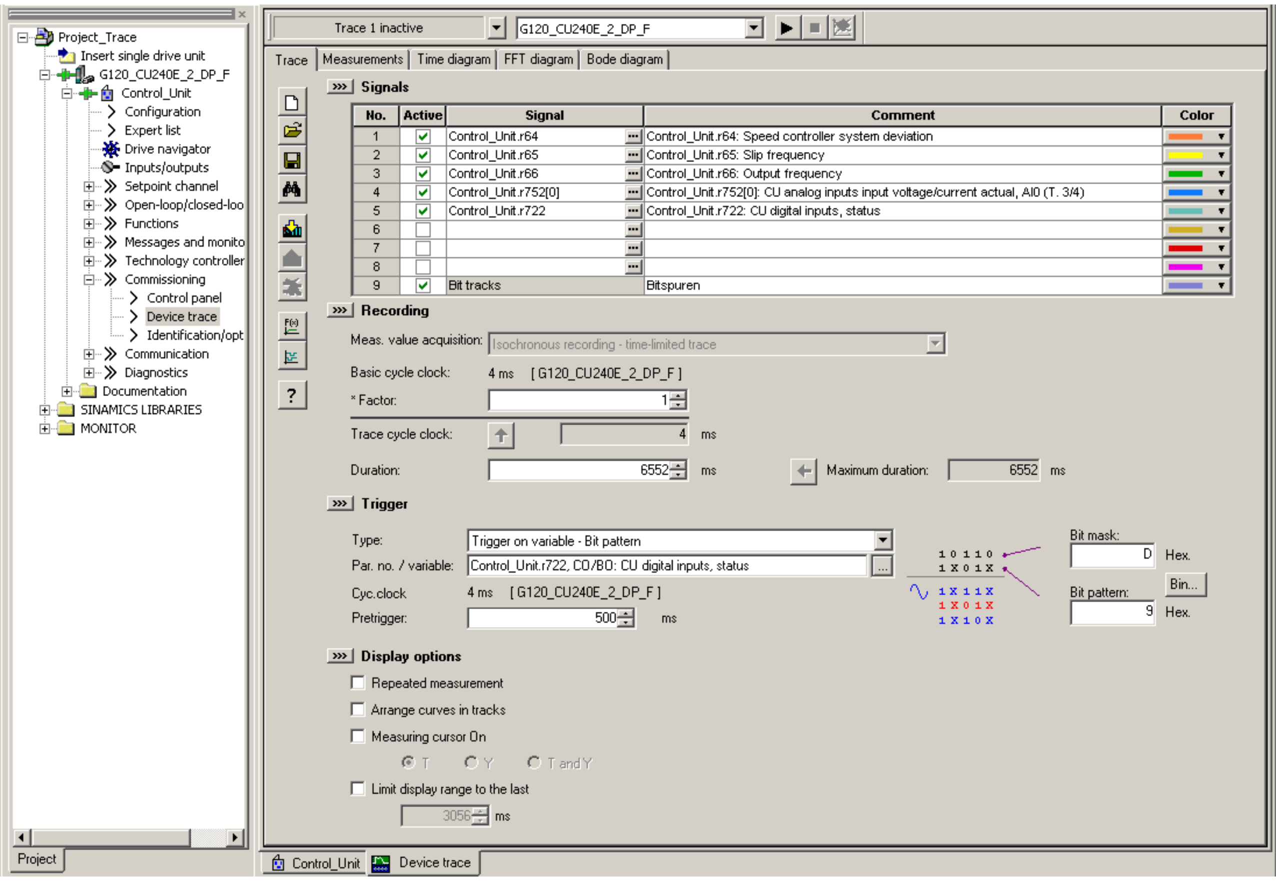


Figure 6-7 Trace dialog box

7 Adapting the terminal strip

Before you adapt the inputs and outputs of the inverter, you should have completed the basic commissioning, see Chapter Basic commissioning (Page 51) .

In the basic commissioning, select an assignment of the inverter interfaces from several predefined configurations, see Section Wiring examples for the factory settings (Page 53).

If none of the predefined configurations completely matches your application, then you must adapt the assignment of the individual inputs and outputs. You do this by changing the internal interconnection of an input or output using BICO technology (Page 315).

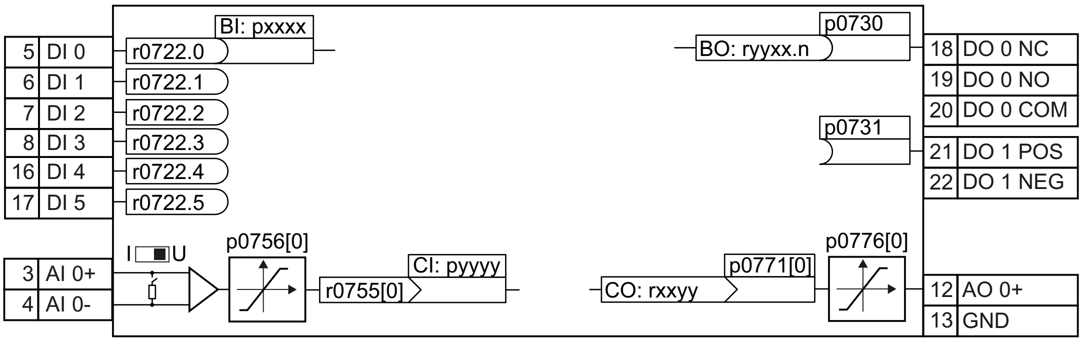


Figure 7-1 Internal connection of the inputs and outputs

7.1 Digital inputs

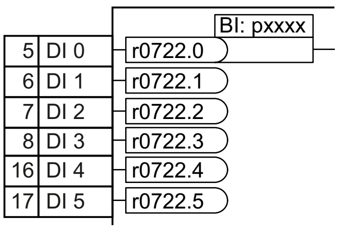
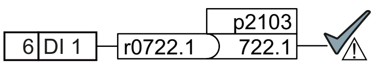
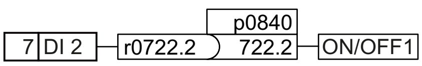
Digital input terminals	Changing the function of the digital input
	Interconnect the status parameter of the digital input with a binector input of your choice. Binector inputs are marked with "BI" in the parameter list of the List Manual.

Table 7- 1 Binector inputs (BI) of the converter (selection)

BI	Significance	BI	Significance
p0810	Command data set selection CDS bit 0	p1036	Motorized potentiometer, setpoint, lower
p0840	ON/OFF1	p1055	Jog bit 0
p0844	OFF2	p1056	Jog bit 1
p0848	OFF3	p1113	Setpoint inversion
p0852	Enable operation	p1201	Flying restart enable signal source
p0855	Unconditionally release holding brake	p2103	1. Acknowledge faults
p0856	Enable speed controller	p2106	External fault 1
p0858	Unconditionally close holding brake	p2112	External alarm 1
p1020	Fixed speed setpoint selection bit 0	p2200	Technology controller enable
p1021	Fixed speed setpoint selection bit 1	p3330	Two-wire/three-wire control, control command 1
p1022	Fixed speed setpoint selection bit 2	p3331	Two-wire/three-wire control, control command 2
p1023	Fixed speed setpoint selection bit 3	p3332	Two-wire/three-wire control, control command 3
p1035	Motorized potentiometer, setpoint, raise		

A complete list of the binector outputs is provided in the List Manual.

Table 7- 2 Examples:

	With Operator Panel	In STARTER
Acknowledge fault with digital input 1: 	Set p2103 = 722.1	Go online with STARTER and select "inputs/outputs". Change the input function via the corresponding screen form.
Switch-on motor with digital input 2: 	Set p0840 = 722.2	

Advanced settings

You can debounce the digital input signal using parameter p0724.

For more information, please see the parameter list and the function block diagrams 2220 f of the List Manual.

Analog input as digital input

When required, you can use the analog input as additional digital input.

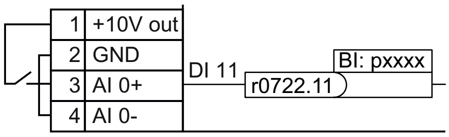


Figure 7-2 Additional digital input

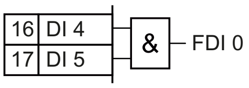
7.2 Fail-safe digital input

This manual describes the STO safety function with control via a fail-safe input. All other safety functions, further fail-safe digital inputs of the converter and the control of the safety functions via PROFIsafe are described in the Safety Integrated Function Manual.

Specifying the fail-safe input

If you use the STO safety function, then you must configure the terminal strip during the basic commissioning for a fail-safe input, e.g. with p0015 = 2 (see Section Selecting the interface assignments (Page 44)).

The converter combines digital inputs DI 4 and DI 5 to form a fail-safe input.

Terminals of the fail-safe digital input	Function
	You must enable STO to select the STO safety function via FDI 0. See also Section Fail-safe function Safe Torque Off (STO) (Page 228).

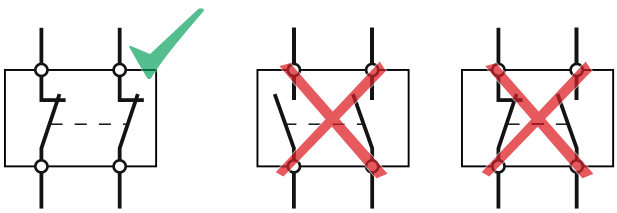
Connect devices

A fail-safe input is designed for the following devices:

- Direct connection of safety sensors, e.g. EMERGENCY STOP command devices or light curtains.
- Pre-processing safety relays, e.g. fail-safe controllers.

Permitted sensors and signals

The fail-safe input of the converter is designed for connecting sensors with two NC contacts.



If you interconnect pre-processing safety relays via two separate cables with the converter, the two transferred must always have the same signal state.

The converter expects the following signals at its fail-safe input:

- High signal: Fail-safe input is not active.
- Low signal: Fail-safe input is active.

Special measures for wiring of a fail-safe input

The converter evaluates deviations in the two signals of the fail-safe input. The converter thus detects, for example the following faults:

- Cable break
- Defective sensor

The converter cannot detect the following faults:

- Cross-circuit of the two cables
- Short-circuit between signal cable and 24 V power supply

You have the following options to reduce the risk of damaged cables during operation of your machine or plant:

- Use shielded cables with grounded shield.
- Lay signal cables in steel pipes.

These special types of cable routing are normally required only if the cables are laid over larger distances, e.g. between remote control cabinets.

Examples of connecting a fail-safe input can be found in Section: Connecting fail-safe digital inputs (Page 336).

7.3 Digital outputs

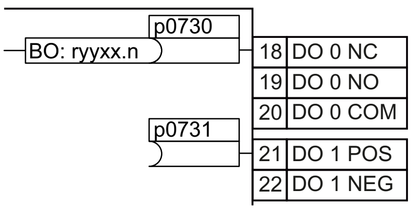
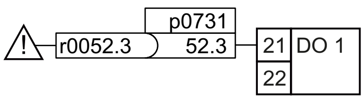
Digital output terminals	Changing the function of the digital output
	Interconnect the digital output with a binector output of your choice. Binector outputs are marked with "BO" in the parameter list of the List Manual.

Table 7- 3 Binector outputs of the converter (selection)

0	Deactivating digital output	r0052.9	Process data control
r0052.0	Drive ready	r0052.10	f_actual >= p1082 (f_max)
r0052.1	Drive ready for operation	r0052.11	Alarm: Motor current/torque limit
r0052.2	Drive running	r0052.12	Brake active
r0052.3	Drive fault active	r0052.13	Motor overload
r0052.4	OFF2 active	r0052.14	Motor CW rotation
r0052.5	OFF3 active	r0052.15	Inverter overload
r0052.6	Closing lockout active	r0053.0	DC braking active
r0052.7	Drive alarm active	r0053.2	f_actual > p1080 (f_min)
r0052.8	Setpoint/actual value discrepancy	r0053.6	f_actual ≥ setpoint (f_setpoint)

A complete list of the binector outputs is provided in the List Manual.

Table 7- 4 Example:

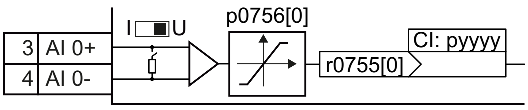
	With Operator Panel	In STARTER
Signal fault via digital output 1. 	Set p0731 = 52.3	Go online with STARTER and select "inputs/outputs". Change the output function via the corresponding screen form.

Advanced settings

You can invert the signal of the digital output using parameter p0748.

For more information, please see the parameter list and the function block diagrams 2230 f of the List Manual.

7.4 Analog inputs

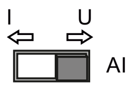
Analog input terminals	Changing the function of the analog input
	1. Define the analog input type using parameter p0756 and the switch on the inverter (e.g. voltage input -10 V … 10 V or current input 4 mA … 20 mA). 2. Interconnect parameter p0755 with a connector input of your choice (e.g. as speed setpoint). Connector inputs are designated with "CI" in the parameter list of the List Manual.

Define the analog input type

The inverter offers a series of default settings, which you can select using parameter p0756:

Unipolar voltage input	0 V … +10 V	p0756[0] =	0
Unipolar voltage input monitored	+2 V … +10 V		1
Unipolar current input	0 mA … +20 mA		2
Unipolar current input monitored	+4 mA … +20 mA		3
Bipolar voltage input	-10 V … +10 V		4
No sensor connected			8

In addition, you must also set the switch belonging to the analog input. You can find the switch on the Control Unit behind the lower front doors.



- Voltage input: Switch position U (factory setting)
- Current input: Switch position I

If you change the analog input type using p0756, then the inverter automatically selects the appropriate scaling of the analog input. The linear scaling characteristic is defined using two points (p0757, p0758) and (p0759, p0760). Parameters p0757 … p0760 are assigned to an analog input via their index, e.g. parameters p0757[0] … p0760[0] belong to analog input 0.

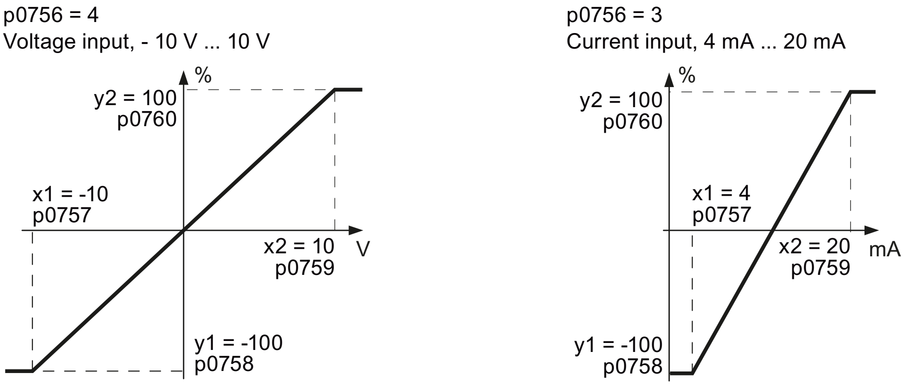


Figure 7-3 Examples for scaling characteristics

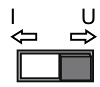
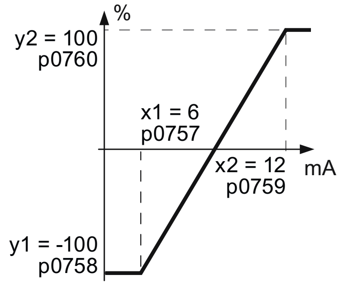
Table 7- 5 Parameters for the scaling characteristic and wire break monitoring

Parameter	Description
p0757	**x-coordinate of 1st characteristic point [V or mA]**
p0758	**y coordinate of the 1st characteristic point [% of p200x]** p200x are the parameters of the reference variables, e.g. p2000 is the reference speed.
p0759	**x-coordinate of 2nd characteristic point [V or mA]**
p0760	**y-coordinate of 2nd characteristic point [% of p200x]**
p0761	**Wire breakage monitoring response threshold**

You must define your own characteristic if none of the default types match your particular application.

Example

The inverter should convert a 6 mA … 12 mA signal into the value range -100 % … 100 % via analog input 0. The wire break monitoring of the inverter should respond when 6 mA is fallen below.

<table>
<tr><th>Parameter</th><th colspan="3">Description</th></tr>
<tr><td>p0756[0] = 3</td><td>Analog input type
Define analog input 0 as current input with wire break monitoring.</td><td>Set DIP switch for AI 0 to current input ("I"):</td><td>
</td></tr>
<tr><td colspan="4">After changing p0756 to the value 3, the inverter sets the scaling characteristic parameters to the following values:
p0757[0] = 4,0; p0758[0] = 0,0; p0759[0] = 20; p0760[0] = 100
Adapt the characteristic:</td></tr>
<tr><td>p0761[0] = 6.0</td><td>Analog inputs wire break monitoring, response threshold</td><td colspan="2" rowspan="5">Current input, 6 mA ... 12 mA

</td></tr>
<tr><td>p0757[0] = 6.0</td><td rowspan="2">Analog inputs, characteristic (x_1, y_1)
6 mA corresponds to -100 %</td></tr>
<tr><td>p0758[0] = -100.0</td></tr>
<tr><td>p0759[0] = 12.0</td><td rowspan="2">Analog inputs, characteristic (x_2, y_2)
12 mA corresponds to 100 %</td></tr>
<tr><td>p0760[0] = 100.0</td></tr>
</table>

Defining the analog input function

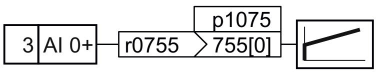
You define the analog input function by interconnecting a connector input of your choice with parameter p0755 . Parameter p0755 is assigned to the particular analog input via its index, e.g. parameter p0755[0] is assigned to analog input 0.

Table 7- 6 Connector inputs (CI) of the converter (selection)

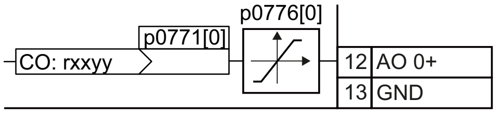
CI	Significance	CI	Significance
p1070	Main setpoint	p1522	Torque limit, upper
p1075	Supplementary setpoint	p2253	Technology controller setpoint 1
p1503	Torque setpoint	p2264	Technology controller actual value
p1511	Supplementary torque 1		

A complete list of the connector inputs is provided in the List Manual.

Table 7- 7 Example:

	With Operator Panel	In STARTER
Analog input 0 is the source for the additional setpoint.  	Set p1075 = 755[0]	Go online with STARTER and select "inputs/outputs". Change the input function via the corresponding screen form.

7.5 Analog outputs

Analog output terminals	Changing the function of the analog output
	1. Define the analog output type using parameter p0776 (e.g. voltage output -10 V … 10 V or current output 4 mA … 20 mA). 2. Interconnect parameter p0771 with a connector output of your choice (e.g. the actual speed). In the parameter list of the List Manual, connector outputs are marked with "CO".

Define the analog output type

The inverter offers a series of default settings, which you can select using parameter p0776:

Current output (factory setting)	0 mA … +20 mA	p0776[0] =	0
Voltage output	0 V … +10 V		1
Current output	+4 mA … +20 mA		2

If you change the analog output type, then the converter automatically selects the appropriate scaling of the analog output. The linear scaling characteristic is defined using two points (p0777, p0778) and (p0779, p0780).

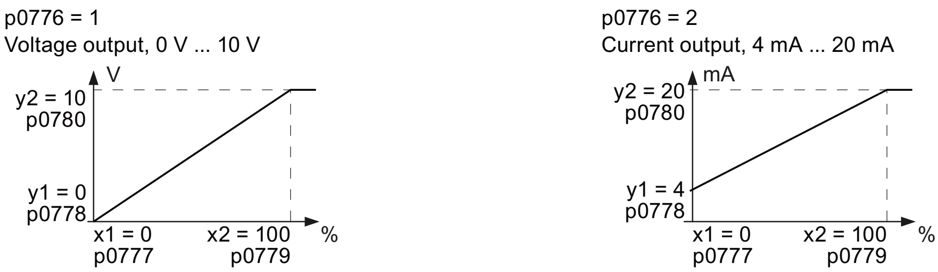


Figure 7-4 Examples for scaling characteristics

Parameters p0777 … p0780 are assigned to an analog output via their index, e.g. parameters p0777[0] … p0770[0] belong to analog output 0.

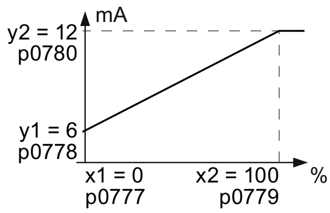
Table 7- 8 Parameters for the scaling characteristic

Parameter	Description
p0777	**X coordinate of the 1st characteristic point [% of P200x]** P200x are the parameters of the reference variables, e.g. P2000 is the reference speed.
p0778	**Y coordinate of the 1st characteristic point [V or mA]**
p0779	**X coordinate of the 2nd characteristic point [% of P200x]**
p0780	**Y coordinate of the 2nd characteristic point [V or mA]**

You must define your own characteristic if none of the default types match your particular application.

Example:

The converter should convert a signal in the value range -100 % … 100 % into a 6 mA … 12 mA output signal via analog output 0.

Parameter	Description	
p0776[0] = 2	**Analog output, type** Define analog output 0 as current output.	
After changing p0776 to the value 2, the converter sets the scaling characteristic parameters to the following values: p0777[0] = 0.0; p0778[0] = 4.0; p0779[0] = 100.0; p0780[0] = 20.0 Adapt the characteristic:		
p0777[0] = 0.0	**Analog output, characteristic (x_1, y_1)**	Current output, 6 mA ... 12 mA 
p0778[0] = 6.0	0.0 % corresponds to 6 mA	
p0779[0] = 100.0	**Analog output, characteristic (x_2, y_2)**	
p0780[0] = 12.0	100 % corresponds to 12 mA	

Defining the analog output function

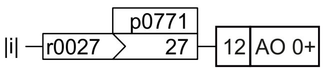
You define the analog output function by interconnecting parameter p0771 with a connector output of your choice. Parameter p0771 is assigned to the particular analog input via its index, e.g. parameter p0771[0] is assigned to analog output 0.

Table 7- 9 Connector outputs (CO) of the converter (selection)

CO	Significance	CO	Significance
r0021	Actual frequency	r0026	Actual DC link voltage
r0024	Output actual frequency	r0027	Output current
r0025	Output actual frequency		

A complete list of the connector outputs is provided in the List Manual.

Table 7- 10 Example:

	With Operator Panel	In STARTER
Output the converter output current via analog output 0.  	Set p0771 = 27	Go online with STARTER and select "inputs/outputs". Change the output function via the corresponding screen form.

For more information, please see the parameter list and the function block diagrams 9572 f of the List Manual.

Advanced settings

You can manipulate the signal that you output via an analog output, as follows:

- Absolute-value generation of the signal (p0775)
- Signal inversion (p0782)

Additional information is provided in the parameter list of the List Manual.

Configuring the fieldbus 8

Fieldbus interfaces of the converter

The converter is available in different versions for communication with higher-level controls with the subsequently listed fieldbus interfaces:

Fieldbus	Profile	Interface
PROFIBUS DP (Page 90)	PROFIdrive and PROFIsafe [1]	SUB D connector (female)
PROFINET IO (Page 86)		Two RJ45 connectors (male)
USS (Page 110)	-	RS485 connector
Modbus RTU (Page 121)	-	RS485 connector
CANopen (Page 131)	-	SUB D connector (male)
	[1] You find information on PROFIsafe only in the Function Manual Safety Integrated, see also section: Manuals for your inverter (Page 340).	

8.1 Communication via PROFINET

The Control Unit provides the following functions

• IRT without isochronous mode	
• MRP	Media redundancy, not bumpless with 200 ms Precondition: Ring topology
• MRPD	Media redundancy, bumpless Precondition: IRT and the ring topology created in the control
• Diagnostic alarms	According to error classes specified in the PROFIdrive profile. See Activate diagnostic messages via STEP 7 (Page 325).
• Device replacement without removable data storage medium	Requirement: Topology created in the control
• Shared Device	Only for Control Units with fail-safe functions (see Safety Function Manual)

The Control Units have two RJ45 sockets, which you can use to implement a line topology. You can implement all topologies by using switches.

Additional information on PROFINET in the Internet

General information about PROFINET can be found at Industrial Communication (http://support.automation.siemens.com/WW/view/en/19292127).

The configuration of the functions is described in the PROFINET system description (http://www.automation.siemens.com/mcms/automation/en/industrial-communications/profinet/Pages/Default.aspx) manual.

8.1.1 What do you need for communication via PROFINET?

Check the communication settings using the following table. If you answer "Yes" to the questions, you have correctly set the communication settings and can control the converter via the fieldbus.

Table 8- 1 Checklist for communication via PROFINET

Questions	Answer/description	Example
Is the converter correctly connected to the PROFINET?	See: Connect the converter to PROFINET (Page 87)	
Do the IP address and device name in the converter and control system match?	See Configuring communication to the control (Page 88)	See Configuring the system in HW Config (Page 322)
Is the same telegram set in the converter as in the higher-level control system?	Set the telegram in the converter, see: Select telegram (Page 88)	See: Configuring the system in HW Config (Page 322)
Are the signals that the converter and the controller exchange via PROFINET correctly interconnected?	PROFIdrive-compliant interconnection in the converter, see: PROFIdrive profile for PROFIBUS and PROFINET (Page 93)	See: STEP 7 programming examples (Page 327)

8.1.2 Connect the converter to PROFINET

Connecting up

Connect the converter (IO device) and your PG/PC (IO supervisor) via PROFINET cables with the control.

See also Section Interfaces, connectors, switches, terminal blocks and LEDs of the converter (Page 42).

Recommended PROFINET connectors and pin assignment

We recommend the following connector with order number: 6GK1901-1BB10-2Ax0 for connecting the PROFINET cable.

Instructions for assembling the SIMATIC NET Industrial Ethernet FastConnect RF45 Plug 180 can be found on the Internet under product information " "Assembly instructions for SIMATIC NET Industrial Ethernet FastConnect RJ45 Plug (http://support.automation.siemens.com/WW/view/en/37217116/133300)".

Laying and shielding the PROFINET cable

Information can be found on the Internet: PROFIBUS user organization installation guidelines (http://www.profibus.com/downloads/installation-guide/).

Note

Communication with the controller, even when the supply voltage on the Power Module is switched off

You will have to supply the Control Unit with 24 VDC on terminals 31 and 32 if you require communication to take place with the controller even when the line voltage is switched off.

In the case of short interruptions of the 24V voltage supply, the converter may report the fault F without communications with the controller being interrupted.

8.1.3 Configuring communication to the control

In order to establish communication between the converter and control system via PROFINET, you must load the device file of the converter "GSDML" into your control. You can then configure the communication.

Procedure

- Import the GSDML of the converter into thePROFINET-Controller, i.e. into your control system.
  You can obtain the GSDML of your converter in two ways:
  - You can find the GSDML of the SINAMICS converter on the Internet (http://support.automation.siemens.com/WW/view/en/22339653/133100).
  - The GSDML is saved in the converter. If you insert the memory card in the converter and set p0804 = 12 , the GSDML will be written to the /SIEMENS/SINAMICS/DATA/CFG folder on the memory card.
- Configure the communication between the control and the converter in your control.

8.1.4 Select telegram

During basic commissioning, you have defined a telegram for communication. In order to set a different telegram, you may need also adapt the assignment of the interfaces.

Procedure

Carry out the basic commissioning again

- Adapt the interface assignment
- Select the telegram.

Table 8- 2 Parameters for setting the telegram

Parameter	Description	
p0015	**Macro drive unit** Configure the interface in basic commissioning, and select a telegram. See also the section: Selecting the interface assignments (Page 44).	
p0922	**PROFIdrive Telegram selection** (factory setting for converters with PROFIBUS- or PROFINETinterface: Standard telegram 1, PZD-2/2) Set the send and receive telegram, see Cyclic communication (Page 93)	
	1:	Standard telegram 1, PZD-2/2
	20:	Standard telegram 20, PZD-2/6
	352	SIEMENS telegram 352, PZD-6/6
	353:	SIEMENS telegram 353, PZD-2/2, PKW-4/4
	354:	SIEMENS telegram 354, PZD-6/6, PKW-4/4
	999:	See Extend telegrams and change signal interconnection (Page 98).

8.1.5 Activating diagnostics via the control

The converter provides the functionality to transmit fault and alarm messages (diagnostic messages) to the control according to the PROFIdrive error classes.

The functionality must be selected in the control (see example ofHotspot-Text (Page 325) STEP 7) and activated by a ramp-up.

You can output the messages directly on an HMI panel via the control.

8.2 Communication via PROFIBUS

8.2.1 What do you need for communication via PROFIBUS?

Check the communication settings using the following table. If you answer "Yes" to the questions, you have correctly set the communication settings and can control the converter via the fieldbus.

Table 8- 3 Checklist for communication via PROFIBUS

Questions	Description	Examples
Is the converter correctly connected to the PROFIBUS?	See section: Connect the frequency inverter to PROFIBUS (Page 90).	---
Have you configured the communication between the converter and the higher-level control system?	See section: Configuring communication to the control (Page 91)	See also the section: Configuring the PROFIBUS communication with STEP 7 (Page 318).
Do the bus addresses in the converter and the higher-level controller match?	See section: Setting the address (Page 91).	
Is the same telegram set in the higher-level controller and in the converter?	Adapt the telegram in the converter. See section: Select telegram (Page 92).	
Are the signals that the converter and the control system exchange via PROFIBUS correctly interconnected?	Adapt the interconnection of the signals in the control system to the converter. For the PROFIdrive-compliant interconnection in the converter, refer to Section: PROFIdrive profile for PROFIBUS and PROFINET (Page 93).	See also the section: STEP 7 programming examples (Page 327).

8.2.2 Connect the frequency inverter to PROFIBUS

Permissible cable lengths, routing and shielding the PROFIBUS cable

Information can be found on the Internet:

1. Product support (http://support.automation.siemens.com/WW/view/en/1971286)
2. PROFIBUS user organization installation guidelines (http://www.profibus.com/downloads/installation-guide/)

Recommended PROFIBUS connectors

We recommend connectors with the following order numbers for connecting the PROFIBUS cable:

- 6GK1500-0FC00
- 6GK1500-0EA02

Pin assignment at the converter

For the pin assignment at the converter refer to Section Interfaces, connectors, switches, terminal blocks and LEDs of the converter (Page 42).

Note

Communication with the controller, even when the supply voltage on the Power Module is switched off

You will have to supply the Control Unit with 24 VDC on terminals 31 and 32 if you require communication to take place with the controller even when the line voltage is switched off.

In the case of short interruptions of the 24V voltage supply, the converter may report the fault F without communications with the controller being interrupted.

8.2.3 Configuring communication to the control

To be able to configure communication between the converter and control, you require the description file GSD of the converter.

Procedure

- Import the GSD of the converter into the PROFIBUS master, i.e. into your control system. You have two options for obtaining the GSD of your converter:
  - You can find the GSD of the SINAMICS converter on the Internet (http://support.automation.siemens.com/WW/view/en/22339653/133100).
  - The GSD is saved in the converter. If you insert the memory card in the converter and set p0804 = 12 , the GSD will be written to the /SIEMENS/SINAMICS/DATA/CFG folder on the memory card.
- Configure the communication between the control and the converter in your control.

8.2.4 Setting the address

You can set the converter's PROFIBUS address via the address switch on the CU via p0918 or in STARTER under "Control Unit/Communications/PROFIBUS".

Valid address range: 1 … 125

Procedure

Method	Description
Address switch	If you have specified a valid address using the address switches, this address will always be the one that takes effect and parameter p0918 cannot be changed. Position and settings of the address switches are described in section: Interfaces, connectors, switches, terminal blocks and LEDs of the converter (Page 42).
P0918 / STARTER	**PROFIBUS address** (factory setting: 126) Setting in p0918 or via STARTER is effective only if you set all address switches to "OFF" (0) or "ON" (1).

CAUTION
For a modified bus address to be effective, you have to switch on and off the converter and - if need be - any external 24 V supply.

8.2.5 Select telegram

During basic commissioning, you have defined a telegram for communication. In order to set a different telegram, you may need also adapt the assignment of the interfaces.

Procedure

Carry out the basic commissioning again

- Adapt the interface assignment
- Select the telegram.

Table 8- 4 Parameters for setting the telegram

Parameter	Description	
p0015	**Macro drive unit** Configure the interface in basic commissioning, and select a telegram. See also the section: Selecting the interface assignments (Page 44).	
p0922	**PROFIdrive Telegram selection** (factory setting for converters with PROFIBUS- or PROFINETinterface: Standard telegram 1, PZD-2/2) Set the send and receive telegram, see Cyclic communication (Page 93)	
	1: 20: 352 353: 354: 999:	Standard telegram 1, PZD-2/2 Standard telegram 20, PZD-2/6 SIEMENS telegram 352, PZD-6/6 SIEMENS telegram 353, PZD-2/2, PKW-4/4 SIEMENS telegram 354, PZD-6/6, PKW-4/4 See Extend telegrams and change signal interconnection (Page 98).

8.3 PROFIdrive profile for PROFIBUS and PROFINET

8.3.1 Cyclic communication

The send and receive telegrams of the converter for cyclic communication are structured as follows:

PZD01	PZD02	PZD03	PZD04	PZD05	PZD06	PZD07	PZD08	PZD09	PZD10	PZD11	PZD12

Telegram 1, speed control with two PZDs each in receive and send directions (PZD 2/2)

STW1	NSOLL_A
ZSW1	NIST_A_ GLATT

Telegram 20, speed control VIK/NAMUR; with two PZDs in receive and six in the send direction (PZD 2/6)

STW1	NSOLL_A				
ZSW1	NIST_A_ GLATT	IAIST_ GLATT	MIST_ GLATT	PIST_ GLATT	MELD_ NAMUR

Telegram 352, speed control for PCS7; with six PZDs each in receive and send directions (PZD 6/6)

STW1	NSOLL_A	Process data for PCS7			
ZSW1	NIST_A_ GLATT	IAIST_ GLATT	MIST_ GLATT	WARN_ CODE	FAULT_ CODE

Telegram 353, speed control with two PZDs each in receive and send directions (PZD 2/2) and four words each to read and write parameters (PIV 4/4)

STW1	NSOLL_A
ZSW1	NIST_A_ GLATT

Telegram 354, speed control for PCS7; with six PZDs each in receive and send directions (PZD 6/6) and four words each to read and write parameters (PIV 4/4)

STW1	NSOLL_A	Process data for PCS7			
ZSW1	NIST_A_ GLATT	IAIST_ GLATT	MIST_ GLATT	WARN_ CODE	FAULT_ CODE

Telegram 999, free interconnection via BiCo; PZD n/m (n/m = 1 ... 12)

STW1	Telegram length configurable for receive data
ZSW1	Telegram length configurable for send data

Figure 8-1 Telegrams for cyclic communication

Table 8- 5 Explanation of the abbreviations

Abbreviation	Meaning	Abbreviation	Meaning
STW1/2	Control word 1/2	PIST_GLATT	Actual active power
ZSW1/2	Status word 1/2	M_LIM	Torque limit
NSOLL_A	Speed setpoint	FAULT_CODE	Fault number
NIST_A_GLATT	Smoothed speed actual value	WARN_CODE	Alarm number
IAIST_GLATT	Smoothed current actual value	MELD_NAMUR	Fault word according to the VIK-NAMUR definition
MIST_GLATT	Actual torque		

Interconnection of the process data

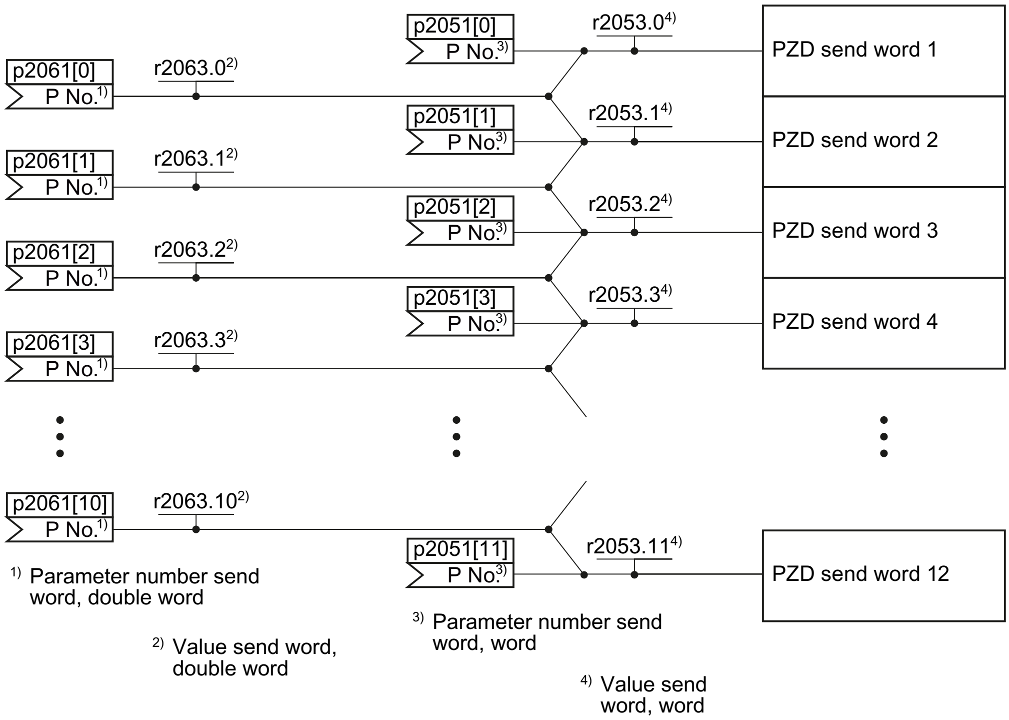


Figure 8-2 Interconnection of the send words

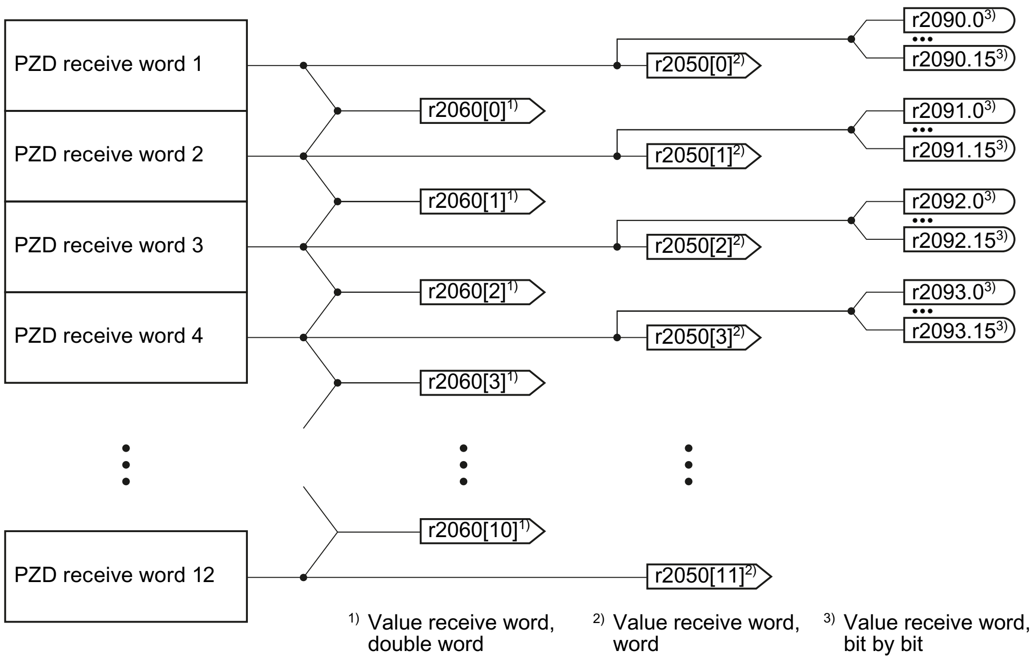


Figure 8-3 Interconnection of the receive words

The telegrams use - with the exception of telegram 999 (free interconnection via BICO) - the word by word transfer of send and receive data (r2050/p2051).

If you require an individual telegram for your application (e.g. for transferring double words), you can adapt one of the predefined telegrams via parameters p0922 and p2079. For details, please refer to the List Manual, function diagrams 2420 and 2472.

8.3.1.1 Control and status word 1

The control and status words fulfill the specifications of PROFIdrive profile version 4.1 for the "closed-loop speed controlled" mode.

Control word 1 (STW1)

Control word 1 (bits 0 … 10 in accordance with PROFIdrive profile and VIK/NAMUR, bits 11 … 15 specific to the converter).

Table 8- 6 Control word 1 and interconnection in the converter

Bit	Meaning		Explanation	Signal interconnection in the converter
	Telegram 20	All other telegrams		
0	0 = OFF1		The motor brakes with the ramp-down time p1121 of the ramp-function generator. The converter switches off the motor at standstill.	p0840[0] = r2090.0
	0 → 1 = ON		The converter goes into the "ready" state. If, in addition bit 3 = 1, then the converter switches on the motor.	
1	0 = OFF2		Switch off the motor immediately, the motor then coasts down to a standstill.	p0844[0] = r2090.1
	1 = No OFF2		The motor can be switched on (ON command).	
2	0 = Quick stop (OFF3)		Quick stop: The motor brakes with the OFF3 ramp-down time p1135 down to standstill.	p0848[0] = r2090.2
	1 = No quick stop (OFF3)		The motor can be switched on (ON command).	
3	0 = Inhibit operation		Immediately switch-off motor (cancel pulses).	p0852[0] = r2090.3
	1 = Enable operation		Switch-on motor (pulses can be enabled).	
4	0 = Disable RFG		The converter immediately sets its ramp-function generator output to 0.	p1140[0] = r2090.4
	1 = Do not disable RFG		The ramp-function generator can be enabled.	
5	0 = Stop RFG		The output of the ramp-function generator stops at the actual value.	p1141[0] = r2090.5
	1 = Enable RFG		The output of the ramp-function generator follows the setpoint.	
6	0 = Inhibit setpoint		The converter brakes the motor with the ramp-down time p1121 of the ramp-function generator.	p1142[0] = r2090.6
	1 = Enable setpoint		Motor accelerates with the ramp-up time p1120 to the setpoint.	
7	0 → 1 = Acknowledge faults		Acknowledge the fault. If the ON command is still active, the converter switches to"closing lockout" state.	p2103[0] = r2090.7
8, 9	Reserved			
10	0 = No control via PLC		Converter ignores the process data from the fieldbus.	p0854[0] = r2090.10
	1 = Control from PLC		Control via fieldbus, converter accepts the process data from the fieldbus.	
11	---1)	0 = Direction reversal	Invert setpoint in the converter.	p1113[0] = r2090.11
12	Not used			
13	---1)	1 = MOP up	Increase the setpoint saved in the motorized potentiometer.	p1035[0] = r2090.13
14	---1)	1 = MOP down	Reduce the setpoint saved in the motorized potentiometer.	p1036[0] = r2090.14
15	CDS bit 0	Reserved	Changes over between settings for different operation interfaces (command data sets).	p0810 = r2090.15

1) If you change over from another telegram to telegram 20, then the assignment of the previous telegram is kept.

Status word 1 (ZSW1)

Status word 1 (bits 0 … 10 in accordance with PROFIdrive profile and VIK/NAMUR, bits 11 … 15 specific to the converter).

Table 8- 7 Status word 1 and interconnection with parameters in the converter

Bit	Meaning		Comments	Signal interconnection in the converter
	Telegram 20	All other telegrams		
0	1 = Ready to start		Power supply switched on; electronics initialized; pulses locked.	p2080[0] = r0899.0
1	1 = Ready		Motor is switched on (ON command = 1), no fault is active. With the command "Enable operation" (STW1.3), the converter switches on the motor.	p2080[1] = r0899.1
2	1 = Operation enabled		Motor follows setpoint. See control word 1, bit 3.	p2080[2] = r0899.2
3	1 = Fault active		The converter has a fault. Acknowledge fault using STW1.7.	p2080[3] = r2139.3
4	1 = OFF2 inactive		Coast down to standstill is not active.	p2080[4] = r0899.4
5	1 = OFF3 inactive		Quick stop is not active.	p2080[5] = r0899.5
6	1 = Closing lockout active		It is only possible to switch on the motor after an OFF1 command and a new ON command.	p2080[6] = r0899.6
7	1 = Alarm active		Motor remains switched on; no acknowledgment is necessary.	p2080[7] = r2139.7
8	1 = Speed deviation within the tolerance range		Setpoint/actual value deviation within tolerance range.	p2080[8] = r2197.7
9	1 = Master control requested		The automation system is requested to accept the converter control.	p2080[9] = r0899.9
10	1 = Comparison speed reached or exceeded		Speed is greater than or equal to the corresponding maximum speed.	p2080[10] = r2199.1
11	0 = I, M or P limit reached		Comparison value for current, torque or power has been reached or exceeded.	p2080[11] = r1407.7
12	---[1)]	1 = Holding brake open	Signal to open and close a motor holding brake.	p2080[12] = r0899.12
13	0 = Alarm, motor overtemperature		--	p2080[13] = r2135.14
14	1 = Motor rotates clockwise		Internal converter actual value > 0	p2080[14] = r2197.3
	0 = Motor rotates counterclockwise		Internal converter actual value < 0	
15	1 = CDS display	0 = Alarm, converter thermal overload		p2080[15] = r0836.0 / r2135.15

1) If you change over from another telegram to telegram 20, then the assignment of the previous telegram is kept.

8.3.1.2 Extend telegrams and change signal interconnection

Following selection of a telegram, the converter interconnects the corresponding signals with the fieldbus interface. The converter protects this interconnection against changes.

Extend telegram

If you want to extend a telegram, you have to do the following:

Table 8- 8 Procedure

Parameter	Description	
p0922 = 999	**PROFIdrive telegram selection**	
	999:	Free telegram configuration with BICO
p2079	**PROFIdrive PZD telegram selection extended** Set the suitable telegram:	
	1: 20: 352: 353: 354:	Standard telegram 1, PZD-2/2 Standard telegram 20, PZD-2/6 SIEMENS telegram 352, PZD-6/6 SIEMENS telegram 353, PZD-2/2, PKW-4/4 SIEMENS telegram 354, PZD-6/6, PKW-4/4
Now you can extend the telegram by interconnecting the PZD send words and PZD receive words with signals of your choice.		

For further information refer to the function block diagrams 2468 and 2470 of the List Manual.

Change the signal interconnection of the telegram

If you want to change the signal interconnection or extend telegrams, you have to do the following:

Table 8- 9 Procedure

Parameter	Description	
p0922 = 999	**PROFIdrive telegram selection**	
	999:	Free telegram configuration with BICO
p2079 = 999	**PROFIdrive PZD telegram selection extended**	
	999:	Free telegram configuration with BICO
Now you can freely interconnect all signals of the fieldbus interface.		

For further information refer to the function block diagrams 2468 and 2470 of the List Manual.

8.3.1.3 Structure of the parameter channel

Structure of the parameter channel

The parameter channel consists of four words. The parameter number and index as well as the type of job (read or write) are transferred in the 1st and 2nd word. The 3rd and 4th word contains the parameter contents. The parameter contents can be 16-bit values (such as baud rate) or 32-bit values (e.g. CO parameters).

Bit 11 in the 1st word is reserved and is always assigned 0.

Parameter channel						
PKE (1st word)			IND (2nd word)		PWE (3rd and 4th word)	
15 ... 12	11	10 ... 0	15 ... 8	7 ... 0	15 ... 0	15 ... 0
AK	SPM	PNU	Subindex	Page index	PWE 1	PWE 2

You can find examples of telegrams at the end of this section.

Request and response IDs

Request and response IDs are written in bits 12 to 15 of the first word of the parameter channel. The possible identifiers and further explanations can be found in the following tables.

Overview of the request identifiers control → converter

Table 8- 10 Request identifiers control → converter

Request identifier	Description	Response identifier	
		positive	negative
0	No request	0	7 / 8
1	Request parameter value	1 / 2	7 / 8
2	Change parameter value (word)	1	7 / 8
3	Change parameter value (double word)	2	7 / 8
4	Request descriptive element 1)	3	7 / 8
6 2)	Request parameter value (field) 1)	4 / 5	7 / 8
7 2)	Change parameter value (field, word) 1)	4	7 / 8
8 2)	Change parameter value (field, double word) 1)	5	7 / 8
9	Request number of field elements	6	7 / 8

1) The required element of the parameter is specified in IND (2nd word).

2) The following request IDs are identical: 1 ≡ 6, 2 ≡ 7 3 ≡ 8.
We recommend that you use identifiers 6, 7, and 8.

Overview of the response identifiers converter → control

The response identifier depends on the request identifier.

Table 8- 11 Response identifiers converter → control

Response identifier	Description
0	No response
1	Transfer parameter value (word)
2	Transfer parameter value (double word)
3	Transfer descriptive element 1)
4	Transfer parameter value (field, word) 2)
5	Transfer parameter value (field, double word) 2)
6	Transfer number of field elements
7	Request cannot be processed, task cannot be executed (with error number)
8	No master controller status / no authorization to change parameters of the parameter channel interface

1) The required element of the parameter is specified in IND (2nd word).

2) The required element of the indexed parameter is specified in IND (2nd word).

Overview of the error numbers in response identifier 7 (request cannot be processed)

For response identifier 7, the converter sends one of the following error numbers in the highest word of the parameter channel to the control.

Table 8- 12 Error numbers for the response "Request cannot be processed"

No.	Description
00 hex	**Illegal parameter number** (access to a parameter that does not exist)
01 hex	**Parameter value cannot be changed** (change request for a parameter value that cannot be changed)
02 hex	**Lower or upper value limit exceeded** (change request with a value outside the value limits)
03 hex	**Incorrect subindex** (access to a subindex that does not exist. Additional diagnosis in error value 2)
04 hex	**No array** (access with a subindex to non-indexed parameters)
05 hex	**Incorrect data type** (change request with a value that does not match the data type of the parameter)
06 hex	**Setting not permitted, only resetting** (change request with a value not equal to 0 without permission)
07 hex	**Descriptive element cannot be changed** (change request to a descriptive element that cannot be changed. Additional diagnosis in error value 2)
0B hex	**No master control** (change request but with no master control, see also p0927.)
0C hex	**Keyword missing**
11 hex	**Request cannot be executed due to the operating state** (access is not possible for temporary reasons that are not specified)
14 hex	**Inadmissible value** (change request with a value that is within the limits but which is illegal for other permanent reasons, i.e. a parameter with defined individual values)

No.	Description
65 hex	**Parameter number is currently deactivated** (depending on the mode of the converter)
66 hex	**Channel width is insufficient** (communication channel is too small for response)
68 hex	**Illegal parameter value** (parameter can only assume certain values)
6A hex	**Request not included / task is not supported.** (The valid request identifications can be found in table "Request identifications control → converter")
6B hex	**No change access for a controller that is enabled**. (Operating status of the converter prevents a parameter change)
86 hex	**Write access only for commissioning (p0010 = 15)** (operating status of the converter prevents a parameter change.)
87 hex	**Know-how protection active, access locked**
C8 hex	**Change request below the currently valid limit** (change request to a value that lies within the "absolute" limits, but is however below the currently valid lower limit)
C9 hex	**Change request above the currently valid limit** (change request to a value that lies within the "absolute" limits, but is however above the currently valid upper limit, e.g. specified as a result of the converter power rating)
CC hex	**Change request not permitted** (change is not permitted as the access code is not available)

Parameter number

Parameter numbers < 2000	PNU = parameter number. Write the parameter number into the PNU (PKE bit 10 ... 0).
Parameter numbers ≥ 2000	PNU = parameter number - offset. Write the parameter number minus the offset into the PNU (PKE bit 10 … 0). Write the offset in the page index (IND bit 7 … 0).

Table 8- 13 Offset and page index of the parameter numbers

Parameter number	Offset	Page index								
		Hex	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0000 … 1999	0	0 hex	0	0	0	0	0	0	0	0
2000 … 3999	2000	80 hex	1	0	0	0	0	0	0	0
6000 … 7999	6000	90 hex	1	0	0	1	0	0	0	0
8000 … 9999	8000	20 hex	0	0	1	0	0	0	0	0
10000 … 11999	10000	A0 hex	1	0	1	0	0	0	0	0
20000 … 21999	20000	50 hex	0	1	0	1	0	0	0	0
30000 … 31999	30000	F0 hex	1	1	1	1	0	0	0	0

Indexed parameters

For indexed parameters, you must write the index number as hex value into the sub-index (IND bit 15 … 8).

Parameter contents

Parameter contents can be parameter values or connector parameters. For interconnecting connector parameters please see section: Interconnecting signals in the inverter (Page 315).

Enter the parameter value, right-justified, as follows in the 4th word of the parameter channel:

- 8-bit values: 4. Word, bit 0 … 7,
  bits 8 … 15 of the 4th word and the 3rd word are zero.
- 16-bit values: 4. Word, bits 0 … 15,
  The 3rd word is zero.
- 32-bit values: 3. and 4th word

Enter a connector parameter as follows:

- Number of the connector parameter: 3. Word
- Drive object of the connector parameter: 4. Word, bits 10 … 15
- The index or bit field number of the connector parameter: 4. Word, bits 0 … 9

Telegram examples

Read request: Read out serial number of the Power Module (p7841[2])

To obtain the value of the indexed parameter p7841, you must fill the telegram of the parameter channel with the following data:

- **PKE, bit 12 … 15 (AK): = 6** (request parameter value (field))
- **PKE, bit 0 … 10 (PNU): = 1841** (Parameter number without offset)
  Parameter number = PNU + offset (page index)
  (7841 = 1841 + 6000)
- **IND, bit 8 … 15 (subindex): = 2** (Index of the parameter)
- **IND, bit 0 … 7 (page index): = 90 hex** (offset 6000 ≙ 90 hex)
- Because you want to read the parameter value, words 3 and 4 in the parameter channel for requesting the parameter value are irrelevant. They should be assigned a value of 0, for example.

Parameter channel							
PKE, 1st word			IND, 2nd word		PWE1 - high, 3rd word	PWE2 - low, 4th word	
15 ... 12	11	10 ... 0	15 ... 8	7 ... 0	15 ... 0	15 ... 10	9 ... 0
AK		Parameter number	Subindex	Page index	Parameter value	Drive object	Index
0 1 1 0	0	1 1 1 0 0 1 1 0 0 0 1	0 0 0 0 0 0 1 0	1 0 0 1 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0

Figure 8-4 Telegram for a read request from p7841[2]

Write request: Assign digital input 2 with the function ON/OFF1 (p0840[1] = 722.2)

In order to link digital input 2 with OFF1/ON, you must assign parameter p0840[1] (source, ON/OFF1) the value 722.2 (DI 2). To do this, you must fill the telegram of the parameter channel as follows:

- **PKE, bit 12 … 15 (AK): = 7 hex** (change, parameter value (field, word))
- **PKE, bit 0 … 10 (PNU): = 348 hex** (840 = 348 hex, no offset, as 840 < 1999)
- **IND bit 8 … 15 (subindex): = 1 hex** (CDS1 = index1)
- **IND, bit 0 … 7 (page index): = 0 hex** (offset 0 ≙ 0 hex)
- **PWE1, bit 0 … 15**: = **2D2 hex** (722 = 2D2 hex)
- **PWE2, bit 10 … 15: = 3f hex** (drive object - for SINAMICS G120, always 63 = 3f hex)
- **PWE2, bit 0 … 9: = 2 hex** (index of parameter (DI 2 = 2))

<table>
<tr><td colspan="8">Parameter channel</td></tr>
<tr><td colspan="3">PKE, 1st word</td><td colspan="2">IND, 2nd word</td><td>PWE1 - high, 3rd word</td><td colspan="2">PWE2 - low, 4th word</td></tr>
<tr><td>15 ... 12</td><td>11</td><td>10 ... 0</td><td>15 ... 8</td><td>7 ... 0</td><td>15 ... 0</td><td>15 ... 10</td><td>9 ... 0</td></tr>
<tr><td>AK</td><td></td><td>Parameter number</td><td>Subindex</td><td>Page index</td><td>Parameter value</td><td>Drive Object</td><td>Index</td></tr>
<tr><td>0 1 1 1</td><td>0</td><td>0 1 1 0 1 0 0 1 0 0 0</td><td>0 0 0 0 0 0 0 1</td><td>0 0 0 0 0 0 0 0</td><td>0 0 0 0 0 0 1 0 1 1 0 1 0 0 1 0</td><td>1 1 1 1 1 1</td><td>0 0 0 0 0 0 0 0 1 0</td></tr>
</table>

Figure 8-5 Telegram, to assign DI 2 with ON/OFF1

Write request: Change restart mode (p1210)

The restart mode is inhibited in the factory setting (p1210 = 0). In order to activate the automatic restart with "acknowledge all faults and restart for an ON command", p1210 must be set to 26:

- **PKE, bit 12 … 15 (AK): = 7** (change parameter value (field, word))
- **PKE, bit 0 … 10 (PNU): = 4BA hex** (1210 = 4BA hex, no offset, as 1210 < 1999)
- **IND, bit 8 … 15 (subindex): = 0 hex** (parameter is not indexed)
- **IND, bit 0 … 7 (page index): = 0 hex** (offset 0 corresponds to 0 hex)
- **PWE1, bit 0 … 15: = 0 hex**
- **PWE2, bit 0 … 15: = 1A hex** (26 = 1A hex)

<table>
<tr><td colspan="7">Parameter channel</td></tr>
<tr><td colspan="3">PKE, 1st word</td><td colspan="2">IND, 2nd word</td><td>PWE1 - high, 3rd word</td><td>PWE2 - low, 4th word</td></tr>
<tr><td>15 ... 12</td><td>11</td><td>10 ... 0</td><td>15 ... 8</td><td>7 ... 0</td><td>15 ... 0</td><td>15 ... 0</td></tr>
<tr><td>AK</td><td></td><td>Parameter number</td><td>Subindex</td><td>Page index</td><td>Parameter value (bit 16 ... 31)</td><td>Parameter value (bit 0 ... 15)</td></tr>
<tr><td>0 1 1 1</td><td>0</td><td>1 0 0 1 0 1 1 1 0 1 0</td><td>0 0 0 0 0 0 0 0</td><td>0 0 0 0 0 0 0 0</td><td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td><td>0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 0</td></tr>
</table>

Figure 8-6 Telegram, to activate the automatic restart with p1210 = 26

8.3.1.4 Slave-to-slave communication

With "Slave-slave communication" (also called "Data Exchange Broadcast") it is possible to quickly exchange data between converters (slaves) without the master being directly involved, for instance to use the actual value of one converter as setpoint for other converters.

Note

Slave-to-slave communication in the current firmware version is only possible for converters with PROFIBUS communication.

For slave-to-slave communication, in the control system you must define which converter acts as publisher (sender) or subscriber (receiver) - and which data or data areas (access points) you wish to use for slave-to-slave communication. In the converters that operate as subscriber, you must define how the data transferred using slave-to-slave communication is processed. Using parameter r2077, in the converter, you can read-out the PROFIBUS addresses of the converters for which the slave-to-slave communication function is configured.

- **Publisher** Slave, which sends the data for slave-to-slave communication.
- **Subscriber** Slave, which receives the data from slave-to-slave communication from the publisher.
- **Links and access points** define the data that are used for slave-to-slave communication.

You must observe the following restrictions for the slave-to-slave communication function:

- a maximum of 12 PZD are permissible for each drive
- To a publisher, a maximum of 4 links are possible

An example of how you configure slave-to-slave communication between two converters in STEP 7 is provided in Section: Configuring slave-to-slave communication in STEP 7 (Page 334).

8.3.2 Acyclic communication

8.3.2.1 Acyclic communication

As well as cyclic communication, the converter also offers the option of acyclic communication for PROFIBUS DP and PROFINET. You can parameterize and diagnose the converter via acyclic communication. Acyclic communication takes place in parallel with cyclic communication, but with a lower priority.

The converter supports the following types of acyclic communication:

- Reading and writing parameters via "data set 47" (up to 240 bytes per write or read request)
- Reading-out profile-specific parameters
- Data exchange with a SIMATIC HMI (**H**uman **M**achine **I**nterface)

You can find a STEP 7 program example for acyclic data transfer in Section Application examples (Page 318).

8.3.2.2 Reading and changing parameters via data set 47

Reading parameter values

Table 8- 14 Request to read parameters

<table>
<tr><th>Data block</th><th>Byte n</th><th>Bytes n + 1</th><th>n</th></tr>
<tr><td rowspan="2">Header</td><td>Reference 01 hex ... FF hex</td><td>01 hex: Read request</td><td>0</td></tr>
<tr><td>01 hex</td><td>Number of parameters (m) 01 hex ... 27 hex</td><td>2</td></tr>
<tr><td rowspan="4">Address, parameter 1</td><td>Attribute
10 hex: Parameter value
20 hex: Parameter description</td><td>Number of indices
00 hex ... EA hex
(for parameters without index: 00 hex)</td><td>4</td></tr>
<tr><td colspan="2">Parameter number 0001 hex ... FFFF hex</td><td>6</td></tr>
<tr><td colspan="2">Number of the 1st index 0000 hex ... FFFF hex
(for parameters without index: 0000 hex)</td><td>8</td></tr>
<tr><td colspan="2">…</td><td>…</td></tr>
<tr><td>Address, parameter 2</td><td colspan="2">…</td><td>…</td></tr>
<tr><td>…</td><td colspan="2">…</td><td>…</td></tr>
<tr><td>Address, parameter m</td><td colspan="2">…</td><td>…</td></tr>
</table>

Table 8- 15 Converter response to a read request

<table>
<tr><th>Data block</th><th>Byte n</th><th>Bytes n + 1</th><th>n</th></tr>
<tr><td rowspan="2">Header</td><td>Reference (identical to a read request)</td><td>01 hex: Converter has executed the read request.
81 hex: Converter was not able to completely execute the read request.</td><td>0</td></tr>
<tr><td>01 hex</td><td>Number of parameters (m)
(identical to the read request)</td><td>2</td></tr>
<tr><td rowspan="3">Values, parameter 1</td><td>Format
02 hex: Integer8
03 hex: Integer16
04 hex: Integer32
05 hex: Unsigned8
06 hex: Unsigned16
07 hex: Unsigned32
08 hex: FloatingPoint
10 hex OctetString
13 hex TimeDifference
41 hex: Byte
42 hex: Word
43 hex: Double word
44 hex: Error</td><td>Number of index values or - for a negative response - number of error values</td><td>4</td></tr>
<tr><td colspan="2">Value of the 1st index or - for a negative response - error value 1
You can find the error values in a table at the end of this section.</td><td>6</td></tr>
<tr><td colspan="2">…</td><td>…</td></tr>
<tr><td>Values, parameter 2</td><td colspan="2">…</td><td></td></tr>
<tr><td>…</td><td colspan="2">…</td><td></td></tr>
<tr><td>Values, parameter m</td><td colspan="2">…</td><td></td></tr>
</table>

Changing parameter values

Table 8- 16 Request to change parameters

Data block	Byte n	Bytes n + 1	n
Header	Reference *01 hex ... FF hex*	02 hex: Change request	0
	01 hex	Number of parameters (m) *01 hex ... 27 hex*	2
Address, parameter 1	10 hex: Parameter value	Number of indices *00 hex ... EA hex* (00 hex and 01 hex have the same significance)	4
	Parameter number *0001 hex ... FFFF hex*		6
	Number of the 1st index *0001 hex ... FFFF hex*		8
	…		…
Address, parameter 2	…		
…	…		…
Address, parameter m	…		
Values, parameter 1	Format *02 hex:* Integer 8 *03 hex:* Integer 16 *04 hex:* Integer 32 *05 hex:* Unsigned 8 *06 hex:* Unsigned 16 *07 hex:* Unsigned 32 *08 hex:* Floating Point *10 hex* Octet String *13 hex* Time Difference *41 hex:* Byte *42 hex:* Word *43 hex:* Double word	Number of index values *00 hex ... EA hex*	
	Value of the 1st index		
	…		
Values, parameter 2	…		
…	…		
Values, parameter m	…		

Table 8- 17 Response, if the converter has executed the change request

Data block	Byte n	Bytes n + 1	n
Header	Reference (identical to a change request)	02 hex	0
	01 hex	Number of parameters (identical to a change request)	2

Table 8- 18 Response, if the converter was not able to completely execute the change request

Data block	Byte n	Bytes n + 1	n
Header	**Reference** (identical to a change request)	**82 hex**	0
	01 hex	**Number of parameters** (identical to a change request)	2
Values, parameter 1	**Format** 40 hex: Zero (change request for this data block executed) 44 hex: Error (change request for this data block not executed)	**Number of error values** 00 hex, 01 hex or 02 hex	4
	Only for "Error" - **error value 1** You can find the error values in the table at the end of this section.		6
	Only if "number of error values" = 02 hex: **Error value 2** Error value 1 defines whether the converter sends error value 2 and what it means.		8
Values, parameter 2	...		
...	…		…
Values, parameter m	...		

Diagnostics

Table 8- 19 Error value in the parameter response

Error value 1	Significance
00 hex	**Illegal parameter number** (access to a parameter that does not exist)
01 hex	**Parameter value cannot be changed** (change request for a parameter value that cannot be changed. Additional diagnostics in error value 2)
02 hex	**Lower or upper value limit exceeded** (change request with a value outside the value limits. Additional diagnostics in error value 2)
03 hex	**Incorrect subindex** (access to a subindex that does not exist. Additional diagnostics in error value 2)
04 hex	**No array** (access with a subindex to non-indexed parameters)
05 hex	**Incorrect data type** (change request with a value that does not match the data type of the parameter)
06 hex	**Setting not permitted, only resetting** (change request with a value not equal to 0 without permission. Additional diagnostics in error value 2)
07 hex	**Descriptive element cannot be changed** (change request to a descriptive element that cannot be changed. Additional diagnostics in error value 2)
09 hex	**Description data not available** (access to a description that does not exist, parameter value is available)
0B hex	**No master control** (change request but with no master control)
0F hex	**Text array does not exist** (although the parameter value is available, the access is made to a text array that does not exist)
11 hex	**Request cannot be executed due to the operating state** (access is not possible for temporary reasons that are not specified)
14 hex	**Inadmissible value** (change request with a value that is within the limits but which is illegal for other permanent reasons, i.e. a parameter with defined individual values. Additional diagnostics in error value 2)
15 hex	**Response too long** (the length of the actual response exceeds the maximum transfer length)

Error value 1	Significance
16 hex	Illegal parameter address *(illegal or unsupported value for attribute, number of elements, parameter number, subindex or a combination of these)*
17 hex	Illegal format (change request for an illegal or unsupported format)
18 hex	Number of values not consistent *(number of values of the parameter data to not match the number of elements in the parameter address)*
19 hex	Drive object does not exist (access to a drive object that does not exist)
6B hex	No change access for a controller that is enabled.
6C hex	Unknown unit.
6E hex	Change request is only possible when the motor is being commissioned (p0010 = 3).
6F hex	Change request is only possible when the power unit is being commissioned (p0010 = 2).
70 hex	Change request is only possible for quick commissioning (basic commissioning) (p0010 = 1).
71 hex	Change request is only possible if the converter is ready (p0010 = 0).
72 hex	Change request is only possible for a parameter reset (restore to factory setting) (p0010 = 30).
73 hex	Change request possible only during commissioning of the safety functions (p0010 = 95).
74 hex	Change request is only possible when a technological application/unit is being commissioned (p0010 = 5).
75 hex	Change request is only possible in a commissioning state (p0010 ≠ 0).
76 hex	Change request is not possible for internal reasons (p0010 = 29).
77 hex	Change request is not possible at download.
81 hex	Change request is not possible at download.
82 hex	Transfer of the control authority (master) is inhibited by BI: p0806.
83 hex	Requested BICO interconnection is not possible (BICO output does not supply a float value, however the BICO input requires a float value)
84 hex	Converter does not accept a change request (converter is busy with internal calculations, see r3996)
85 hex	No access methods defined.
86 hex	Write access only during commissioning of the data records (p0010 = 15) (operating status of the converter prevents a parameter change.)
87 hex	Know-how protection active, access locked
C8 hex	Change request below the currently valid limit (change request to a value that lies within the "absolute" limits, but is however below the currently valid lower limit)
C9 hex	Change request above the currently valid limit (change request to a value that lies within the "absolute" limits, but is however above the currently valid upper limit, e.g. specified as a result of the converter power rating)
CC hex	Change request not permitted (change is not permitted as the access code is not available)

8.4 Communication via RS485

8.4.1 Integrating inverters into a bus system via the RS485 interface

Connecting to a network via RS485

Connect the inverter to your fieldbus via the RS485 interface. Position and assignment of the RS485 interface can be found in section Interfaces, connectors, switches, terminal blocks and LEDs of the converter (Page 42). This connector has short-circuit proof, isolated pins.

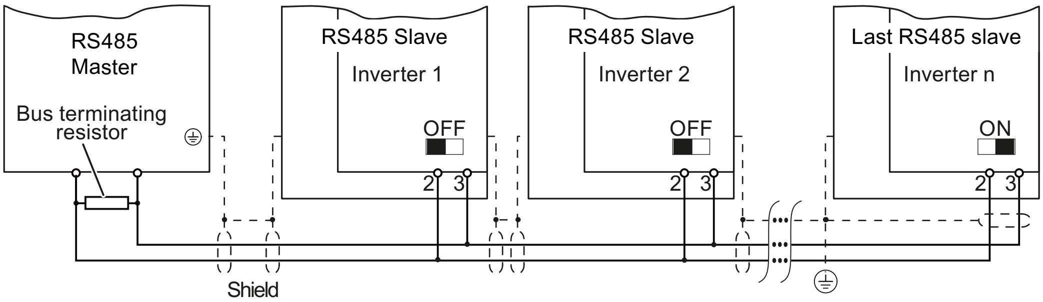


Figure 8-7 Communication network via RS485

You must switch-in the bus terminating resistor for the first and last participants. The position of the bus terminating resistor can be found in section Interfaces, connectors, switches, terminal blocks and LEDs of the converter (Page 42).

You can disconnect one or more slaves from the bus (by unplugging the bus connector) without interrupting the communication for the other stations, but not the first or last.

NOTICE
When the bus is operating, the first and last bus station must be continuously connected to the supply.

Note

Communication with the controller, even when the supply voltage on the Power Module is switched off

You will have to supply the Control Unit with 24 VDC on terminals 31 and 32 if you require communication to take place with the controller even when the line voltage is switched off.

In the case of short interruptions of the 24V voltage supply, the converter may report the fault F without communications with the controller being interrupted.

8.4.2 Communication via USS

Using the USS protocol (protocol of the universal serial interface), users can set up a serial data connection between a higher-level master system and several slave systems (RS 485 interface). Master systems include programmable logic controllers (e.g. SIMATIC S7-200) or PCs. The inverters are always slaves on the bus system.

Communication using the USS protocol takes place over the RS485 interface with a maximum of 31 slaves.

The maximum cable length is 1200 m (3300 ft)

Information about how to connect the inverter to the USS fieldbus is provided in Section: Integrating inverters into a bus system via the RS485 interface (Page 109).

8.4.2.1 Basic settings for communication

Setting the address

You can set the converter's USS address via the address switch on the CU via p2021 or in STARTER under "Control Unit/Communications/fieldbus".

Valid address range: 1 … 30

Procedure

Method	Description
Address switch	If you have specified a valid address using the address switch, this address will always be the one that takes effect and parameter p2021 cannot be changed. The positions and settings of the address switches are described in section: Interfaces, connectors, switches, terminal blocks and LEDs of the converter (Page 42).
p2021 / STARTER	**Fieldbus address** (factory setting: 0) The setting in p2021 or via STARTER is only effective if the address, set using the address switch, is invalid (0 or >30).

CAUTION
For a modified bus address to be effective, you have to switch the converter and - if need be - any external 24 V supply off and on.

Additional settings

Parameter	Description
P0015 = 21	**Macro drive device** Select the I/O configuration
p2020	**Setting the baud rate** Value – Baud rate 4 – 2400 5 – 4800 6 – 9600 7 – 19200 8 – 38400 9 – 57600 10 – 76800 11 – 93750 12 – 115200 13 – 187500
p2022	**Fieldbus interface USS PZD number** Sets the number of 16-bit words in the PZD part of the USS telegram Setting range: 0… 8 (0 … 8 words)
p2023	**Fieldbus interface USS PIV number** Sets the number of 16-bit words in the PIV part of the USS telegram Setting range: • 0, 3, 4: 0, 3 or 4 words • 127: variable length
p2040	**Fieldbus interface monitoring time [ms]** Sets the monitoring time to monitor the process data received via the fieldbus. If no process data are received within this time, an appropriate message is output

8.4.2.2 Telegram structure

Overview

A USS telegram comprises a sequence of elements, which are sent in a defined sequence. Each element contains 11 bits.

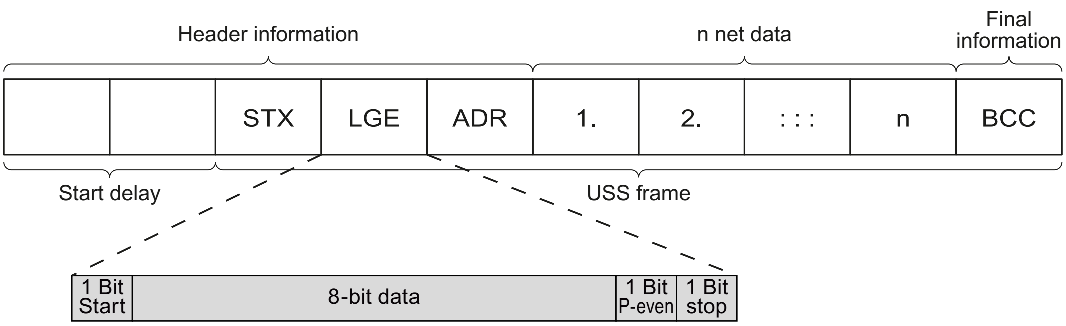


Figure 8-8 Structure of a USS telegram

Telegram part	Description
Start delay / response delay	There is always a start and/or response delay between two telegrams (see alsoTime-out and other errors (Page 119))
STX	An ASCII character (02 hex) indicates the beginning of the message.
LGE	The telegram length "LGE" is calculated as follows: LGE = user data (n bytes) + ADR (1 byte) + BCC (1 byte)
ADR	Bit 7: Special telegram; Bit 6: Mirror telegram; Bit 5: Broadcast bit; Bits 4 3 2 1 0: Address • Bit 7 = 0: Normal data exchange. Bit 7 =1, to transfer telegrams that require a net data structure different from the device profile. • Bit 6 = 0: Normal data exchange. Bit 6 = 1: Testing the bus connection: The converter returns the telegram unchanged to the master. • Bit 5 = 0: Normal data exchange. (Bit 5 = 1: Not supported in the converter.) • Bits 0 ... 4: Address of the converter.
Net data	See section User data range of the USS telegram (Page 112).
BCC	Checksum (exclusive or) across all telegram bytes – with the exception of BCC.

8.4.2.3 User data range of the USS telegram

The user data area consists of the following elements:

- Parameter channel (PIV) for writing and reading parameter values
- Process data (PZD) for controlling the drive.

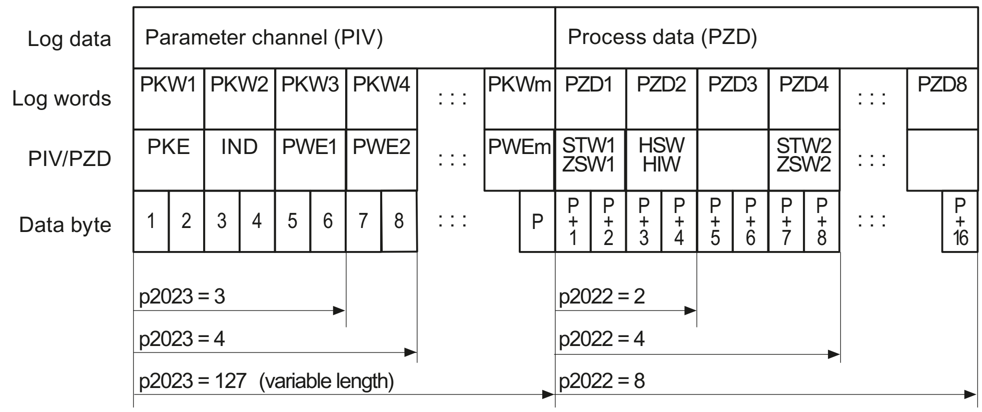


Figure 8-9 USS telegram - user data structure

Parameter channel

In parameter p2023 you specify the length of the parameter channel.

Parameter channel with fixed and variable length

- P2023 = 0
  With this setting, no parameter values are transferred.
- P2023 = 3
  You can select this setting if you only want to read or write 16-bit data or alarm signals.
- P2023 = 4:
  If you want to read or write 32-bit values (for example indexed parameters or bit parameter, e.g. r0722.2), then this setting is required. In this case, the send or receive telegram always contains 4 words, even if only 3 would be required. The values are enter right-justified in the 4th word.
- P2023 = 127:
  If you set p2023 = 27 (variable length), the send and response telegrams are as long as the task actually requires.

Process data

Parameter p2022 defines the length for the process data. You can transfer up to 8 process data in one telegram (p2022 = 0 … 8). For p2022 = 0, no process data is transferred.

8.4.2.4 USS parameter channel

Structure of the parameter channel

Depending on the setting in p2023, the parameter channel has a fixed length of three or four words, or a variable length, depending on the length of the data to be transferred.

The parameter number and index as well as the type of job (read or write) are transferred in the 1st and 2nd word. The other words of the parameter channel contain parameter contents. The parameter contents can be 8-bit values, 16-bit values (such as baud rate) or 32-bit values (e.g. CO parameters). The parameter contents are entered right justified in the word with the highest number. Words that are not required are assigned 0.

Bit 11 in the 1st word is reserved and is always assigned 0.

The diagram shows a parameter channel that is four words long.

Parameter channel						
PKE, 1st word			IND (2nd word)		PWE (3rd and 4th word)	
15 ... 12	11	10 ... 0	15 ... 8	7 ... 0	15 ... 0	15 ... 0
AK	SPM	PNU	Page index	Subindex	PWE 1, high word	PWE 2, low word

You can find examples of telegrams at the end of this section.

Request and response IDs

Request and response IDs are written in bits 12 to 15 of the first word of the parameter channel. The possible identifiers and further explanations can be found in the following tables.

Overview of the request identifiers control → converter

Table 8- 20 Request identifiers control → converter

Request identifier	Description	Response identifier	
		positive	negative
0	No request	0	7 / 8
1	Request parameter value	1 / 2	7 / 8
2	Change parameter value (word)	1	7 / 8
3	Change parameter value (double word)	2	7 / 8
4	Request descriptive element [1)]	3	7 / 8
6[2)]	Request parameter value (field) [1)]	4 / 5	7 / 8
7[2)]	Change parameter value (field, word) [1)]	4	7 / 8
8[2)]	Change parameter value (field, double word) [1)]	5	7 / 8
9	Request number of field elements	6	7 / 8

1) The required element of the parameter is specified in IND (2nd word).

2) The following request IDs are identical: 1 ≡ 6, 2 ≡ 7 3 ≡ 8.
We recommend that you use identifiers 6, 7, and 8.

Overview of the response identifiers converter → control

The response identifier depends on the request identifier.

Table 8- 21 Response identifiers converter → control

Response identifier	Description
0	No response
1	Transfer parameter value (word)
2	Transfer parameter value (double word)
3	Transfer descriptive element [1)]
4	Transfer parameter value (field, word) [2)]
5	Transfer parameter value (field, double word) [2)]
6	Transfer number of field elements
7	Request cannot be processed, task cannot be executed (with error number)
8	No master controller status / no authorization to change parameters of the parameter channel interface

1) The required element of the parameter is specified in IND (2nd word).

2) The required element of the indexed parameter is specified in IND (2nd word).

Overview of the error numbers in response identifier 7 (request cannot be processed)

For response identifier 7, the converter sends one of the following error numbers in the highest word of the parameter channel to the control.

Table 8- 22 Error numbers for the response "Request cannot be processed"

No.	Description
00 hex	**Illegal parameter number** (access to a parameter that does not exist)
01 hex	**Parameter value cannot be changed** (change request for a parameter value that cannot be changed)
02 hex	**Lower or upper value limit exceeded** (change request with a value outside the value limits)
03 hex	**Incorrect subindex** (access to a subindex that does not exist. Additional diagnosis in error value 2)
04 hex	**No array** (access with a subindex to non-indexed parameters)
05 hex	**Incorrect data type** (change request with a value that does not match the data type of the parameter)
06 hex	**Setting not permitted, only resetting** (change request with a value not equal to 0 without permission)
07 hex	**Descriptive element cannot be changed** (change request to a descriptive element that cannot be changed. Additional diagnosis in error value 2)
0B hex	**No master control** (change request but with no master control, see also p0927.)
0C hex	**Keyword missing**
11 hex	**Request cannot be executed due to the operating state** (access is not possible for temporary reasons that are not specified)
14 hex	**Inadmissible value** (change request with a value that is within the limits but which is illegal for other permanent reasons, i.e. a parameter with defined individual values)
65 hex	**Parameter number is currently deactivated** (depending on the mode of the converter)
66 hex	**Channel width is insufficient** (communication channel is too small for response)
68 hex	**Illegal parameter value** (parameter can only assume certain values)
6A hex	**Request not included / task is not supported.** (The valid request identifications can be found in table "Request identifications control → converter")
6B hex	**No change access for a controller that is enabled**. (Operating status of the converter prevents a parameter change)
86 hex	**Write access only for commissioning (p0010 = 15)** (operating status of the converter prevents a parameter change.)
87 hex	**Know-how protection active, access locked**
C8 hex	**Change request below the currently valid limit** (change request to a value that lies within the "absolute" limits, but is however below the currently valid lower limit)
C9 hex	**Change request above the currently valid limit** (change request to a value that lies within the "absolute" limits, but is however above the currently valid upper limit, e.g. specified as a result of the converter power rating)
CC hex	**Change request not permitted** (change is not permitted as the access code is not available)

Parameter number

Parameter numbers < 2000	PNU = parameter number. Write the parameter number into the PNU (PKE bit 10 ... 0).
Parameter numbers ≥ 2000	PNU = parameter number - offset. Write the parameter number minus the offset into the PNU (PKE bit 10 … 0). Write the offset in the page index (IND bit 15 … 8).

Table 8- 23 Offset and page index of the parameter numbers

Parameter number	Offset	Page index								
		Hex	Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
0000 … 1999	0	0 hex	0	0	0	0	0	0	0	0
2000 … 3999	2000	80 hex	1	0	0	0	0	0	0	0
6000 … 7999	6000	90 hex	1	0	0	1	0	0	0	0
8000 … 9999	8000	20 hex	0	0	1	0	0	0	0	0
10000 … 11999	10000	A0 hex	1	0	1	0	0	0	0	0
20000 … 21999	20000	50 hex	0	1	0	1	0	0	0	0
30000 … 31999	30000	F0 hex	1	1	1	1	0	0	0	0

Indexed parameters

For indexed parameters, you must write the index number as hex value into the sub-index (IND bit 7 … 0).

Parameter contents

Parameter contents can be parameter values or connector parameters. For connector parameters you need two words. For interconnecting connector parameters please see section: Interconnecting signals in the inverter (Page 315).

Enter the parameter value in the parameter channel right-justified as follows:

- 8-bit values: Low word, bit 0 ... 7, bits 8 … 15 are zero.
- 16-bit values: Low word, bits 0 … 15,
- 32-bit values: Low word and high word

Enter a connector parameter right-justified as follows:

- Number of the connector parameter: High word
- Drive object of the connector parameter: Low word, bits 10 … 15
- The index or bit field number of the connector parameter: Low word, bits 0 … 9

Telegram examples, parameter channel length = 4

Read request: Read out serial number of the Power Module (p7841[2])

To obtain the value of the indexed parameter p7841, you must fill the telegram of the parameter channel with the following data:

- **PKE, bit 12 … 15 (AK): = 6** (request parameter value (field))
- **PKE, bit 0 … 10 (PNU): = 1841** (Parameter number without offset)
  Parameter number = PNU + offset (page index)
  (7841 = 1841 + 6000)
- **IND, bit 8 … 15 (page index): = 90 hex** (offset 6000 ≙ 90 hex)
- **IND, bit 0 … 7 (subindex): = 2** (Index of the parameter)
- Because you want to read the parameter value, words 3 and 4 in the parameter channel for requesting the parameter value are irrelevant. They should be assigned a value of 0, for example.

Parameter channel							
PKE (1st word)			IND, 2nd word		PWE1 - high, 3rd word	PWE2 - low, 4th word	
15 ... 12	11	10 ... 0	15 ... 8	7 ... 0	15 ... 0	15 ... 10	9 ... 0
AK		Parameter number	Page index	Subindex	Parameter value	Drive Object	Index
0 1 1 0	0	1 1 1 0 0 1 1 0 0 0 1	1 0 0 1 0 0 0 0	0 0 0 0 0 0 1 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0

Figure 8-10 Telegram for a read request from p7841[2]

Write request: Change restart mode (p1210)

The restart mode is inhibited in the factory setting (p1210 = 0). In order to activate the automatic restart with "acknowledge all faults and restart for an ON command", p1210 must be set to 26:

- **PKE, bit 12 … 15 (AK): = 7** (change parameter value (field, word))
- **PKE, bit 0 … 10 (PNU): = 4BA hex** (1210 = 4BA hex, no offset, as 1210 < 1999)
- **IND, bit 8 … 15 (page index): = 0 hex** (offset 0 corresponds to 0 hex)
- **IND, bit 0 … 7 (subindex): = 0 hex** (parameter is not indexed)
- **PWE1, bit 0 … 15: = 0 hex**
- **PWE2, bit 0 … 15: = 1A hex** (26 = 1A hex)

Parameter channel						
PKE, 1st word			IND, 2nd word		PWE1 - high, 3rd word	PWE2 - low, 4th word
15 ... 12	11	10 ... 0	15 ... 8	7 ... 0	15 ... 0	15 ... 0
AK		Parameter number	Page index	Subindex	Parameter value (bit 16 ... 31)	Parameter value (bit 0 ... 15)
0 1 1 1	0	1 0 0 1 0 1 1 1 0 1 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 1 1 0 1 0

Figure 8-11 Telegram, to activate the automatic restart with p1210 = 26

Write request: Assign digital input 2 with the function ON/OFF1 (p0840[1] = 722.2)

In order to link digital input 2 with ON/OFF1, you must assign parameter p0840[1] (source, ON/OFF1) the value 722.2 (DI 2). To do this, you must fill the telegram of the parameter channel as follows:

- **PKE, bit 12 … 15 (AK): = 7 hex** (change, parameter value (field, word))
- **PKE, bit 0 … 10 (PNU): = 348 hex** (840 = 348 hex, no offset, as 840 < 1999)
- **IND, bit 8 … 15 (page index): = 0 hex** (offset 0 ≙ 0 hex)
- **IND bit 0 … 7 (subindex): = 1 hex** (command data set, CDS1 = index1)
- **PWE1, bit 0 … 15**: = **2D2 hex** (722 = 2D2 hex)
- **PWE2, bit 10 … 15: = 3f hex** (drive object - for SINAMICS G120, always 63 = 3f hex)
- **PWE2, bit 0 … 9: = 2 hex** (index or bit number of the parameter: DI 2 = r0722.2)

Parameter channel							
PKE, 1st word			IND, 2nd word		PWE1 - high, 3rd word	PWE2 - low, 4th word	
15 ... 12	11	10 ... 0	15 ... 8	7 ... 0	15 ... 0	15 ... 10	9 ... 0
AK		Parameter number	Page index	Subindex	Parameter value	Drive Object	Index
0 1 1 1	0	0 1 1 0 1 0 0 1 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 1	0 0 0 0 0 0 1 0 1 1 0 1 0 0 1 0	1 1 1 1 1 1	0 0 0 0 0 0 0 0 1 0

Figure 8-12 Telegram, to assign DI 2 with ON/OFF1

8.4.2.5 USS process data channel (PZD)

Description

The process data channel (PZD) contains the following data depending on the transmission direction:

- Control words and setpoints for the slave
- Status words and actual values for the master.

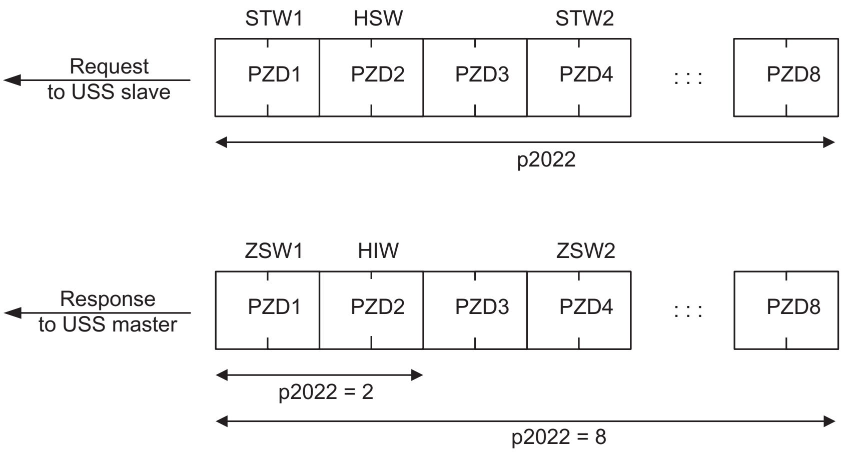


Figure 8-13 Process data channel

The first two words are:

- Control 1 (STW1) and main setpoint (HSW)
- Status word 1 (ZSW1) and main actual value (HIW)

If p2022 is greater than or equal to 4, the additional control word (STW2) is transferred.

You define the sources of the PZD using parameter p2051.

For further information, please refer to the Parameter Manual.

8.4.2.6 Time-out and other errors

You require the telegram runtimes in order to set the telegram monitoring. The character runtime is the basis of the telegram runtime:

Table 8- 24 Character runtime

Baud rate in bit/s	Transmission time per bit	Character run time (= 11 bits)
9600	104.170 µs	1.146 ms
19200	52.084 µs	0.573 ms
38400	26.042 µs	0.286 ms
115200	5.340 µs	0.059 ms

The telegram runtime is longer than just purely adding all of the character runtimes (=residual runtime). You must also take into consideration the character delay time between the individual characters of the telegram.

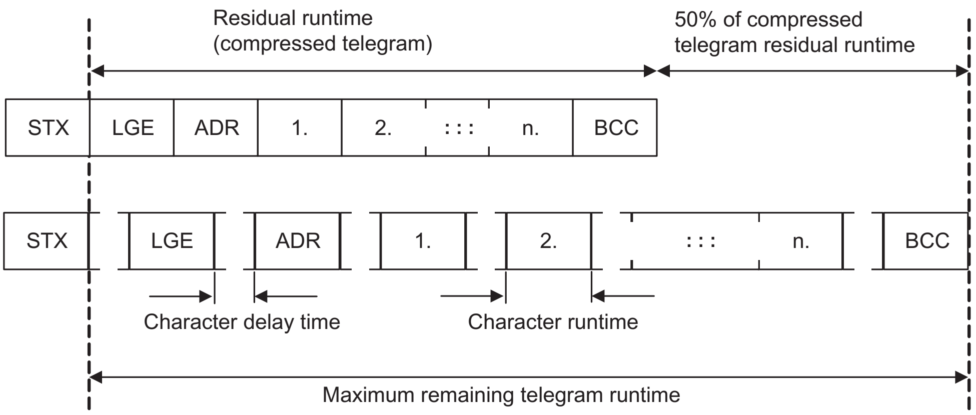


Figure 8-14 Telegram runtime as the sum of the residual runtime and character delay times

The total telegram runtime is always less than 150% of the pure residual runtime.

Before each request telegram, the master must maintain the start delay. The start delay must be > 2 × character runtime.

The slave only responds after the response delay has expired.

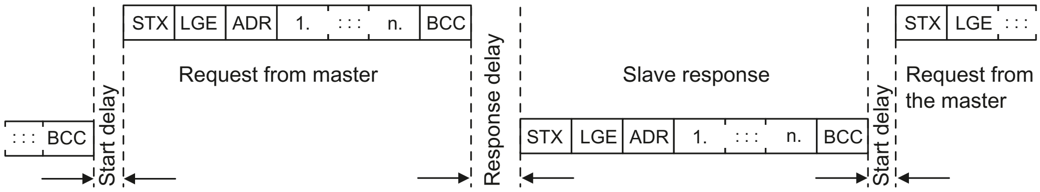


Figure 8-15 Start delay and response delay

The duration of the start delay must at least be as long as the time for two characters and depends on the baud rate.

Table 8- 25 Duration of the start delay

Baud rate in bit/s	Transmission time per character (= 11 bits)	Min. start delay
9600	1.146 ms	> 2.291 ms
19200	0.573 ms	> 1.146 ms
38400	0.286 ms	> 0.573 ms
57600	0.191 ms	> 0.382 ms
115200	0.059 ms	> 0.117 ms

Note: The character delay time must be shorter than the start delay.

Telegram monitoring of the master

With your USS master, we recommend that the following times are monitored:

- Response delay: Response time of the slave to a request from the master

  The response delay must be < 20 ms, but longer than the start delay
- Telegram runtime: Transmission time of the response telegram sent from the slave

Telegram monitoring of the converter

The converter monitors the time between two requests of the master. Parameter p2040 defines the permissible time in ms. If a time p2040 ≠ 0 is exceeded, then the converter interprets this as telegram failure and responds with fault F01910.

150% of the residual runtime is the guide value for the setting of p2040, i.e. the telegram runtime without taking into account the character delay times.

For communication via USS, the converter checks bit 10 of the received control word 1. If the bit is not set when the motor is switched on ("Operation"), then the converter responds with fault F07220.

8.4.3 Communication over Modbus RTU

8.4.3.1 Modbus

Overview of communication using Modbus

The Modbus protocol is a communication protocol with linear topology based on a master/slave architecture.

Modbus offers three transmission modes:

- Modbus ASCII
  Data is transferred in ASCII code. The data can therefore be read directly by humans, however, the data throughput is lower in comparison to RTU.
- Modbus RTU
  Modbus RTU (RTU: Remote Terminal Unit): Data is transferred in binary format and the data throughput is greater than in ASCII code.
- Modbus TCP
  This type of data transmission is very similar to RTU, except that TCP/IP packages are used to send the data. TCP port 502 is reserved for Modbus TCP. Modbus TCP is currently undergoing definition as a standard (IEC PAS 62030 (pre-standard)).

The Control Unit supports Modbus RTU as a slave with even parity.

1 Bit Start	8 bits of data	1 Bit P-even	1 Bit stop

Communication settings

- Communication using Modbus RTU takes place over the RS485 interface with a maximum of 247 slaves.
- The maximum cable length is 1200 m (3281 ft).
- Two 100 kΩ resistors are provided to polarize the receive and send cables.

> ⚠ CAUTION
>
> **It is not permitted to change over the units!**
>
> The "Unit changover (Page 200)" function is not permissible with this bus system!

8.4.3.2 Basic settings for communication

Setting the address

You can set the converter's Modbus-RTU address via the address switches on the CU via p2021 or in STARTER under "Control Unit/Communications/fieldbus".

Valid address range: 1 … 247

Procedure

Method	Description
Address switch	If you have specified a valid address using the address switch, this address will always be the one that takes effect and parameter p2021 cannot be changed. The positions and settings of the address switches are described in section: Interfaces, connectors, switches, terminal blocks and LEDs of the converter (Page 42).
p2021 / STARTER	**Fieldbus address** (factory setting: 1) The setting in p2021 or via STARTER is effective only if you set all address switches to "OFF" (0).

CAUTION
For a modified bus address to be effective, you have to switch the converter and - if need be - any external 24 V supply off and on.

Additional settings

Parameter	Description
P0015 = 21	**Macro drive unit** Selecting the I/O configuration
p2030 = 2	**Fieldbus protocol selection** 2: Modbus
p2020	**Fieldbus baud rate** Baud rates from 4800 bit/s to 187500 bit/s can be set for communication, factory setting = 19200 bit/s.
p2024	**Modbus timing** (see Section "Baud rates and mapping tables (Page 124)") • **Index 0: Maximum slave telegram processing time:** The time after which the slave must have sent a response to the master. • **Index 1: Character delay time:** Character delay time: Maximum permissible delay time between the individual characters in the Modbus frame. (Modbus standard processing time for 1.5 bytes). • **Index2: Inter-telegram delay:** Maximum permissible delay time between Modbus telegrams. (Modbus standard processing time for 3.5 bytes).

Parameter	Description
p2029	**Fieldbus fault statistics** Displays receive faults on the fieldbus interface
p2040	**Process data monitoring time** Determines the time after which an alarm is generated if no process data are transferred. **Note:** This time must be adapted depending on the number of slaves and the baud rate set for the bus (factory setting = 100 ms).

8.4.3.3 Modbus RTU telegram

Description

For Modbus, there is precisely one master and up to 247 slaves. Communication is always triggered by the master. The slaves can only transfer data at the request of the master. Slave-to-slave communication is not possible. The Control Unit always operates as slave.

The following figure shows the structure of a Modbus RTU telegram.

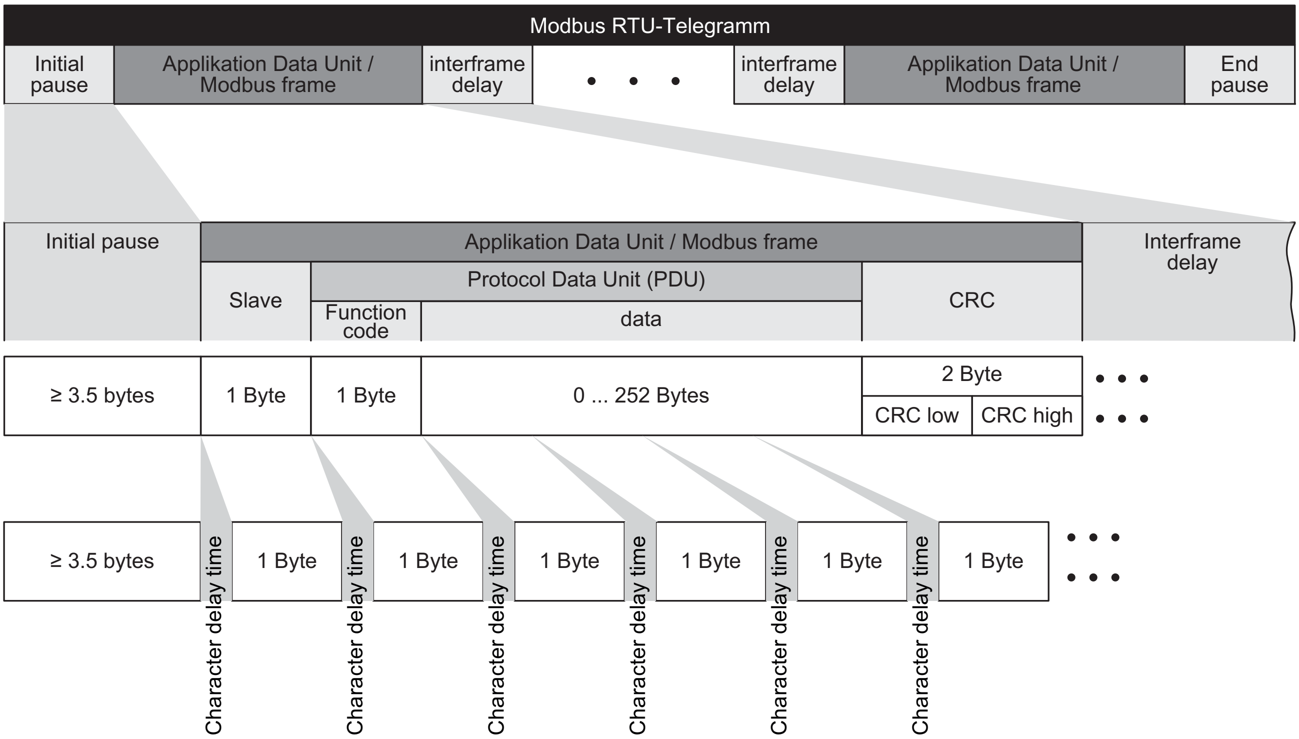


Figure 8-16 Modbus with delay times

The data area of the telegram is structured according to the mapping tables.

8.4.3.4 Baud rates and mapping tables

Permissible baud rates and telegram delay

The Modbus RTU telegram requires a pause for the following cases:

- Start detection
- Between the individual frames
- End detection

Minimum duration: Processing time for 3.5 bytes (can be set via p2024[2]).

A character delay time is also permitted between the individual bytes of a frame. Maximum duration: Processing time for 1.5 bytes (can be set via p2024[1]).

Table 8- 26 Baud rates, transmission times, and delays

Baud rate in bit/s (p2020)	Transmission time per character (11 bits)	Minimum pause between two telegrams (p2024[2])	Maximum pause between two bytes (p2024[1])
4800	2.292 ms	≥ 8.021 ms	≤ 3.438 ms
9600	1.146 ms	≥ 4.010 ms	≤ 1.719 ms
19200 (factory setting)	0.573 ms	≥ 1.75 ms	≤ 0.859 ms
38400	0.286 ms	≥ 1.75 ms	≤ 0.75 ms
57600	0.191 ms	≥ 1.75 ms	≤ 0.556 ms
76800	0.143 ms	≥ 1.75 ms	≤ 0.417 ms
93750	0.117 ms	≥ 1.75 ms	≤ 0.341 ms
115200	0.095 ms	≥ 1.75 ms	≤ 0.278 ms
187500	0.059 ms	≥ 1.75 ms	≤ 0.171 ms

Note

The factory setting for p2024[1] and p2024[2] is 0. The particular values are pre-assigned depending on the protocol selection (p2030) or the baud rate.

Modbus register and Control Unit parameters

Since the Modbus protocol can only handle register or bit numbers for addressing the memory, assignment to the appropriate control words, status words and parameters is performed on the slave side.

The converter supports the following addressing ranges:

Addressing range	Remark
40001 … 40065	Compatible with Micromaster MM436
40100 … 40522	

The valid holding register addressing range extends from 40001 to 40522. Access to other holding registers generates the fault "Exception Code".

The registers 40100 to 40111 are described as process data. A telegram monitoring time can be activated in p2040 for these registers.

Note

R"; "W"; "R/W" in the column Modbus access stands for read (with FC03); write (with FC06); read/write.

Table 8- 27 Assigning the Modbus register to the parameters of the Control Unit

Modbus Reg. No.	Description	Modbus access	Unit	Scaling factor	On/Off text or value range		Data / parameter
Process data							
Control data							
40100	Control word	R/W	--	1			Process data 1
40101	Main setpoint	R/W	--	1			Process data 2
Status data							
40110	Status word	R	--	1			Process data 1
40111	Main actual value	R	--	1			Process data 2
Parameter data							
Digital outputs							
40200	DO 0	R/W	--	1	HIGH	LOW	p0730, r747.0, p748.0
40201	DO 1	R/W	--	1	HIGH	LOW	p0731, r747.1, p748.1
40202	DO 2	R/W	--	1	HIGH	LOW	p0732, r747.2, p748.2
Analog outputs							
40220	AO 0	R	%	100	-100.0 … 100.0		r0774.0
40221	AO 1	R	%	100	-100.0 … 100.0		r0774.1
Digital inputs							
40240	DI 0	R	--	1	HIGH	LOW	r0722.0
40241	DI 1	R	--	1	HIGH	LOW	r0722.1
40242	DI 2	R	--	1	HIGH	LOW	r0722.2
40243	DI 3	R	--	1	HIGH	LOW	r0722.3
40244	DI 4	R	--	1	HIGH	LOW	r0722.4
40245	DI 5	R	--	1	HIGH	LOW	r0722.5
Analog inputs							
40260	AI 0	R	%	100	-300.0 … 300.0		r0755 [0]
40261	AI 1	R	%	100	-300.0 … 300.0		r0755 [1]
40262	AI 2	R	%	100	-300.0 … 300.0		r0755 [2]
40263	AI 3	R	%	100	-300.0 … 300.0		r0755 [3]

Modbus Reg. No.	Description	Modbus access	Unit	Scaling factor	On/Off text or value range		Data / parameter
Converter identification							
40300	Powerstack number	R	--	1	0 … 32767		r0200
40301	Converter firmware	R	--	0.0001	0.00 … 327.67		r0018
Converter data							
40320	Rated power of the power unit	R	kW	100	0 … 327.67		r0206
40321	Current Limit	R/W	%	10	10.0 … 400.0		p0640
40322	Rampup time	R/W	s	100	0.00 … 650.0		p1120
40323	Ramp-down time	R/W	s	100	0.00 … 650.0		p1121
40324	Reference speed	R/W	RPM	1	6.000 … 32767		p2000
Converter diagnostics							
40340	Speed setpoint	R	RPM	1	-16250 … 16250		r0020
40341	Speed actual value	R	RPM	1	-16250 … 16250		r0022
40342	Output frequency	R	Hz	100	- 327.68 … 327.67		r0024
40343	Output voltage	R	V	1	0 … 32767		r0025
40344	DC link voltage	R	V	1	0 … 32767		r0026
40345	Actual value of current	R	A	100	0 … 163.83		r0027
40346	Actual torque value	R	Nm	100	- 325.00 … 325.00		r0031
40347	Actual active power	R	kW	100	0 … 327.67		r0032
40348	Energy consumption	R	kWh	1	0 … 32767		r0039
40349	Control priority	R	--	1	HAND	AUTO	r0807
Fault diagnostics							
40400	Fault number, Index 0	R	--	1	0 … 32767		r0947 [0]
40401	Fault number, Index 1	R	--	1	0 … 32767		r0947 [1]
40402	Fault number, Index 2	R	--	1	0 … 32767		r0947 [2]
40403	Fault number, Index 2	R	--	1	0 … 32767		r0947 [3]
40404	Fault number, Index 3	R	--	1	0 … 32767		r0947 [4]
40405	Fault number, Index 4	R	--	1	0 … 32767		r0947 [5]
40406	Fault number, Index 5	R	--	1	0 … 32767		r0947 [6]
40407	Fault number, Index 6	R	--	1	0 … 32767		r0947 [7]
40408	Alarm number	R	--	1	0 …32767		r2110 [0]
40499	PRM ERROR code	R	--	1	0 …99		--
Technology controller							
40500	Technology controller enable	R/W	--	1	0 … 1		p2200, r2349.0
40501	Technology controller MOP	R/W	%	100	-200.0 … 200.0		p2240

Modbus Reg. No.	Description	Modbus access	Unit	Scaling factor	On/Off text or value range	Data / parameter
Technology controller adjustment						
40510	Time constant for actual value filter of the technology controller	R/W	--	100	0.00 … 60.0	p2265
40511	Scaling factor for actual value of the technology controller	R/W	%	100	0.00 … 500.00	p2269
40512	Proportional amplification of the technology controller	R/W	--	1000	0.000 … 65.000	p2280
40513	Integral time of the technology controller	R/W	s	1	0 … 60	p2285
40514	Time constant D-component of the technology controller	R/W	--	1	0 … 60	p2274
40515	Max. limit of technology controller	R/W	%	100	-200.0 … 200.0	p2291
40516	Min. limit technology controller	R/W	%	100	-200.0 … 200.0	p2292
PID diagnostics						
40520	Effective setpoint acc. to internal technology controller MOP ramp-function generator	R	%	100	-100.0 … 100.0	r2250
40521	Actual value of technology controller after filter	R	%	100	-100.0 … 100.0	r2266
40522	Output signal technology controller	R	%	100	-100.0 … 100.0	r2294

8.4.3.5 Write and read access via FC 3 and FC 6

Function codes used

For data exchange between the master and slave, predefined function codes are used for communication via Modbus.

The Control Unit uses the Modbus function code 03, FC 03, (read holding registers) for reading and the Modbus function code 06, FC 06, (preset single register) for writing.

Structure of a read request via Modbus function code 03 (FC 03)

All valid register addresses are permitted as a start address. If a register address is invalid, exception code 02 (invalid data address) is returned. An attempt to read a write-only register or a reserved register is replied to with a normal telegram in which all values are set to 0.

Using FC 03, it is possible to address more than 1 register with one request. The number of addressed registers is contained in bytes 4 and 5 of the read request.

Number of registers

If more than 125 registers are addressed, exception code 03 (Illegal data value) is returned. If the start address plus the number of registers for an address are outside of a defined register block, exception code 02 (invalid data address) is returned.

Table 8- 28 Structure of a read request for slave number 17

Example		
	Byte	Description
11 h	0	Slave address
03 h	1	Function code
00 h	2	Register start address "High" (register 40110)
6D h	3	Register start address "Low"
00 h	4	No. of registers "High" (2 registers: 40110; 40111)
02 h	5	Number of registers "Low"
xx h	6	CRC "Low"
xx h	7	CRC "High"

The response returns the corresponding data set:

Table 8- 29 Slave response to the read request

Example		
	Byte	Description
11 h	0	Slave address
03 h	1	Function code
04 h	2	No. of bytes (4 bytes are returned)
11 h	3	Data of first register "High"
22 h	4	Data of first register "Low"
33 h	5	Data of second register "High"
44 h	6	Data of second register "Low"
xx h	7	CRC "Low"
xx h	8	CRC "High"

Structure of a write request via Modbus function code 06 (FC 06)

The start address is the holding register address. If an incorrect address is entered (a holding register address does not exist), exception code 02 (invalid data address) is returned. An attempt to write to a "read-only" register or a reserved register is replied to with a Modbus error telegram (Exception Code 4 - device failure). In this instance, the detailed internal error code that occurred on the last parameter access via the holding registers can be read out via holding register 40499.

Using FC 06, precisely one register can always be addressed with one request. The value which is to be written to the addressed register is contained in bytes 4 and 5 of the write request.

Table 8- 30 Structure of a write request for slave number 17

Example		
	Byte	Description
11 h	0	Slave address
06 h	1	Function code
00 h	2	Register start address "High" (write register 40100)
63 h	3	Register start address "Low"
55 h	4	Register data "High"
66 h	5	Register data "Low"
xx h	6	CRC "Low"
xx h	7	CRC "High"

The response returns the register address (bytes 2 and 3) and the value (bytes 4 and 5) that was written to the register.

Table 8- 31 Slave response to the write request

Example		
	Byte	Description
11 h	0	Slave address
06 h	1	Function code
00 h	2	Register start address "High"
63 h	3	Register start address "Low"
55 h	4	Register data "High"
66 h	5	Register data "Low"
xx h	6	CRC "Low"
xx h	7	CRC "High"

8.4.3.6 Communication procedure

Procedure for communication in a normal case

Normally, the master sends a telegram to a slave (address range 1 ... 247). The slave sends a response telegram to the master. This response telegram mirrors the function code, and the slave enters its own address in the telegram, which enables the master to assign the slave.

The slave only processes orders and telegrams which are directly addressed to it.

Communication errors

If the slave detects a communication error on receipt (parity, CRC), it does not send a response to the master (this can lead to "setpoint timeout").

Logical error

If the slave detects a logical error within a request, it responds to the master with an "exception response". In the response, the highest bit in the function code is set to 1. If the slave receives, for example, an unsupported function code from the master, the slave responds with an "exception response" with code 01 (Illegal function code).

Table 8- 32 Overview of exception codes

Exception code	Modbus name	Remark
01	Illegal function code	An unknown (not supported) function code was sent to the slave.
02	Illegal Data Address	An invalid address was requested.
03	Illegal data value	An invalid data value was detected.
04	Server failure	Slave has terminated during processing.

Maximum processing time, p2024[0]

For error-free communication, the slave response time (time within which the Modbus master expects a response to a request) must have the same value in the master and the slave (p2024[0] in the converter).

Process data monitoring time (setpoint timeout), p2040

The alarm "Setpoint timeout" (F1910) is issued by the Modbus if p2040 is set to a value > 0 ms and no process data are requested within this time period.

The alarm "Setpoint timeout" only applies for access to process data (40100, 40101, 40110, 40111). The alarm "Setpoint timeout" is not generated for parameter data (40200 … 40522).

Note

This time must be adapted depending on the number of slaves and the baud rate set for the bus (factory setting = 100 ms).

8.5 Communication via CANopen

Connecting an inverter to a CAN bus

Connect the inverter to the fieldbus via the 9-pin SUB-D pin connector.

The connections of this pin connector are short-circuit proof and isolated. If the inverter forms the first or last slave in the CANopen network, then you must switch-in the bus terminating resistor.

For additional information on the SUB-D pin connector and on the bus terminating resistor, please refer to Section Interfaces, connectors, switches, terminal blocks and LEDs of the converter (Page 42).

Integrating the converter into CANopen

We recommend the following procedure to integrate the converter into CANopen:

1. Setting the node ID and baud rate
2. Monitoring the communication and response of the inverter (Page 134) set
3. Integrating the converter into CAN using the Predefined Connection Set
4. if required, make additional specific changes using the free PDO mapping.
5. Adapting the BiCo interconnection

Note

In the configuration example (Page 156) you can find a detailed description of how you integrate the converter into a CANopen system.

More information about how to configure the communication is provided in Sections Further CANopen functions (Page 145) and List of objects (Page 148).

General information on CAN

You can find general information on CAN in the CAN Internet pages (http://www.can-cia.org); you can obtain an explanation of CAN terminology in the CANdictionary under CAN downloads (http://www.can-cia.org/index.php?id=6).

8.5.1 Configuring communication to the control

The EDS file is the description file of the SINAMICS G120 converter for CANopen networks.

If you load the EDS file into your CAN controller, you can use the objects of the DSP 402 device profile.

1. You can find the EDS file of the converter inInternet (http://support.automation.siemens.com/WW/view/en/48351511).

In Section Engineering example (Page 156), you can find an example of how you can integrate the converter into a CAN controller using the EDS.

8.5.2 CANopen functionality of the inverter

CANopen is a CAN-based communication protocol with linear topology that operates on the basis of communication objects (COB).

Communication between the converter and control can be established via Predefined connection set (Page 143) or via Free PDO mapping (Page 144)

Communication objects (COB)

The converter operates with communication objects from the following profiles:

- CANopen communication profile DS 301 version 4.0
- Device profile DSP 402 (drives and motion control) version 2.0
- Indicator profile DR303-3 version 1.0.

Specifically, these are:

- SDO
  Service data objects for reading and changing parameters
- PDO
  Process data objects to transfer process data, TPDO to send, RPDO to receive
- NMT
  Network management objects (NMT) for controlling CANopen communication and for monitoring the individual nodes on the basis of a master-slave relationship.
- SYNC
  Synchronization objects
- EMCY
  Time stamp and fault messages

COB ID

A communication object includes data – which is transferred – and an 11 bit COB-ID, which uniquely identifies it. The priority when executing the communication objects is controlled using the COB-ID. The communication object with the lowest COB-ID always has the highest priority.

COB ID for individual communication objects

You will find the specifications for the COB IDs of the individual communication objects below

- COB ID$_{NMT}$ = 0 cannot be changed
- COB ID$_{SYNC}$ = free in most cases, this is preassigned with 80 hex
- COB ID$_{EMCY}$ = free In most of the cases, COB ID$_{SYNC}$ + node-ID = COB-ID$_{EMCY}$
- COB-ID$_{TPDO}$= free In the free PDO mapping *)
- COB-ID$_{RPDO}$= free In the free PDO mapping *)
- COB ID$_{TSDO}$ = 580 + Node-ID
- COB ID$_{RSDO}$ = 600 + Node-ID
- COB ID$_{Node\ Guarding/Heartbeat}$= 700 + Node-ID

*) COB-ID for RPDO and TPDO for the "Predefined Connection Set", seePage (Page 143).

8.5.3 Commissioning CANopen

8.5.3.1 Setting the node ID and baud rate

In the converter you must set the node ID and the baud rate to permit communication.

CAUTION
Changes made to the node ID or baud rate only become effective after switching off and on again. It is particularly important that any external 24 V supply is switched off. Note that before turning off, you must save the changes using RAM -> ROM (). The currently active Node ID is displayed in parameter r8621.

Setting the node ID

You can define the node ID either using the address switch on the CU via parameter p8620 or in STARTER in the screen form under "Control Unit/Communications/CAN" under the CAN interface tab.

Valid address range: 1 … 126

When a valid node ID has been set using the address switches, then this is always effective and p8620 cannot be changed.

If you set all address switches to "OFF" (0) or "ON" (1), specify the node ID via p8620 or STARTER.

The positions and settings of the address switches are described in section Interfaces, connectors, switches, terminal blocks and LEDs of the converter (Page 42).

Setting the data transmission rate

You can set the transmission rate in the range from 10 kbit/s … 1 Mbit/s using parameter p8622 or in the STARTER screen form "Control Unit/Communication/CAN" under the CAN interface tab.

8.5.3.2 Monitoring the communication and response of the inverter

The communication monitoring can be used via both node guarding and heartbeat protocol (heartbeat producer).

Node guarding

The master sends monitoring queries to the slaves via the node guarding protocol.

If the converter does not receive a Node Guarding protocol within the Life Time, then it outputs fault (F08700).

Life Time = Guard time (p8601.0) * Life Time Factor (p8604.1)

Heartbeat

The slave periodically sends heartbeat messages. Other slaves and the master can monitor this message. If a heartbeat goes missing, then appropriate responses can be set in the master.

The settings for the heartbeat protocol are made in parameter p8606.

Note

Note

Node guarding and heartbeat are mutually interlocked. This means that if the parameter for one of these functions is not equal to 0, then the other cannot be used.

Both functions are deactivated in the factory setting.

Converter response to a bus fault - CAN controller state "Bus off" (converter fault F8700, fault value 1)

If you acknowledge the bus fault using OFF/ON, the bus OFF state is also canceled and communication is restarted.

If you acknowledge the bus fault via DI 2 or directly via p3981, then the converter remains in the bus OFF state. To restart communication, in this case, you must set p8608 to 1.

⚠ WARNING
If you acknowledge the bus fault via DI 2 or directly via p3981 - and p8641 is set to 0 (for a bus fault, the converter does not go into a fault condition), then you must restart communication via p8608 = 1 before you can stop the motor via the control.

8.5.3.3 SDO services

You can access the object directory of the connected drive unit using the SDO services. An SDO connection is a peer-to-peer coupling between an SDO client and a server.

The drive unit with its object directory is an SDO server.

The identifiers for the SDO channel of a drive unit are defined according to CANopen as follows.

Receiving:	Server <= Client:	COB ID = 600 hex + node ID
Transmitting:	Server => Client:	COB ID = 580 hex + node ID

Properties

The SDOs have the following properties:

- SDO are transferred in the Preoperational and Operational states
- The transfer is confirmed
- Transfer is asynchronous (corresponds to acyclic data exchange for PROFIBUS DB)
- Transmission of values > 4 bytes (normal transfer)
- Transmission of values ≤ 4 bytes (expedited transfer)
- All drive unit parameters can be addressed via SDO.

Structure of the SDO protocols

The SDO services use the appropriate protocol depending on the task. The basic structure is shown below:

Header information			n user data
Byte 0	Byte 1 und 2	Byte 3	Byte 4 ... 7
CS	index	sub index	length

- The protocol type is contained in byte 0:
  - 2F hex: write 4 bytes
  - 2B hex: write 3 bytes
  - 27 hex: write 2 bytes
  - 23 hex: write 1 byte
  - 40 hex: read request
  - 4F hex: read 4 bytes
  - 4B hex: read 3 bytes
  - 47 hex: read 2 bytes
  - 43 hex: read 1 byte
  - 60 hex: write acknowledgment
  - 80 hex: error
- Bytes 1 and 2 contain the index (SINAMICS parameter number)
- Byte 3 contains the subindex (SINAMICS parameter index)
- Bytes 4 … 7 contain the data corresponding to the second position of byte 0. In the case of an error, these bytes contain the abort code

SDO abort codes

Table 8- 33 SDO abort codes

Abort code	Description
0503 0000h	Toggle bit not alternated. Toggle bit has not changed
0504 0000h	SDO protocol timed out. Timeout for SDO protocol
0504 0001h	Client/server command specifier not valid or unknown. Client/server command not valid or unknown
0504 0005h	Out of memory. Memory overflow
0601 0000h	Unsupported access to an object. Access to an object that is not supported
0601 0001h	Attempt to read a write only object. An attempt is made to read a "write-only object"
0601 0002h	Attempt to write a read only object. An attempt is made to write to a "read-only object"
0602 0000h	Object does not exist in the object dictionary. Object does not exist in an object dictionary
0604 0041h	Object cannot be mapped to the PDO. Object cannot be linked with the PDO
0604 0042h	The number and length of the objects to be mapped would exceed PDO length. The number and length of the objects that are to be linked exceeds the PDO length
0604 0043h	General parameter incompatibility reason. Basic parameter incompatibility
0604 0047h	General internal incompatibility in the device. Basic incompatibility in the device
0602 0000h	Object does not exist in the object dictionary. Object does not exist in an object dictionary
0604 0041h	Object cannot be mapped to the PDO. Object cannot be linked with the PDO
0604 0042h	The number and length of the objects to be mapped would exceed PDO length. The number and length of the objects that are to be linked exceeds the PDO length
0604 0043h	General parameter incompatibility reason. Basic parameter incompatibility
0604 0047h	General internal incompatibility in the device. Basic incompatibility in the device
0606 0000h	Access failed due to an hardware error. Access has failed due to a hardware fault
0607 0010h	Data type does not match, length of service parameter does not match. Data type and length of the service parameter do not match

0607 0012h	Data type does not match, length of service parameter too high. Data type is not correct, service parameter is too long
0607 0013h	Data type does not match, length of service parameter too low. Data type is not correct, service parameter is too short
0609 0011h	Subindex does not exist Subindex does not exist
0609 0030h	Value range of parameter exceeded (only for write access). Value range of the parameter exceeded (only for write access)
0609 0031h	Value of parameter written too high. Subindex does not exist
0609 0032h	Value of parameter written too low. Value of written parameter too low
0609 0036h	Maximum value is less than minimum value. Maximum value is less than the minimum value
0800 0000h	General error. General error
0800 0020h	Data cannot be transferred or stored to the application. Data cannot be transferred or saved in the application
0800 0021h	Data cannot be transferred or stored to the application because of local control. Data cannot be transferred or saved due to the local control
0800 0022h	Data cannot be transferred or stored to the application because of the current device state. Data cannot be transferred or saved due to the device condition
0800 0023h	Object dictionary dynamic generation failed or no object dictionary is present (e.g. object dictionary is generated from file and generation fails because of a file error). Dynamic creation of the object dictionary failed - or an object dictionary does not exist (e.g. object directory was generated from a defective file)

8.5.3.4 Access to SINAMICS parameters via SDO

If you wish to change inverter parameters in CANopen using the control, then use the service data objects (SDO). SDO are transferred in the operational as well as in the pre-operational states.

You can also configure RPDO and TPDO telegrams via SDO. You can find the objects that are available to do this in Section List of objects (Page 148).

Adapting the parameter numbers

The inverter parameters can be addressed via the SDO parameter channel in the range from 2000 hex ... 470F hex of the CANopen object directory.

Not all of the parameters can be directly addressed via this range. This is the reason that in CAN, an inverter parameter always comprises two parameters from the inverter; these are the offset specified using parameter p8630[2] and the parameter itself.

- for all parameters < 9999 the following applies:
  - p8630[2] = 0,
  - Inverter parameters -> hex + 2000 hex

    Example: For parameter p0010, 200A hex follows as object number in the SDO job
- for all parameters 9999 < 19999 the following applies:
  - p8630[2] = 1,
  - (inverter parameters - 10000) -> hex + 2000 hex

    Example: For parameter p11000, 23E8 hex follows as object number in the SDO job
- for all parameters 19999 < 29999 the following applies:
  - p8630[2] = 2,
  - (inverter parameters - 20000) -> hex + 2000 hex

    Example: For parameter r20001, 2001 hex follows as object number in the SDO job
- for all parameters 29999 < 39999, the following applies:
  - p8630[2] = 3,
  - (inverter parameters - 30000) -> hex + 2000 hex

    Example: For parameter p31020, 23FC hex follows as object number in the SDO job

Selection, index range

Further, no more than 255 indices can be transferred in a CANopen object. This means that additional CANopen objects must be created for parameters that have more indices. This is realized using p8630[1]. It is possible to transfer a maximum of 1024 indices.

- P8630[1] = 0: 0 … 255
- P8630[1] = 1: 256 … 511
- P8630[1] = 2: 512 … 767
- P8630[1] = 3: 768 … 1023

Accessing CANopen objects and inverter parameters

- p8630[0] = 0: only accessing CANopen objects (SDO, PDO, ...)
- p8630[0] = 1: Access to virtual CANopen objects (inverter parameters)
- p8630[0] = 2: not relevant for G120 inverters

8.5.3.5 PDO and PDO services

Process data objects (PDO)

For CANopen, (real-time) transfer of process data is realized using "Process Data Objects" (PDO). There are send and receive PDO. With the G120 inverter, eight send PDO (TPDO) and eight receive PDO (RPDO) are transferred.

A PDO is defined by the PDO communication parameter and the PDO mapping parameter.

The PDO must be linked with the objects of the object dictionary which contain process data. You can use Free PDO mapping (Page 144) or the Predefined connection set (Page 143) to do this.

Note

Changing over between an interconnection via free PDO mapping and Predefined Connection Set

For changing over from free PDO mapping (factory setting) to mapping via the Predefined Connection Set you require parameters p8744 and p8741 from the expert list.

You can select the method of the interconnection using p8744 (p8744 = 0: Free PDO mapping, p8744 = 1: Predefined Connection Set), with p8741 =1 you confirm the transfer. After transfer, p8741 returns to 0.

Parameter area for PDO

- RPDO
  - In the inverter: p8700 … p8717
  - In CAN: 1400 hex ff
- TPDO
  - In the inverter: p8720 … p8737
  - In CAN: 1800 hex ff

Note

One channel in the CAN controller is assigned for each RPDO. TPDO always use two permanently set channels in the CAN controller

---

The structure of this communication and mapping parameter is listed in the following tables.

Table 8- 34 PDO communications parameter
RPDO: 1400h ff (p8700 … 8707), TPDO: 1800h ff (p8720 … p8727)

Subindex	Name	Data type	Parameter index (inverter)
00h	Highest subindex that is supported	UNSIGNED8	---
01h	COB ID	UNSIGNED32	0
02h	Transfer mode	UNSIGNED8	1
03h	Inhibit time (only for TPDO)	UNSIGNED16	2
04h	Reserved (only for TPDO)	UNSIGNED8	3
05h	Event timer (only for TPDO)	UNSIGNED16	4

Table 8- 35 PDO mapping parameter
RPDO: 1600h ff (p8710 … 8717), TPDO: 1A00h ff (p8730 … p8730)

Subindex	Name	Data type	Parameter index (inverter)
00h	Number of objects mapped to the PDO (max. 4)	UNSIGNED8	---
01h	First mapped object	UNSIGNED32	0
02h	Second mapped object	UNSIGNED32	1
03h	Third mapped object	UNSIGNED32	2
04h	Fourth mapped object	UNSIGNED32	3

For process data objects, the following transfer types are available, which you set in index 1 of the communication parameter (p8700 … p8707 / p8720 … p8727) in the inverter.

- Synchronous cyclic (index 1: n = 1 … 240) - for TPDO (Transmit PDO) and RPDO (Receive PDO):
  - TPDO is sent after each nth SYNC
  - RPDO is received after each nth SYNC
- Synchronous acyclic (index 1: 0) - for TPDO
  - TPDO is sent if a SYNC is received and a process data has changed in the telegram.
- asynchronous cyclic (index 1: 254, 255 + event time) - for TPDO
  - TPDO is sent if process data has changed in the telegram.
- asynchronous acyclic (index 1: 254, 255) - for TPDO and RPDO
  - TPDO is sent if process data has changed in the telegram.
  - RPDO is directly accepted when it is received.

Synchronous data transmission

In order for the devices on the CANopen bus to remain synchronized during transmission, a synchronization object (SYNC object) must be transmitted at periodic intervals.

Each PDO that is transferred as a synchronous object must be assigned a transmission type 1 ... n. The following is applicable:

- Transmission type 1: the PDO is transferred in every SYNC cycle.
- Transmission type n: the PDO is transferred in every nth SYNC cycle.

The following diagram shows the principle of synchronous and asynchronous transmission:

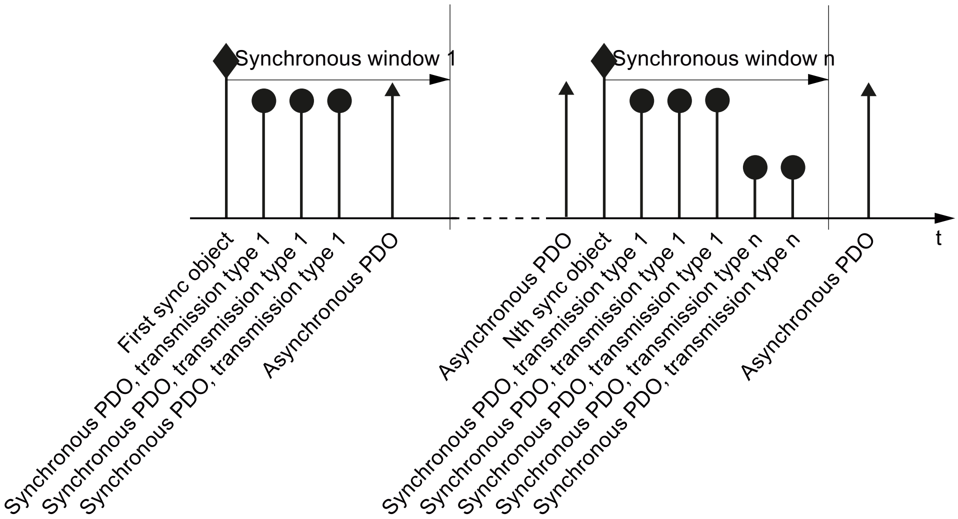


Figure 8-17 Principle of synchronous and asynchronous transmission

For synchronous TPDOs, the transmission mode also identifies the transmission rate as a factor of the SYNC object transmission intervals. Here, transmission type "1" means that the message will be transmitted in every SYNC object cycle. Transmission type "n" means that the message will be transmitted in every nth SYNC object cycle.

Data from synchronous RPDOs that are received after a SYNC signal is not transmitted to the application until after the next SYNC signal.

Note

The SYNC signal does not synchronize the applications in the SINAMICS drive, only the communication on the CANopen bus

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Asynchronous data transmission

Asynchronous PDOs are transferred - cyclically or acyclically - without reference to the SYNC signal.

PDO services

The PDO services can be subdivided as follows:

- Write PDO
- Read PDO
- SYNC service

Write PDO

The "Write PDO" service is based on the "push" model. The PDO has exactly one producer. There can be no consumer, one consumer, or multiple consumers.

Via Write PDO, the producer of the PDO sends the data of the mapped application object to the individual consumer.

Read PDO

The "Read PDO" service is based on the "pull" model. The PDO has exactly one producer. There can be one consumer or multiple consumers.

Via Read PDO, the consumer of the PDO receives the data of the mapped application object from the producer.

SYNC service

The SYNC object is periodically sent from the SYNC producer. The SYNC signal represents the basic network cycle. The time interval between two SYNC signals is determined in the master by the standard parameter "Communication cycle time".

In order to ensure CANopen accesses in real-time, the SYNC object has a high priority, which is defined using the COB ID. This can be changed via p8602 (factory setting = 80hex). The service runs unconfirmed.

Note

The COB ID of the SYNC object must be set to the same value for all nodes of a bus that should respond to the SYNC telegram from the master

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The COB ID of the SYNC object is defined in object 1005h (p8602).

8.5.3.6 Predefined connection set

When integrating the converter via the predefined connection set, the converter is interconnected so that the motor can be switched-on via the control and a setpoint can be entered without having to make any additional settings or requiring CANopen know-how. The converter returns the status word and the speed actual value to the control.

In the factory, the converter is set to free PDO mapping. Changeover to the Predefined Connection Set, see Section PDO and PDO services (Page 140).

Once you have made the settings for the predefined connection set, then in the screen form "Control Unit/Communication/CAN", select the Operational status under the Network-Management tab. You can then switch-on the motor from the control and enter a setpoint.

Data, which you transfer using the predefined connection set

- TPDO 1 with Control word 1
- RPDO 1 with Status word 1
- TPDO 2 with Control word 1 and speed setpoint
- RPDO 2 with Status word 1 and speed actual value

The COB IDs are calculated according to the following formula and entered into parameters p8700, p8701, p8720 and 8721.

COB-Id for TPDO and RPDO in the Predefined Connection Set

- **COB-ID**$_{TPDO}$ = 180 hex + Node-ID + ((TPDO-No. - 1) * 100 hex)

  Example: COB-ID of the TPDO 2, (Node ID = C hex)
  180 hex + C hex + ((2 - 1)*100 hex) = 18C hex + 100 hex = 28C hex is required
- **COB ID**$_{RPDO}$ = 200 hex + Node-ID + ((RPDO-No. - 1) * 100 hex)

  Example: COB-ID of the 3rd RPDO, (Node ID = C hex)
  200 hex + C hex + ((2 - 1) * 100 hex) = 20C hex + 100 hex = 30C hex is required

8.5.3.7 Free PDO mapping

Using the free PDO mapping, you can interconnect additional process data from the object directory corresponding to the requirements of your particular system for the PDO service.

In the factory, the converter is set to free PDO mapping. If your converter has been changed over to the Predefined Connection Set, you must change over to free PDO mapping, see Section PDO and PDO services (Page 140).

A PDO can transfer up to eight bytes of user data. With mapping, you define which user data are transferred in a PDO.

Example

The following diagram shows an example of PDO mapping (values are hexadecimal (e.g. object size 10 hex = 16 bits)):

For the control word and the setpoint speed

p08711[0] = 6040

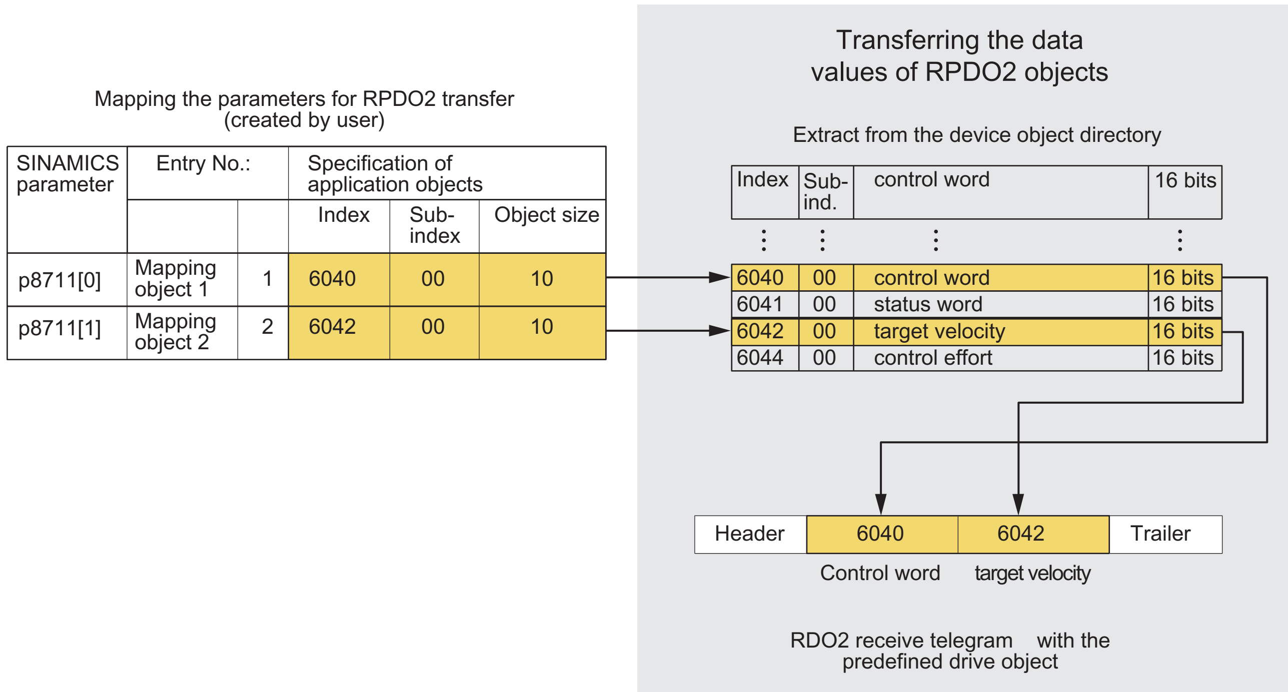


Figure 8-18 PDO mapping for control word and speed setpoint

8.5.4 Further CANopen functions

8.5.4.1 Network management (NMT service)

Network management (NMT) is node-oriented and has a master-slave topology.

The NMT services can be used to initialize, start, monitor, reset, or stop nodes. Two data bytes follow each NMT service. All NMT services have the COB ID = 0. This cannot be changed.

The SINAMICS converter is an NMT slave and can adopt the following states in CANopen:

- Initializing
  The converter passes through this state after Power On. In the factory setting, the converter then enters the "Pre-Operational" state, which also corresponds to the CANopen standard.
  Using p8684, you can set that after the bus has booted, the converter does not go into the "Pre-Operational" state, but instead, into the "Stopped" or "Operational" state.
- Pre-Operational
  In this state, the node cannot process any process data (PDO). It can, however, be parameterized or operated via SDOs, which means that you can also enter setpoints via SDO.

- Operational
  In this state, the node can process both SDO and PDO.
- Stopped
  In this state, the node cannot process either PDO or SDO. The Stopped mode is exited by specifying one of the following commands:
  - Enter Pre-Operational
  - Start Remote Node
  - Reset Node
  - Reset Communication

The NMT recognizes the following transitional states:

- Start Remote Node:
  command for switching from the "Pre-Operational" communication status to "Operational". The drive can only transmit and receive process data (PDO) in "Operational" status.
- Stop Remote Node
  command for switching from "Pre-Operational" or "Operational" to "Stopped". The node can only process NMT commands in the "Stopped" status.
- Enter Pre-Operational
  command for switching from "Operational" or "Stopped" to "Pre-Operational". In this state, the node cannot process any process data (PDO). It can, however, be parameterized or operated via SDOs, which means that you can also enter setpoints via SDO.
- Reset Node:
  command for switching from "Operational", "Pre-Operational", or "Stopped" to "Initialization". When the Reset Node command is issued, all the objects (1000 hex - 9FFF hex) are reset to the status that was present after "Power On".
- Reset Communication:
  command for switching from "Operational", "Pre-Operational", or "Stopped" to "Initialization". When the Reset Communication command is issued, all communication objects (1000 hex - 1FFF hex) are reset to the status that was present after "Power On".

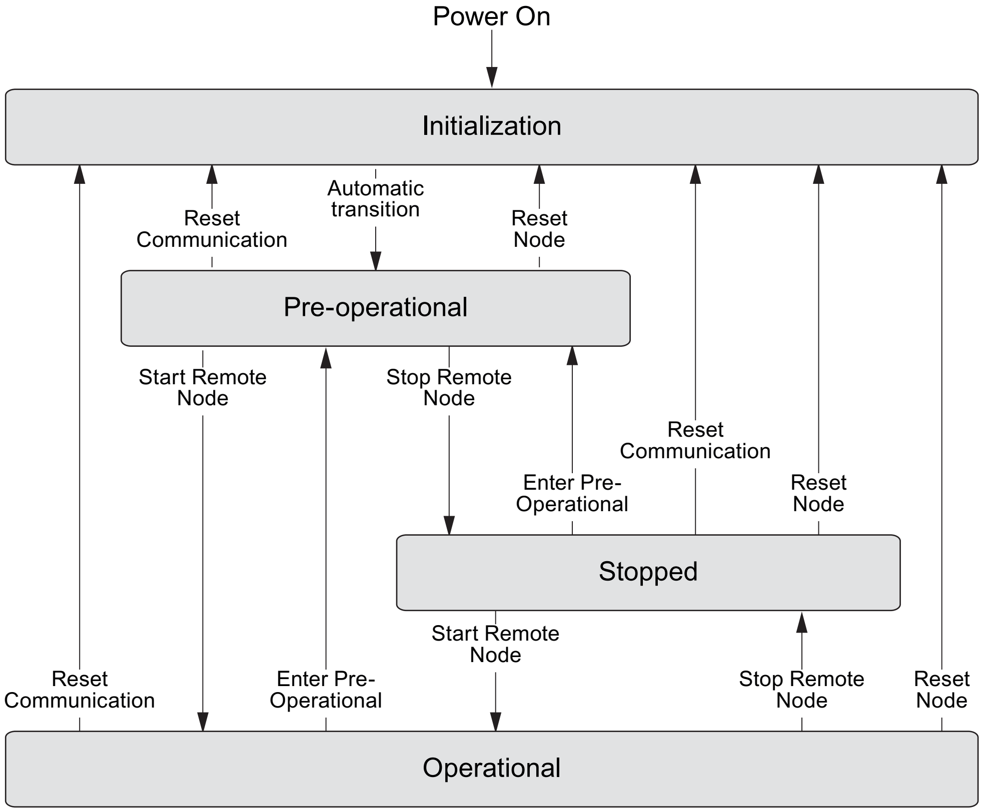


Figure 8-19 CANopen status diagram

The transition states and addressed nodes are displayed using the command specifier and the Node_ID:

Table 8- 36 Overview of NMT commands

NMT Master Request ----> NMT Slave message		
Command	**Byte 0 (command specifier, CS)**	**Byte 1**
Start	1 (01hex)	Node ID of the addressed node
Stop	2 (02hex)	Node ID of the addressed node
Enter Pre-Operational	128 (80hex)	Node ID of the addressed node
Reset Node	129 (81hex)	Node ID of the addressed node
Reset Communication	130 (82 hex)	Node ID of the addressed node

The NMT master can simultaneously direct a request to one or more slaves. The following is applicable:

- Requirement of a slave:
  The slave is addressed using its node ID (1 - 127).
- Requirement for all slaves:
  Node ID = 0

The current state of the node is displayed via p8685. It can also be changed directly using this parameter:

- p8685 = 0 Initializing (display only)
- p8685 = 4 Stopped
- p8685 = 5 Operational
- p8685 = 127 Pre-Operational (factory setting)
- p8685 = 128 Reset Node
- p8685 = 129 Reset Communication

You can also change the NMT status in STARTER via "Control_Unit / Communication / CAN" under the "Network-Management" tab.

8.5.5 List of objects

RPDO configuration objects

The following tables list the communication and mapping parameters together with the indices for the individual RPDO configuration objects. The configuration objects are established via SDO.

Table 8- 37 RPDO configuration objects - communication parameters

OD Index (hex)	Sub-Index (hex)	Name of the object	SINAMICS parameters	Data type	Predefined connection set	Can be read/ written to
1400		Receive PDO 1 communication parameter				
	0	Largest subindex supported		Unsigned8	2	R
	1	COB ID used by PDO	p8700.0	Unsigned32	200 hex + node ID	R/W
	2	Transmission type	p8700.1	Unsigned8	FE hex	R/W
1401		Receive PDO 2 communication parameter				
	0	Largest subindex supported		Unsigned8	2	R
	1	COB ID used by PDO	p8701.0	Unsigned32	300 hex + node ID	R/W
	2	Transmission type	p8701.1	Unsigned8	FE hex	R/W
1402		Receive PDO 3 communication parameter				
	0	Largest subindex supported		Unsigned8	2	R
	1	COB ID used by PDO	p8702.0	Unsigned32	8000 06DF hex	R/W
	2	Transmission type	p8702.1	Unsigned8	FE hex	R/W
1403		Receive PDO 4 communication parameter				
	0	Largest subindex supported		Unsigned8	2	R
	1	COB ID used by PDO	p8703.0	Unsigned32	8000 06DF hex	R/W
	2	Transmission type	p8703.1	Unsigned8	FE hex	R/W

OD Index (hex)	Sub-Index (hex)	Name of the object	SINAMICS parameters	Data type	Predefined connection set	Can be read/ written to
1404		Receive PDO 5 communication parameter				
	0	Largest subindex supported		Unsigned8	2	R
	1	COB ID used by PDO	p8704.0	Unsigned32	8000 06DF hex	R/W
	2	Transmission type	p8704.1	Unsigned8	FE hex	R/W
1405		Receive PDO 6 communication parameter				
	0	Largest subindex supported		Unsigned8	2	R
	1	COB ID used by PDO	p8705.0	Unsigned32	8000 06DF hex	R/W
	2	Transmission type	p8705.1	Unsigned8	FE hex	R/W
1406		Receive PDO 7 communication parameter				
	0	Largest subindex supported		Unsigned8	2	R
	1	COB ID used by PDO	p8706.0	Unsigned32	8000 06DF hex	R/W
	2	Transmission type	p8706.1	Unsigned8	FE hex	R/W
1407		Receive PDO 8 communication parameter				
	0	Largest subindex supported		Unsigned8	2	R
	1	COB ID used by PDO	p8707.0	Unsigned32	8000 06DF hex	R/W
	2	Transmission type	p8707.1	Unsigned8	FE hex	R/W

Table 8- 38 RPDO configuration objects - mapping parameters

OD Index (hex)	Sub-Index (hex)	Name of the object	SINAMICS parameters	Data type	Predefined connection set	Can be read/ written to
1600		Receive PDO 1 mapping parameter				
	0	Number of mapped application objects in PDO		Unsigned8	1	R
	1	PDO mapping for the first application object to be mapped	p8710.0	Unsigned32	6040 hex	R/W
	2	PDO mapping for the second application object to be mapped	p8710.1	Unsigned32	0	R/W
	3	PDO mapping for the third application object to be mapped	p8710.2	Unsigned32	0	R/W
	4	PDO mapping for the fourth application object to be mapped	p8710.3	Unsigned32	0	R/W
1601		Receive PDO 2 mapping parameter				
	0	Number of mapped application objects in PDO		Unsigned8	2	R
	1	PDO mapping for the first application object to be mapped	p8711.0	Unsigned32	6040 hex	R/W
	2	PDO mapping for the second application object to be mapped	p8711.1	Unsigned32	6042 hex	R/W
	3	PDO mapping for the third application object to be mapped	p8711.2	Unsigned32	0	R/W
	4	PDO mapping for the fourth application object to be mapped	p8711.3	Unsigned32	0	R/W

OD Index (hex)	Sub-Index (hex)	Name of the object	SINAMICS parameters	Data type	Predefined connection set	Can be read/ written to
1602		Receive PDO 3 mapping parameter				
	0	Number of mapped application objects in PDO		Unsigned8	0	R
	1	PDO mapping for the first application object to be mapped	p8712.0	Unsigned32	0	R/W
	2	PDO mapping for the second application object to be mapped	p8712.1	Unsigned32	0	R/W
	3	PDO mapping for the third application object to be mapped	p8712.2	Unsigned32	0	R/W
	4	PDO mapping for the fourth application object to be mapped	p8712.3	Unsigned32	0	R/W
1603		Receive PDO 4 mapping parameter				
	0	Number of mapped application objects in PDO		Unsigned8	0	R
	1	PDO mapping for the first application object to be mapped	p8713.0	Unsigned32	0	R/W
	2	PDO mapping for the second application object to be mapped	p8713.1	Unsigned32	0	R/W
	3	PDO mapping for the third application object to be mapped	p8713.2	Unsigned32	0	R/W
	4	PDO mapping for the fourth application object to be mapped	p8713.3	Unsigned32	0	R/W
1604		Receive PDO 5 mapping parameter				
	0	Number of mapped application objects in PDO		Unsigned8	0	R
	1	PDO mapping for the first application object to be mapped	p8714.0	Unsigned32	0	R/W
	2	PDO mapping for the second application object to be mapped	p8714.1	Unsigned32	0	R/W
	3	PDO mapping for the third application object to be mapped	p8714.2	Unsigned32	0	R/W
	4	PDO mapping for the fourth application object to be mapped	p8714.3	Unsigned32	0	R/W
1605		Receive PDO 6 mapping parameter				
	0	Number of mapped application objects in PDO		Unsigned8	0	R
	1	PDO mapping for the first application object to be mapped	p8715.0	Unsigned32	0	R/W
	2	PDO mapping for the second application object to be mapped	p8715.1	Unsigned32	0	R/W
	3	PDO mapping for the third application object to be mapped	p8715.2	Unsigned32	0	R/W
	4	PDO mapping for the fourth application object to be mapped	p8715.3	Unsigned32	0	R/W

OD Index (hex)	Sub-Index (hex)	Name of the object	SINAMICS parameters	Data type	Predefined connection set	Can be read/ written to
1606		**Receive PDO 7 mapping parameter**				
	0	Number of mapped application objects in PDO		Unsigned8	0	R
	1	PDO mapping for the first application object to be mapped	p8716.0	Unsigned32	0	R/W
	2	PDO mapping for the second application object to be mapped	p8716.1	Unsigned32	0	R/W
	3	PDO mapping for the third application object to be mapped	p8716.2	Unsigned32	0	R/W
	4	PDO mapping for the fourth application object to be mapped	p8716.3	Unsigned32	0	R/W
1607		**Receive PDO 8 mapping parameter**				
	0	Number of mapped application objects in PDO		Unsigned8	0	R
	1	PDO mapping for the first application object to be mapped	p8717.0	Unsigned32	0	R/W
	2	PDO mapping for the second application object to be mapped	p8717.1	Unsigned32	0	R/W
	3	PDO mapping for the third application object to be mapped	p8717.2	Unsigned32	0	R/W
	4	PDO mapping for the fourth application object to be mapped	p8717.3	Unsigned32	0	R/W

TPDO configuration objects

The following tables list the communication and mapping parameters together with the indices for the individual TPDO configuration objects. The configuration objects are established via SDO.

Table 8- 39 TPDO configuration objects - communication parameters

OD Index (hex)	Sub-Index (hex)	Object name	SINAMICS parameters	Data type	Predefined connection set	Can be read/ written to
1800		**Transmit PDO 1 communication parameter**				
	0	Largest subindex supported		Unsigned8	5	R
	1	COB ID used by PDO	p8720.0	Unsigned32	180 hex + node ID	R/W
	2	Transmission type	p8720.1	Unsigned8	FE hex	R/W
	3	Inhibit time	p8720.2	Unsigned16	0	R/W
	4	Reserved	p8720.3	Unsigned8	---	R/W
	5	Event timer	p8720.4	Unsigned16	0	R/W

OD Index (hex)	Sub-Index (hex)	Object name	SINAMICS parameters	Data type	Predefined connection set	Can be read/ written to
1801		Transmit PDO 2 communication parameter				
	0	Largest subindex supported		Unsigned8	5	R
	1	COB ID used by PDO	p8721.0	Unsigned32	280 hex + node ID	R/W
	2	Transmission type	p8721.1	Unsigned8	FE hex	R/W
	3	Inhibit time	p8721.2	Unsigned16	0	R/W
	4	Reserved	p8721.3	Unsigned8	---	R/W
	5	Event timer	p8721.4	Unsigned16	0	R/W
1802		Transmit PDO 3 communication parameter				
	0	Largest subindex supported		Unsigned8	5	R
	1	COB ID used by PDO	p8722.0	Unsigned32	C000 06DF hex	R/W
	2	Transmission type	p8722.1	Unsigned8	FE hex	R/W
	3	Inhibit time	p8722.2	Unsigned16	0	R/W
	4	Reserved	p8722.3	Unsigned8	---	R/W
	5	Event timer	p8722.4	Unsigned16	0	R/W
1803		Transmit PDO 4 communication parameter				
	0	Largest subindex supported		Unsigned8	5	R
	1	COB ID used by PDO	p8723.0	Unsigned32	C000 06DF hex	R/W
	2	Transmission type	p8723.1	Unsigned8	FE hex	R/W
	3	Inhibit time	p8723.2	Unsigned16	0	R/W
	4	Reserved	p8723.3	Unsigned8	---	R/W
	5	Event timer	p8723.4	Unsigned16	0	R/W
1804		Transmit PDO 5 communication parameter				
	0	Largest subindex supported		Unsigned8	5	R
	1	COB ID used by PDO	p8724.0	Unsigned32	C000 06DF hex	R/W
	2	Transmission type	p8724.1	Unsigned8	FE hex	R/W
	3	Inhibit time	p8724.2	Unsigned16	0	R/W
	4	Reserved	p8724.3	Unsigned8	---	R/W
	5	Event timer	p8724.4	Unsigned16	0	R/W
1805		Transmit PDO 6 communication parameter				
	0	Largest subindex supported		Unsigned8	5	R
	1	COB ID used by PDO	p8725.0	Unsigned32	C000 06DF hex	R/W
	2	Transmission type	p8725.1	Unsigned8	FE hex	R/W
	3	Inhibit time	p8725.2	Unsigned16	0	R/W
	4	Reserved	p8725.3	Unsigned8	---	R/W
	5	Event timer	p8725.4	Unsigned16	0	R/W

OD Index (hex)	Sub-Index (hex)	Object name	SINAMICS parameters	Data type	Predefined connection set	Can be read/ written to
1806		Transmit PDO 7 communication parameter				
	0	Largest subindex supported		Unsigned8	5	R
	1	COB ID used by PDO	p8726.0	Unsigned32	C000 06DF hex	R/W
	2	Transmission type	p8726.1	Unsigned8	FE hex	R/W
	3	Inhibit time	p8726.2	Unsigned16	0	R/W
	4	Reserved	p8726.3	Unsigned8	---	R/W
	5	Event timer	p8726.4	Unsigned16	0	R/W
1807		Transmit PDO 8 communication parameter				
	0	Largest subindex supported		Unsigned8	5	R
	1	COB ID used by PDO	p8727.0	Unsigned32	C000 06DF hex	R/W
	2	Transmission type	p8727.1	Unsigned8	FE hex	R/W
	3	Inhibit time	p8727.2	Unsigned16	0	R/W
	4	Reserved	p8727.3	Unsigned8	---	R/W
	5	Event timer	p8727.4	Unsigned16	0	R/W

Table 8- 40 TPDO configuration objects - mapping parameters

OD Index (hex)	Sub-Index (hex)	Object name	SINAMICS parameters	Data type	Predefined connection set	Can be read/ written to
1A00		Transmit PDO 1 mapping parameter				
	0	Number of mapped application objects in PDO		Unsigned8	1	R
	1	PDO mapping for the first application object to be mapped	p8730.0	Unsigned32	6041 hex	R/W
	2	PDO mapping for the second application object to be mapped	p8730.1	Unsigned32	0	R/W
	3	PDO mapping for the third application object to be mapped	p8730.2	Unsigned32	0	R/W
	4	PDO mapping for the fourth application object to be mapped	p8730.3	Unsigned32	0	R/W
1A01		Transmit PDO 2 mapping parameter				
	0	Number of mapped application objects in PDO		Unsigned8	2	R
	1	PDO mapping for the first application object to be mapped	p8731.0	Unsigned32	6041 hex	R/W
	2	PDO mapping for the second application object to be mapped	p8731.1	Unsigned32	6044 hex	R/W
	3	PDO mapping for the third application object to be mapped	p8731.2	Unsigned32	0	R/W
	4	PDO mapping for the fourth application object to be mapped	p8731.3	Unsigned32	0	R/W

OD Index (hex)	Sub-Index (hex)	Object name	SINAMICS parameters	Data type	Predefined connection set	Can be read/ written to
1A02		Transmit PDO 3 mapping parameter				
	0	Number of mapped application objects in PDO		Unsigned8	0	R
	1	PDO mapping for the first application object to be mapped	p8732.0	Unsigned32	0	R/W
	2	PDO mapping for the second application object to be mapped	p8732.1	Unsigned32	0	R/W
	3	PDO mapping for the third application object to be mapped	p8732.2	Unsigned32	0	R/W
	4	PDO mapping for the fourth application object to be mapped	p8732.3	Unsigned32	0	R/W
1A03		Transmit PDO 4 mapping parameter				
	0	Number of mapped application objects in PDO		Unsigned8	0	R
	1	PDO mapping for the first application object to be mapped	p8733.0	Unsigned32	0	R/W
	2	PDO mapping for the second application object to be mapped	p8733.1	Unsigned32	0	R/W
	3	PDO mapping for the third application object to be mapped	p8733.2	Unsigned32	0	R/W
	4	PDO mapping for the fourth application object to be mapped	p8733.3	Unsigned32	0	R/W
1A04		Transmit PDO 5 mapping parameter				
	0	Number of mapped application objects in PDO		Unsigned8	0	R
	1	PDO mapping for the first application object to be mapped	p8734.0	Unsigned32	0	R/W
	2	PDO mapping for the second application object to be mapped	p8734.1	Unsigned32	0	R/W
	3	PDO mapping for the third application object to be mapped	p8734.2	Unsigned32	0	R/W
	4	PDO mapping for the fourth application object to be mapped	p8734.3	Unsigned32	0	R/W
1A05		Transmit PDO 6 mapping parameter				
	0	Number of mapped application objects in PDO		Unsigned8	0	R
	1	PDO mapping for the first application object to be mapped	p8735.0	Unsigned32	0	R/W
	2	PDO mapping for the second application object to be mapped	p8735.1	Unsigned32	0	R/W
	3	PDO mapping for the third application object to be mapped	p8735.2	Unsigned32	0	R/W
	4	PDO mapping for the fourth application object to be mapped	p8735.3	Unsigned32	0	R/W

OD Index (hex)	Sub-Index (hex)	Object name	SINAMICS parameters	Data type	Predefined connection set	Can be read/ written to
1A06		Transmit PDO 7 mapping parameter				
	0	Number of mapped application objects in PDO		Unsigned8	0	R
	1	PDO mapping for the first application object to be mapped	p8736.0	Unsigned32	0	R/W
	2	PDO mapping for the second application object to be mapped	p8736.1	Unsigned32	0	R/W
	3	PDO mapping for the third application object to be mapped	p8736.2	Unsigned32	0	R/W
	4	PDO mapping for the fourth application object to be mapped	p8736.3	Unsigned32	0	R/W
1A07		Transmit PDO 8 mapping parameter				
	0	Number of mapped application objects in PDO		Unsigned8	0	R
	1	PDO mapping for the first application object to be mapped	p8737.0	Unsigned32	0	R/W
	2	PDO mapping for the second application object to be mapped	p8737.1	Unsigned32	0	R/W
	3	PDO mapping for the third application object to be mapped	p8737.2	Unsigned32	0	R/W
	4	PDO mapping for the fourth application object to be mapped	p8737.3	Unsigned32	0	R/W

8.5.5.1 Free objects

You can interconnect any process data objects of the received and transmit buffer using receive and transmit double words.

- Scaling the process data of the free objects:
  - 16 bit (word): 4000hex ≙100 %
  - For temperature values: 16 bit (word): 4000hex ≙ 100 °C

OD index (hex)	Description	Data type per PZD	Default values	Can be read/ written to
5800 to 580F	16 freely-interconnectable receive process data	Integer16	0	R/W
5810 to 581F	16 freely-interconnectable transmit process data	Integer16	0	R

8.5.5.2 Objects in drive profile DSP402

The following table lists the object directory with the index of the individual objects for the drives.

Table 8- 41 Objects in drive profile DSP402

OD index (hex)	Sub-index (hex)	Name of the object	SINAMICS parameters	Transmission	Data type	Default setting	Can be read/ written to
Predefinitions							
67FF		Single device type		SDO	Unsigned32		R
Common entries in the object dictionary							
6007		Abort connection option code	p8641	SDO	Integer16	3	R/W
6502		Supported drive modes		SDO	Integer32		R
6504		Drive manufacturer		SDO	String	SIEMENS	R
Device control							
6040		Control word	r8795	PDO/SDO	Unsigned16	–	R/W 1)
6041		Status word	r8784	PDO/SDO	Unsigned16	–	R
6060		Modes of operation	p1300	SDO	Integer8	–	R/ 2)
6061		Modes of operation display	p1300	SDO	Integer8	–	R
Profile torque mode							
6071		Target torque Set torque	p1513[0]	SDO/PDO	Integer16	–	R/W 1)
6072		Max. torque	p1520/p1521	SDO	Real32	-	R/W
6074		Torque demand value Actual torque	r0080	SDO/PDO	Integer16	–	R
Velocity mode							
6042	0	vl target velocity	r0060	SDO/PDO	Integer16	-	R/W
6044	0	vl control effort	r0063	SDO/PDO	Integer16	-	R

1) SDO access is only possible after mapping the objects and the BICO interconnection to display parameters.

2) Object cannot be written to as a CANopen device profile is not supported, only manufacturer-specific operating data

8.5.6 Engineering example

The following example describes how you can integrate the converter into a CANopen bus system using STARTER in two steps.

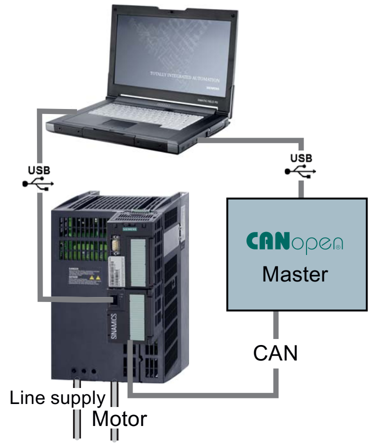
In the first step, the converter is integrated into the communication via the CAN bus using the Predefined Connection Set. In this case, the control word, the speed setpoint as well the status word and speed actual value are transferred.

In the second step, using the free PDO mapping, the torque setpoint as well as the current actual value are mapped and the BiCo wiring established.

Preconditions for integrating in CAN

The following preconditions must be fulfilled in order to be able to integrate the converter into a CAN bus:

- The converter and motor must have been completely installed
- STARTER V4.2 or higher has been installed on your computer.
- You have a CAN controller via which you can control the converter.
- The converter is connected online with Starter.
- The EDS file has been installed on your CAN controller.



Integrate the converter into a CAN bus system using the Predefined Connection Set

- Carry out the commissioning (Page 64) using the wizards and for the I/O configuration (second commissioning step) select the setting "22 CAN fieldbus" (macro 15 = 22). As a consequence, you establish the BICO interconnection of the speed setpoint/control word as well as speed actual value/status word corresponding to the Predefined Connections Set.
- In STARTER, in the screen form "…/Control_Unit/Communication/CAN" set the node ID and data transmission rate (Page 133) - (in the example, Node ID = 50, transmission rate = 500 kbit/s).
- Using the Expert List, in Starter set the mapping via the Predefined connection set (Page 143): p8744 = 1 and accept with p8744 = 1 (p8744 jumps back to 0 again after a few seconds).

As a consequence, you have established communication with CAN via the "Predifined Connection Set" (speed setpoint/control word as well as the actual value/status word, also see Objects in drive profile DSP402 (Page 156)).

Integrate the current actual value and torque limit into the communication via the free PDO mapping

In order to integrate the current actual value and torque limit into the communication, you must switch over from the Predefined Connection Set to the free PDO mapping. The current actual value and torque limit are integrated as free objects.

In the example, the actual current value is transferred in TPDO1 and the torque limit in RPDO1, i.e. it is not necessary to create new communication parameters (node ID and transmission mode). However, you must map the OD indices for the current actual value and the torque limits and adapt to the BiCo interconnection.

1. Switching over from the Predefined Connection Set to free PDO mapping

In the expert list, set p8744 to 1.

2. Mapping the current actual value (r0068) with TPDO1

- Define the OD index for the current actual value: 5810
- Set the COB ID from TPDO1 to "Mapping permissible":
  p8720[0] = 400001B2H (mapping not permitted) on p8720.0 = 800001B2H (mapping permissible)
- Set p8730[1] = 5810010H - the first four digits are the OD index for the current actual value (r0068), 00: Sub-index (corresponds to the parameter index) 10: Object size (10H = 16 bit) must be attached to the OD index
- Reset p8720[0] to 400001B2H
- r8751 shows which object has been matched to which PZD

3. Mapping the torque limit (p1522) with RPDO1

- Define the OD index for the torque limit: 5800
- Set the COB ID from RPDO1 to"Mapping permissible":
  Set p8700[0] = 232H (mapping not permissible) to p8700.0 = 80000232H (mapping permissible)
- Set p8710[1] = 5800010H - the first four digits are the OD index for the torque limit (p1522), 010 is CAN-specific and for all linked parameters in free PDO mapping must be attached to the OD index
- Reset p8700[0] to 232H
- r8750 shows which object has been matched to which PZD

4. Adapting BiCo interconnections

Object	Mapped receive objects	Receive word r2050	
Control word	r8750[0] = 6040H (PZD1)	Also mapped in r2050[0] to PZD1 -> OK	
Torque limit	r8750[1] = 5800H (PZD2)	Link PZD2 with torque limit:	p1522 = 2050[1]
Speed setpoint	r8750[2] = 6042H (PZD3)	Link PZD3 with speed setpoint:	p1070 = 2050[2]

Object	Mapped send objects	Send word p2051	
Status word	r8751[0] = 6041H (PZD1)	Also mapped in r2051[0] to PZD1 -> OK	
Current actual value	r8751[1] = 5810H (PZD2)	Link PZD2 with current actual value	p2051[1] = r68[1]
Speed actual value	r8751[2] = 6044H (PZD3)	Link PZD3 with speed actual value	p2051[2] = r63[0]

You have now made all of the necessary settings, in order to transfer status and control word, speed setpoint and actual value as well as the current actual value and torque limit.

Functions

9

Before you set the inverter functions, you should have completed the following commissioning steps:

- Basic commissioning (Page 51)
- If necessary: Adapting the terminal strip (Page 73)
- If necessary: Configuring the fieldbus (Page 85)

9.1 Overview of the inverter functions

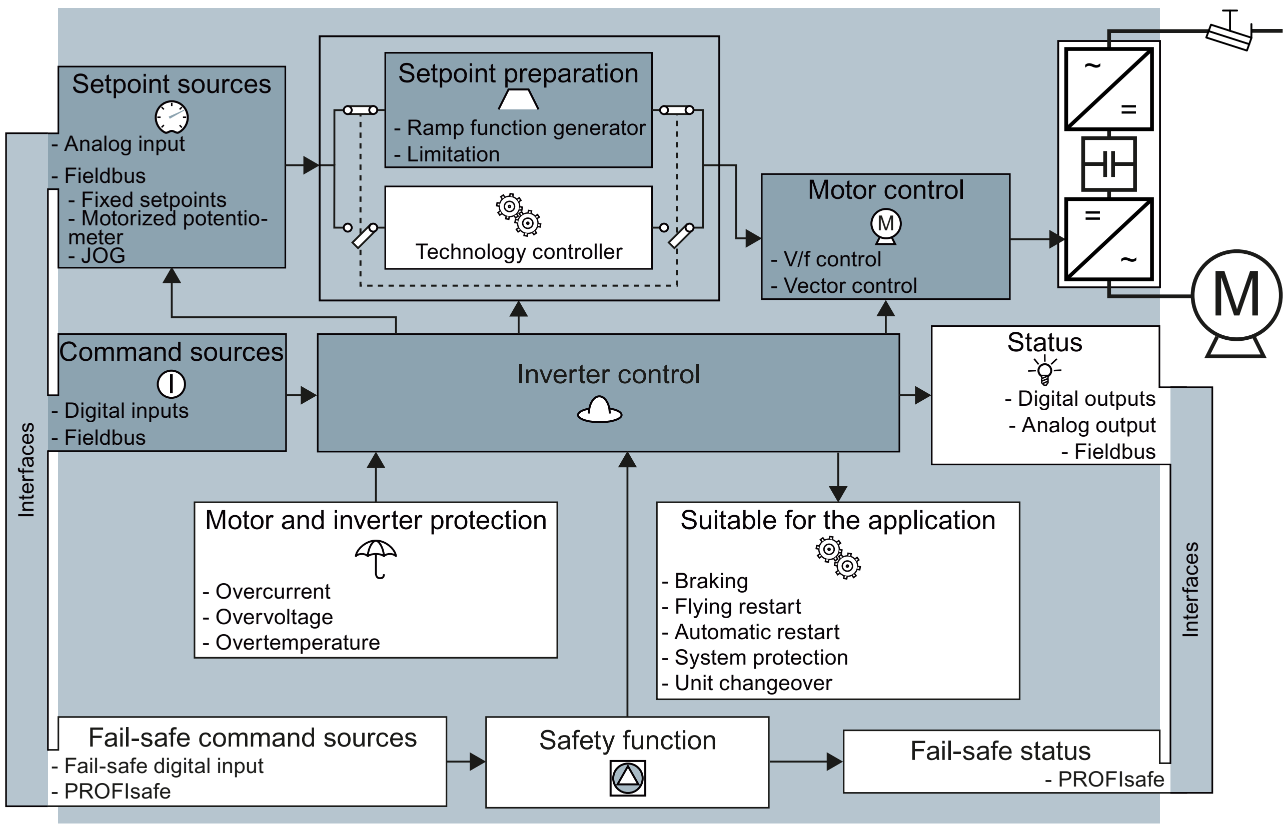
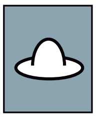
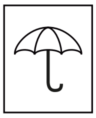
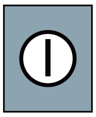
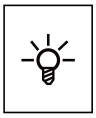
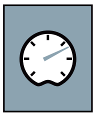
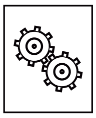
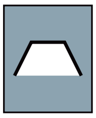
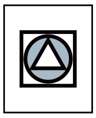
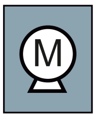


Figure 9-1 Overview of inverter functions

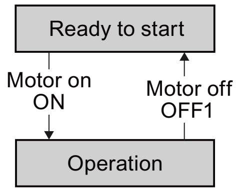
Functions relevant to all applications		Functions required in special applications only	
The functions that you require in your application are shown in a dark color in the function overview above. You set these functions during the basic commissioning, so that in many cases, the motor can be operated without having to make any additional settings.		The functions whose parameters you only need to adapt when actually required are shown in white in the function overview above.	
	**Inverter control** is responsible for all of the other inverter functions. Among other things, it defines how the inverter responds to external control signals. Converter control (Page 161)		The **production functions** avoid overloads and operating states that could cause damage to the motor, inverter and driven load. The motor temperature monitoring, for example, is set here. Protection functions (Page 194)
	The **command source** defines where the control signals are received from to switch on the motor, e.g. via digital inputs or a fieldbus. Command sources (Page 173)		The **status messages** provide digital and analog signals at the inverter outputs or via the fieldbus. Examples include the current speed of the motor or fault message issued by the inverter. Status messages (Page 200)
	The **setpoint source** defines how the speed setpoint for the motor is specified, e.g. via an analog input or a fieldbus. Setpoint sources (Page 174)		The functions **matching the application** provide e.g. the control of a motor holding brake or allow a higher-level pressure or temperature control to be implemented using the technology controller. Application-specific functions (Page 200)
	The **setpoint processing** uses a ramp-function generator to prevent speed steps occurring and to limit the speed to a permissible maximum value. Setpoint preparation (Page 181)		The **safety functions** are used in applications that must fulfill special requirements in terms of functional safety. Fail-safe function Safe Torque Off (STO) (Page 228)
	The **motor closed-loop control** ensures that the motor follows the speed setpoint. Motor control (Page 185)		

9.2 Converter control

9.2.1 Switching the motor on and off

After switching on the supply voltage, the converter normally goes into the "Ready to start" state. In this state, the converter waits for the command to switch-on the motor:

- The converter switches on the motor with the ON command. The converter changes to the "Operation" state.
- After the OFF1 command, the converter brakes the motor with the ramp-down time of the ramp-function generator. The converter switches off the motor once standstill has been reached. The converter is again "ready to start".



Converter states and commands for switching the motor on and off

In addition to the OFF1command, there are other commands that are used to switch off the motor:

- OFF2 - the converter immediately switches off the motor without first braking it.
- OFF3 - this command means "quick stop". After an OFF3 command, the converter brakes the motor with the OFF3 ramp-down time. After reaching standstill, the converter switches off the motor.
  The command is frequently used for exceptional operating situations where it is necessary to brake the motor especially quickly, e.g. when it involves collision protection.

The following diagram shows the internal sequence control of the converter when switching the motor on and off.

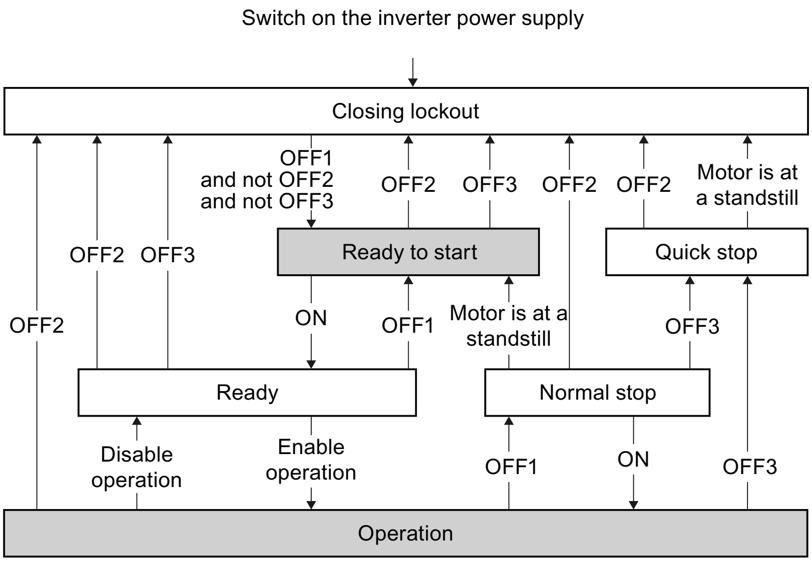


Figure 9-2 State overview of the converter

Table 9- 1 Explanation of the converter states

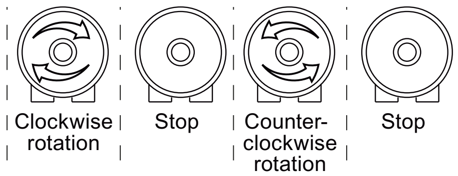
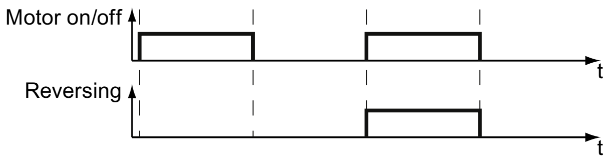
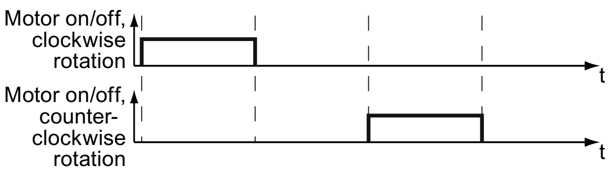
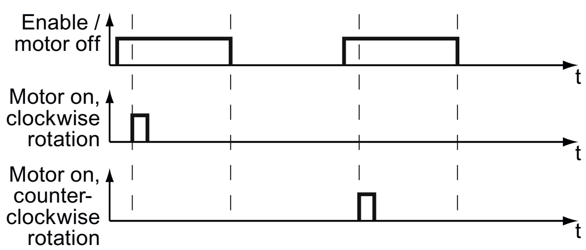
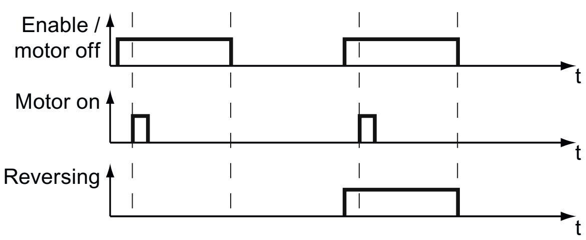
State	Explanation
Closing lockout	In this state, the converter does not respond to the ON command. The converter goes into this state under the following conditions: • The ON command was active when switching on the converter. Exception: When the automatic start function is active, the ON command must be active after switching on the power supply. • The OFF2 or OFF3 command is selected.
Ready to start	This state is required to switch on the motor.
Ready	The converter waits for the operating enable. If the converter is controlled via a fieldbus, then you must set the operating enable in a control word bit. If the converter is exclusively controlled via its digital inputs, then the operating enable signal is automatically set in the factory setting.
Operation	The motor is switched on.
Normal stop	The motor was switched off with an OFF1 command and brakes with the ramp-down time of the ramp-function generator.
Quick stop	The motor was switched off with an OFF3 command and brakes with the OFF3 ramp-down time.

9.2.2 Inverter control using digital inputs

If you are controlling the inverter using digital inputs, you use parameter p0015 during basic commissioning to define how the motor is switched on and off and how it is changed over from clockwise to counter-clockwise rotation.

Five different methods are available for controlling the motor. Three of the five methods just require two control commands (two-wire control). The other two methods require three control commands (three-wire control).

Table 9- 2 Two-wire control and three-wire control

Behavior of the motor		
	**Control commands**	**Typical application**
	**Two-wire control, method 1** 1. Switch the motor on and off (ON/OFF1). 2. Reverse the motor direction of rotation.	Local control in conveyor systems.
	**Two-wire control, method 2 and two-wire control, method 3** 1. Switch the motor on and off (ON/OFF1), clockwise rotation. 2. Switch the motor on and off (ON/OFF1), counter-clockwise rotation.	Traction drives with control via joystick
	**Three-wire control, method 1** 1. Issue enable for switching on motor and switch off motor (OFF1). 2. Switch on motor (ON), clockwise rotation. 3. Switch on motor (ON), counter-clockwise rotation.	Traction drives with control via joystick
	**Three-wire control, method 2** 1. Issue enable for switching on motor and switch off motor (OFF1). 2. Switch on motor (ON). 3. Reverse the motor direction of rotation.	-

9.2.3 Two-wire control: method 1

You switch the motor on and off using a control command (ON/OFF1). while the other control command reverses the motor direction of rotation.

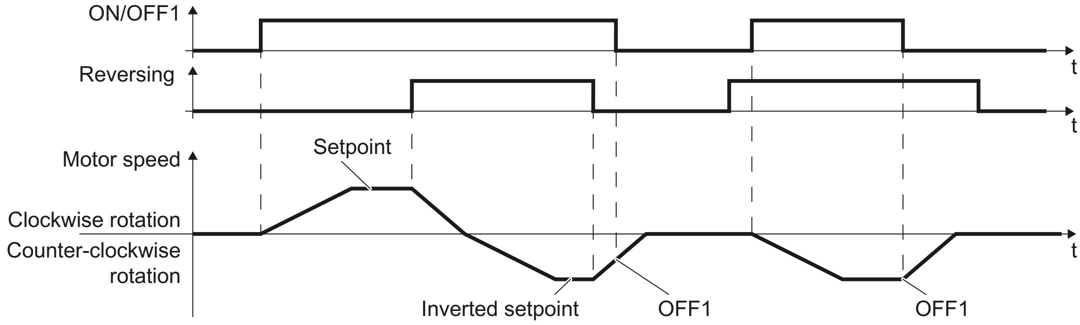


Figure 9-3 Two-wire control, method 1

Table 9- 3 Function table

ON/OFF1	Reversing	Function
0	0	OFF1: The motor stops.
0	1	OFF1: The motor stops.
1	0	ON: Clockwise rotation of motor.
1	1	ON: Counter-clockwise rotation of motor.

Table 9- 4 Parameter

Parameter	Description		
p0015 = 12	**Macro drive unit** (factory setting for inverters without PROFIBUS interface)		
	Controlling the motor using the digital inputs of the inverter:	DI 0	DI 1
		ON/OFF1	Reversing
Advanced setting Interconnecting control commands with digital inputs of your choice (DI x).			
p0840[0 … n] = 722.x	**BI: ON/OFF1** (ON/OFF1)		
p1113[0 … n] = 722.x	**BI: Setpoint inversion** (reversing)		
Example			
p0840 = 722.3	DI 3: ON/OFF1. Also see Section Digital inputs (Page 74).		

9.2.4 Two-wire control, method 2

You switch the motor on and off using a control command (ON/OFF1) and at the same time select clockwise motor rotation. You also use the other control command to switch the motor on and off, but in this case you select counter-clockwise rotation for the motor.

The inverter only accepts a new control command when the motor is at a standstill.

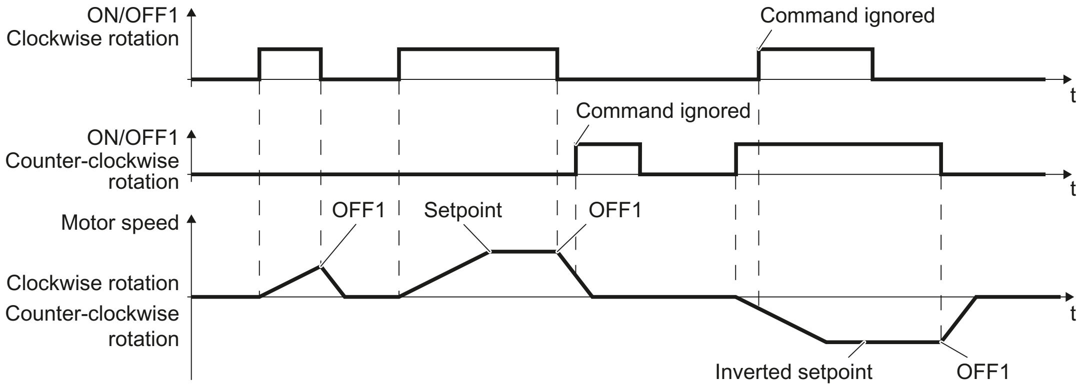


Figure 9-4 Two-wire control, method 2

Table 9- 5 Function table

ON/OFF1 clockwise rotation	ON/OFF1 , counter-clockwise rotation	Function
0	0	OFF1: The motor stops.
1	0	ON: Clockwise rotation of motor.
0	1	ON: Counter-clockwise rotation of motor.
1	1	ON: The motor direction of rotation is based on the signal that takes on the status "1" first.

Table 9- 6 Parameter

Parameter	Description		
p0015 = 17	**Macro drive unit**		
	Controlling the motor using the digital inputs of the inverter:	DI 0	DI 1
		ON/OFF1 clockwise rotation	ON/OFF1 , counter-clockwise rotation
Advanced setting Interconnecting control commands with digital inputs of your choice (DI x).			
p3330[0 … n] = 722.x	**BI: 2-3-WIRE Control Command 1** (ON/OFF1 clockwise rotation)		
p3331[0 … n] = 722.x	**BI: 2-3-WIRE Control Command 2** (ON/OFF1 , counter-clockwise rotation)		
Example			
p3331 = 722.0	DI 0: ON/OFF1 Counter-clockwise rotation Also see Section Digital inputs (Page 74).		

9.2.5 Two-wire control, method 3

You switch the motor on and off using a control command (ON/OFF1) and at the same time select clockwise motor rotation. You also use the other control command to switch the motor on and off, but in this case you select counter-clockwise rotation for the motor.

Unlike method 2, the inverter will accept the control commands at any time, regardless of the motor speed.

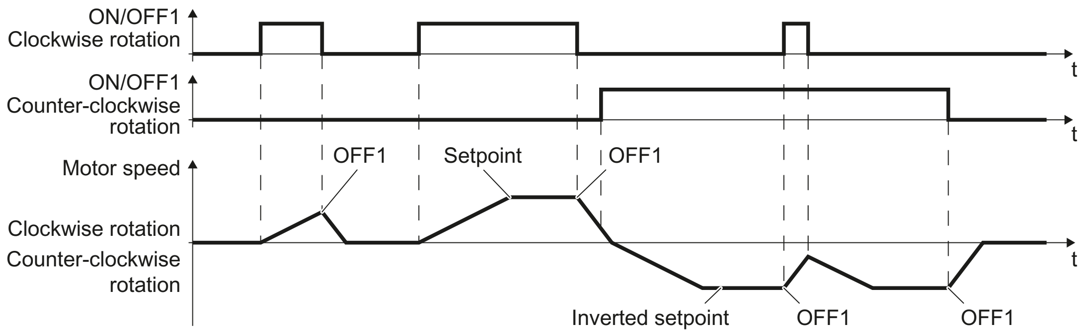


Figure 9-5 Two-wire control, method 3

Table 9- 7 Function table

ON/OFF1 clockwise rotation	ON/OFF1 , counter-clockwise rotation	Function
0	0	OFF1: The motor stops.
1	0	ON: Clockwise rotation of motor.
0	1	ON: Counter-clockwise rotation of motor.
1	1	OFF1: The motor stops.

Table 9- 8 Parameter

<table>
<tr><th>Parameter</th><th colspan="3">Description</th></tr>
<tr><td rowspan="3">p0015 = 18</td><td colspan="3">Macro drive unit</td></tr>
<tr><td rowspan="2">Controlling the motor using the digital inputs of the inverter:</td><td>DI 0</td><td>DI 1</td></tr>
<tr><td>ON/OFF1 clockwise rotation</td><td>ON/OFF1 , counter-clockwise rotation</td></tr>
<tr><td colspan="4">Advanced setting
Interconnecting control commands with digital inputs of your choice (DI x).</td></tr>
<tr><td>p3330[0 … n] = 722.x</td><td colspan="3">BI: 2-3-WIRE Control Command 1 (ON/OFF1 clockwise rotation)</td></tr>
<tr><td>p3331[0 … n] = 722.x</td><td colspan="3">BI: 2-3-WIRE Control Command 2 (ON/OFF1 , counter-clockwise rotation)</td></tr>
<tr><td colspan="4">Example</td></tr>
<tr><td>p3331[0 … n] = 722.2</td><td colspan="3">DI 2: ON/OFF1 Counter-clockwise rotation
Also see Section Digital inputs (Page 74).</td></tr>
</table>

9.2.6 Three-wire control, method 1

With one control command, you enable the two other control commands. You switch the motor off by canceling the enable (OFF1).

You switch the motor's direction of rotation to clockwise rotation with the positive edge of the second control command. If the motor is still switched off, switch it on (ON).

You switch the motor's direction of rotation to counter-clockwise rotation with the positive edge of the third control command. If the motor is still switched off, switch it on (ON).

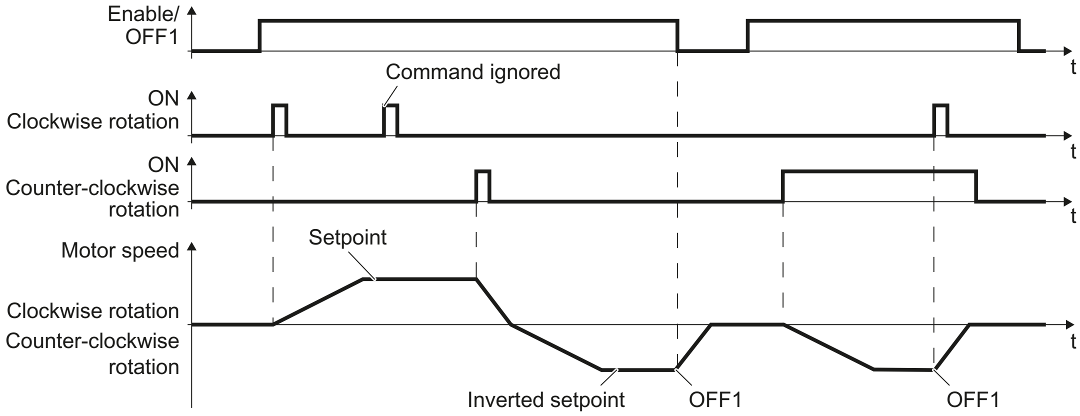


Figure 9-6 Three-wire control, method 1

Table 9- 9 Function table

Enable/OFF1	ON clockwise rotation	ON , counter-clockwise rotation	Function
0	0 or 1	0 or 1	OFF1: The motor stops.
1	0→1	0	ON: Clockwise rotation of motor.
1	0	0→1	ON: Counter-clockwise rotation of motor.
1	1	1	OFF1: The motor stops.

Table 9- 10 Parameter

<table>
<tr><th>Parameter</th><th colspan="4">Description</th></tr>
<tr><td rowspan="3">p0015 = 19</td><td colspan="4">Macro drive unit</td></tr>
<tr><td rowspan="2">Controlling the motor using the digital inputs of the inverter:</td><td>DI 0</td><td>DI 1</td><td>DI 2</td></tr>
<tr><td>Enable/OFF1</td><td>ON clockwise rotation</td><td>ON , counter-clockwise rotation</td></tr>
<tr><td colspan="5">Advanced setting
Interconnecting control commands with digital inputs of your choice (DI x).</td></tr>
<tr><td>p3330[0 … n] = 722.x</td><td colspan="4">BI: 2-3-WIRE Control Command 1 (enable/OFF1)</td></tr>
<tr><td>p3331[0 … n] = 722.x</td><td colspan="4">BI: 2-3-WIRE Control Command 2 (ON clockwise rotation)</td></tr>
<tr><td>p3332[0 … n] = 722.x</td><td colspan="4">BI: 2-3-WIRE Control Command 3 (ON , counter-clockwise rotation)</td></tr>
<tr><td colspan="5">Example</td></tr>
<tr><td>p3332 = 722.0</td><td colspan="4">DI 0: ON Counter-clockwise rotation.
Also see Section Digital inputs (Page 74).</td></tr>
</table>

9.2.7 Three-wire control, method 2

With one control command, you enable the two other control commands. You switch the motor off by canceling the enable (OFF1).

You switch on the motor with the positive edge of the second control command (ON).

The third control command defines the motor's direction of rotation (reversing).

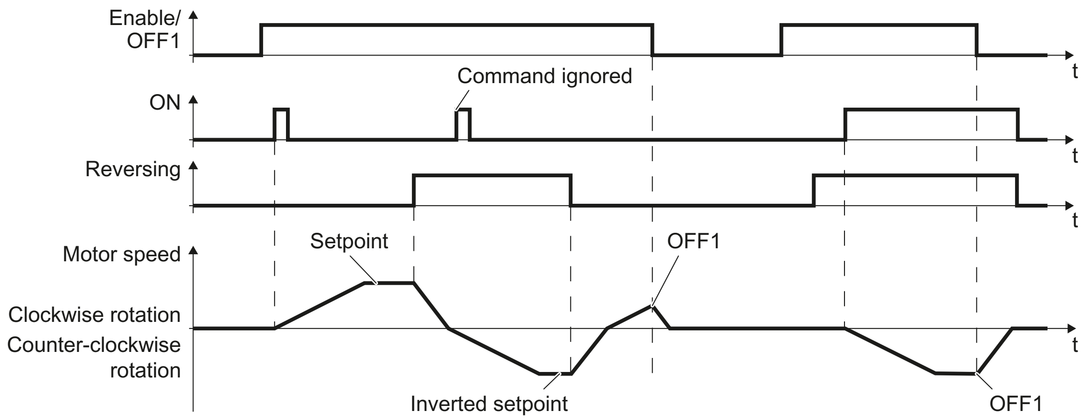


Figure 9-7 Three-wire control, method 2

Table 9- 11 Function table

Enable/OFF1	ON	Reversing	Function
0	0 or 1	0 or 1	OFF1: The motor stops.
1	0→1	0	ON: Clockwise rotation of motor.
1	0→1	1	ON: Counter-clockwise rotation of motor.

Table 9- 12 Parameter

<table>
<tr><th>Parameter</th><th colspan="4">Description</th></tr>
<tr><td rowspan="3">p0015 = 20</td><td colspan="4">Macro drive unit</td></tr>
<tr><td rowspan="2">Controlling the motor using the digital inputs of the inverter:</td><td>DI 0</td><td>DI 1</td><td>DI 2</td></tr>
<tr><td>Enable/OFF1</td><td>ON</td><td>Reversing</td></tr>
<tr><td colspan="5">Advanced setting
Interconnecting control commands with digital inputs of your choice (DI x).</td></tr>
<tr><td>p3330[0 … n] = 722.x</td><td colspan="4">BI: 2-3-WIRE Control Command 1 (enable/OFF1)</td></tr>
<tr><td>p3331[0 … n] = 722.x</td><td colspan="4">BI: 2-3-WIRE Control Command 2 (ON)</td></tr>
<tr><td>p3332[0 … n] = 722.x</td><td colspan="4">BI: 2-3-WIRE Control Command 3 (reversing)</td></tr>
<tr><td colspan="5">Example</td></tr>
<tr><td>p3331 = 722.0</td><td colspan="4">DI 0: ON.
Also see Section Digital inputs (Page 74).</td></tr>
</table>

9.2.8 Running the motor in jog mode (JOG function)

The "Jog" function is typically used to a slowly move a machine part, e.g. a conveyor belt. The function is frequently used when the converter is temporarily not operated via the fieldbus, but via digital inputs instead.

With the "Jog" function, you switch the motor on and off using a digital input. When the motor is switched on, it accelerates to the jogging setpoint. There are two different setpoints available, e.g. for motor counterclockwise rotation and clockwise rotation.

The same ramp-function generator acts on the setpoint as for the ON/OFF1 command.

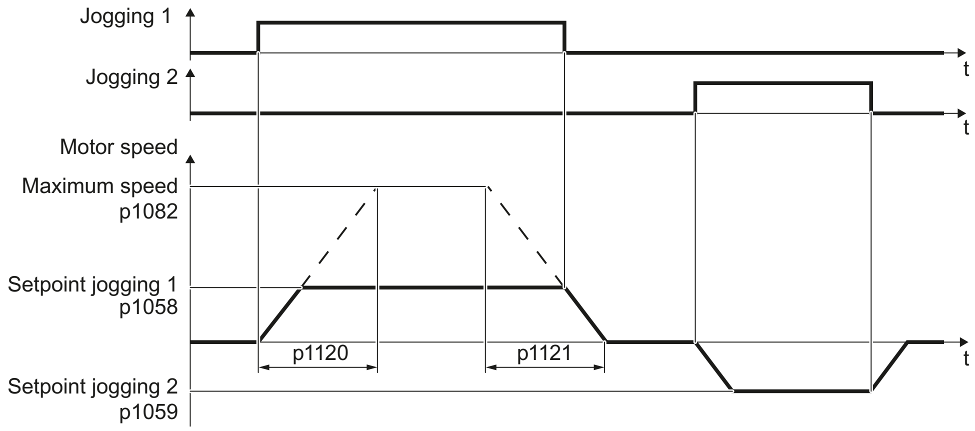
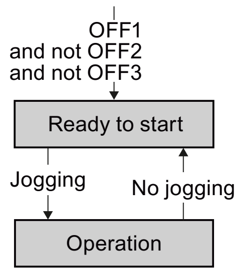


Figure 9-8 Behavior of the motor when "jogging",

The converter must be ready to start before you issue the "Jog" control command. If the motor is already switched on, then the "Jog" command has no effect.



Setting jogging

Table 9- 13 Settings

Parameter	Description	
p1058	**Jogging 1 speed setpoint** (factory setting, 150 rpm)	
p1059	**Jogging 2 speed setpoint** (factory setting, -150 rpm)	
p1082	**Maximum speed** (factory setting 1500 rpm)	
p1110	**Inhibit negative direction**	
	=0	Negative direction of rotation is enabled
	=1	Negative direction of rotation is inhibited
p1111	**Inhibit positive direction**	
	=0	Positive direction of rotation is enabled
	=1	Positive direction of rotation is inhibited
p1113	**Setpoint inversion**	
	=0	Setpoint is not inverted
	=1	Setpoint is inverted
p1120	**Ramp-function generator ramp-up time** (factory setting 10 s)	
p1121	**Ramp-function generator ramp-down time** (factory setting 10 s)	
p1055 = 722.0	**Jogging bit 0:** Select jogging 1 via digital input 0	
p1056 = 722.1	**Jogging bit 1:** Select jogging 2 via digital input 1	

9.2.9 Switching over the inverter control (command data set)

In several applications, the inverter must be able to be operated from different, higher-level control systems.

Example: Switchover from automatic to manual operation

A motor is switched on and off and its speed varied either from a central control system via a fieldbus or from a local control box.

Command data set (CDS)

This means that you can set the inverter control in various ways and toggle between the settings. For instance, as described above, the inverter can either be operated via a fieldbus or via the terminal strip.

The settings in the inverter, which are associated with a certain control type of the inverter, are known as a command data set.

Example:

Command data set 0: Controlling the inverter via the fieldbus
Command data set 1: Controlling the inverter via terminal strip

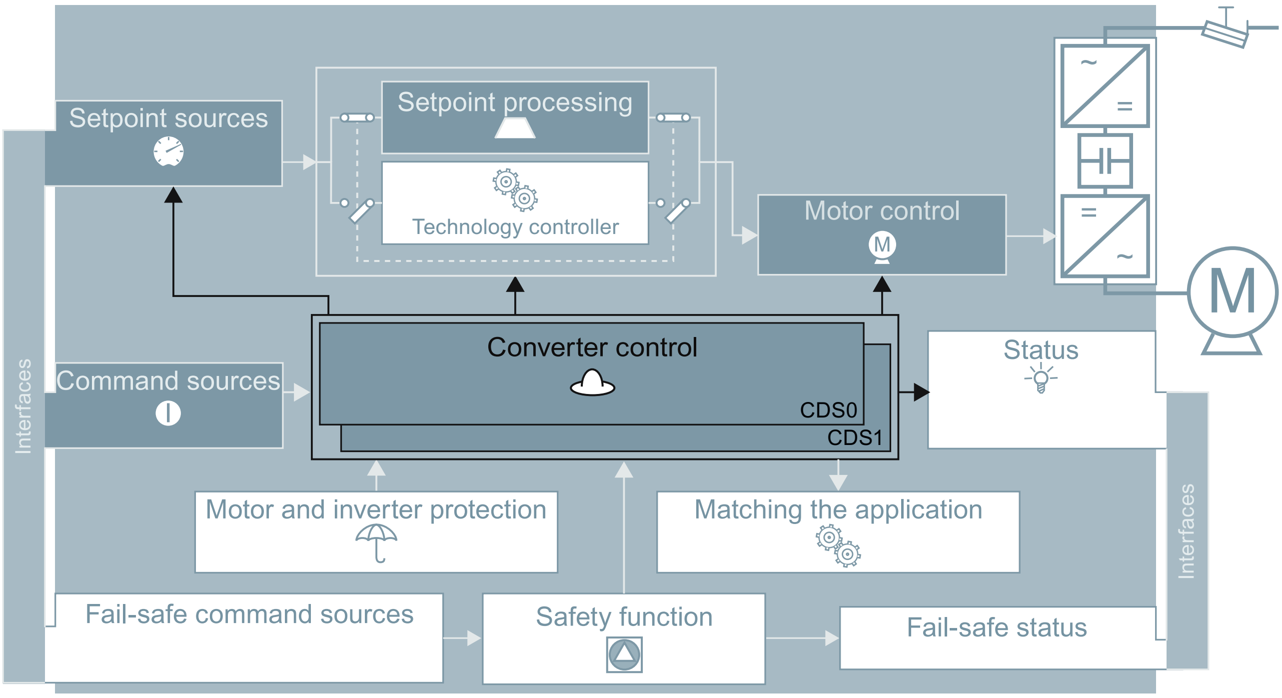


Figure 9-9 Control data set switchover in the converter

You select the command data set using parameter p0810. To do this, you must interconnect parameter p0810 with a control command of your choice, e.g. a digital input.

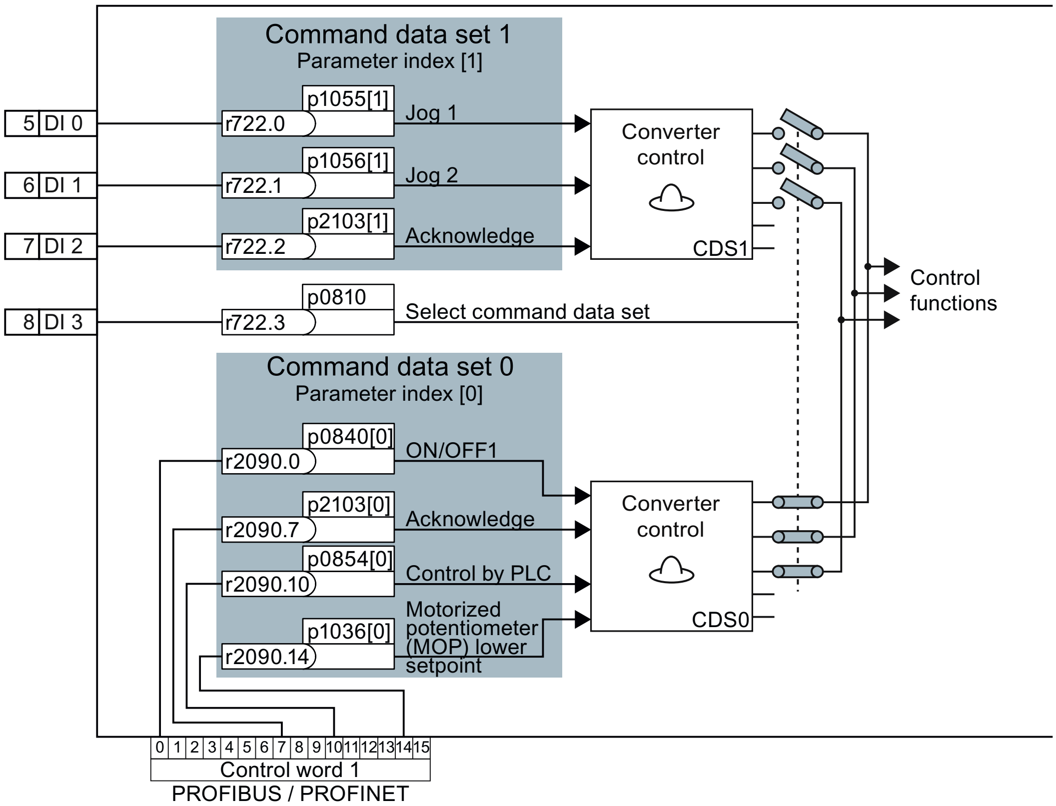


Figure 9-10 Example for the various command data sets

You obtain the interconnection as in the example above, if you configured the interfaces of the inverter with p0015 = 7 in the basic commissioning, also see Section Selecting the interface assignments (Page 44).

An overview of all the parameters that belong to the command data sets is provided in the List Manual.

Note

It takes approximately 4 ms to toggle between command data sets.

9.3 Command sources

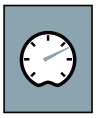
The command source is the interface via which the inverter receives its control commands. You define the assignment of the inverter interfaces when carrying out the basic commissioning.

Change command source

You have two options to change the command sources:

1. Carry out the basic commissioning again and select a different assignment of the inverter interfaces.
2. Adapt the function of individual digital inputs or change the fieldbus interface. You can find more information on this in Sections Adapting the terminal strip (Page 73) and Configuring the fieldbus (Page 85).

9.4 Setpoint sources



The inverter receives its main setpoint from the setpoint source. The main setpoint generally specifies the motor speed.

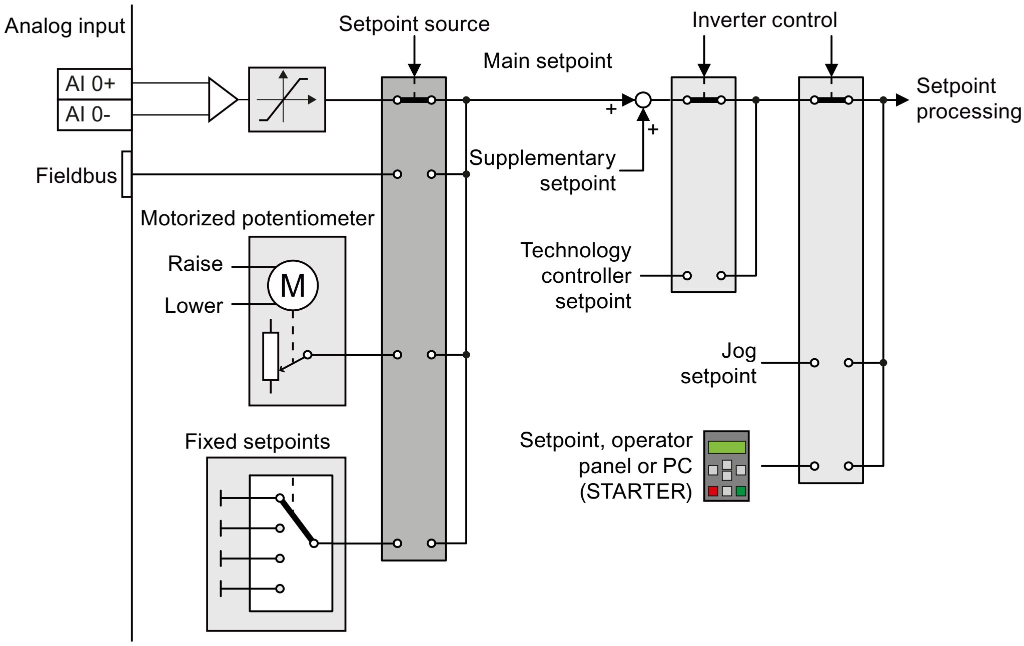


Figure 9-11 Setpoint sources for the inverter

You have the following options when selecting the source of the main setpoint:

- Inverter analog input.
- Inverter fieldbus interface.
- Motorized potentiometer simulated in the inverter.
- Fixed setpoints saved in the inverter.

You have the same selection options when selecting the source of the supplementary setpoint.

Under the following conditions, the inverter switches from the main setpoint to other setpoints:

- When the technology controller is active, it's output specifies the motor speed.
- When jogging is active.
- When controlling from an operator panel or the STARTER PC tool.

In the basic commissioning, you have already selected a setpoint source. Refer also to Section: Selecting the interface assignments (Page 44).

However, you can change this setting. The setpoint sources will be described in more detail on the following pages.

9.4.1 Analog input as setpoint source

Procedure

If you have selected a pre-assignment without a function of the analog input, then you must interconnect the parameter of the main setpoint with an analog input.

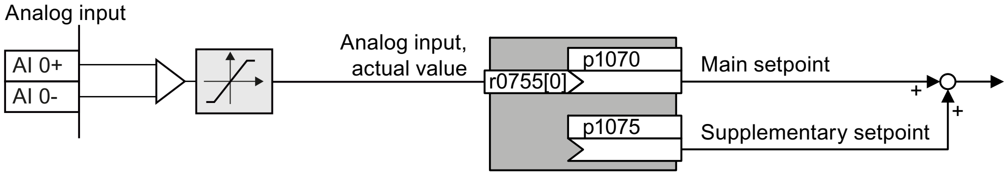


Figure 9-12 Example: Analog input 0 as setpoint source

Table 9- 14 Setting with analog input 0 as setpoint source

Parameter	Remark
p1070 = 755[0]	**Main setpoint** Interconnect the main setpoint with analog input 0
p1075 = 755[0]	**Additional setpoint** Interconnect the additional setpoint with analog input 0

You must adapt the analog input to the connected signal, e.g. ± 10 V or 4 … 20 mA. You will find additional information in the section: Analog inputs (Page 79).

9.4.2 Motorized potentiometer as setpoint source

The "Motorized potentiometer" function emulates an electromechanical potentiometer The output value of the motorized potentiometer can be continually set using the "up" and "down" control signals.

Interconnecting the motorized potentiometer (MOP) with the setpoint source

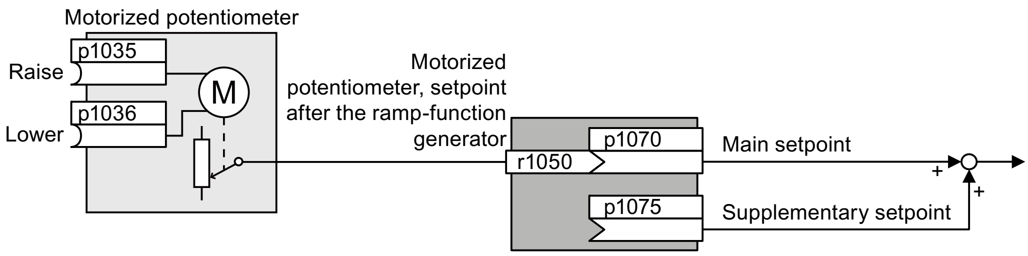


Figure 9-13 Motorized potentiometer as setpoint source

Table 9- 15 Setting the MOP as setpoint source

Parameter	Remark
p1070 = 1050	**Main setpoint** Interconnecting the main setpoint with MOP.
p1035	**Motorized potentiometer, increase setpoint** (factory setting 0) Interconnect this signal, for example with a digital input of your choice: p1035 = 722.1 (digital input 1)
p1036	**Motorized potentiometer, decrease setpoint** (factory setting 0) Interconnect this signal, for example with a digital input of your choice.

Adapting the behavior of the motorized potentiometer

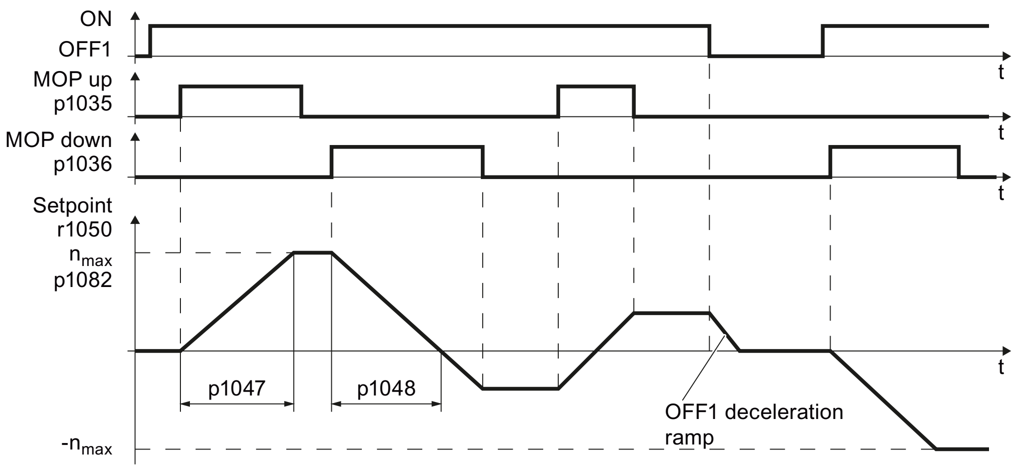


Figure 9-14 Function chart of motorized potentiometer

Table 9- 16 Basic setup of motorized potentiometer

Parameter	Description
p1047	**MOP ramp-up time** (factory setting 10 s)
p1048	**MOP ramp-down time** (factory setting 10 s)
p1040	**MOP start value** (factory setting 0 rpm) Defines the start value [rpm], which is effective when first switching on the motor.

Table 9- 17 Extended setup of motorized potentiometer

Parameter	Description
p1030	**MOP configuration** (factory setting 00110 bin) **Parameter value with four independently adjustable bits 00 … 03** **Bit 00:** Save setpoint after switching off motor 0: After the motor is switched on, p1040 is specified as the setpoint 1: Setpoint is saved after the motor is switched off and set to the saved value once it is switched on **Bit 01:** Configure ramp-function generator in automatic mode (1-signal via BI: p1041) 0: No ramp-function generator in automatic mode (ramp-up/-down time = 0) 1: With ramp-function generator in automatic mode In manual mode (0-signal via BI: p1041) the ramp-function generator is always active **Bit 02:** Configure initial rounding 0: No initial rounding 1: With initial rounding. Using the initial rounding function it is possible to enter very small setpoint changes **Bit 03:** Store setpoint in power-independent manner 0: No power-independent saving 1: Setpoint is saved in the event of a power failure (bit 00 = 1) **Bit 04:** Ramp-function generator always active 0: Setpoint is only calculated with enabled pulses 1: The setpoint is calculated independent of the pulse enable.
p1037	**MOP maximum speed** (factory setting 0 rpm) This is automatically preassigned when commissioning
p1038	**MOP minimum speed** (factory setting 0 rpm) This is automatically preassigned when commissioning
p1044	**MOP setting value** (factory setting 0) Signal source for the setting value.

For more information about the motorized potentiometer, refer to function diagram 3020 in the List Manual.

9.4.3 Fixed speed as setpoint source

In many applications after switching on the motor, all that is needed is to run the motor at a constant speed or to switch between different speeds.

Examples: After it has been switched on, a conveyor belt only runs with two different velocities.

Interconnecting the fixed speeds with a main setpoint

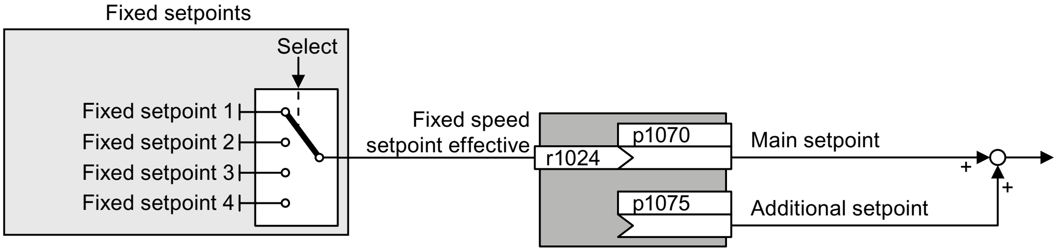


Figure 9-15 Fixed speeds as setpoint source

Table 9- 18 Setting the fixed speeds as setpoint source

Parameter	Remark
p1070 = 1024	**Main setpoint** Interconnecting the main setpoint with fixed speeds.
p1075 = 1024	**Additional setpoint** Interconnecting the additional setpoint with fixed speeds

Direct or binary selection of the fixed setpoints

The converter has up to 16 different fixed setpoints. The fixed setpoints can be selected via digital inputs or the fieldbus.

The various fixed setpoints can be selected in two ways:

1. Direct selection:
   You set four different fixed setpoints. By adding one or more of the four fixed setpoints, up to 16 different resulting setpoints are obtained.
   Direct selection is the most suitable method for controlling the converter via the digital inputs.
2. Binary selection:
   You set 16 different fixed setpoints. You precisely select one of these fixed setpoints by a combination of four selection bits.
   The binary selection is the preferred solution for a central control and connecting the converter to a fieldbus.
   Additional information about binary selection can be found in function diagram 3010 of the List Manual.

Direct selection of fixed setpoints

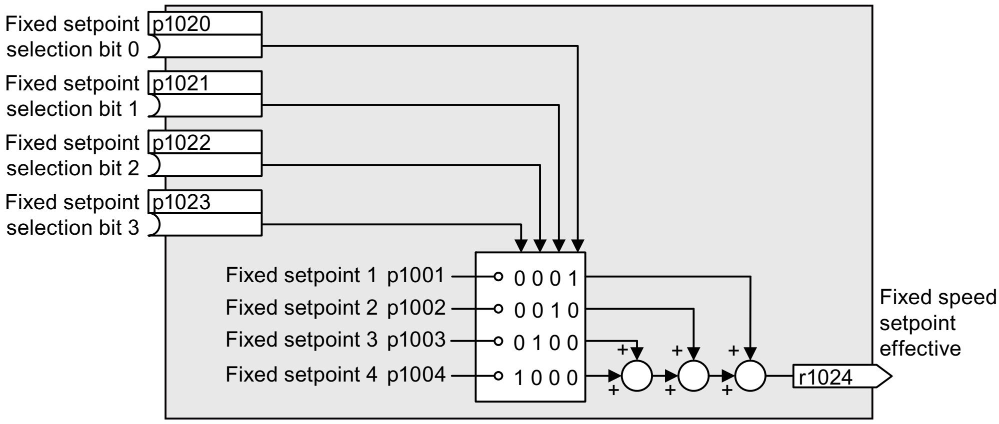


Figure 9-16 Simplified function diagram for directly selecting fixed setpoints

Additional information about direct selection can be found in function diagram 3011 in the List Manual.

Example: Direct selection of two fixed speed setpoints

The motor is to operate at two different speeds as follows:

- The motor is switched on with digital input 0 and then accelerates to 300 rpm.
- When digital input 1 is selected, the motor accelerates up to a speed of 2000 rpm.
- The motor reverses when selecting digital input 3.

Table 9- 19 Settings for the example

Parameter	Description
p1001 = 300.000	**Fixed speed setpoint 1** in [rpm]
p1002 = 2000.000	**Fixed speed setpoint 2** in [rpm]
p0840 = 722.0	**ON/OFF1:** Switch on motor with digital input 0
p1070 = 1024	**Main setpoint:** Interconnect the main setpoint with the speed setpoint
p1020 = 722.0	**Fixed speed setpoint selection bit 0:** Interconnect fixed setpoint 1 with digital input 0 (DI 0).
p1021 = 722.1	**Fixed speed setpoint selection bit 1:** Interconnect fixed setpoint 2 DI 2.
p1016 = 1	**Fixed speed setpoint mode:** Direct selection of the fixed setpoints

Table 9- 20 Resulting fixed setpoints for the example above

Fixed setpoint selected by	Resulting setpoint
DI 0 = LOW	Motor stops
DI 0 = HIGH and DI 1 = LOW	300 rpm
DI 0 = HIGH and DI 1 = HIGH	2300 rpm

9.4.4 Specifying the motor speed via the fieldbus

If you enter the setpoint via a fieldbus, you must connect the converter to a higher-level control. For additional information, see chapter Configuring the fieldbus (Page 85).

Interconnecting the fieldbus with the main setpoint

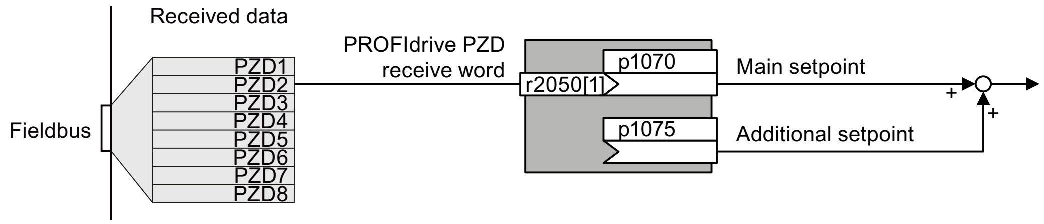


Figure 9-17 Fieldbus as setpoint source

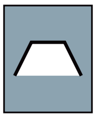
Most standard frames receive the speed setpoint as a second process data PZD2.

Table 9- 21 Setting the fieldbus as setpoint source

Parameter	Remark
p1070 = 2050[1]	**Main setpoint** Interconnect the main setpoint with process data PZD2 from the fieldbus.
p1075 = 2050[1]	**Additional setpoint** Interconnect the additional setpoint with process data PZD2 from the fieldbus.

9.5 Setpoint preparation

9.5.1 Overview of setpoint processing



The setpoint can be modified as follows using the setpoint processing:

- Invert setpoint to reverse the motor direction of rotation (reversing).
- Inhibit positive or negative direction of rotation, e.g. for conveyor belts, pumps or fans.
- Minimum speed to avoid standstill when the motor is switched on.
- Limit to a maximum speed to protect the motor and mechanical system.
- Ramp-function generator to accelerate and brake the motor with an optimum torque.

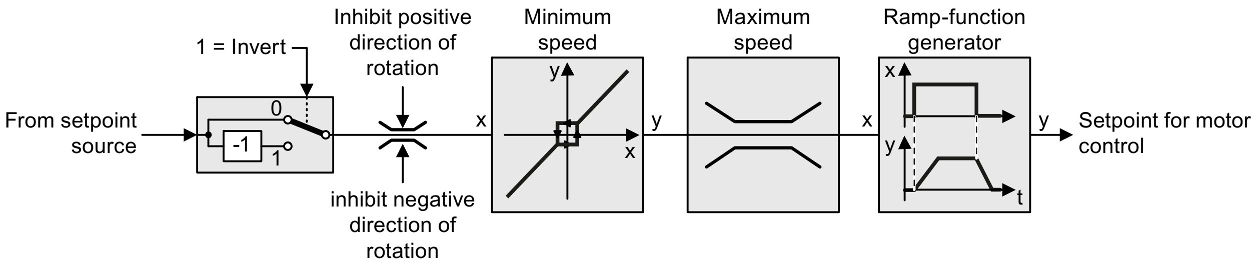


Figure 9-18 Setpoint processing in the inverter

9.5.2 Invert setpoint

Procedure

Interconnect parameter p1113 with a binary signal, e.g. digital input 1.

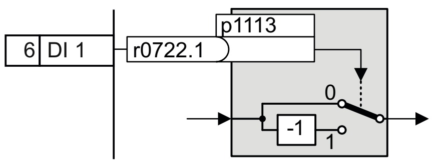


Table 9- 22 Examples of settings to invert the setpoint

Parameter	Remark
p1113 = 722.1	**Setpoint inversion** Digital input 1 = 0: Setpoint remains unchanged. Digital input 1 = 1: Converter inverts the setpoint.
p1113 = 2090.11	Invert setpoint via control word 1, bit 11.

9.5.3 Inhibit direction of rotation

Procedure

In the factory setting of the converter, both motor directions of rotation are enabled.

If you want to permanently inhibit one of the directions of rotation, then you must set the corresponding parameter to 1.

With the value 0, the converter enables the direction of rotation.

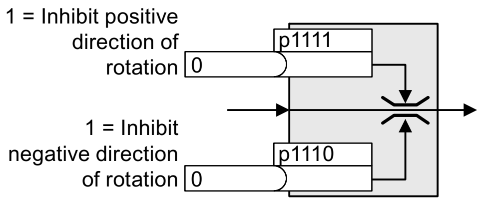


Table 9- 23 Examples of settings to inhibit the direction of rotation

Parameter	Remark
p1110 = 1	**Inhibit negative direction** Negative direction is permanently inhibited.
p1110 = 722.3	**Inhibit negative direction** Digital input 3 = 0: Negative direction of rotation is enabled. Digital input 3 = 1: Negative direction of rotation is inhibited.

9.5.4 Minimum speed

Function

The inverter prevents continuous motor operation at speeds < minimum speed.

Speeds, where the absolute value is less than the minimum speed, can only be passed through when accelerating or braking.

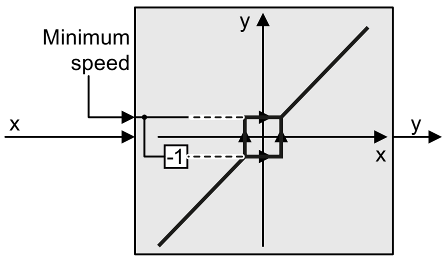


Table 9- 24 Setting the minimum speed

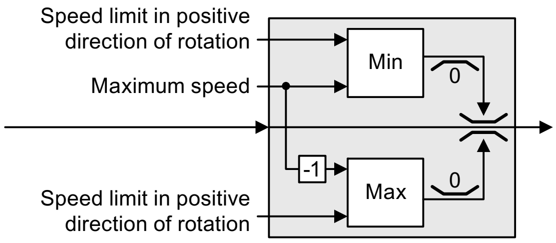
Parameter	Description
p1080	Minimum speed

9.5.5 Maximum speed

Function

The maximum speed limits the speed setpoint range for both directions of rotation.

The inverter generates a message (fault or alarm) when the maximum speed is exceeded.



The maximum speed also acts as a reference value for several other functions, e.g. the ramp-function generator.

If you must limit the speed depending on the direction of rotation, then you can define speed limits for each direction.

Table 9- 25 Parameters for minimum and maximum speed

Parameter	Description
p1082	**Maximum speed** (factory setting: 1500 rpm)
p1083	**Speed limit, positive direction of rotation** (factory setting: 210,000 rpm)
p1086	**Speed limit, negative direction of rotation** (factory setting: -210,000 rpm)

9.5.6 Ramp-function generator

Function

The ramp-function generator in the setpoint channel limits the speed of changes to the speed setpoint. The ramp-function generator does the following:

- The soft acceleration and braking of the motor reduces the stress on the mechanical system of the driven machine.
- Acceleration and braking distance of the driven machine (e.g. a conveyor belt) are independent of the motor load.

The ramp-up and ramp-down times of the ramp-function generator can be set independently of each other. The times that you select depend on the application in question and can range from just a few 100 ms (e.g. for belt conveyor drives) to several minutes (e.g. for centrifuges).

When the motor is switched on/off via ON/OFF1, the motor also accelerates/decelerates in accordance with the times set in the ramp-function generator.

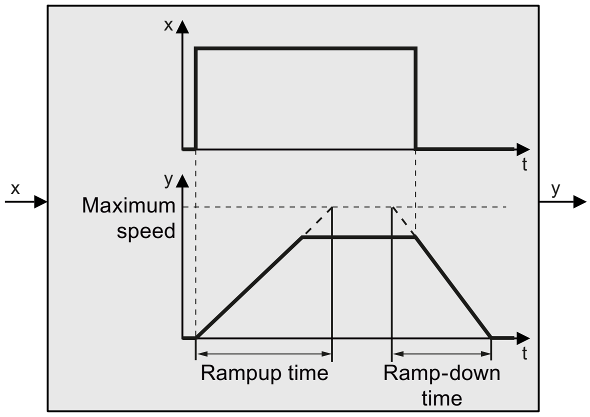


Table 9- 26 Parameters for minimum and maximum speed

Parameter	Description
p1120	**Ramp-function generator, ramp-up time** (factory setting: 10 s) Accelerating time in seconds from zero speed up to the maximum speed p1082
p1121	**Ramp-function generator, ramp-down time** (factory setting: 10 s) braking time in seconds from the maximum speed down to standstill
p1135	**OFF3 ramp-down time** (factory setting: 0 s) The quick stop (OFF3) has its own ramp-down time.

Note

Excessively short ramp-up and ramp-down times mean that the motor reaches its current limit when accelerating or braking. In this case, the set times are exceeded.

Extended ramp-function generator

In the extended ramp-function generator, the acceleration process can be made "softer" using initial and final rounding via parameters p1130 … p1134. Here, the ramp-up and ramp-down times of the motor are increased by the rounding times.

Rounding does not affect the ramp-down time in the event of a quick stop (OFF3).

You can find more information in function diagram 3070 and in the parameter list of the List Manual.

9.6 Motor control

Decision-making criteria for the control mode that is suitable for your application is provided in Section Factory setting of the inverter control (Page 55).

9.6.1 V/f control

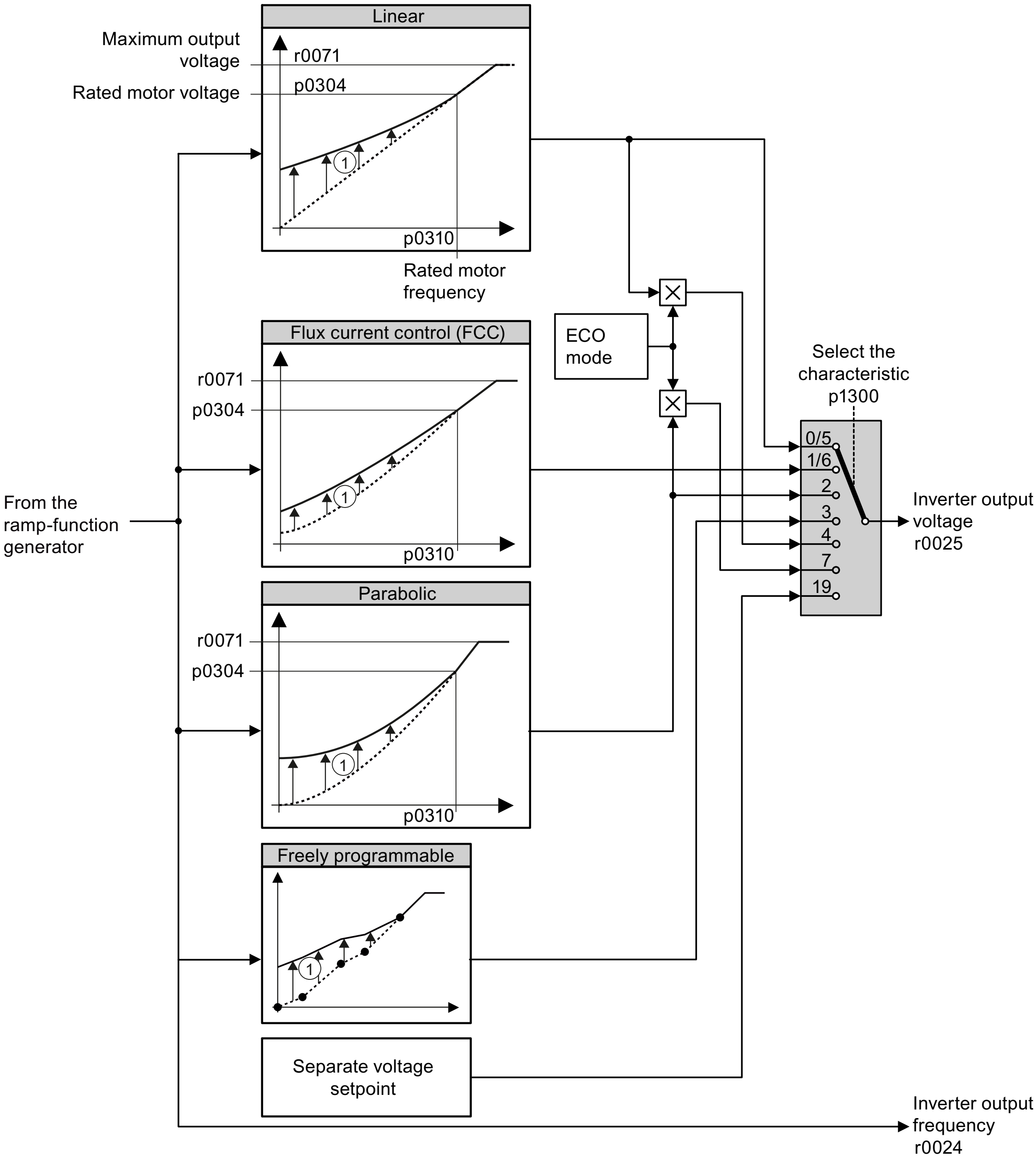
V/f control sets the voltage at the motor terminals on the basis of the specified speed setpoint. The relationship between the speed setpoint and stator voltage is calculated using characteristic curves. The required output frequency is calculated on the basis of the speed setpoint and the number of pole pairs of the motor (f = n * number of pole pairs / 60, in particular: f_{max} = p1082 * number of pole pairs / 60). The inverter provides the two most important characteristics (linear and square-law). User-defined characteristic curves are also supported.

V/f control is not a high-precision method of controling the speed of the motor. The speed setpoint and the speed of the motor shaft are always slightly different. The deviation depends on the motor load. If the connected motor is loaded with the rated torque, the motor speed is below the speed setpoint by the amount of the rated slip. If the load is driving the motor (i.e. the motor is operating as a generator), the motor speed is above the speed setpoint.

The characteristic is selected during commissioning, using p1300.

9.6.1.1 Characteristics of U/f control

The inverter has several U/f characteristics. Based on the characteristic, as the speed increases the inverter increases its output voltage.



① Voltage boost as a function of speed and torque

Figure 9-19 U/f characteristics of the inverter

The inverter increases its output voltage – also above the motor rated speed up to the maximum output voltage. The higher the line voltage, the greater the maximum inverter output voltage.

If the inverter has reached its maximum output voltage, then it can only increase its output frequency. From this point onwards, the motor is operated in field weakening; this means that the available torque linearly decreases with increasing speed.

The voltage boost of the characteristic improves motor behavior at low speeds.

9.6.1.2 Selecting the U/f characteristic

Procedure

With the Operator Panel:

- Select the suitable characteristic curve and set parameter p1300.

Using STARTER:

- Go online with STARTER.
- Select the U/f characteristic curve in one of the screen forms "speed controller" or "U/f control".

Table 9- 27 Linear and parabolic characteristics

Requirement	Application examples	Remark	Characteristic	Parameter
The required torque is independent of the speed	Conveyor belts, roller conveyors, chain conveyors, eccentric worm pumps, compressors, extruders, centrifuges, agitators, mixers	-	Linear	p1300 = 0
		The inverter equalizes the voltage drops across the stator resistance. Recommended for motors with a low power rating. Precondition: You have set the motor data according to the rating plate and have performed the motor identification after the basic commissioning.	Linear with Flux Current Control (FCC)	p1300 = 1
The required torque increases with the speed	Centrifugal pumps, radial fans, axial fans	Lower losses in the motor and inverter than for a linear characteristic.	Parabolic	p1300 = 2

Table 9- 28 Characteristics for special applications

Requirement	Application examples	Remark	Characteristic	Parameter
Applications with a low dynamic response and constant speed	Centrifugal pumps, radial fans, axial fans	The ECO mode results in additional energy saving when compared to the parabolic characteristic. If the speed setpoint is reached and remains unchanged for 5 seconds, then the inverter again reduces its output voltage.	ECO mode	p1300 = 4 or p1300 = 7
The inverter must keep the motor speed constant under all circumstances.	Drives in the textile sector	When the maximum current limit is reached, the inverter only reduces the stator voltage but not the speed.	precise frequency characteristic	p1300 = 5 or p1300 = 6
Freely adjustable U/f characteristic	Operating the inverter with a synchronous motor	-	Parameterizable characteristic	p1300 = 3
U/f characteristic with independent voltage setpoint	-	The interrelationship between the frequency and voltage is not calculated in the inverter, but is specified by the user.	Independent voltage setpoint	p1300 = 19

Additional information on U/f characteristics can be found in the parameter list and in the function diagrams 6300 ff of the List Manual.

9.6.1.3 Optimizing with a high break loose torque and brief overload

Voltage boost of the U/f control

The voltage boost acts on every U/f characteristic. The adjacent diagram shows the voltage boost using a linear characteristic as example.

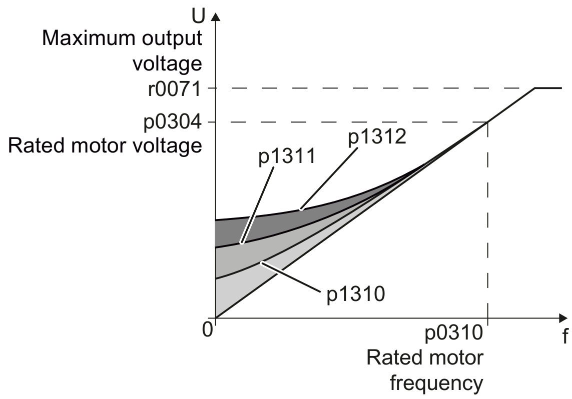


Table 9- 29 Parameters for the voltage boost

Parameter	Description
p1310	**Permanent voltage boost** (factory setting 50 %) Compensates voltage drops as a result of long motor cables and the ohmic losses in the motor.
p1311	**Voltage boost when accelerating** (Factory setting 0 %) Provides additional torque when the motor accelerates.
p1312	**Voltage boost when starting** (Factory setting 0 %) Provides additional torque, however, only when the motor accelerates for the first time after it has been switched on ("break loose torque").

Procedure

Only increase the voltage boost in small steps. Excessively high values in p1310 ... p1312 can cause the motor to overheat and switch off (trip) the inverter due to overcurrent .

- Power-up the motor with an average speed.
- Reduce the speed to just a few revolutions per minute.
- Check whether the motor rotates smoothly.
- If the motor does not rotate smoothly, or even remains stationary, increase the voltage boost p1310 until you are satisfied with the motor behavior.
- Accelerate the motor to the maximum speed with maximum load and check whether the motor follows the setpoint.
- If, when accelerating, the motor stalls, increase the voltage boost p1311 until the motor accelerates to the maximum speed without any problems.

In most cases, your motor will now behave satisfactorily. You will only have to increase parameter p1312 for applications with a noticeable break loose torque.

You will find more information about this function in the parameter list and in function diagram 6300 of the List Manual.

9.6.2 Vector control

9.6.2.1 Properties of the sensorless vector control

Sensorless vector control

Using a motor model, the speed control calculates the load and the motor slip. As a result of this calculation, the inverter controls its output voltage and frequency so that the motor speed follows the setpoint, independent of the motor load.

Speed control is possible without directly measuring the motor speed and is therefore also called "sensorless vector control".

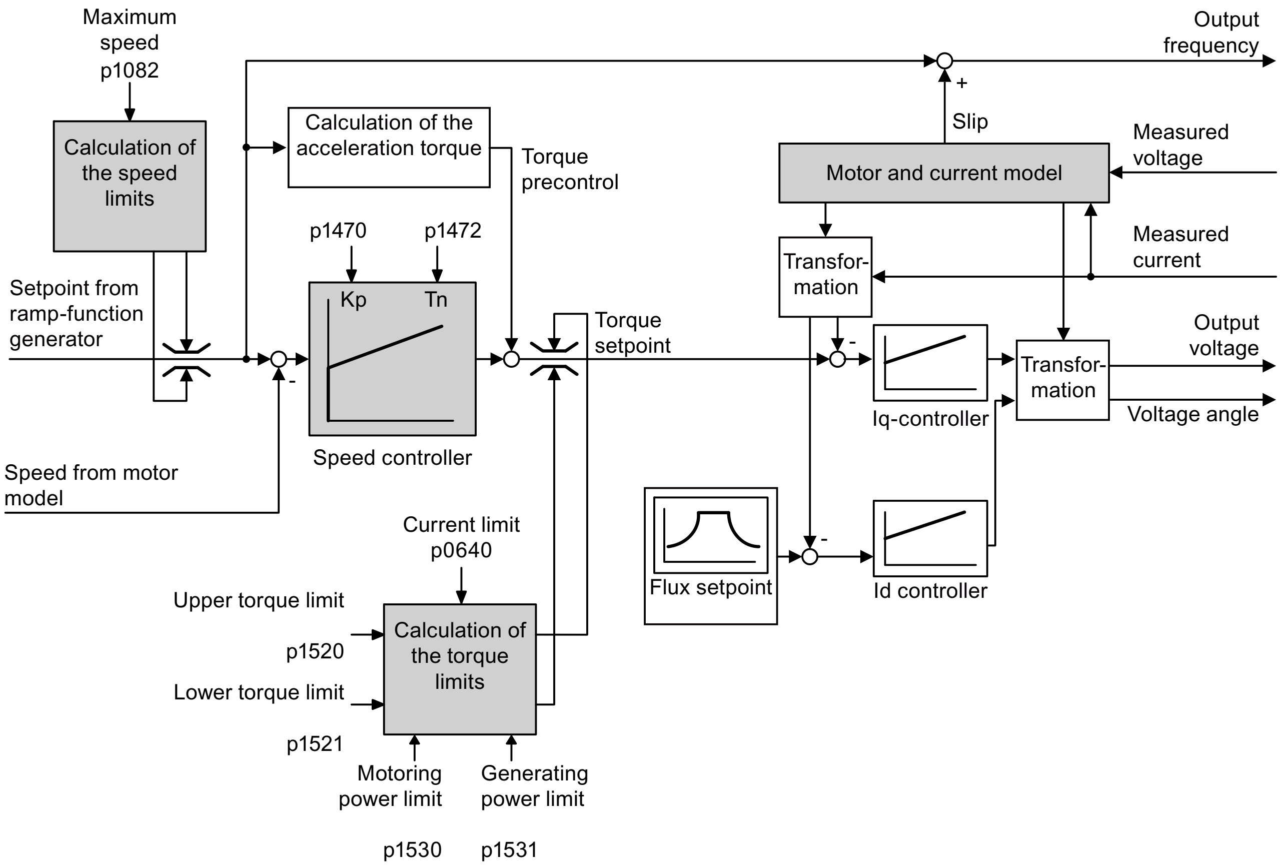


Figure 9-20 Simplified function diagram of sensorless vector control

9.6.2.2 Select motor control

Speed control is already preset

To achieve a good controller response, you must adapt the elements marked in gray in the figure in the overview diagram above. If you selected speed control as control mode in the basic commissioning, you will already have set the following:

- The maximum speed for your application.
- The motor and current model: If the motor data in the converter correspond to the motor data on the rating plate, then the motor and current model in the converter are correct and the vector control can operate satisfactorily.
- The converter calculates the torque limits matching the current limit that you have set for the basic commissioning.
  Regardless of it, you can also set additional positive and negative torque limits or limit the power of the motor.
- The converter has a preset speed controller with self-optimization (rotating measurement).
  If you want to continue to optimize this setting, follow the instructions further down in this chapter.

Select encoderless vector control

Procedure

With an Operator Panel:

- Set p1300 = 20.

Using STARTER:

- Go online with STARTER.
- Select speed control without encoder in the "Speed controller" or "V/f control" mask.

9.6.2.3 Re-optimize the speed controller

In the following cases you will need to manually optimize the speed controller:

- Your application does not permit self-optimization because the motor cannot rotate freely.
- You are dissatisfied with the result of the converter self-optimization.
- The converter interrupted the self-optimization with a fault message.

Procedure

- Temporarily set the ramp-up and ramp-down time of the ramp-function generator to zero.

  With an Operator Panel:
  - Set p1120 = 0 and p1121 = 0.

  Using STARTER:
  - Go online with STARTER.
  - Set the times to 0 in the "Ramp-function generator" screen form.
- Temporarily set the pre-control of the speed controller to zero.

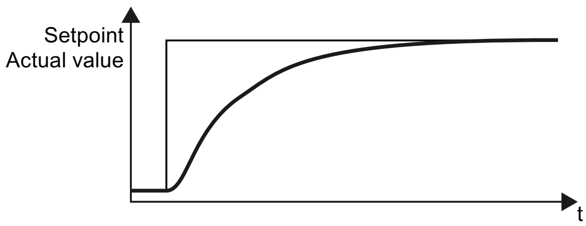
  With an Operator Panel:
  - Set p1496 = 0.

  Using STARTER:
  - Go online with STARTER.
  - Set the precontrol to 0 in the "Speed controller" screen form.
- Enter a setpoint step and monitor the associated actual value, e.g. using the trace function in STARTER.
- Optimize the speed controller by changing controller parameters K_P and T_N until the drive runs optimally (see the diagrams below).

  With an Operator Panel:
  - K_P = p1470
  - T_N = p1472

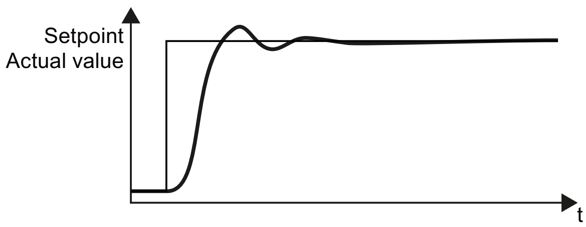
  Using STARTER:
  - Go online with STARTER.
  - Set the controller in the "Speed controller" screen form.
- Set the ramp-up and ramp-down times of the ramp-function generator back to their original value.
- Set the pre-control of the speed controller back to 100 %.

Table 9- 30 Optimum control response



Optimum control response for applications that do not permit any overshoot.

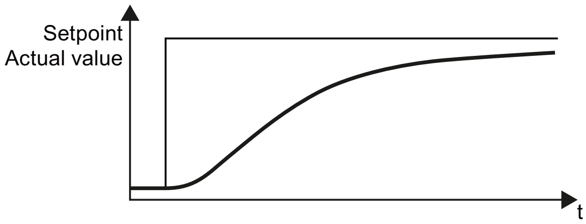
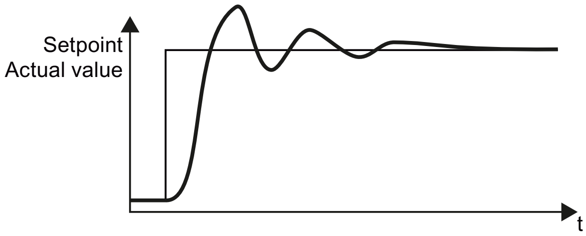
The actual value approaches the setpoint, without any significant overshoot.



Optimum control behavior for fast correction and quick compensation of noise components.

The actual value approaches the setpoint and slightly overshoots (maximum 10% of the setpoint step).

Table 9- 31 Optimizing the control response

	**The actual value only slowly approaches the setpoint.** • Increase the proportional component K_P and reduce the integration time T_N.
	**The actual value quickly approaches the setpoint, but overshoots too much** • Decrease the proportional component K_P and increase the integration time T_N.

9.7 Protection functions

The frequency inverter offers protective functions against overtemperature and overcurrent for both the frequency inverter as well as the motor. Further, the frequency inverter protects itself against an excessively high DC link voltage when the motor is regenerating.

9.7.1 Inverter temperature monitoring

The inverter protects itself against overtemperature with different monitoring functions:

1. I2t monitoring (alarm A07805, fault F30005)
   The I^2t monitoring measures the actual utilization on the basis of a current reference value. Parameter r0036 [%] displays the actual utilization as a %. As long as the actual current does not exceed the reference value, then the utilization in r0036 = 0.
2. Monitoring the chip temperature of the power unit (alarm A05006 - fault F30024)
   The inverter monitors the difference in temperature between the power chip (IGBT) and the heat sink. The measured values are in r0037[1] [°C].
3. Heat sink monitoring (alarm A05000, fault F30004)
   The inverter monitors the heat sink temperature of the Power Module. The values are in r0037[0] [°C].

Inverter response

The inverter temperature is essentially determined by the resistive losses of the output current and the switching losses which occur when pulsing the motor. Parameter p0290 defines how the inverter responds to an excessively high temperature.

Parameter	Description
P0290	**Power unit overload response** (factory setting for SINAMICS G120 inverters with Power Module PM260: 0; factory setting for all of the inverters: 2) Setting the reaction to a thermal overload of the power unit: 0: Reduce output current (in vector control mode) or speed (in V/f mode) 1: No reduction, shutdown when overload threshold is reached (F30024) 2: Reduce pulse frequency and output current (in vector control mode) or pulse frequency and speed (in V/f mode) 3: Reduce pulse frequency
P0292	**Power unit temperature warning threshold** (factory setting: Heat sink [0] 5°C, power semiconductor [1] 15°C) The value is set as a difference to the shutdown temperature.

9.7.2 Motor temperature monitoring using a temperature sensor

Connecting the temperature sensor

You can use one of the following sensors to protect the motor against overtemperature:

- Temperature switch (e.g. bimetallic switch)
- PTC sensor
- KTY84 sensor

Connect the temperature sensor of the motor to terminals 14 and 15 of the inverter.

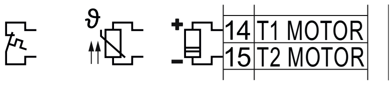


Figure 9-21 Connecting the motor temperature sensor at the inverter

Temperature switch

The inverter evaluates the temperature switch as follows:

- Overtemperature alarm (A07910):
  The inverter interprets a resistance ≥ 100 Ω as an open-circuit temperature switch and responds with an alarm.
- Overtemperature fault (F07011):
  If p0610 = 1 or p0610 = 2, in addition to an alarm, the inverter responds to this with a fault.

PTC sensor

The inverter evaluates the PTC sensor as follows:

- Overtemperature alarm (A07910):
  For a resistance > 1650 Ω, the inverter responds with an alarm.
- Overtemperature fault (F07011):
  If p0610 = 1 or p0610 = 2, in addition to an alarm, the inverter responds to this with a fault.
- Alarm and fault, sensor monitoring (A07015 or F07016):
  - The inverter interprets a resistance < 20 Ω as short-circuit.
  - The inverter responds to the short circuit with an alarm. If the alarm is present longer than 100 milliseconds, then this is followed by a fault.

KTY84 sensor

CAUTION
Ensure the correct polarity when connecting the KTY sensor: If a KTY sensor sensor is connected with the incorrect polarity, this can destroy the motor due to overheating, as the inverter cannot detect a motor overtemperature condition.

The inverter evaluates the KTY sensor as follows:

- Temperature measurement:
  The inverter determines the motor temperature in the range from -48 °C ... +248 °C.
- Overtemperature alarm (A07910):
  The inverter signals an alarm for a motor temperature > p0604.
- Overtemperature fault (F07011):
  The inverter signals a fault in the following cases:
  - Always for a motor temperature > p0605.
  - In addition, for a motor temperature > p0604, if p0610 = 1 or p0610 = 2.
- Alarm and fault, sensor monitoring (A07015 or F07016):
  - Wire-break:
    The inverter interprets a resistance > 2120 Ω as a wire break.
  - Short-circuit:
    The inverter interprets a resistance < 50 Ω as short-circuit.
  - The inverter responds to a wire break or short circuit with an alarm. If the alarm is present longer than 100 milliseconds, then this is followed by a fault.

Parameters for the temperature monitoring

Table 9- 32 Setting the monitoring

Parameter	Description
p0335	**Specify the motor cooling** 0: Self-ventilated - with fan on the motor shaft (factory setting) 1: Forced ventilation - with a separately driven fan 2: Self-ventilated and inner cooling (open-circuit cooling) 3: Forced ventilated and inner cooling (open-circuit cooling)
p0601	**Motor temperature sensor type** 0: No sensor (factory setting) 1: PTC (→ p0604) 2: KTY84 (→ p0604, p0605) 4: Temperature switch
p0604	**Motor temperature alarm threshold** (factory setting 130 °C)
p0605	**Motor temperature fault threshold** (Factory setting: 145 °C) Setting for KTY84 sensor. The parameter has no significance for a PTC sensor.
p0610	**Motor overtemperature response** Determines the response when the motor temperature reaches the alarm threshold p0604. 0: Alarm (A07910), but no response of the motor. 1: Alarm (A07910) and reduction of the current limit (factory setting) - this reduces the motor speed. 2: Fault (F07011) and shutdown.
p0640	**Current limit** (input in A)

Additional information on the motor temperature monitoring can be found in function diagram 8016 of the List Manual.

9.7.3 Overcurrent protection

During vector control, the motor current remains within the torque limits set there.

During U/f control, the maximum current controller (I_{max} controller) protects the motor and inverter against overload by limiting the output current.

Method of operation of I_{max} controller

If an overload situation occurs, the speed and stator voltage of the motor are reduced until the current is within the permissible range. If the motor is in regenerative mode, i.e. it is being driven by the connected machine, the I_{max} controller increases the speed and stator voltage of the motor to reduce the current.

Note

The inverter load is only reduced if the motor torque decreases at lower speeds (e.g. for fans).

In the regenerative mode, the current only decreases if the torque decreases at a higher speed.

Settings

You only have to change the factory settings of the I_{max} controller if the drive tends to oscillate when it reaches the current limit or it is shut down due to overcurrent.

Table 9- 33 I_{max} controller parameters

Parameter	Description
P0305	Rated motor current
P0640	Motor current limit
P1340	Proportional gain of the I_{max} controller for speed reduction
P1341	Integral time of the I_{max} controller for speed reduction
r0056.13	Status: I_{max} controller active
r1343	Speed output of I_{max} controller Shows the amount to which the I-max controller reduces the speed.

For more information about this function, see function diagram 1690 in the List Manual.

9.7.4 Limiting the maximum DC link voltage

How does the motor generate overvoltage?

An induction motor operates as a generator if it is driven by the connected load. A generator converts mechanical power into electrical power. The electric power flows back into the converter and causes V_{DC} in the converter to increase.

Above a critical DC link voltage both the converter as well as the motor will be damaged. Before the voltage can reach critical levels, however, the converter switches the motor off with the fault message "DC link overvoltage".

Protecting the motor and converter against overvoltage

The V_{DCmax} controller prevents – as far as the application permits – the DC link voltage from reaching critical levels. The V_{DCmax} controller increases the ramp-down time of the motor during braking, so that the motor feeds back only as little power to the converter as is covered by the losses in the converter.

The V_{DCmax} controller is not suitable for applications in which the motor is permanently in the regenerative mode, e.g. in hoisting gear or when large flywheel masses are braked. Further information on converter braking methods can be found in Section Braking functions of the inverter (Page 205).

There are two different groups of parameters for the V_{DCmax} controller, depending on whether the motor is being operated with U/f control or vector control.

Table 9- 34 V_{DCmax} controller parameters

Parameter for U/f control	Parameter for vector control	Description
p1280 = 1	p1240 = 1	**V_{DC} controller or V_{DC} monitoring configuration**(factory setting: 1)1: Enable V_{DCmax} controller
r1282	r1242	**V_{DCmax} controller switch-on level** Shows the value of the DC-link voltage above which the V_{DCmax} controller is active
p1283	p1243	**V_{DCmax} controller dynamic factor** (factory setting: 100 %) scaling of the control parameters P1290, P1291 and P1292
p1294	p1254	**V_{DCmax}-controller automatic recording ON-signal level**(factory setting p1294: 0, factory setting p1254: 1)Activates or deactivates automatic detection of the switch-on levels of the V_{DCmax}controller. 0: Automatic detection disabled 1: Automatic detection enabled
p0210	p0210	**Unit supply voltage** If p1254 or p1294 = 0, the inverter uses this parameter to calculate the intervention thresholds of the V_{DCmax} controller. Set this parameter to the actual value of the input voltage.

For more information about this function, see the List Manual (function diagrams 6320 and 6220).

9.8 Status messages

Information about the inverter state (alarms, faults, actual values) can be output via inputs and outputs and also via the communication interface.

Details on evaluating the inverter state via inputs and outputs are provided in Section Adapting the terminal strip (Page 73).

The evaluation of the inverter state via the communication interface is realized using the inverter status word. Details on this are provided in the individual sections of Chapter Configuring the fieldbus (Page 85).

9.9 Application-specific functions

9.9.1 Functions that match the application

The inverter offers a series of functions that you can use depending on your particular application, e.g.:

- Unit changeover
- Braking functions
- Automatic restart and flying restart
- Basic process control functions

Please refer to the following sections for detailed descriptions.

9.9.2 Unit changover

9.9.2.1 Unit changeover

Description

With the unit changeover function, you can adapt the inverter to the line supply (50/60 Hz) and also select US units or SI units as base units.

Independent of this, you can define the units for process variables or change over to percentage values.

Specifically, you have the following options:

- Changing over the motor standard (Page 202) IEC/NEMA (adaptation to the line supply)
- Changing over the unit system (Page 202)
- Changing over units for the technology controller (Page 203)

NOTICE
The motor standard, the unit system as well as the process variables can only be changed offline. The procedure is described in Section Changing of the units with STARTER (Page 204).

Note

Restrictions for the unit changeover function

- The values on the rating plate of the inverter or motor cannot be displayed as percentage values.
- Using the unit changeover function a multiple times (for example, percent → physical unit 1 → physical unit 2 → percent) may lead to the original value being changed by one decimal place as a result of rounding errors.
- If the unit is changed over into percent and the reference value is then changed, the percentage values relate to the new reference value.
  Example:
  - For a reference speed of 1500 rpm, a fixed speed of 80% corresponds to a speed of 1200 rpm.
  - If the reference speed is changed to 3000 rpm, then the value of 80% is kept and now means 2400 rpm.

Reference variables for unit changeover

p2000 Reference frequency/speed

p2001 Reference voltage

p2002 Reference current

p2003 Reference torque

r2004 Reference power

9.9.2.2 Changing over the motor standard

You change over the motor standard using p0100. The following applies:

- p0100 = 0: IEC motor (50 Hz, SI units)
- p0100 = 1: NEMA motor (60 Hz, US units)
- p0100 = 2: NEMA motor (60 Hz, SI units)

The parameters listed below are affected by the changeover.

Table 9- 35 Variables affected by changing over the motor standard

P no.	Designation	Unit for p0100 =		
		0*)	1	2
r0206	Power Module rated power	kW	HP	kW
p0307	Rated motor power	kW	HP	kW
p0316	Motor torque constant	Nm/A	lbf ft/A	Nm/A
r0333	Rated motor torque	Nm	lbf ft	Nm
r0334	Motor torque constant, actual	Nm/A	lbf ft/A	Nm/A
p0341	Motor moment of inertia	kgm^2	$lb\ ft^2$	kgm^2
p0344	Motor weight (for thermal motor type)	kg	Lb	kg
r1969	Speed_cont_opt moment of inertia determined	kgm^2	$lb\ ft^2$	kgm^2

*) Factory setting

9.9.2.3 Changing over the unit system

You change over the unit system using p0505. The following selection options are available:

- P0505 = 1: SI units (factory setting)
- P0505 = 2: SI units or % relative to SI units
- P0505 = 3: US units
- P0505 = 4: US units or % relative to US units

Note

Special features

The percentage values for p0505 = 2 and for p0505 = 4 are identical. In order to perform internal calculations and output values that are changed back over to physical variables, however, an important factor is whether the changeover process relates to SI or US units.

In the case of variables for which changeover to % is not possible, the following applies:
p0505 = 1 ≙ p0505 = 2 and p0505 = 3 ≙ p0505 = 4.

In the case of variables whose units are identical in the SI system and US system, and which can be displayed as a percentage, the following applies:
p0505 = 1 ≙ p0505 = 3 and p0505 = 2 ≙ p0505 = 4.

Parameters affected by changeover

The parameters affected by changing over the unit system are grouped according to unit. An overview of the unit groups and the possible units can be found in the List Manual in the Section "Unit group and unit selection".

9.9.2.4 Changing over units for the technology controller

Note

We recommend that the units and reference values of the technology controller are coordinated and harmonized with one another during commissioning.

Subsequent modification in the reference variable or the unit can result in incorrect calculations or displays.

Changing over process variables of the technology controller

You change over the process variables of the technology controller using p0595. For physical values, you define the reference variable in p0596.

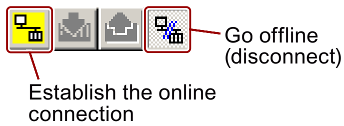
The parameters affected by changing over units of the technology controller belong to unit group 9_1. For details, please refer to the section titled "Unit group and unit choice" in the List Manual.

9.9.2.5 Changing of the units with STARTER

The converter must be in the offline mode in order to change over the units.

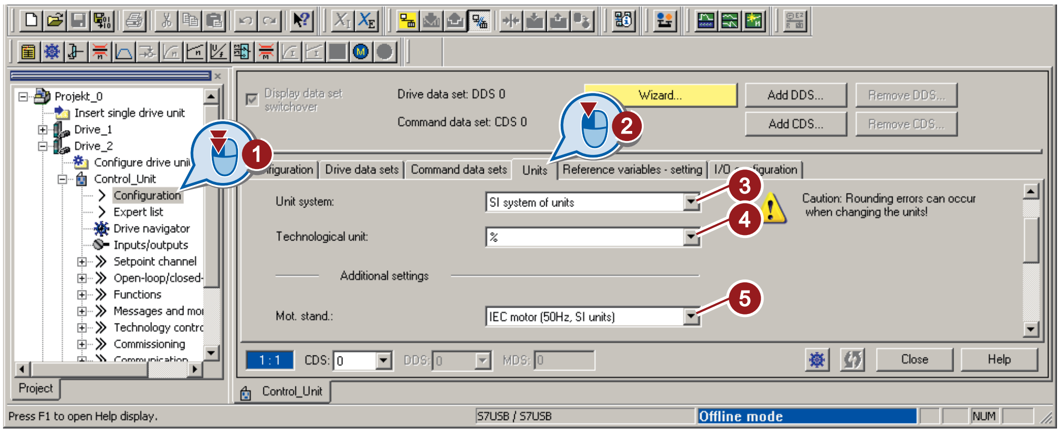
STARTER shows whether you change settings online in the converter or change offline in the PC (**Online mode** / **Offline mode**).

You switch over the mode using the adjacent buttons in the menu bar.



Procedure

- Go to the "Units" tab in the configuration screen form to change over the units.



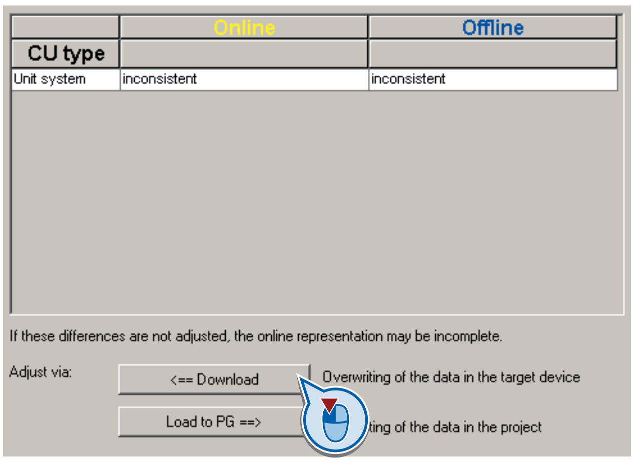
③ Changing over the unit system

④ Selecting process variables of the technology controller

⑤ adapting to the line supply

Figure 9-22 Unit changeover

- Save your settings and go online. In this case, the converter detects that other units or process variables have been set offline than are actually in the converter; the converter displays this in the following screen form:
- Accept these settings in the converter.



9.9.3 Braking functions of the inverter

A differentiation is made between mechanically braking and electrically braking a motor:

- Mechanical brakes are generally motor holding brakes that are closed when the motor is at a standstill. Mechanical operating brakes, that are closed while the motor is rotating are subject to a high wear and are therefore often only used as an emergency brake.
  If your motor is equipped with a motor holding brake, then you should use the inverter functions to control this motor holding brake, see Section Motor holding brake (Page 214).
- The motor is electrically braked by the inverter. An electrical braking is completely wear-free. Generally, a motor is switched off at standstill in order to save energy and so that the motor temperature is not unnecessarily increased.

9.9.3.1 Comparison of electrical braking methods

Regenerative power

If an induction motor electrically brakes the connected load and the mechanical power exceeds the electrical losses, then it operates as a generator. The motor converts mechanical power into electrical power. Examples of applications, in which regenerative operation briefly occurs, include:

- Grinding disk drives
- Fans

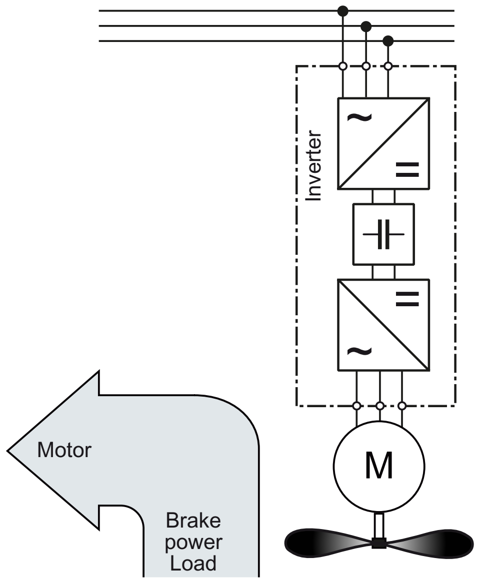
For certain drive applications, the motor can operate in the regenerative mode for longer periods of time, e.g.:

- Centrifuges
- Hoisting gear and cranes
- Conveyor belts with downward movement of load (vertical or inclined conveyors)

The inverter offers the following options to convert the regenerative power of the motor into heat or to feed it back into the line:

- DC braking (Page 207)
- Compound braking (Page 210)
- Dynamic braking (Page 212)

Main features of the braking functions



DC braking

The motor converts the regenerative power into heat.

- *Advantage:* The motor brakes without the inverter having to process the regenerative energy
- *Disadvantages:* significant increase in the motor temperature; no defined braking characteristics; no constant braking torque; no braking torque at standstill; regenerative power is lost as heat; does not function when the line supply fails

Compound braking

The motor converts the regenerative power into heat.

- *Advantage:* Defined braking characteristics, the motor brakes without the inverter having to convert any regenerative energy
- *Disadvantages:* significant motor temperature rise; no constant braking torque; regenerative power is dissipated as heat; does not function when the line supply fails

Dynamic braking

The inverter converts the regenerative power into heat using a braking resistor.

- *Advantages:* defined braking characteristics; no additional motor temperature increase; constant braking torque; in principle, also functions when the power fails
- *Disadvantages:* Braking resistor required; regenerative power is dissipated as heat

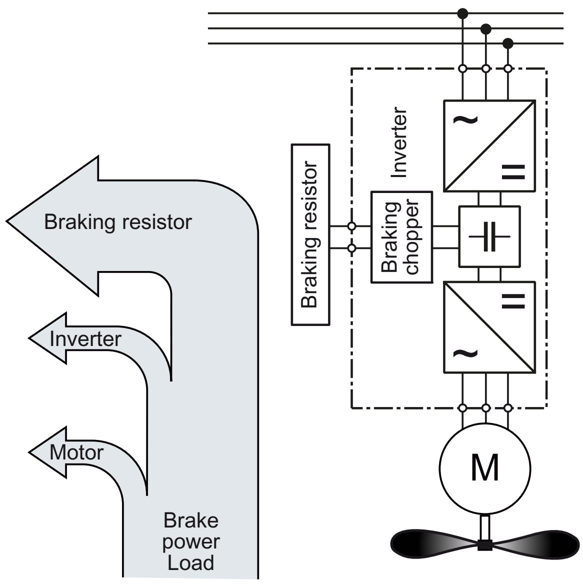


Table 9- 36 What braking method is suitable for what application?

Application examples	Electrical braking methods
Pumps, fans, mixers, compressors, extruders	Not required
Grinding machines, conveyor belts	DC braking, compound braking
Centrifuges, vertical conveyors, hoisting gear, cranes, winders	Dynamic braking

9.9.3.2 DC braking

DC braking is used for applications without regenerative feedback into the line supply, where the motor can be more quickly braked by impressing a DC current than along a braking ramp.

Typical applications for DC braking include:

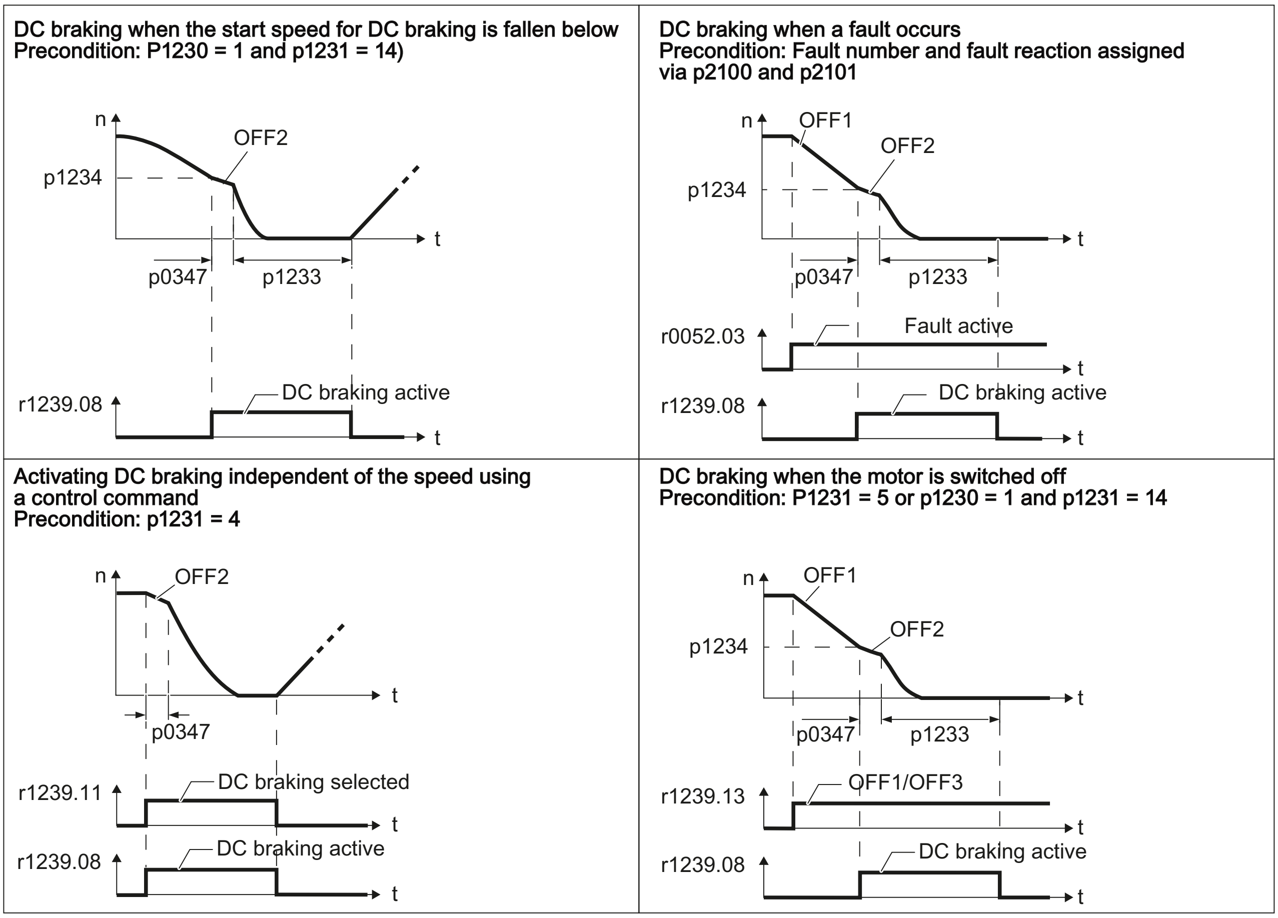
- Centrifuges
- Saws
- Grinding machines
- Conveyor belts

Whether DC braking or ramp-down with an OFF1 command is more effective depends on the motor properties.

Principle of operation

With DC braking, the inverter outputs an internal OFF2 command for the time that it takes to demagnetize the motor - and then impresses the braking current for the duration of the DC braking.

The following operating modes are available for DC braking.



DC braking when the start speed for DC braking is fallen below

DC braking is automatically activated as soon as the motor speed falls below the start speed for DC braking. However, the motor speed must have first exceeded the start speed for DC braking. Once the DC braking time is complete, the inverter switches to normal operation. If p1230 is set to 0, DC braking can also be canceled before the time defined in p1233.

DC braking when a fault occurs

If a fault occurs, where the configured response is DC braking, then the inverter first brakes the motor along the down ramp until the start speed for DC braking is reached, and then starts DC braking.

Activating DC braking independent of the speed using a control command

DC braking starts independent of the motor speed, as soon as the control command for braking (e.g. via DI3: P1230 = 722.3) is issued. If the braking command is revoked, the inverter returns to normal operation and the motor accelerates to its setpoint.

Note: The value of p1230 is displayed in r1239.11.

DC braking when the motor is switched off

If the motor is switched off with OFF1 or OFF3, the inverter first brakes the motor along the down ramp until the start speed for DC braking is reached, and then starts DC braking. The motor is then switched into a torque-free condition (OFF2).

Note

In the following operating modes, it is possible that the motor is still rotating after DC braking. This is the reason that in these operating modes "Flying restart (Page 219)" must be activated:

- DC braking when the start speed for DC braking is fallen below
- Activating DC braking independent of the speed using a control command
- DC braking when the motor is switched off

The DC braking function can only be set for induction motors.

⚠ CAUTION

DC braking converts some of the kinetic energy of the motor and load into heat in the motor (temperature rise). The motor will overheat if the braking operation lasts too long or the motor is braked too often.

DC braking parameters

Table 9- 37 Parameters for configuring DC braking

Parameter	Description
p1230	**Activate DC braking (BICO parameter)** The value for this parameter (0 or 1) can be either entered directly or specified by means of an interconnection with a control command.
p1231	**Configure DC braking** • p1231 = 0, no DC braking • p1231 = 4, general enabling of DC braking • p1231 = 5, DC braking for OFF1/3, independent of p1230 • P1231 = 14, enables DC braking for the case that the motor speed falls below the start speed for DC braking.

Table 9- 38 Parameters for configuring DC braking in the event of faults

Parameter	Description
p2100	**Set fault number for fault reaction** (factory setting: 0) Enter the fault number for which DC braking should be activated, e.g.: p2100[3] = 7860 (external fault 1).
p2101 = 6	**Fault reaction setting** (factory setting: 0) Assigning the fault response: p2101[3] = 6.
The fault is assigned an index of p2100. The associated fault response must be assigned the same index in p2101. In the List Manual of the inverter - in the "Faults and alarms" list - possible fault responses are listed for every fault. The entry "DCBRAKE" means that for this particular fault, DC braking can be set as fault response.	

Table 9- 39 Additional parameters for setting DC braking

Parameter	Description
p1232	**DC braking braking current** (factory setting: 0 A) Setting the braking current for the DC braking.
p1233	**DC braking duration** (factory setting: 1 s)
p1234	**DC braking start speed** (factory setting: 210000 rpm) DC braking starts – assuming that it has been correspondingly parameterized (p1230/p1231) – as soon as the actual speed falls below this threshold.
p0347	**Motor de-excitation** The parameter is calculated via p0340 = 1, 3. The inverter can trip due to an overcurrent during DC braking if the de-excitation time is too short.

9.9.3.3 Compound braking

Compound braking is typically used for applications in which the motor is normally operated at a constant speed and is only braked down to standstill in longer time intervals, e.g.:

- Centrifuges
- Saws
- Grinding machines
- Horizontal conveyors

Principle of operation

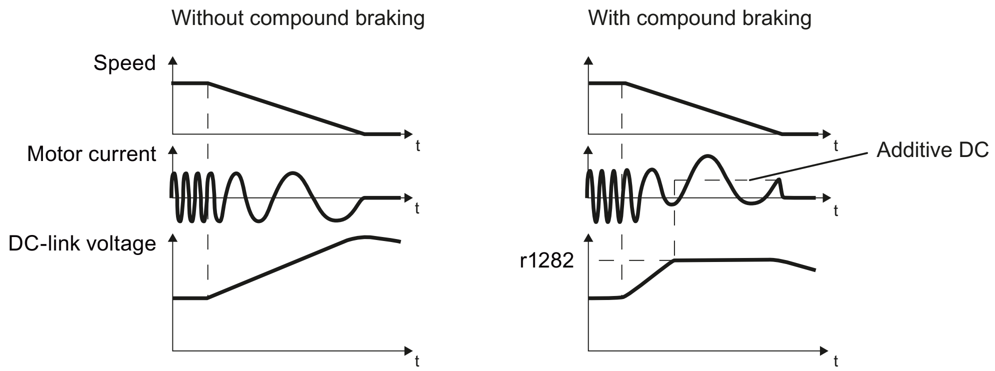


Figure 9-23 Motor brakes with and without active compound braking

Compound braking prevents the DC link voltage increasing above a critical value. The inverter activates compound braking depending on the DC link voltage. Above a DC link voltage threshold (r1282), the inverters adds a DC current to the motor current. The DC current brakes the motor and prevents an excessive increase in the DC link voltage.

Note

Compound braking is only active in conjunction with the V/f control.

Compound braking does not operate in the following cases:

- The "flying restart" function is active
- DC braking is active
- Vector control is selected

Parameterizing compound braking

Table 9- 40 Parameters to enable and set compound braking

Parameter	Description
P3856	**Compound braking current (%)** With the compound braking current, the magnitude of the DC current is defined, which is additionally generated when stopping the motor for operation with V/f control to increase the braking effect. P3856 = 0 Compound braking locked P3856 = 1 … 250 Current level of the DC braking current as a % of the rated motor current (P0305) Recommendation: p3856 < 100 % × (r0209 - r0331) / p0305 / 2
r3859.0	**Status word, compound braking** r3859.0 = 1: Compound braking is active

⚠ CAUTION

Compound braking converts part of the kinetic energy of the motor and load into motor heat (temperature rise). The motor can overheat if braking lasts too long or the drive is braked too frequently.

9.9.3.4 Dynamic braking

Dynamic braking is typically used in applications in which dynamic motor behavior is required at different speeds or continuous direction changes, e.g.:

- Horizontal conveyors
- Vertical and inclined conveyors
- Hoisting gear

Principle of operation

The inverter controls the braking chopper depending on its DC link voltage. The DC link voltage increases as soon as the inverter absorbs the regenerative power when braking the motor. The braking chopper converts this power into heat in the braking resistor. This therefore prevents the DC link voltage increasing above the limit value $V_{DC\ link,\ max}$.

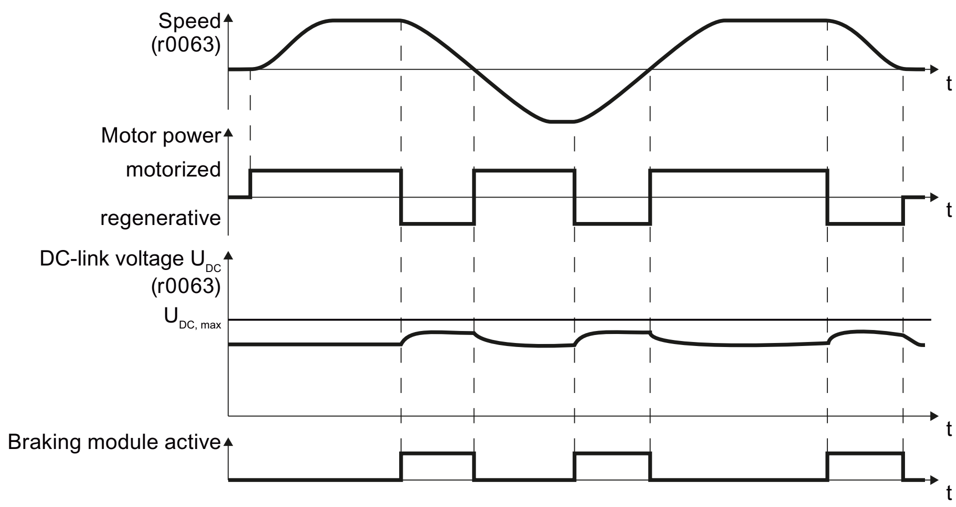


Figure 9-24 Simplified representation of dynamic braking with respect to time

Mounting the braking resistor

You find the mounting instructions in the section: Mounting the braking resistor (Page 28).

Connecting the braking resistor

1. Connect the braking resistor to terminals R1 and R2 on the converter.
2. Ground the braking resistor directly to the control cabinet's grounding bar. The braking resistor must not be grounded using the PE terminals on the converter.
3. If you have to comply with EMC requirements, observe the rules for shielding.
4. Connect the braking resistor's temperature monitoring (terminals T1 and T2 on the braking resistor) with a free digital input of your choice on the converter. Set the function of this digital input to the OFF2 command.

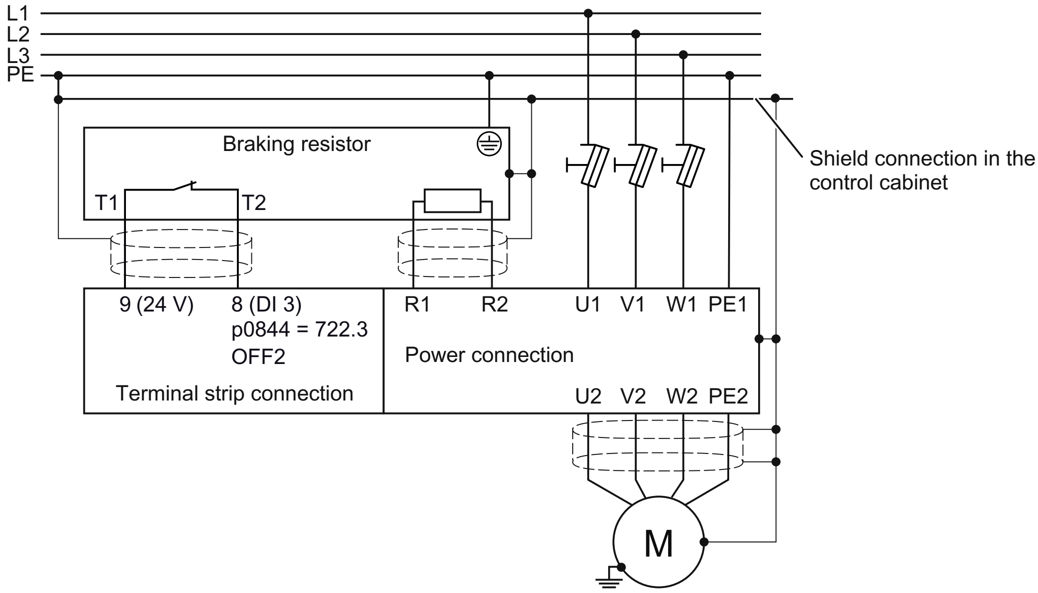


Figure 9-25 Braking resistor connections (Example: temperature monitoring via DI 3)

CAUTION
Without temperature monitoring the resistor might get damaged.

WARNING

Risk of fire, severe personal and property damage

If an unsuitable braking resistor is used, this could result in a fire and severely damage, people, property and equipment. It is essential that not only the correct braking resistor is used, but it is installed correctly according to the instructions delivered with the braking resistor.

The temperature of braking resistors increases significantly during operation. For this reason, avoid coming into direct contact with braking resistors. Maintain sufficient clearances around the braking resistor and ensure that there is adequate ventilation.

Procedure: Set dynamic braking

In order to optimally utilize the connected braking resistor, you must know the braking power that occurs in your particular application.

Table 9- 41 Parameter

Parameter	Description	
p0219	**Braking power of the braking resistor** (factory setting: 0 kW) Set the maximum braking power that the braking resistor must handle in your particular application. Under certain circumstances, for low braking power ratings, the converter extends the ramp-down time of the motor. **Example**: In your particular application, the motor brakes every 10 seconds. In so doing, the braking resistor must handle a braking power of 1 kW for 2 s. Use a braking resistor with a continuous power rating of 1 kW × 2 s / 10 s = 0.2 kW and set the maximum braking power to: p0219 = 1 (kW).	
p0844	**No coast down/coast down (OFF2) signal source 1**	
	p0840 = 722.x	Monitor the overtemperature of the braking resistor with digital input x of the converter.

9.9.3.5 Motor holding brake

The motor holding brake prevents the motor turning when it is switched off. The converter has internal logic to optimally control a motor holding brake.

The converter-internal control of the motor holding brake is suitable typically for horizontal, inclined and vertical conveyors.

A motor holding brake can also be useful in several applications for pumps or fans to ensure that the powered-down motor does not rotate in the wrong direction through a liquid or air flow.

Connecting the motor holding brake

You have to define which of the digital outputs is to be used for controlling the motor holding brake function.

There are two digital outputs to choose from, for example, the motor holding brake can be connected to the converter using digital output 0 (DO 0) on terminals 19 and 20.

The converter supplies the control for the motor holding brake.

You have to supply the following equipment:

- A motor holding brake suitable for the attached motor and the purposes of the application.
- A power supply for the motor holding brake.
- A relay to allow the digital output to enable or disable the motor holding brake.

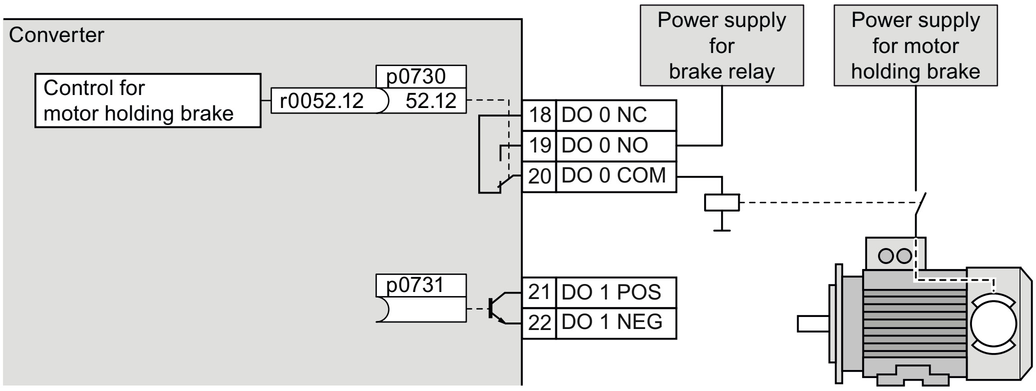


Figure 9-26 Simplified diagram of motor holding brake connected to DO 0 of the converter

Principle of operation after OFF1 and OFF3 command

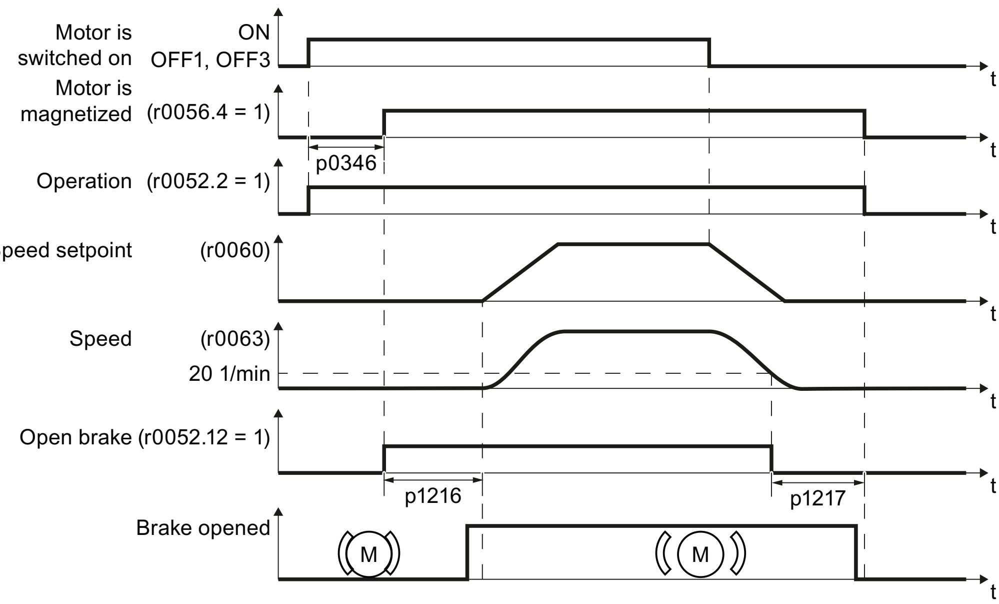


Figure 9-27 Controlling the motor holding brake when the motor is switched on and off

The motor brake is controlled as shown in the following diagram:

1. After the ON command (switch on motor), the inverter magnetizes the motor. At the end of the magnetizing time (p0346), the inverter issues the command to open the brake.
2. The motor remains at a standstill until the end of the brake opening time p1216. The motor holding brake must open within this time.
3. At the end of the brake opening time the motor accelerates to its speed setpoint.
4. After the OFF command (OFF1 or OFF3) the motor brakes to a standstill.
5. If the actual speed is less than 20 rpm, then the inverter issues the command to close the brake. The motor comes to a standstill but remains switched on.
6. At the end of the brake closing time p1217, the motor is switched off.
   The motor holding brake must close within this time.

Principle of operation after OFF2 or STO command

For the following signals, the brake closing time is not taken into account:

- OFF2 command
- For fail-safe applications, in addition, after "Safe Torque Off" (STO)

After these control commands, the signal to close the motor holding brake is immediately output independent of the motor speed. The inverter does not monitor the motor speed until the brake closes.

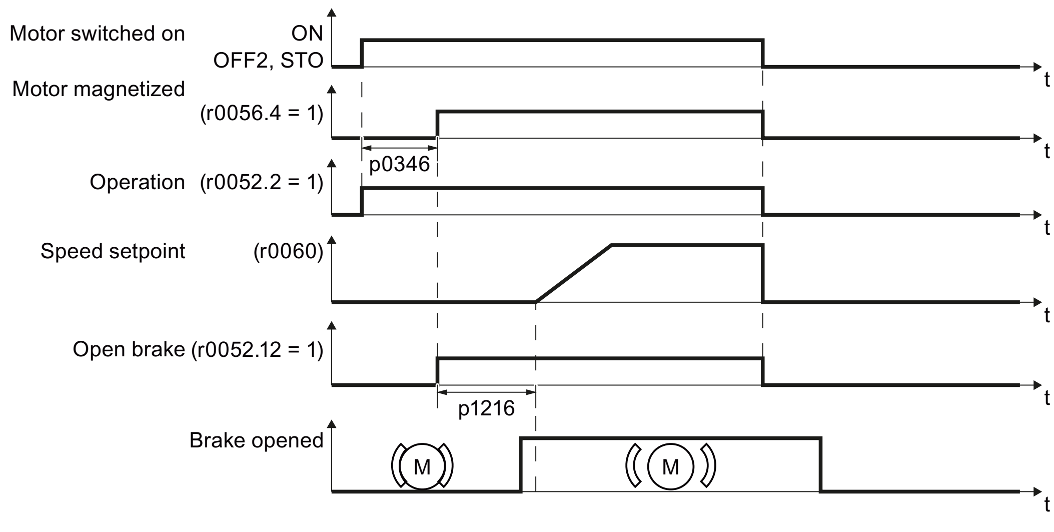


Figure 9-28 Controlling the motor holding brake after an OFF2 command or STO

Commissioning

⚠ WARNING
The following applications require special settings of the motor holding brake. In these cases, the motor holding brake control may only be commissioned by experienced personnel: • All applications that involve moving and transporting people • Hoisting gear • Elevators • Cranes

- Before commissioning, secure any dangerous loads (e.g. loads on inclined conveyors)
- Suppress the motor holding brake control, e.g. by disconnecting the control cables
- When opening the motor holding brake, ensure that a torque is established that prevents the load from briefly dropping.
  - Check the magnetizing time p0346; the magnetizing time is pre-assigned during commissioning and must be greater than zero
  - V/f control (p1300 = 0 to 3):
    Set the boost parameters p1310 and p1311.
    Define the motor torque when switching on using p1351 and p1352.
  - Vector control (p1300 ≥ 20):
    Define the motor torque when switching on using p1475.
- Assigning parameters for the opening and closing times of the motor holding brake.
  It is extremely important that electromechanical brakes are controlled with the correct timing in order to protect the brakes against long-term damage. The exact values can be found in the technical data of the connected brake. Typical values:
  - Depending on the brake size, brake opening times lie between 25 ms and 500 ms.
  - Depending on the brake size, brake closing times lie between 15 ms and 300 ms.
- Reestablish the control of the motor holding brake.
  r0052.12 ("Motor holding brake open") controls the brake.

Table 9- 42 Control logic parameters of the motor holding brake

Parameter	Description
p1215 = 1	**Enable motor holding brake** 0 Motor holding brake locked (factory setting) 3: Motor holding brake just like the sequential control, connected via BICO
p1216	**Motor holding brake opening time** (factory setting 0.1 s) p1216 > braking signal relay runtimes + brake release time
p1217	**Motor holding brake closing time** (factory setting 0.1 s) p1217 > braking signal relay runtimes + brake closing time
r0052.12	**"Open motor holding brake" command**
p0730 = 52.12	**Signal source for terminal DO 0** Control motor holding brake via digital output 0
p0731 = 52.12	**Signal source for terminal DO 1** Control motor holding brake via digital output 1

Table 9- 43 Advanced settings

Parameter	Description
p0346	**Magnetizing time** (factory setting 0 s) During this time the induction motor is magnetized. The inverter calculates this parameter using p0340 = 1 or 3.
p0855	**Open motor holding brake (imperative)** (factory setting 0)
p0858	**Close motor holding brake (imperative)** (factory setting 0)
p1351	**Starting frequency of motor holding brake** (factory setting 0%) Setting the frequency set value at the slip compensation output when starting with motor holding brake. When the parameter p1351 is set to > 0, slip compensation is automatically switched on.
p1352	**Starting frequency for motor holding brake** (factory setting 1351) Setting the signal source for the frequency set value at the slip compensation output when starting with motor holding brake.
p1475	**Speed controller torque set value for motor holding brake** (factory setting 0) Setting the signal source for the torque set value when starting with motor holding brake.

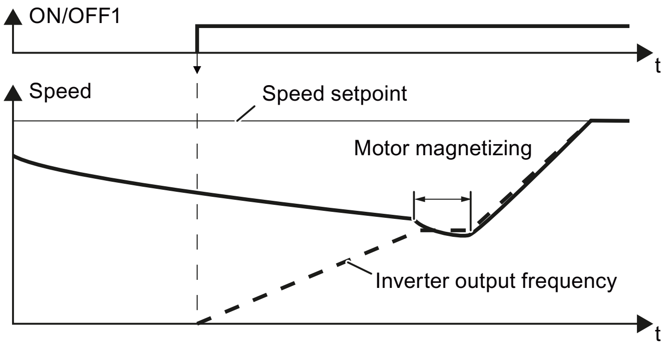
9.9.4 Automatic restart and flying restart

9.9.4.1 Flying restart – switching on while the motor is running

If you switch on the motor while it is still running, then with a high degree of probability, a fault will occur due to overcurrent (overcurrent fault F07801). Examples of applications involving an unintentionally rotating motor directly before switching on:

- The motor rotates after a brief line interruption.
- A flow of air turns the fan impeller.
- A load with a high moment of inertia drives the motor.

After the ON command, the "flying restart" function initially synchronizes the inverter output frequency to the motor speed and then accelerates the motor up to the setpoint.



If the inverter simultaneously drives several motors, then you must only use the "flying restart" function if the speed of all of the motors is always the same (group drive with a mechanical coupling).

Table 9- 44 Basic setting

Parameter	Description
P1200	**Flying restart operating mode** (factory setting: 0) 0 Flying restart is locked 1 Flying restart is enabled, look for the motor in both directions, start in direction of setpoint 4 Flying restart is enabled, only search in direction of setpoint

Table 9- 45 Advanced settings

Parameter	Description
P1201	**Flying restart enable signal source** (factory setting: 1) Defines a control command, e.g. a digital input, through which the flying restart function is enabled.
P1202	**Flying restart search current** (factory setting 100 %) Defines the search current with respect to the motor magnetizing current (r0331), which flows in the motor while the flying restart function is being used.
P1203	**Flying restart search speed factor** (factory setting 100 %) The value influences the speed with which the output frequency is changed during the flying restart. A higher value results in a longer search time. If the inverter does not find the motor, reduce the search speed (increase p1203).

9.9.4.2 Automatic switch-on

The automatic restart includes two different functions:

1. The inverter automatically acknowledges faults.
2. After a fault occurs or after a power failure, the inverter automatically switches-on the motor again.

This automatic restart function is primarily used in applications where the motor is controlled locally via the inverter's inputs. In applications with a connection to a fieldbus, the central control should evaluate the feedback signals of the drives, specifically acknowledge faults or switch-on the motor.

The inverter interprets the following events as power failure:

- The inverter signals fault F30003 (DC link undervoltage), as the line supply voltage of the inverter has briefly failed.
- The inverter power supply has failed for a long enough time so that the inverter has been switched-off.

> ⚠ **WARNING**
>
> When the "automatic restart" function is active (p1210 > 1), the motor automatically starts after a power failure. This is especially critical after longer power failures.
>
> Reduce the risk of accidents in your machine or system to an acceptable level by applying suitable measures, e.g. protective doors or covers.

Commissioning the automatic restart

- If it is possible that the motor is still rotating for a longer period of time after a power failure or after a fault, then in addition, you must activate the "flying restart" function, see Flying restart – switching on while the motor is running (Page 219).
- Using p1210, select the automatic restart mode that best suits your application.

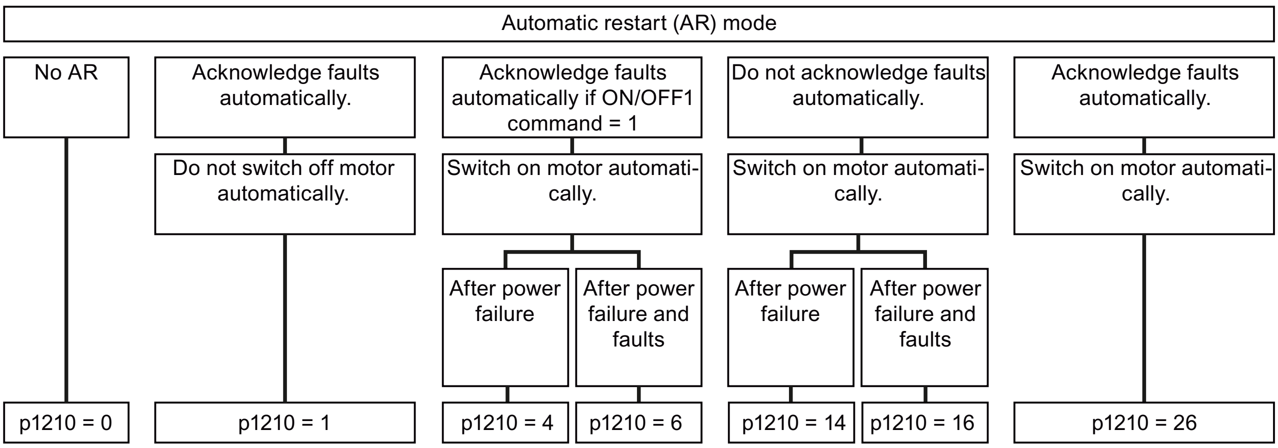
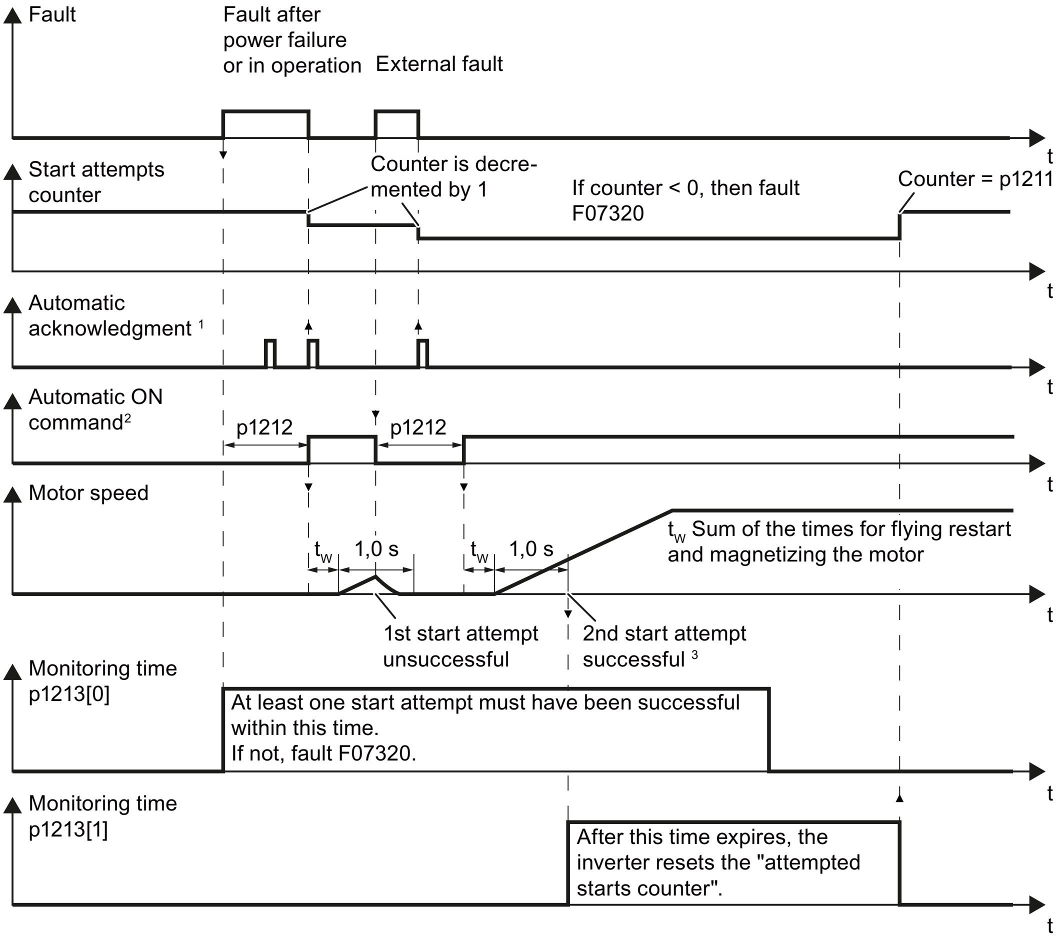


Figure 9-29 Selecting the automatic restart mode

- Set the parameters of the automatic restart function.
  The method of operation of the parameters is explained in the following diagram and in the table.



[1] The inverter automatically acknowledges faults under the following conditions:

- p1210 = 1 or 26: always.
- p1210 = 4 or 6: If the command to switch on the motor is available at a digital input or via the fieldbus (ON/OFF1 command = HIGH).
- p1210 = 14 or 16: never.

[2] The inverter attempts to automatically switch-on the motor under the following conditions:

- p1210 = 1: never.
- p1210 = 4, 6, 14, 16, or 26: If the command to switch on the motor is available at a digital input or via the fieldbus (ON/OFF1 command = HIGH).

[3] The start attempt is successful if flying restart has been completed and the motor has been magnetized (r0056.4 = 1) and one additional second has expired without a new fault having occurred.

Figure 9-30 Time response of the automatic restart

Table 9- 46 Setting the automatic restart

Parameter	Explanation
p1210	**Automatic restart mode** (factory setting: 0) 0: Disable automatic restart 1: Acknowledge all faults without restarting 4: Restart after power failure without further restart attempts 6: Restart after fault with further restart attempts 14: Restart after power failure after manual fault acknowledgement 16: Restart after fault after manual fault acknowledgement 26: Acknowledgement of all faults and restart with ON command
p1211	**Automatic restart start attempts** (factory setting: 3) This parameter is only effective for the settings p1210 = 4, 6, 14, 16, 26. You define the maximum number of start attempts using p1211. After each successful fault acknowledgement, the inverter decrements its internal counter of start attempts by 1. For p1211 = n, up to n + 1 start attempts are made. Fault F07320 is output after n + 1 unsuccessful start attempts. The inverter sets the start attempt counter back again to the value of p1211, if one of the following conditions is fulfilled: • After a successful start attempt, the time in p1213[1] has expired. • After fault F07320, withdraw the ON command and acknowledge the fault. • You change the start value p1211 or the mode p1210.
p1212	**Automatic restart wait time start attempt** (factory setting: 1.0 s) This parameter is only effective for the settings p1210 = 4, 6, 26. Examples for setting this parameter: 1. After a power failure, a certain time must elapse before the motor can be switched-on, e.g. because other machine components are not immediately ready. In this case, set p1212 longer than the time, after which all of the fault causes have been removed. 2. In operation, the inverter develops a fault condition. The lower you select p1212, then the sooner the inverter attempts to switch-on the motor again.

Parameter	Explanation
p1213[0]	**Automatic restart monitoring time for restart** (factory setting: 60 s) This parameter is only effective for the settings p1210 = 4, 6, 14, 16, 26. With this monitoring function, you limit the time in which the inverter may attempt to automatically switch-on the motor again. The monitoring function starts when a fault is identified and ends with a successful start attempt. If the motor has not successfully started after the monitoring time has expired, fault F07320 is signaled. Set the monitoring time longer than the sum of the following times: + P1212 + time that the inverter requires to start the motor on the fly. + Motor magnetizing time (p0346) + 1 second You deactivate the monitoring function with p1213 = 0.
p1213[1]	**Automatic restart monitoring time to reset the fault counter** (factory setting: 0 s) This parameter is only effective for the settings p1210 = 4, 6, 14, 16, 26. Using this monitoring time, you prevent that faults, which continually occur within a certain time period, are automatically acknowledged each time. The monitoring function starts with a successful start attempt and ends after the monitoring time has expired. If the inverter has made more than (p1211 + 1) successful start attempts within monitoring time p1213[1], the inverter cancels the automatic restart function and signals fault F07320. In order to switch on the motor again, you must acknowledge the fault and issue a new ON command.

Additional information is provided in the parameter list of the List Manual.

Advanced settings

If you with to suppress the automatic restart function for certain faults, then you must enter the appropriate fault numbers in p1206[0 … 9].

Example: P1206[0] = 07331 ⇒ No restart for fault F07331.

Suppressing the automatic restart only functions for the setting p1210 = 6, 16 or 26.

> ⚠ **WARNING**
>
> In the case of communication via the field bus interface, the motor restarts with the setting p1210 = 6 even if the communication link is interrupted. This means that the motor cannot be stopped via the open-loop control. To avoid this dangerous situation, you must enter the fault code of the communications error in parameter p1206.
>
> Example: A communication failure via PROFIBUS is signaled using fault code F01910. You should therefore set p1206[n] = 1910 (n = 0 … 9).

9.9.5 PID technology controller

9.9.5.1 Overview

The technology controller controls process variables, e.g. pressure, temperature, level or flow.

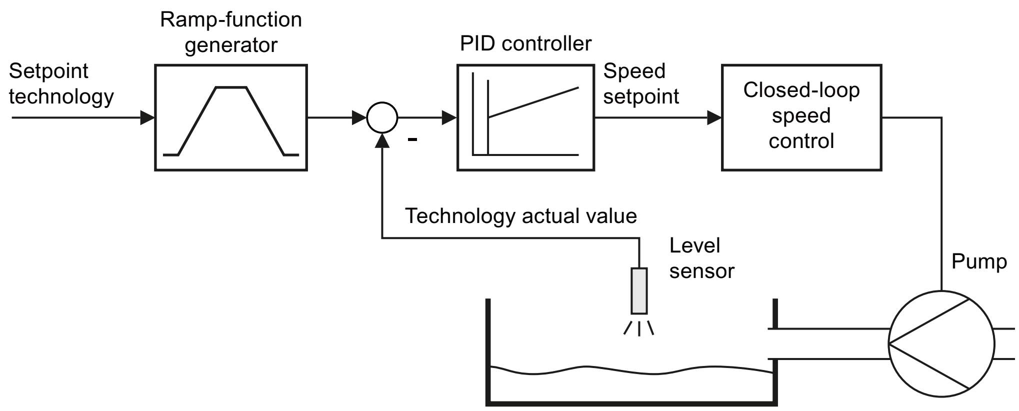


Figure 9-31 Example: technology controller as a level controller

9.9.5.2 Setting the controller

Simplified representation of the technology controller

The technology controller is designed as a PID controller, which makes it highly flexible.

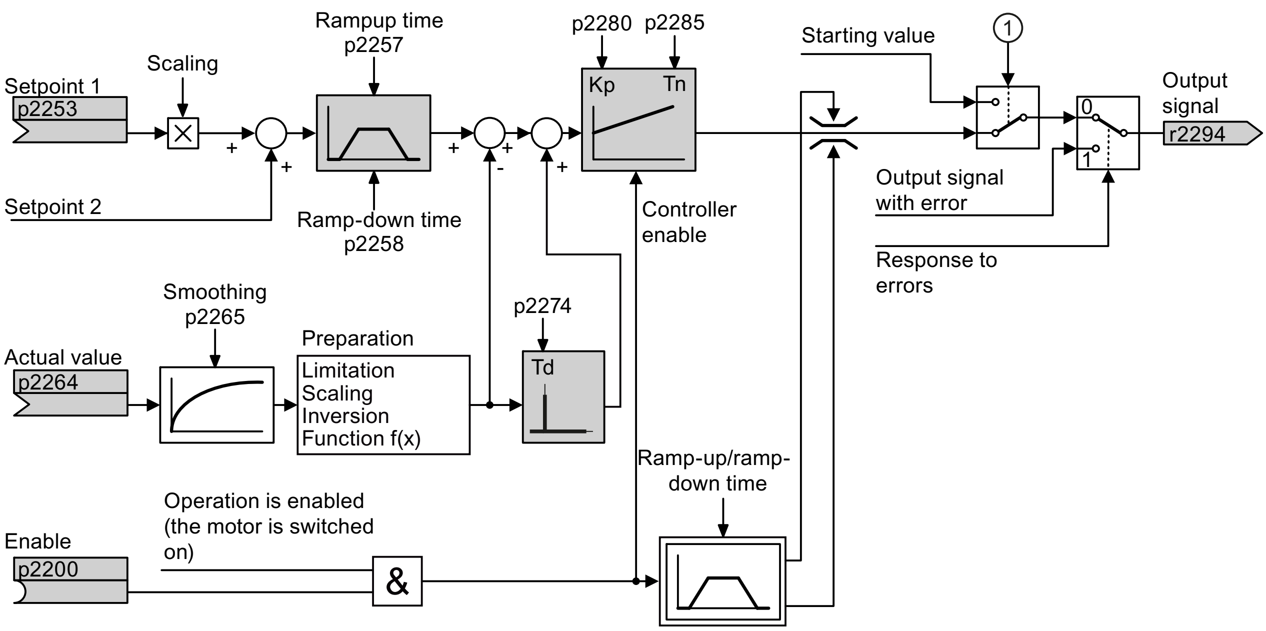


Figure 9-32 Simplified representation of the technology controller

Table 9- 47 Setting the technology controller

Parameter	Remark
p2200 = 1	Enable technology controller.
p1070 = 2294	Interconnect the main speed setpoint with the output of the technology controller.
p2253 = …	Define the setpoint for the technology controller. Example: p2253 = 2224: The inverter interconnects the fixed setpoint p2201 with the setpoint of the technology controller. p2220 = 1: The fixed setpoint p2201 is selected.
p2264 = …	Define the actual value for the technology controller. Example: For p2264 = 755[0], analog input 0 is the source for the actual value.
p2257, p2258	Define the ramp-up and ramp-down times [s]
p2274	Differentiation time constant [s] The differentiation improves the rise time characteristics for very slow controlled variables, e.g. a temperature control. p2274 = 0: The differentiation is switched off.
p2280	Proportional gain K_P
p2285	Integral time T_N [s] Without an integral time, the controller cannot completely equalize deviations between the setpoint and actual value. p2285 = 0: The integral time is switched off.

Advanced settings

Table 9- 48 Settings

Parameter	Remark
Limiting the output of the technology controller In the factory setting, the output of the technology controller is limited to ± maximum speed. You must change this limit, depending on your particular application. Example: The output of the technology controller supplies the speed setpoint for a pump. The pump should only run in the positive direction.	
p2297 = 2291	Interconnect the upper limit with p2291.
p2298 = 2292	Interconnect the lower limit with p2292.
p2291	Upper limit for the technology controller output e.g.: p2291 =100
p2292	Lower limit for the technology controller output e.g.: p2292 = 0
Manipulating the actual value of the technology controller	
p2267, p2268	Limit the actual value
p2269	Scale the actual value
p2271	Invert the actual value
p2270	Actual value

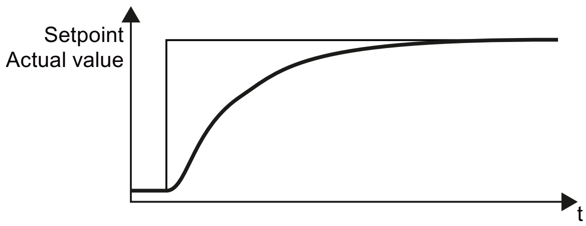
You can find additional information in function block diagram 7958 of the List Manual.

9.9.5.3 Optimizing the controller

Setting PID controllers from a practical perspective

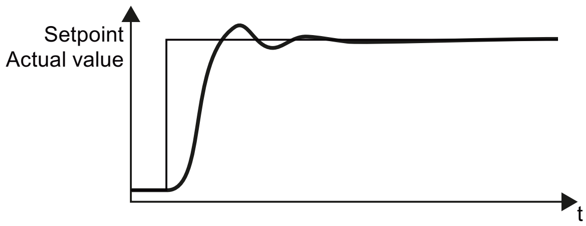
- Temporarily set the ramp-up and ramp-down times of the ramp-function generator (p2257 and p2258) to zero.
- Enter a setpoint step and monitor the associated actual value, e.g. with the trace function of STARTER.
  The slower the process to be controlled response, the longer you must monitor the controller response. Under certain circumstances (e.g. for a temperature control), you need to wait several minutes until you can evaluate the controller response.

Table 9- 49 Optimum control response



Optimum controller response for applications that do not permit any overshoot.

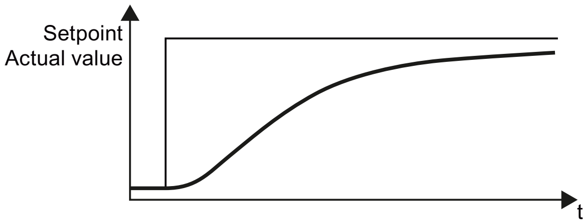
The actual value approaches the setpoint, without any significant overshoot.



Optimum controller behavior for fast correction and quick compensation of noise components.

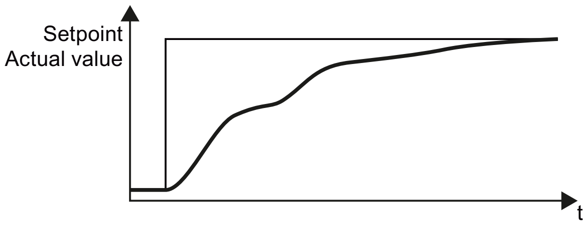
The actual value approaches the setpoint and slightly overshoots (maximum 10% of the setpoint step).

Table 9- 50 Optimizing the control response



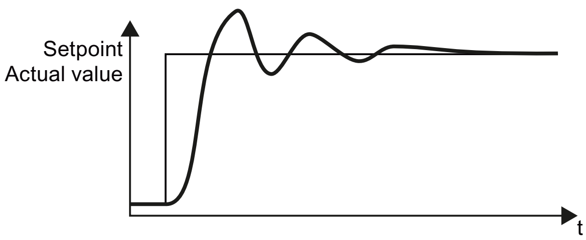
The actual value only slowly approaches the setpoint.

- Increase the proportional component K_P and reduce the integration time T_N.



Actual value only slowly approaches the setpoint with slight oscillation.

- Increase the proportional component K_P and reduce the rate time T_D (differentiating time).

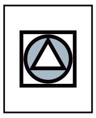


The actual value quickly approaches the setpoint, but overshoots too much

- Decrease the proportional component K_P and increase the integration time T_N.

- Set the ramp-up and ramp-down times of the ramp-function generator back to their original value.

9.10 Fail-safe function Safe Torque Off (STO)

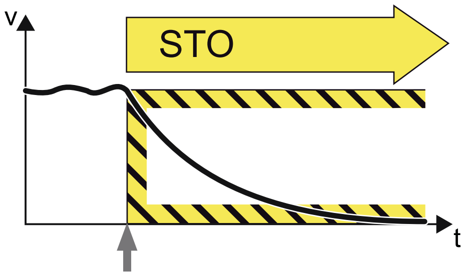


These operating instructions describe the commissioning of the STO safety function when it is controlled via a fail-safe digital input.

You will find a detailed description of all safety functions and control using PROFIsafe in the Safety Integrated Function Manual, see Section Further information on your inverter (Page 340).

9.10.1 Functional description

Definition according to EN 61800-5-2:
"The STO function prevents energy from being supplied to the motor, which can generate a torque."



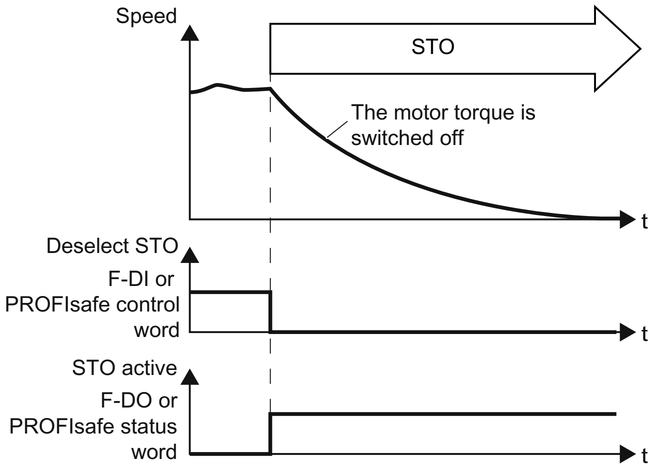
Examples of how the function can be used

Example	Solution option
When the Emergency Stop button is pressed, it is not permissible that a stationary motor undesirably starts.	• Wire the Emergency Stop button with a fail-safe input. • Select STO via the fail-safe input.
A central Emergency Stop button ensures that several drives cannot unintentionally start.	• Evaluating an Emergency Stop pushbutton in a central control. • Select STO via PROFIsafe.

How does STO function in detail?

The converter recognizes the selection of STO via a fail-safe input or via the safe communication PROFIsafe.

The converter then safely switches off the torque of the connected motor.



If no motor holding brake is present, the motor coasts to a standstill.

If you use a motor holding brake, the converter closes the brake immediately after selecting STO.

9.10.2 Prerequisite for STO use

In order to use the STO safety function, your machine should have already performed a risk assessment (e.g. in compliance with EN ISO 1050, "Safety of machinery - Risk assessment - Part 1: Principles"). The risk assessment must confirm that the inverter is permitted for use in accordance with SIL 2 or PL d.

9.10.3 Commissioning STO

9.10.3.1 Commissioning tool

We strongly recommend that you commission the safety functions using the STARTER PC tool.

If you use STARTER for commissioning, then you set the functions using the graphic screen forms and you do not have to work with parameters. In this case, you can ignore the parameter tables in the following sections.

Table 9- 51 STARTER commissioning tool (PC software)

Download	Order number
STARTER (http://support.automation.siemens.com/WW/view/en/10804985/130000)	6SL3255-0AA00-2CA0 PC Connection Kit, includes STARTER DVD and USB cable

9.10.3.2 Password

The safety functions are protected against unauthorized changes by a password.

Note

If you want to change the parameters of the safety functions, but do not know the password, please contact customer support.

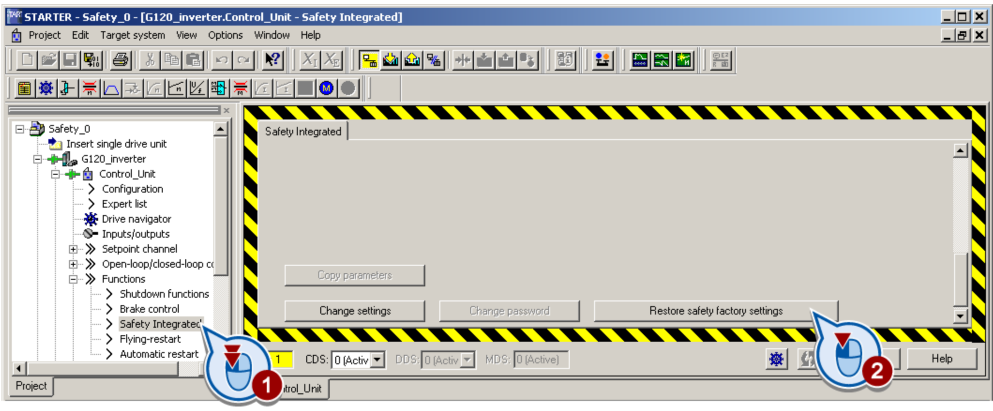
Table 9- 52 Parameter

Parameter	Description
p9761	**Entering a password** (factory setting: 0000 hex) Permissible passwords lie in the range 1 … FFFF FFFF.
p9762	**New password**
p9763	**Confirm password**

9.10.3.3 Resetting the safety function parameters to the factory setting

Proceed as follows if you wish to reset the safety function parameters to the factory setting, without influencing the standard parameters:

- Go online with STARTER .
- ① Open the screen form of the safety functions.



- ② Select the button to restore the factory settings.
- Enter the password,for the safety functions.
- Confirm saving parameters (RAM to ROM).
- Go offline with STARTER .
- Switch off the converter supply voltage.
- Wait until all of the LED on the converter go dark. Now switch on the converter power supply again (power on reset).

Table 9- 53 Parameter

Parameter	Description	
p0010	**Drive, commissioning parameter filter**	
	0	Ready
	95	Safety Integrated commissioning
p0970	**Reset drive parameters**	
	0	Inactive
	5	Starts a safety parameter reset. After the reset, the converter sets p0970 = 0.

Procedure

- ① Go online with STARTER.
- ② In STARTER, select the fail-safe functions.
- ③ Change the settings.

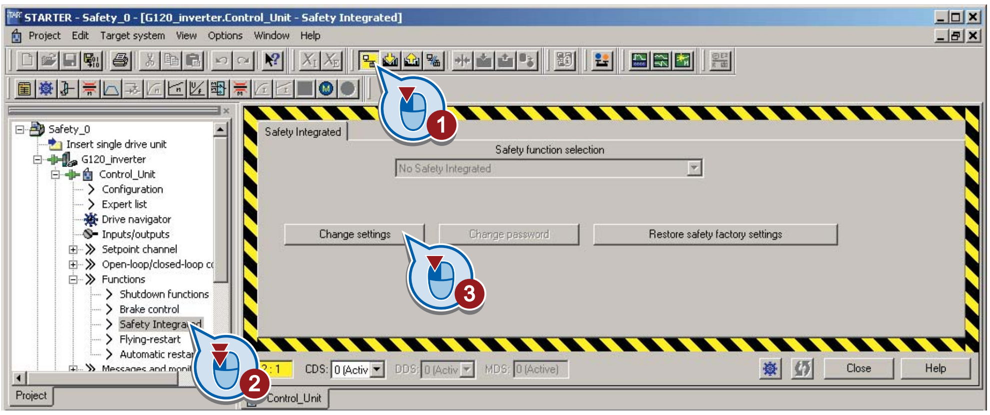


Table 9- 54 Parameter

Parameter	Description
p0010 = 95	**Drive commissioning parameter filter** Safety Integrated commissioning

- Selecting "STO via terminal":

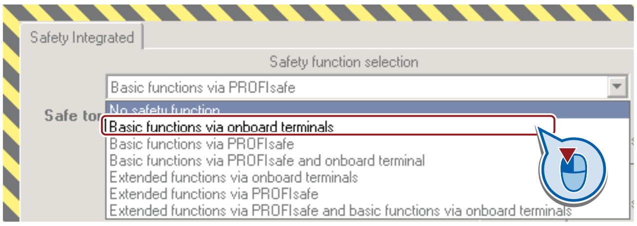


Table 9- 55 Parameter

Parameter	Description	
p9601	**Enable functions integrated in the drive** (factory setting: 0000 bin)	
	p9601 = 0	Safety functions integrated in the drive inhibited
	p9601 = 1	Enable basic functions via onboard terminals

The other selection options are described in the "Safety Integrated Function Manual". See also the section: Manuals for your inverter (Page 340).

9.10.3.4 Interconnecting the "STO active" signal

Procedure

- If you require the status signal "STO active" in your higher-level controller, interconnect it accordingly.

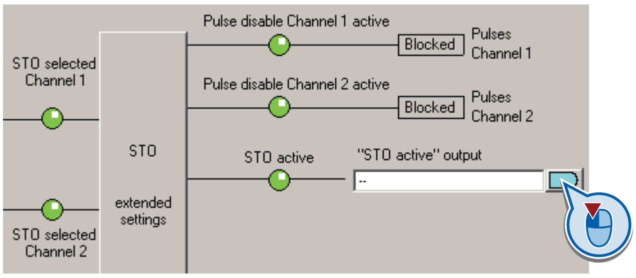


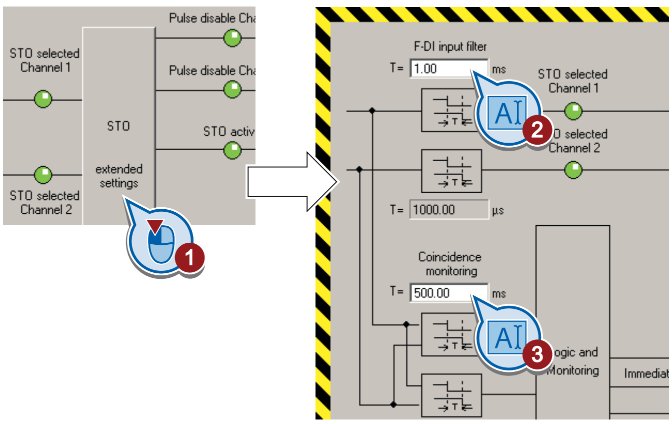
Table 9- 56 Parameter

Parameter	Description
r9773.01	**1 signal**: STO active in drive

9.10.3.5 Setting the signal filter

Procedure

- ① Select the advanced settings for STO.



- ② Set the debounce time for the F-DI input filter.
- ③ Set the discrepancy for the monitoring for simultaneous operation.
- Close the screen form.

Description

The following are available for the signal processing of the fail-safe inputs:

- A tolerance for the simultaneous monitoring.
- A filter to suppress short signals, e.g. test pulses.

A tolerance for the simultaneous monitoring

The converter checks whether the signals at both inputs always have the same signal status (high or low).

With electromechanical sensors (e.g. emergency stop buttons or door switches), the two sensor contacts never switch at exactly the same time and are therefore temporarily inconsistent (discrepancy). A long-term discrepancy indicates a fault in the wiring of a fail-safe input, e.g. a wire break.

When appropriately set, the converter tolerates brief discrepancies.

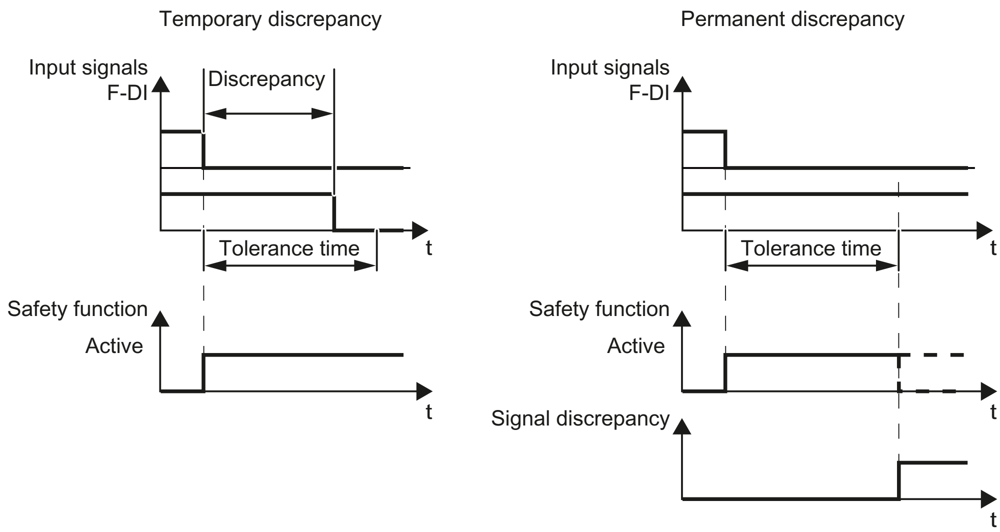


Figure 9-33 Tolerance regarding discrepancy

The tolerance time does not extend the converter response time. The converter selects its safety function as soon as one of the two F-DI signals changes its state from high to low.

Filter to suppress short signals

The converter normally responds immediately to signal changes at its fail-safe inputs. This is not required in the following cases:

1. When you interconnect a fail-safe input of the converter with an electromechanical sensor, contact bounce may result in signal changes occurring, to which the converter responds.
2. Several control modules test their fail-safe outputs using bit pattern tests (on/off tests), in order to identify faults due to either short-circuit or cross-circuit faults. When you interconnect a fail-safe input of the converter with a fail-safe output of a control module, the converter responds to these test signals.
   A signal change during a bit pattern test usually lasts:
   – On test: 1 ms
   – Off test: 4 ms

If the fail-safe input signals too many signal changes within a certain time, then the converter responds with a fault.

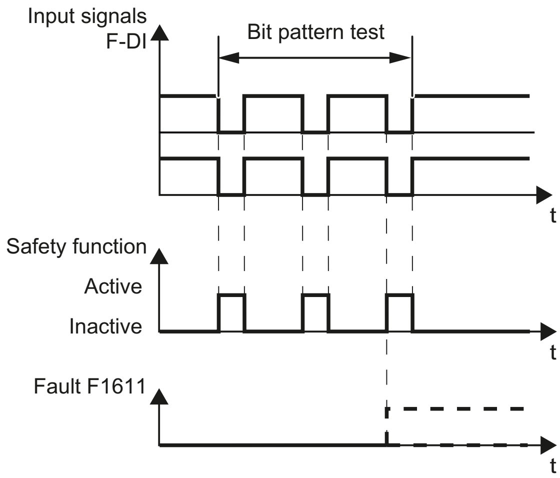


Figure 9-34 Converter response to a bit pattern test

An adjustable signal filter in the converter suppresses temporary signal changes using bit pattern test or contact bounce.

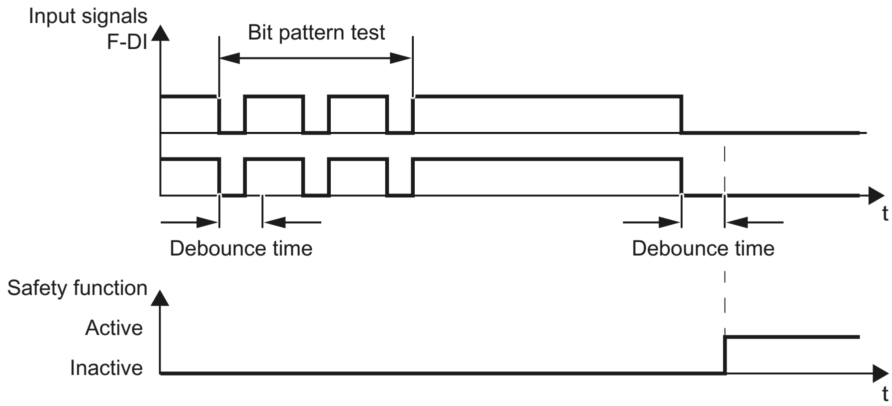


Figure 9-35 Filter for suppressing temporary signal changes

Note

The filter increases the converter response time. The converter only selects its safety function after the debounce time has elapsed.

Table 9- 57 Parameters for the filters

Parameter	Description
p9650	**F-DI changeover tolerance time** (factory setting: 500 ms) Tolerance time to changeover the fail-safe digital input for the basic functions.
p9651	**STO debounce time** (factory setting: 1 ms) Debounce time of the fail-safe digital input for the basic functions.

Note

Debounce times for standard and safety functions

The debounce time p0724 for "standard" digital inputs has no influence on the fail-safe input signals. Conversely, the same applies: The F-DI debounce time does not affect the signals of the "standard" inputs.

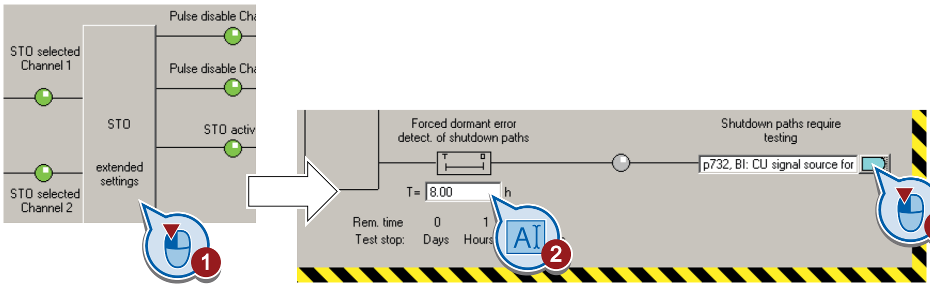
If you use an input as a standard input, set the debounce time using parameter p0724 .

If you use an input as a fail-safe input, set the debounce time as described above.

9.10.3.6 Setting forced dormant error detection

Procedure

- ① Select the advanced settings for STO.



- ② Set the monitoring time to a value to match your particular application.
- ③ Using this signal, the converter signals that a forced checking procedure is required. Interconnect this signal - for example - with a digital output of your choice.

Description

To meet the requirements of the standards ISO 13849-1 and IEC 61508 in terms of timely fault detection, the converter must test its safety-related circuits regularly - at least once a year - to ensure that they are functioning correctly.

Forced checking procedure of the basic functions

The forced checking procedure of the basic functions is the regular self-test of the converter that causes the converter to check its circuits to switch-off the torque.

The converter executes a forced checking procedure under the following circumstances:

- every time the supply voltage is connected.
- every time after the STOfunction has been selected.

The converter monitors the regular forced checking procedure.

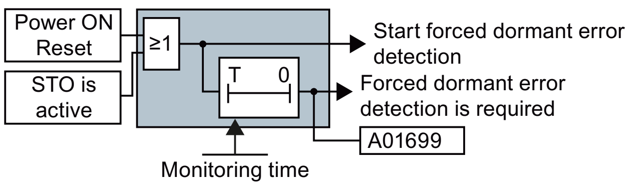


Figure 9-36 Triggering and monitoring the forced checking procedure

Table 9- 58 Parameters for the forced checking procedure

Parameter	Description
p9659	**Forced checking procedure timer** (Factory setting: 8 h) Monitoring time for the forced checking procedure.
r9660	**Forced checking procedure remaining time** Displays the remaining time until the forced checking procedure and testing the safety switch-off signal paths.
r9773.31	**1 signal: Forced checking procedure is required** Signals for the higher-level control system.

Time of the forced checking procedure

In the case of warning A01699 , you must initiate a forced checking procedure at the next opportunity. These alarms do not affect the operation of your machine.

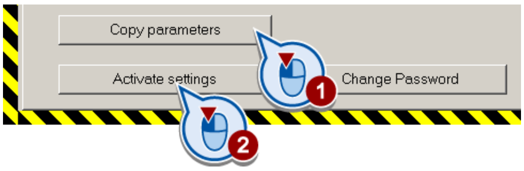
- Stop the drive.
- Select function STO or switch off the converter supply voltage temporarily and on again.

Examples for the times when forced checking procedure is performed:

- When the drives are at a standstill after the system has been switched on.
- When the protective door is opened.
- At defined intervals (e.g. every 8 hours).
- In automatic mode (time and event dependent).

9.10.3.7 Activate settings

- ① Copy the parameters of the safety functions in order to create a redundant image of the settings.



- ② Activate the settings.
- If the password is the factory default, you are prompted to change the password.
  If you try to set a password that is not permissible, the old password will not be changed.
  Further information can be found in the section Password (Page 230).
- Confirm the prompt for saving your settings (copy RAM to ROM).
- Switch off the converter supply voltage.
- Wait until all of the LEDs on the converter go dark. Now switch on the converter supply voltage again. Your settings only become effective after this power-on reset.

Parameter

Table 9- 59 Parameters for the forced dormant error detection

Parameter	Description
p9700 = 57 hex	**SI copy function** (factory setting: 0) Start copy function SI parameter.
p9701 = AC hex	**Confirm data change** (factory setting: 0)Confirm data change overall.
p0010 = 0	**Drive commissioning parameter filter** 0: Ready

9.10.3.8 Checking the assignment of the digital inputs

- Check whether the digital inputs used as fail-safe input are also assigned a further function.

NOTICE
Both, the assignment of digital inputs with the selection of a safety function or with a "standard" function can lead to an unexpected behavior of the motor.

- Remove multiple assignments of the digital inputs:

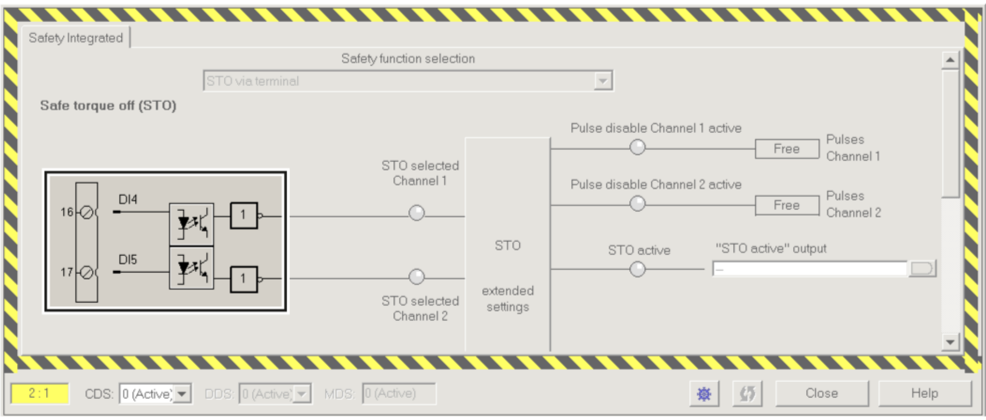


Figure 9-37 Example: automatic assignment of digital inputs DI 4 and DI 5 with STO

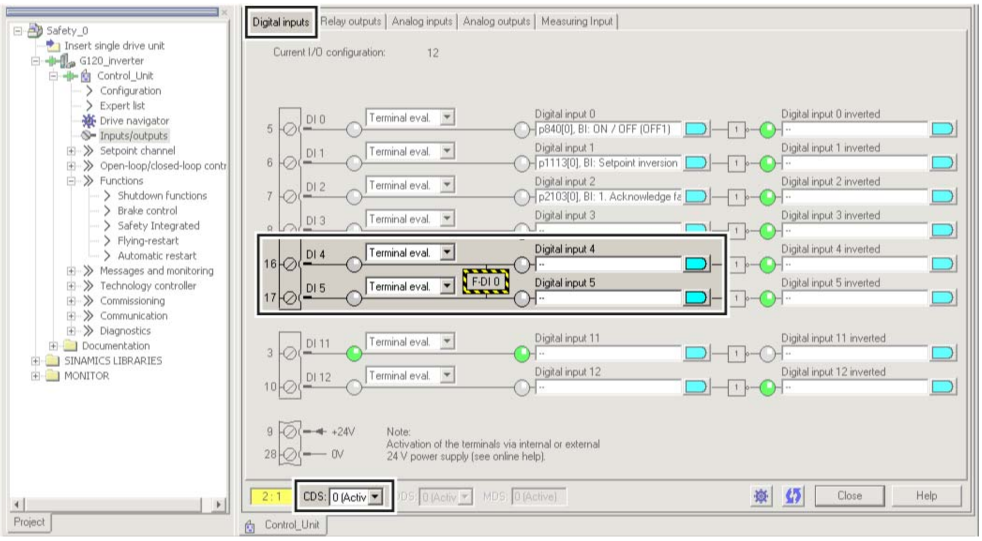


Figure 9-38 Remove pre-assignment of digital inputs DI 4 and DI 5

- When you use the data set changeover CDS, you must delete the multiple assignment of the digital inputs for all CDS.

9.10.3.9 Acceptance test

Requirements for an acceptance are derived from the EC Machinery Directive and ISO 13849-1:

- You must check safety-related functions and machine parts after commissioning.
- You must create an "acceptance report" showing the test results.

Prerequisites for the acceptance test

- The machine is properly wired.
- All safety equipment such as protective door monitoring devices, light barriers or emergency-off switches are connected and ready for operation.
- Commissioning of the open-loop and closed-loop control has been completed. These include, for example:
  - Configuration of the setpoint channel.
  - Closed loop control in the higher-level controller.
  - Motor control.

Authorized persons

Authorization within the scope of the acceptance test is a person authorized by the machine manufacturer who, on account of his or her technical qualifications and knowledge of the safety functions, is in a position to perform the acceptance test in the correct manner.

Full acceptance tests

The full acceptance tests for the safety functions include the following:

1. Acceptance test
   - Check the safety functions in the machine or in the plant/system
2. Documentation
   - Described the safety-relevant components and functions of the machine or plant
   - Logging of the settings of the safety functions
   - Countersigning documentation

Reduced acceptance

A full acceptance test is necessary only after first commissioning. An acceptance test with a reduced scope is sufficient when safety functions are expanded.

The acceptance test must be carried out individually for each drive as far as the machine allows it.

Table 9- 60 Reduced scope acceptance test for function expansions

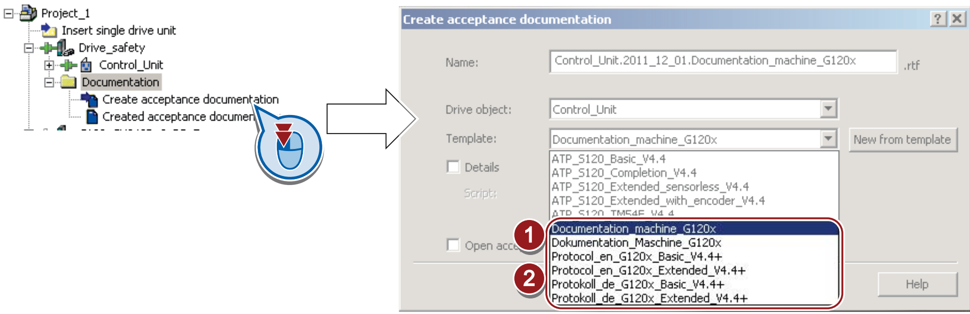
Measure	Acceptance test	
	Acceptance test	Documentation
Replacing the Control Unit (SINAMICS G120) or the inverter.	Yes	• Supplement inverter data • Log the new checksum • Countersignature
Replacing the Power Module.	Yes	Supplement the hardware version in the inverter data
Replacing the motor	Yes, but only for the safety function SDI.	No change
Replacing the gear unit	Yes	No change
Replacing the safety-related peripherals (e.g. Emergency Stop switch).	Yes, but only for the replaced components.	No change
Inverter firmware update.	Yes	• Supplement firmware version in the inverter data • Log the new checksum • Countersignature
Changing a single limit (e.g. SLS level).	Yes, but only for the changed limit value.	• Supplement function table • Supplement limit values • Log the new checksum • Countersignature
Functional expansion of the machine (additional drive).	Yes, but only for the additional functions.	• Supplement machine overview • Supplement inverter data • Supplement function table • Supplement limit values • Log the new checksum • Countersignature
Functional expansion of a drive (e.g. additional SLS level).	Yes, but only for the additional functions.	• Supplement function table • Supplement limit values • Log the new checksum • Countersignature
Transfer of inverter parameters to other identical machines by means of standard commissioning.	Yes	• Supplement machine description • Check the checksums • Check the firmware versions

Documents for the acceptance

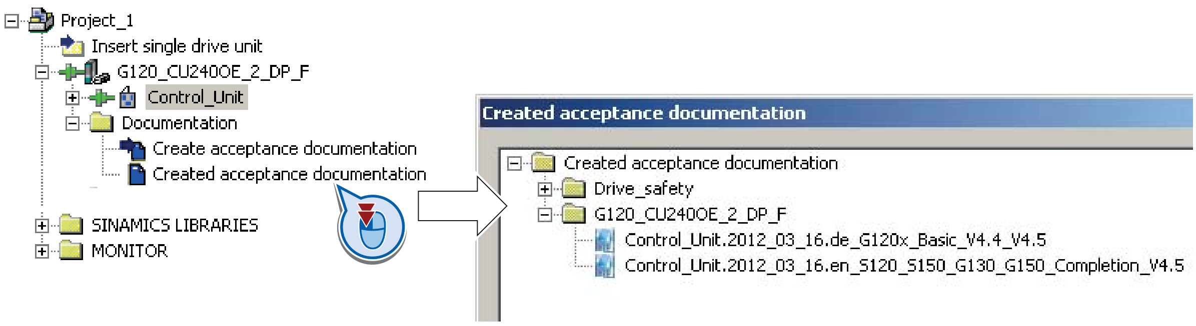
The STARTER provides you with a number of documents to be regarded as a recommendation for the acceptance tests of the safety functions.

Procedure

- In STARTER create the acceptance documentation.



- ① This template contains a recommendation for your machine or plant documentation.
  Dokumentation_Maschine_G120x: German template.
  Documentation_machine_G120x: English template.
- ② Select the suitable template for the basic functions and create a report for each drive of your machine or plant.
  For firmware version V4.4 and higher:
  Protokoll_de_G120x_Basic_V4.4+: German template.
  Protocol_en_G120x_Basic_V4.4+: English template.
- You load the created reports for archiving and the machine documentation for further processing:



- Archive the acceptance reports and the machine documentation.

The reports and the machine documentation can also be found in the section: Documentation for acceptance of safety functions (Page 337).

Recommended acceptance test

The following descriptions for the acceptance test are recommendations and describe the principle of acceptance. You can deviate from the recommendations, if, after completion of the commissioning, you check the following:

- Correct assignment of the interfaces of each converter with the safety function:
  – Fail-safe inputs
  – PROFIsafe address
- Correct setting of the STO safety function.

Note

Perform the acceptance test with the maximum possible velocity and acceleration in order to test the expected maximum braking distances and braking times.

Note

Non-critical alarms

The following alarms occur each time the system boots, and are not critical for the acceptance:

- A01697
- A01796

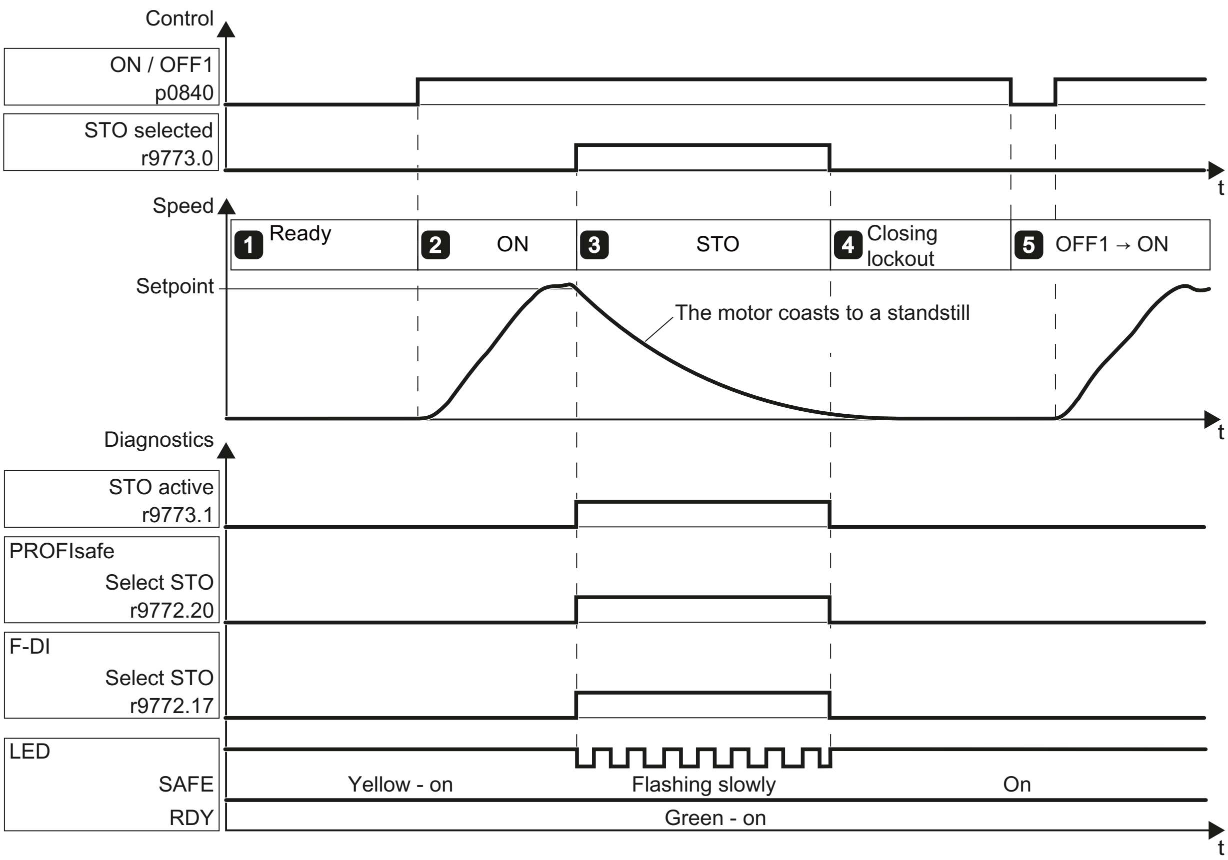


Figure 9-39 STO acceptance test for basic functions

Table 9- 61 Function "Safe Torque Off" (STO)

No.	Description	Status
1.	**Initial state**	
	• The converter is "ready" (p0010 = 0).	
	• The converter signals neither faults nor alarms for the safety functions (r0945[0…7], r2122[0…7]).	
	• STO is not active (r9773.1 = 0).	
2.	**Switch on the motor**	
	• Enter a speed setpoint ≠ 0, and switch on the motor (ON command).	
	• Ensure that the correct motor is running.	
3.	**STO select**	
	• Select STO while the motor is running **Note:** Test each configured control, e.g. via digital inputs and via PROFIsafe.	
	• Check the following:	
	For control via PROFIsafe: • The converter signals the following: "STO Selection via PROFIsafe" (r9772.20 = 1) For control via terminal: • The converter signals the following: "STO Selection via terminal " (r9772.17 = 1)	
	• If a mechanical brake is not available, the motor coasts down. A mechanical brake brakes the motor and holds it to ensure that it remains at a standstill.	
	• The converter signals neither faults nor alarms for the safety functions (r0945[0…7], r2122[0…7]).	
	• The converter signals the following: "STO is selected" (r9773.0 = 1). "STO is active" (r9773.1 = 1).	
4.	**STO deselect**	
	• Deselect STO .	
	• Check the following:	
	• The converter signals neither faults nor alarms for the safety functions (r0945[0…7], r2122[0…7]).	
	• The converter signals the following: "STO is not selected " (r9773.0 = 0). "STO is not active" (r9773.1 = 0).	
	• The converter is in the "switching on inhibited" state (r0046.0 = 1).	
5.	**Switch on the motor**	
	• Switch the motor off (OFF1 command) and then on again (ON command).	
	• Ensure that the correct motor is running.	

9.11 Switchover between different settings

In several applications, the inverter must be able to be operated with different settings.

Example:

You connect different motors to one inverter. Depending on the particular motor, the inverter must operate with the associated motor data and the appropriate ramp-function generator.

Drive data sets (DDS)

Your can parameterize several inverter functions differently and then switch over between the different settings.

The associated parameters are indexed (index 0 or 1). Via control commands select one of the two indices and therefore one of the two saved settings.

The settings in the inverter with the same index are known as drive data set.

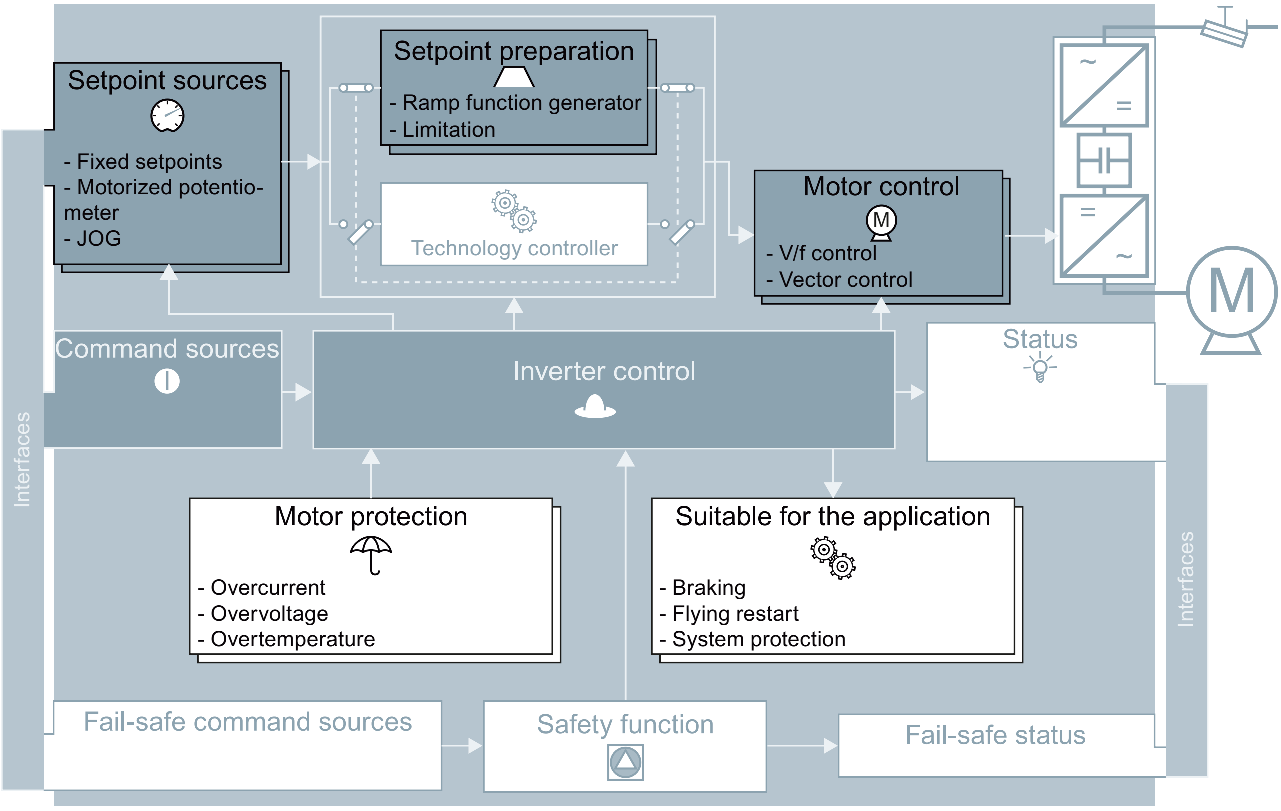


Figure 9-40 DDS switchover in the inverter

Via parameter p0180 you can define the number of command data sets (1 or 2).

Table 9- 62 Selecting the number of command data sets

Parameter	Description
p0010 = 15	**Drive commissioning:** Data sets
p0180	**Drive data sets (DDS) number**(factory setting: 1)
p0010 = 0	**Drive commissioning:** Ready

Table 9- 63 Parameters for switching the drive data sets:

Parameter	Description
p0820	**Drive data set selection DDS**
p0826	**Motor changeover, motor number**
r0051	**Displaying the number of the DDS that is currently effective**

For an overview of all the parameters that belong to the drive data sets and can be switched, see the Parameter Manual.

Note

You can only switch over the motor data of the drive data sets in the "ready for operation" state with the motor switched-off. The switchover time is approx. 50 ms.

If you do not switch over the motor data together with the drive data sets (i.e. same motor number in p0826), then the drive data sets can also be switched over in operation.

Table 9- 64 Parameters for copying the drive data sets

Parameter	Description
p0819[0]	**Source drive data set**
p0819[1]	**Target drive data set**
p0819[2] = 1	**Start copy operation**

For more information, see the List Manual (the parameter list and function diagram 8565).

Data backup and series commissioning 10

External data backup

After commissioning, your settings are saved in the converter so that they are protected against power failure.

We recommend that you additionally back up the parameter settings on a storage medium outside the converter. Without backup, your settings could be lost if the converter developed a defect (see also Steps for replacing the inverter (Page 269)).

The following storage media are available for your settings:

1. Memory card
2. PC/PG
3. Operator Panel

Series commissioning

Series commissioning is the commissioning of several identical drives. After commissioning of the first drive, you must do the following:

1. Back up the settings of the first converter to an external storage medium.
2. Transfer the settings of the first converter to another converter via the storage medium.

Note

The control unit to which the parameters are transferred must have the same order number and the same or a higher firmware version as the source control unit.

10.1 Backing up and transferring settings using memory card

What memory cards do we recommend?

We recommend that you use one of the memory cards with the following order numbers:

- MMC (order number 6SL3254-0AM00-0AA0)
- SD (order number 6ES7954-8LB01-0AA0)

Using memory cards from other manufacturers

If you use other SD or MMC memory cards, then you must format the memory card as follows:

- MMC: Format FAT 16
  - Insert the card into your PC's card reader.
  - Command to format the card:
    format x: /fs:fat (x: Drive code of the memory card on your PC)
- SD: Format FAT 32
  - Insert the card into your PC's card reader.
  - Command to format the card:
    format x: /fs:fat32 (x: Drive code of the memory card on your PC.)

⚠ CAUTION
You use memory cards from other manufacturers at your own risk. Depending on the card manufacturer, not all functions are supported (e.g. download).

10.1.1 Saving setting on memory card

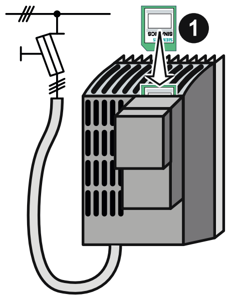
We recommend that you insert the memory card before switching on the converter. The converter always also backs up its settings on an inserted card.

If you wish to backup the converter settings on a memory card, you have two options:

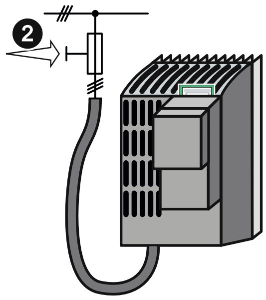
Procedure: Automatic backup

- The converter power supply has been switched off.

1. Insert an empty memory card into the converter.



2. Then switch-on the converter power supply.

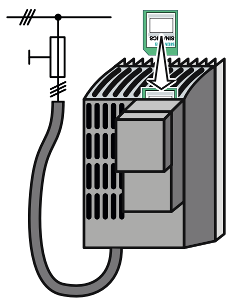


- After it has been switched on, the frequency converter copies its settings to the memory card.

NOTICE
If the memory card is not empty, then the converter accepts the data from the memory card. The previous setting in the converter will be deleted and will not be able to be restored.

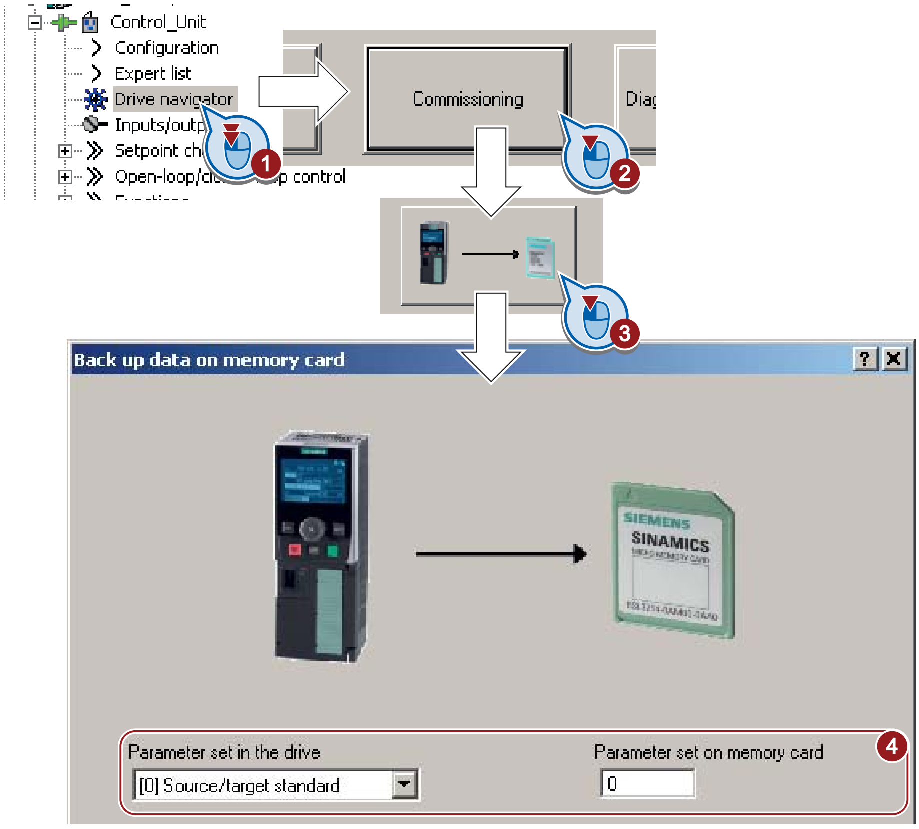
Procedure: Overwrite data on a memory card

- The converter power supply has been switched on.
- Insert a memory card into the converter.



Procedure using STARTER

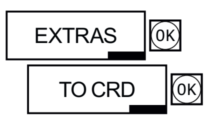
- Go online with STARTER.



- ① In your drive, select "Drive Navigator".
- ② Select the "Commissioning" button.
- ③ Select the button to transfer the settings to the memory card.
- ④ Select the settings as shown in the diagram and start the data backup.
- Close the screen forms.

Procedure with the BOP-2

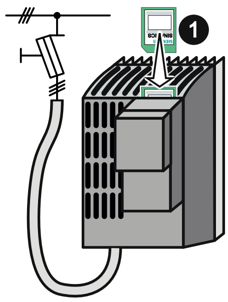
- Start data transfer in the menu "EXTRAS" - "TO CRD".

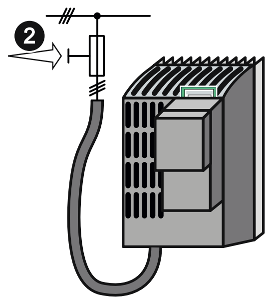


10.1.2 Transferring the setting from the memory card

Procedure

- The converter power supply has been switched off.
  1. Insert the memory card into the converter.
  2. Then switch-on the converter power supply.

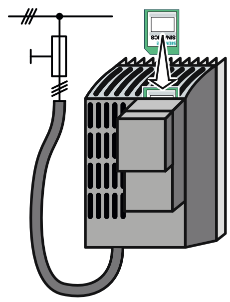




- If there is valid parameter data on the memory card, then the converter accepts the data from the memory card.

Procedure: Manual data transfer from a memory card

- The converter power supply has been switched on.
- Insert a memory card into the converter.

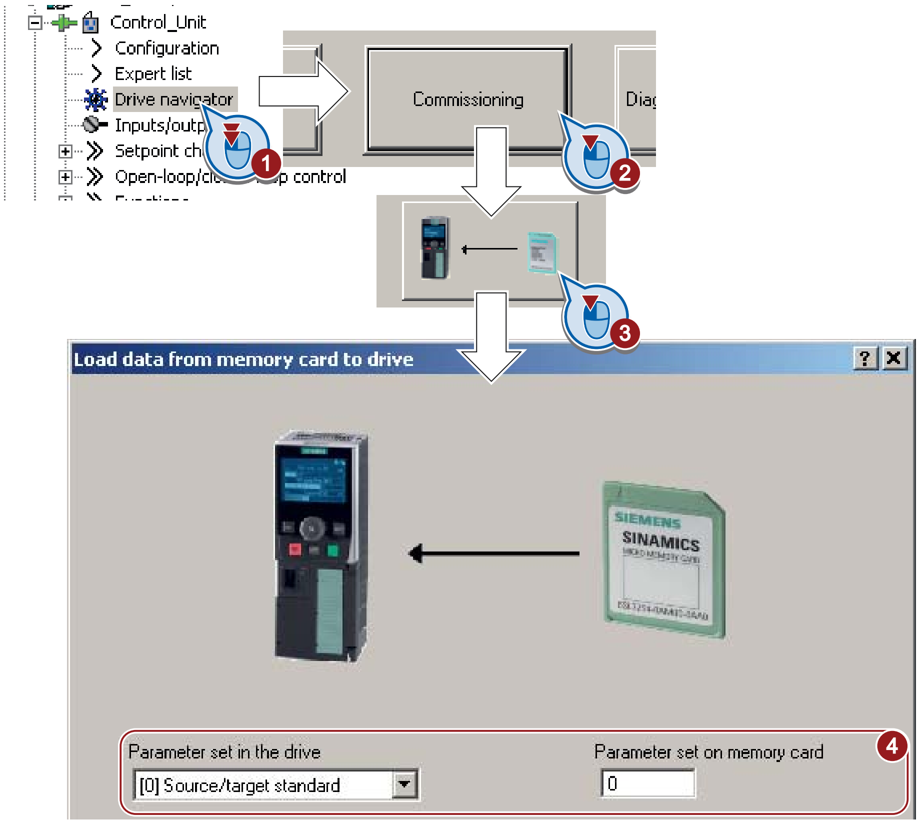


Procedure with the BOP-2

- Start data transfer in the menu "EXTRAS" - "FROM CRD".
- Switch off the converter power supply.
- Wait until all LED on the converter go dark. Now switch on the converter power supply again. Your settings only become effective after this power-on reset.

Procedure using STARTER

- Go online with STARTER.



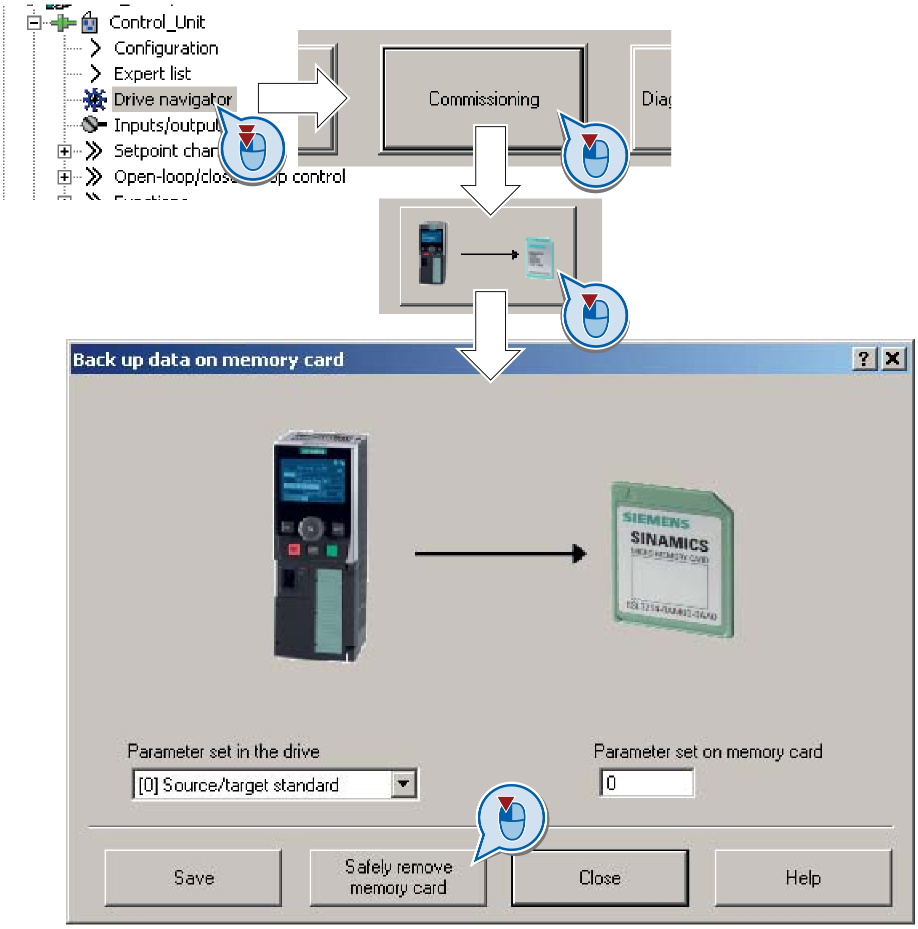
- ① In your drive, select "Drive Navigator".
- ② Select the "Commissioning" button.
- ③ Select the button to transfer the data from the memory card to the converter.
- ④ Select the settings as shown in the diagram and start the data backup.
- Close the screen forms.
- Go offline with STARTER.
- Switch off the converter power supply.
- Wait until all LED on the converter go dark. Now switch on the converter power supply again. Your settings only become effective after this power-on reset.

10.1.3 Safely remove the memory card

CAUTION
The file system on the memory card can be destroyed if the memory card is removed while the converter is switched on without first requesting and confirming this using the "safe removal" function. The memory card will then no longer function.

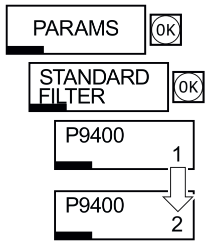
Procedure with STARTER

- In the Drive Navigatorselect the following screen form:



- Click on the button to safely remove the memory card.
- You may remove the memory card from the converter after the appropriate message has been output.

Procedure with the BOP-2

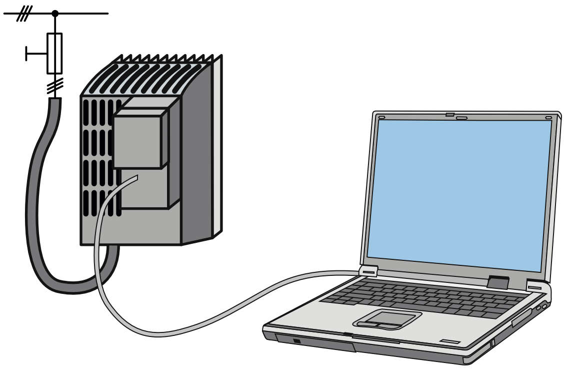


- Go to parameter p9400. If a memory card is correctly inserted, then p9400 = 1.
- Set p9400 = 2 The BOP-2 displays "BUSY" for several seconds and then jumps to either p9400 = 3 or p9400 = 100.
- For Bei p9400 = 3 you may remove the memory card.
- For p9400 = 100, you may not remove the memory card at the moment.
  In this case, try again by setting p9400 = 2.

10.2 Backing up and transferring settings using STARTER

With the supply voltage switched on, you can transfer the converter settings from the converter to a PG/PC, or the data from a PG/PC to the converter.

This requires you to have installed the STARTER commissioning tool on your PG/PC.



You will find additional information about STARTER in the section: Commissioning tools (Page 18).

Procedure converter → PC/PG

- Go online with STARTER : .
- Select the button "Download project to PG": .
- To save the data in the PG, select the button: .
- Go offline with STARTER : .

Procedure PC/PG → Converter

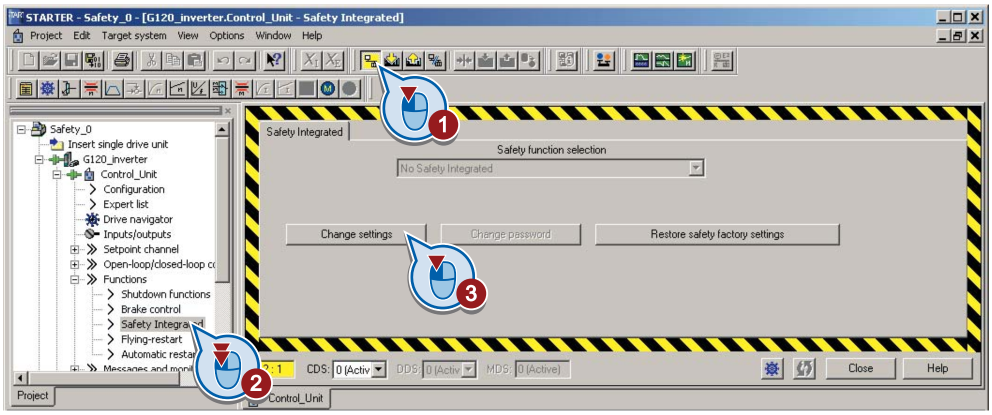
The procedure depends on whether you also transfer settings of safety functions or not.

Converter without safety functions:

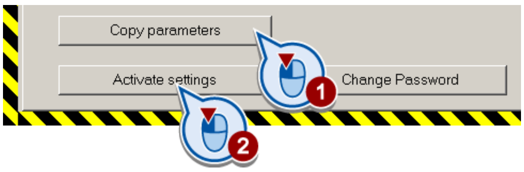
- Go online with STARTER : .
- Select the button "Download project to target system": .
- To save the data in the converter, select the "Copy RAM to ROM" button: .
- Go offline with STARTER : .

Converter with safety functions:

- ① Go online with STARTER : .
- ② Select the button "Download project to target system": .
- ③ Open the STARTER screen for the safety functions.



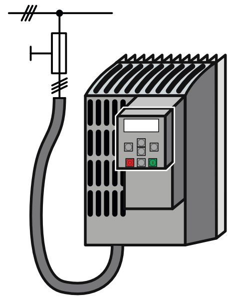
- ① Copy the safety function parameters.
- ② Activate the settings.



- To save the data in the converter, select the "Copy RAM to ROM" button: .
- Go offline with STARTER : .
- Switch off the converter power supply.
- Wait until all LED on the converter go dark. Now switch on the converter power supply again. Your settings only become effective after this power-on reset.

10.3 Saving settings and transferring them using an operator panel

When the power supply is switched on, you can transfer the settings of the converter to the BOP-2 or, vice versa, transfer the data from the BOP-2 to the converter.



Procedure converter → BOP-2

- Start data transfer in the menu "EXTRAS" - "TO BOP".

Procedure BOP-2 → converter

- Start data transfer in the menu "EXTRAS" - "FROM BOP".
- Switch off the converter power supply.
- Wait until all LED on the converter go dark. Now switch on the converter power supply again. Your settings only become effective after this power-on reset.

10.4 Other ways to back up settings

Description

In addition to the default setting, the converter has an internal memory for backing up three other settings.

On the memory card, you can back up 99 other settings in addition to the default setting.

You will find additional information on the Internet at: Memory options (http://support.automation.siemens.com/WW/view/en/43512514).

Table 10- 1 Backing up settings in the converter

Parameter	Description
p0970	**Reset drive parameters** Load backed-up setting (number 10, 11 or 12). You overwrite your actual parameter setting when loading.
p0971	**Save parameters** Back up the setting (10, 11 or 12).

Table 10- 2 Backing up additional settings on the memory card

Parameter	Description
p0802	**Data transfer with memory card as source/target** (factory setting: 0) Default setting: p802 = 0 Further settings: p802 = 1 … 99
p0803	**Data transfer with device memory as source/target** (factory setting: 0) Default setting: p803 = 0 Further settings: p803 = 10, 11 or 12

Table 10- 3 Operation on the BOP-2

	Description	
	EXTRAS OK TO CRD OK	The converter writes its setting 0, 10, 11 or 12 to the memory card in accordance with p0802. The file on the memory card is assigned the number according to p0802.
	EXTRAS OK FROM CRD OK	The converter loads the setting with the number according to p0802 from the memory card and thus overwrites its setting 0, 10, 11 or 12.

10.5 Write and know how protection

The converter offers the option to protect configured settings from being changed or copied.

Write protection and know how protection are available for this purpose.

Write protection - overview

Write protection is primarily used to prevent converter settings from being inadvertently changed. No password is required for write protection, there is no encryption.

The following functions are excluded from the write protection:

- Activating/deactivating write protection (p7761)
- Changing the access level (p0003)
- Saving parameters (p0971)
- Safely removing the memory card (p9400)
- Access to service parameters (p3950) - only for service personnel, a password is required
- Restoring the factory setting
- Upload
- Acknowledging alarms and faults
- Switching over to the control panel
- Trace
- Function generator
- Measuring functions
- Reading out diagnostic buffer

The individual parameters that are excluded from the write protection, can be found in the List Manual in Chapter "Parameters for write protection and protection of know-how".

Know-how protection - overview

The know-how protection is used, for example, so that a machine manufacturer can encrypt his configuration know-how and protect it against changes or copying.

The know-how protection is available in the following versions:

- **Know-how protection without copy protection** (possible with or without memory card)
- **Know-how protection with copy protection** (possible only with Siemens memory card)

A password is required for the know-how protection.

In case of active know-how protection, the STARTER dialog screens are locked. You can, however, read the values of the display parameters from the expert list. The values of the adjustment parameters are not displayed and cannot be changed.

Actions that are also possible during active know-how protection

Actions listed below can also be executed during active know-how protection:

- Restoring factory settings
- Acknowledging messages
- Displaying messages
- Displaying the alarm history
- Reading out diagnostic buffer
- Switching to the control panel (complete control panel functionality: Fetch master control, all buttons and setting parameters)
- Upload (only parameters, which are accessible even though know-how protection is active)

Actions that are not possible during active know-how protection

Actions listed below cannot be executed during active know-how protection:

- Download
- Export/import
- Trace
- Function generator
- Measuring functions
- Automatic controller setting
- Stationary/rotating measurement
- Deleting the alarm history

The individual parameters that are excluded from the know-how protection can be found in the List Manual in Chapter "Parameters for write protection and protection of know-how".

10.5.1 Write protection

Set write protection

In order that you can set write protection, your converter must be connected online with STARTER.

Activate and deactivate write protection

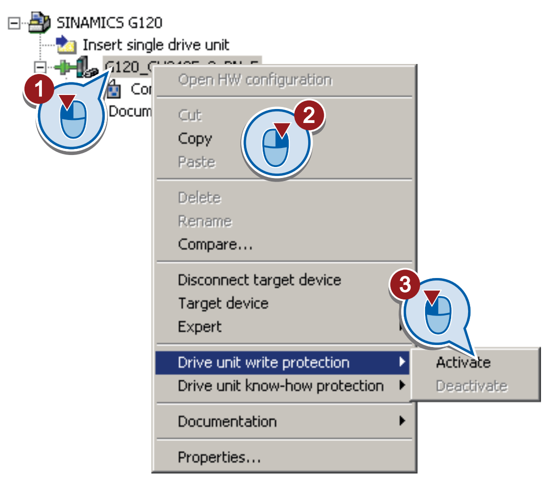
Select the converter in your STARTER project with the left mouse button ①.

Open the shortcut menu by right-clicking ②

Activate write protection ③

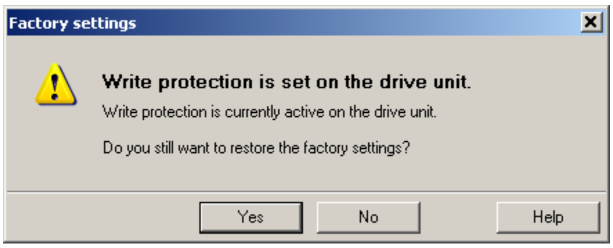
Deactivation is executed in analog.

To make this setting permanent, you need to select "Copy RAM to ROM" . Otherwise, your settings will be lost when the converter is switched off.



Points to note about restoring the factory settings

If you select "Reset to factory settings" using the button when write protection is active, the following confirmation prompt opens.



If you initiate reset using other methods such as the expert list, there is no prompt.

Note

Points to note regarding CAN, BACnet and MODBUS

Using these bus systems, parameter factory settings can be changed despite active write protection. So that write protection is also active when accessing via these fieldbuses, you must additionally set p7762 to 1.

This setting is only possible via the expert list.

10.5.2 Know-how protection

When the converter is operated with know-how protection, please take note of the following information:

Note

Support provided by technical support for active know-how protection

In the case of active know-how protection, support by the technical support is only possible with the consent of the machine manufacturer.

Know-how protection can only be activated online.

If you have created a project offline on your computer, you must download it to the converter and go online. Only then can you activate the know-how protection.

You cannot activate know-how protection in the project on the computer.

Know-how protection with copy protection is only possible with a Siemens memory card.

For "know-how protection with copy protection", a Siemens memory card must be plugged in!

If you try to activate the "know-how protection with copy protection" without a memory card, or with a different memory card, the error message "know-how protection for the drive unit could not be activated" is displayed.

Password check for know-how protection and Windows language settings

Please note that if the Windows language settings are changed, after activating know-how protection, errors can occur when subsequently checking the password. Therefore, only use characters from the ASCII character set for your password.

Commissioning the converter with know-how protection

Recommended procedure for commissioning with know-how protection.

1. Commission the converter.
2. Create the exception list (Page 264)
3. Activate the know-how protection (Page 263).
4. Save the settings in the converter by copying RAM to ROM with or via p0971 = 1.
5. Save the project with on the PG/PC. Also back up any other project-related data (machine type, password, etc.) that may be required for the support of the end customer.

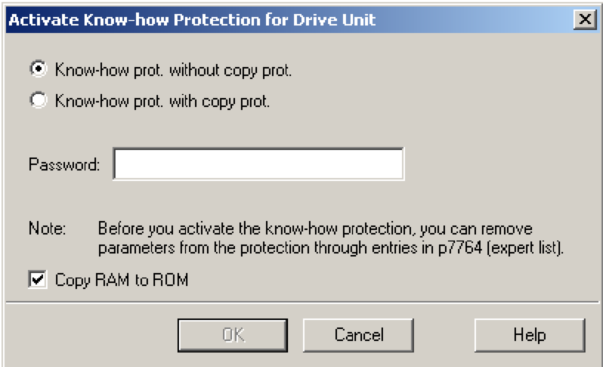
10.5.2.1 Settings for the know-how protection

Activating know-how protection

Select the converter in the STARTER project, and then select "Know-how protection drive unit/activate ..." in the shortcut menu (see also Write protection (Page 261))..

The adjacent screen form then opens:

Enter your password in this screen and confirm with OK. The password must consist of at least one character and can be no longer than 30 characters. All characters are permissible.



In this screen form "Copy RAM to ROM" has been selected in the factory. This will ensure that your settings are permanently stored.

If "Copy RAM to ROM" is not selected, then your know-how protection settings are only saved in the volatile memory, and will no longer be available the next time the system is switched on.

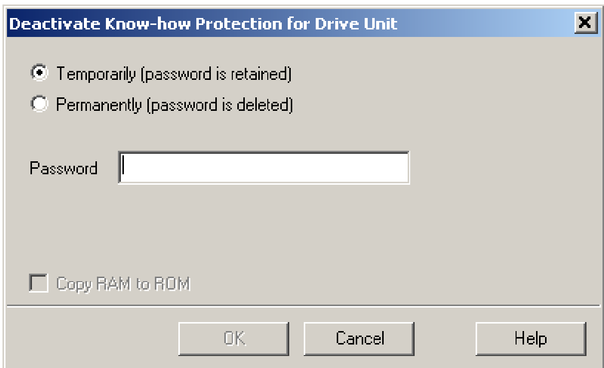
Backing up parameter settings on the memory card

When the know-how protection is activated, you may save the parameter settings via p0971 on the memory card.

To do this, set p0971 = 1. The data is encrypted before being written to the memory card. After saving, p0971 is reset to 0.

Deactivate know-how protection, delete password

1. Select the converter in the STARTER project, and right-click to open the dialog box "Know-how protection drive unit/deactivate …".
2. There, select the desired option.
3. Enter the password and exit the screen form with OK.



Note

Permanently or temporarily deactivating know-how protection

Temporarily deactivating know-how protection means that know-how protection is active again after switching off and switching on. Permanently deactivating means that know-how protection is no longer active after switching off and switching on again.

It goes without saying that you can always reactivate know-how protection, even if you have permanently canceled it, by following the procedure described above in this section.

Deactivating know-how protection temporarily

To temporarily deactivate the know-how protection means that you can change the settings in the converter until you switch the converter off and on again, or until you reactivate the know-how protection.

Finally deactivating know-how protection (delete password)

To finally deactivating the know-how protection means that you delete the password

- Immediately and finally, if you select "Copy RAM to ROM"
- Until the next OFF/ON if you do not select "Copy RAM to ROM"

Changing the password

Select the converter in the STARTER project and open the dialog box via the shortcut menu "know-how protection drive unit/change password … ".

10.5.2.2 Creating an exception list for the know-how protection

Using the exception list, you as a machine manufacturer may make individual adjustable parameters accessible to end customers although know-how protection is active. You may define the exception list via parameters p7763 and p7764 in the expert list. Specify the number of parameters for the selection list in p7763. Assign the individual indices to the parameter numbers of the selection list in p7764.

NOTICE
Procedure to change p7763 (number of parameters for the selection list) 1. Save the converter settings via an upload ( ) on the computer/PG and go offline ( ) 2. In the project on the computer, set p7763 to the desired value. Save the project. 3. Go online and load the project into the converter ( ). 4. Now make the additional settings in p7764.

Factory setting for the exception list:

- p7763 = 1 (selection list contains precisely one parameter)
- p7764[0] = 7766 (parameter number for entering the password)

⚠ CAUTION
Take special care when creating the exception list!
If you remove p7766 from the exception list, you can no longer enter a password and therefore no longer deactivate know-how protection. The only possibility to be able to access the converter again is to reset the converter to the factory settings.

10.5.2.3 Replacing devices during know-how protection

Replacing devices during know-how protection without copy protection

During know-how protection without copy protection, you can save the configuration settings of the converter with the automatic upload (see Saving setting on memory card (Page 249)) on an empty memory card, and with the automatic download (see Transferring the setting from the memory card (Page 251)) you can transfer these to another converter – and thus replace devices or commission other converters.

Replacing devices for know-how protection with copy protection

The know-how protection with copy protection prevents the converter settings from being copied and passed on. This function is predominantly used by machine manufacturers.

If know-how protection with copy protection is active, the converter cannot be replaced as described in "Overview of how to replace an inverter (Page 267)".

However, to allow the converter to be replaced, it must be operated with a Siemens memory card, and the machine manufacturer must have an identical machine that he uses as sample.

There are two options for replacing the device:

Case 1: The machine manufacturer only knows the serial number of the new converter

Procedure:

1. The end customer provides the machine manufacturer with the following information:
   - For which machine must the converter be replaced?
   - What is the serial number (r7758) of the new converter?

2. The machine manufacturer goes online on the sample machine.
   – deactivates the know-how protection, see Settings for the know-how protection (Page 263)
   – enters the serial number of the new converter in p7759
   – enters the serial number of the inserted memory card as reference serial number in p7769
   – activates the know-how protection with copy protection ("Copy RAM to ROM" must be activated!), see Settings for the know-how protection (Page 263)
   – writes the configuration with p0971 = 1 to the memory card
   – sends the memory card to the end customer
3. The end customer inserts the memory card and switches on the converter.

When powering up, the converter checks the serial numbers of the card and when there is a match, the converter goes into the "ready to start" state.

If the numbers do not match, then the converter signals fault F13100 (no valid memory card).

Case 2: The machine manufacturer knows the serial number of the new converter and the serial number of the MMC

Procedure

1. The end customer provides the machine manufacturer with the following information:
   – For which machine must the converter be replaced?
   – What is the serial number (r7758) of the new converter?
   – What is the serial number of the memory card?
2. The machine manufacturer goes online on the sample machine.
   – deactivates the know-how protection, see Settings for the know-how protection (Page 263)
   – enters the serial number of the new converter in p7759
   – enters the serial number of the customer's memory card as reference serial number in p7769
   – activates the know-how protection with copy protection ("Copy RAM to ROM" must be activated!), see Settings for the know-how protection (Page 263)
   – writes the configuration with p0971 = 1 to the memory card
   – copies the encrypted project from the card to his PC
   – for example, sends it by e-mail to the end customer
3. The end customer copies the project to the Siemens memory card that belongs to the machine, inserts it in the converter and switches on the converter.

When powering up, the converter checks the serial numbers of the card and when there is a match, the converter goes into the "ready to start" state.

If the numbers do not match, then the converter signals fault F13100 (no valid memory card).

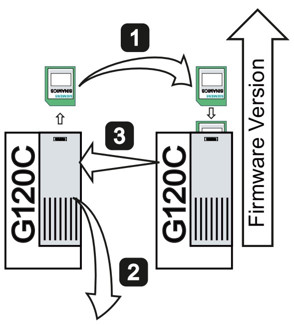
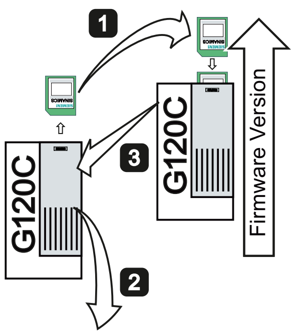
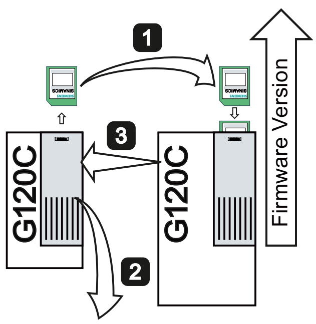
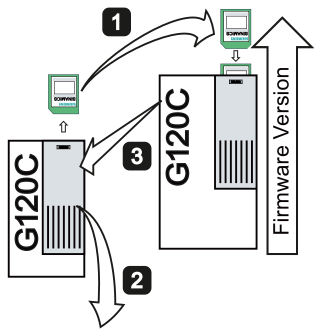
11 Servicing and maintaining

11.1 Overview of how to replace an inverter

You must replace the inverter if it continually malfunctions. In the following cases, you may immediately switch on the motor again after the replacement.

⚠ WARNING
In all other cases, you must recommission the drive.

Component replacement, general

<table>
<tr><td colspan="4">Replacing the inverter with external backup of the settings, e.g. on a memory card.</td></tr>
<tr><td colspan="4">The inverter automatically loads the settings on the memory card.
If you have saved the settings of your inverter on another medium, e.g. on an operator panel or on a PC, then after the replacement, the settings must be loaded into the inverter.</td></tr>
<tr>
<td>Replacement:
• Same type
• Same power rating
• Same firmware version</td>
<td>Replacement:
• Same type
• Same power rating
• higher firmware version (e.g. replace FW V4.2 by FW V4.3)</td>
<td>Replacement:
• Same type
• Higher power rating
• Same firmware version</td>
<td>Replacement:
• Same type
• Higher power rating
• higher firmware version (e.g. replace FW V4.2 by FW V4.3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr><td colspan="2"></td><td colspan="2">Inverter and motor must be adapted to one another (ratio of the motor and inverter rated power > 1/8)</td></tr>
</table>

Device replacement without removable storage medium - only for communications via PROFINET

If you have created a topology in your control, using the environment detection, you can replace a defective converter by a new device of the same type and with the identical software release without having to recommission the system.

You can either load the converter settings into the converter using the memory card, or – if you are using a SIMATIC S7 control with DriveES – using DriveES.

Details of the device replacement without removable storage medium can be found in the Profinet system description (http://support.automation.siemens.com/WW/view/en/19292127).

11.2 Steps for replacing the inverter

We recommend that you save your settings of the converter after commissioning to an external device. You find information about saving the converter settings in the section Data backup and series commissioning (Page 247).

If the settings are not saved to an external device, you will have to recommission the converter when it is replaced.

Procedure for replacing the converter with a memory card

- Disconnect the line voltage of the converter.

⚠ DANGER
Dangerous voltage!
Hazardous voltage is still present for up to 5 minutes after the power supply has been switched off. Do not to carry out any installation work before this time has expired!

- Remove the connectors for line, motor and braking resistor of the converter.
- Remove the signal cables of the converter.
- Remove the defective converter.
- Mount the new converter.
- Remove the memory card from the old converter and insert it in the new converter.
- Reconnect the signal cables of the Control Unit.
- Reconnect the connectors for line, motor and braking resistor of the converter.
- Connect up the line voltage again.
- The converter adopts the settings from the memory card, saves them (protected against power failure) in its internal parameter memory, and switches to "ready to start" state.
- For converters of the same type and an equal or higher firmware version, you can switch on the converter without any additional commissioning.
  Alarm A01028 will be output for converters of different types. This alarm indicates that the parameter settings are not compatible with the converter. In this case, delete the message using p0971 = 1 and recommission the drive.

Procedure for replacing the converter without a memory card

- Disconnect the line voltage of the converter.

⚠DANGER
Dangerous voltage! Hazardous voltage is still present for up to 5 minutes after the power supply has been switched off. Do not to carry out any installation work before this time has expired!

- Remove the connectors for line, motor and braking resistor of the converter.
- Remove the signal cables of the converter.
- Remove the defective converter.
- Mount the new converter.
- Reconnect the signal cables of the converter.
- Reconnect the connectors for line, motor and braking resistor of the converter.
- Connect up the line voltage again.
- The converter goes into the "ready-to-switch-on" state.
- If you have saved your settings:
  - Load the settings from the Operator Panel or via the STARTER in your converter.
  - For converters of the same type and an equal or higher firmware version, you can now switch on the motor. Check the function of the motor.
    Alarm A01028 will be output for converters of different types. This alarm indicates that the parameter settings are not compatible with the converter. In this case, delete the message using p0971 = 1 and recommission the drive.
- If you did not save the parameter setting, you have to recommission the drive.

Inverter with enabled safety functions

If you replace an inverter with enabled safety functions, then you also need to confirm the safety function settings on the new inverter. You will find the procedure in Section: Data backup and series commissioning (Page 247).

Acceptance test

If you activated the safety functions in the inverter, after replacing the inverter you must perform an acceptance test for the safety functions.

- Switch off the inverter supply voltage.
- Wait until all LEDs on the inverter go dark. Now switch on the inverter power supply again (power on reset).
- If you commissioned the inverter for the first time, carry out a **complete** acceptance test, see Full acceptance tests (Page 240).
- In all other cases, after downloading the parameters into the inverter, carry-out a **reduced** acceptance test. The reduced acceptance test is described in Section Reduced acceptance (Page 241).

11.3 Replacing the heat sink fan

When do you have to replace the fan?

A defect fan involves an over temperature of the converter. Indications for a defective fan are e. g. the following alarms and faults:

- A05002 (Air intake overtemperature)
- A05004 (Rectifier overtemperature)
- F30004 (Overtemperature heat sink)
- F30024 (Overtemperature thermal model)
- F30025 (Chip overtemperature)
- F30035 (Air intake overtemperature)
- F30037 (Rectifier overtemperature)

Preparatory steps

- Power-down the converter
- Disconnect all the cable connectors for line, motor and braking resistor.
- Remove the screening plate.

Removal

The heat sink fan of the converter is situated at the bottom of the converter below the detachable connectors.

1. Using your fingers, press the locking latches to release the fan module.
2. Pull the fan module out from the fan module housing.

Installation

1. Ensure the fan module is correctly orientated (see figure below).
2. Gently push the fan module into the fan module housing, ensuring that the power connections are aligned correctly.
3. The fan module will click into place as the locking latches are engaged correctly.
4. Re-assemble the Converter by following the preparatory steps in reverse.

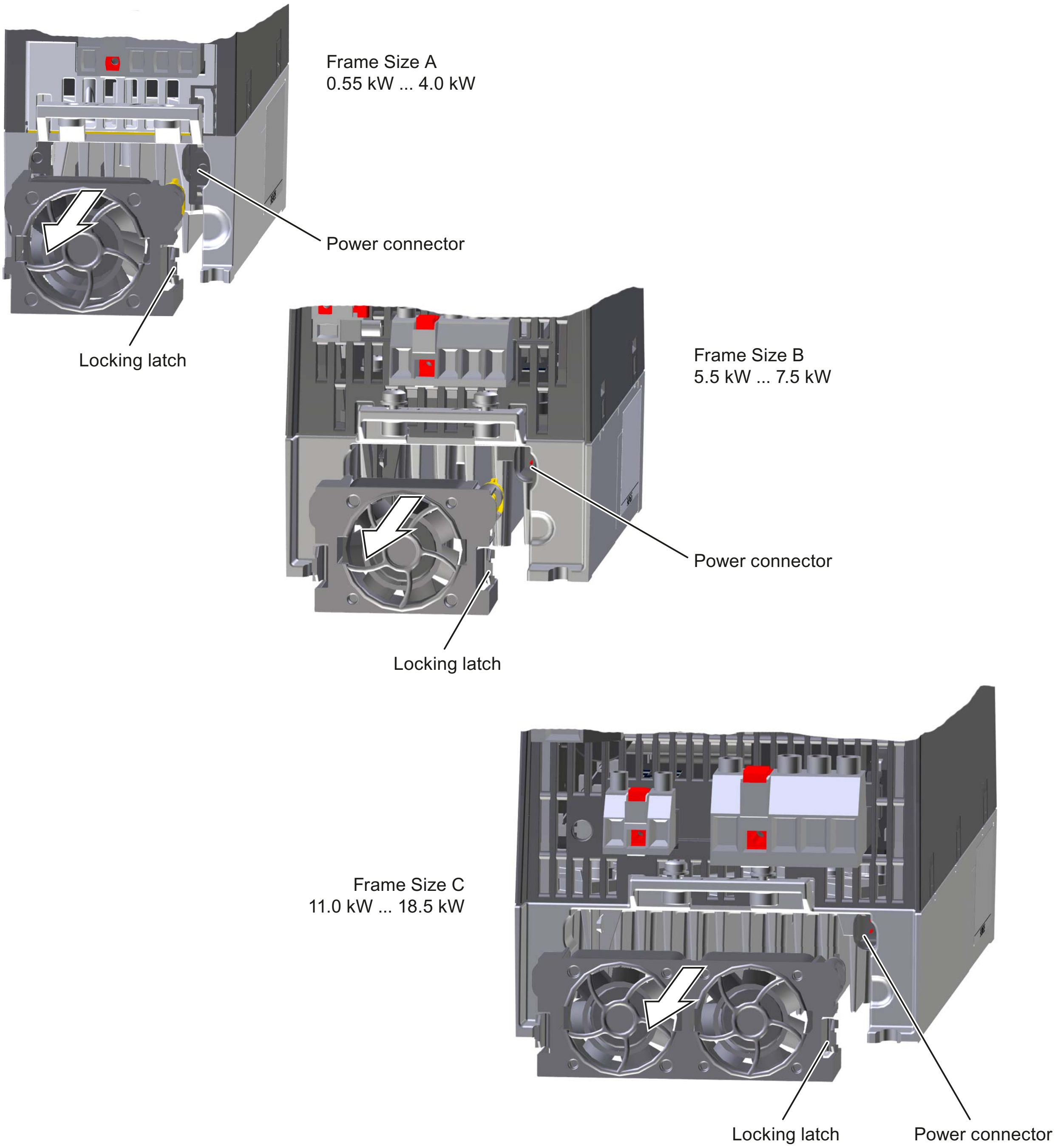


Figure 11-1 Heat sink fan replacement

11.4 Replaing the internal fan

When do you have to replace the fan?

A defective fan involves an over temperature of the converter. Indications for a defective fan are e. g. the following alarms and faults:

- A30034 (Internal overtemperature)
- F30036 (Internal overtemperature)
- A30049 (Internal fan faulty)
- F30059 (Internal fan faulty)

Removal

The fan is situated at the top of the converter.

1. Power-down the Converter

> **DANGER**
>
> **Dangerous voltage!**
>
> Hazardous voltage is still present for up to 5 minutes after the power supply has been switched off. Do not to carry out any installation work before this time has expired!

2. Using a screw driver, bend the locking latches to release the fan.
3. Pull the fan out.

Installation

1. Gently push the fan module into the converter, ensuring that the power connections are aligned correctly.
2. The fan will click into place as the locking latches are engaged correctly.
3. Power-up the converter.

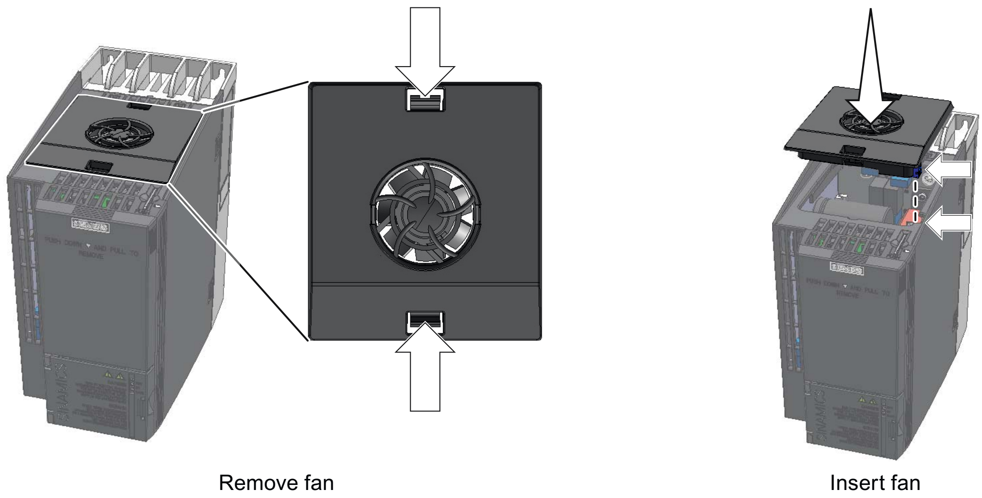


Figure 11-2 Fan replacement

12 Alarms, faults and system messages

The converter has the following diagnostic types:

- LED

  The LED at the front of the converter immediately informs you about the most important converter states right at the converter.

- Alarms and faults

  The converter signals alarms and faults via the fieldbus, the terminal strip (when appropriately set), on a connected operator panel or STARTER.
  Alarms and faults have a unique number.

If the converter no longer responds

Due to faulty parameter settings, e.g. by loading a defective file from the memory card, the converter can adopt the following condition:

Case 1

- The motor is switched off.
- You cannot communicate with the converter, either via the Operator Panel or other interfaces.
- The LEDs flicker and after 3 minutes the converter has still not powered up.

In this case, proceed as follows:

- Remove the memory card if one is inserted in the converter.
- Perform a power-on reset. Procedure for power on reset:
  - Switch off the converter power supply.
  - Wait until all LEDs on the converter go dark. Now switch on the converter power supply again
- Repeat the power on reset as often as required until the converter outputs fault F01018:
- Now set p0971 = 1 and perform an additional power-on reset. The converter now powers up with the factory settings.
- Recommission the converter.

Case 2

- The motor is switched off.
- You cannot communicate with the converter, either via the Operator Panel or other interfaces.
- The LEDs flash and are dark - this process is continually repeated.

In this case, proceed as follows:

- Remove the memory card if one is inserted in the converter.
- Perform a power-on reset. Procedure for power on reset:
  - Switch off the converter power supply.
  - Wait until all LEDs on the converter go dark. Now switch on the converter power supply again
- Repeat the power on reset until the converter outputs fault F01018, whereby you must switch off the converter if the LED flashes orange.
- Now set p0971 = 1 and perform an additional power-on reset. The converter now powers up with the factory settings.
- Recommission the converter.

12.1 Operating states indicated on LEDs

The LED RDY (Ready) is temporarily orange after the power supply voltage is switched-on. As soon as the color of the LED RDY changes to either red or green, the LEDs signal the inverter state.

Signal states of the LED

In addition to the signal states "on" and "off" there are two different flashing frequencies:

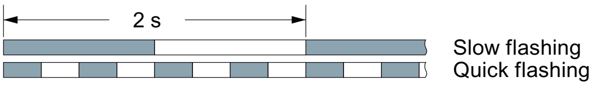


Table 12- 1 Inverter diagnostics

LED		Explanation
RDY	BF	
GREEN - on	---	There is presently no fault
GREEN - slow	---	Commissioning or reset to factory settings
RED - fast	---	There is presently a fault
RED - fast	RED - fast	Incorrect memory card

Table 12- 2 Inverter diagnostics

LNK LED	Explanation
GREEN - on	The communication via PROFINET is in order.
GREEN - slow	Device naming is active.
Off	No communication via PROFINET.

Table 12- 3 Communication diagnostics via RS485

LED BF	Explanation
On	Receive process data
RED - slow	Bus active - no process data
RED - fast	No bus activity

Table 12- 4 Communication diagnostics via PROFIBUS DP

LED BF	Explanation
off	Cyclic data exchange (or PROFIBUS not used, p2030 = 0)
RED - slow	Bus fault - configuration fault
RED - fast	Bus fault - no data exchange - baud rate search - no connection

Table 12- 5 Diagnostics of the safety functions

SAFE LED	Meaning
YELLOW - on	One or more safety functions are enabled, but not active.
YELLOW - slow	One or more safety functions are active; no safety function faults have occurred.
YELLOW - rapid	The converter has detected a safety function fault and initiated a STOP response.

LED BF display for CANopen

In addition to the signal states "on" and "off" there are three different flashing frequencies:

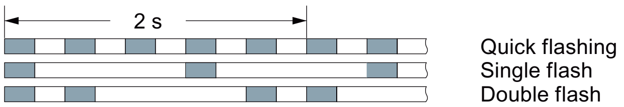


Table 12- 6 Communication diagnostics via CANopen

BF LED	Explanation
GREEN - on	Bus state "Operational"
GREEN - fast	Bus state "Pre-Operational"
GREEN - single flash	Bus state "Stopped"
RED - on	No bus
RED - single flash	Alarm - limit reached
RED - double flash	Error event in control (Error Control Event)

12.2 Alarms

Alarms have the following properties:

- They do not have a direct effect in the inverter and disappear once the cause has been removed
- They do not need have to be acknowledged
- They are signaled as follows
  - Status display via bit 7 in status word 1 (r0052)
  - at the Operator Panel with a Axxxxx
  - via STARTER

In order to pinpoint the cause of an alarm, there is a unique alarm code and also a value for each alarm.

Alarm buffer

The inverter saves an alarm code and an alarm value for every alarm it receives.

	Alarm code	Alarm value	
1st alarm	r2122[0]	r2124[0] I32	r2134[0] Float

Figure 12-1 Saving the first alarm in the alarm buffer

r2124 and r2134 contain the alarm value - important for diagnostics - as "fixed point" or "floating point" number.

The alarm remains in the alarm buffer even if the alarm has been removed.

If an additional alarm is received, then this is also saved. The first alarm is still saved. The alarms that have occurred are counted in p2111.

	Alarm code	Alarm value	
1st alarm	r2122[0]	r2124[0]	r2134[0]
2nd alarm	[1]	[1]	[1]

Figure 12-2 Saving the second alarm in the alarm buffer

The alarm buffer can contain up to eight alarms. If an additional alarm is received after the eighth alarm - and none of the last eight alarms have been removed - then the next to last alarm is overwritten.

	Alarm code	Alarm value	
1st alarm	r2122[0]	r2124[0]	r2134[0]
2nd alarm	[1]	[1]	[1]
3rd alarm	[2]	[2]	[2]
4th alarm	[3]	[3]	[3]
5th alarm	[4]	[4]	[4]
6th alarm	[5]	[5]	[5]
7th alarm	[6]	[6]	[6]
last alarm	[7]	[7]	[7]

Figure 12-3 Complete alarm buffer

Emptying the alarm buffer: Alarm history

The alarm history traces up to 56 alarms.

The alarm history only takes alarms that have been removed from the alarm buffer. If the alarm buffer is completely filled - and an additional alarm occurs - then the inverter shifts all alarms that have been removed from the alarm buffer into the alarm history. The inverter sorts the alarms in the alarm history in the inverse sequence to the alarm buffer.

- the youngest alarm is in index 8
- the second youngest alarm is in index 9
- etc.

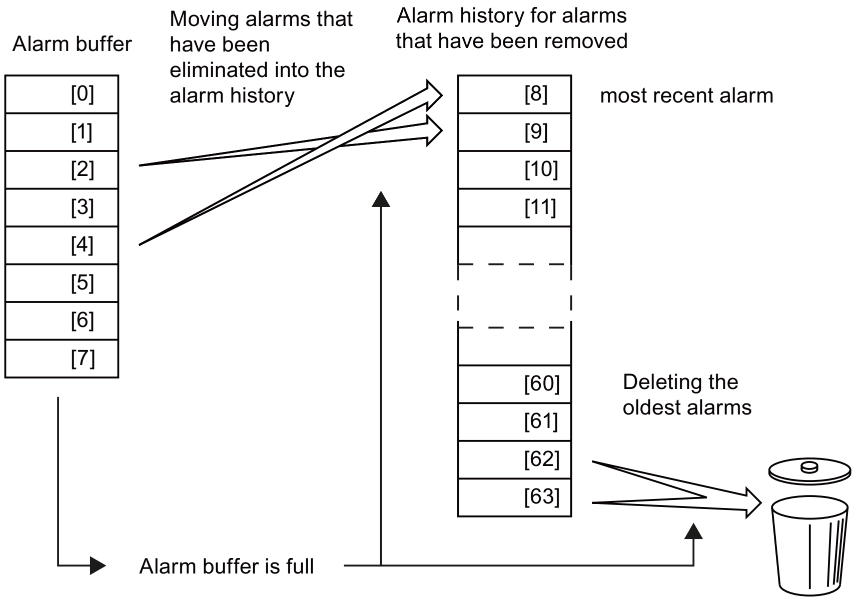


Figure 12-4 Shifting alarms that have been removed into the alarm history

The alarms that have still not been removed remain in the alarm buffer and are resorted so that gaps between the alarms are filled.

If the alarm history is filled up to index 63, each time a new alarm is accepted in the alarm history, the oldest alarm is deleted.

Parameters of the alarm buffer and the alarm history

Table 12- 7 Important parameters for alarms

Parameter	Description
r2122	**Alarm code** Displays the numbers of alarms that have occurred
r2124	**Alarm value** Displays additional information about the alarm
p2111	**Alarm counter** Number of alarms that have occurred after the last reset When setting p2111 = 0, all of the alarms that have been removed from the alarm buffer [0...7] are transferred into the alarm history [8...63]
r2132	**Actual alarm code** Displays the code of the alarm that last occurred
r2134	**Alarm value for float values** Displays additional information about the alarm that occurred for float values

Extended settings for alarms

Table 12- 8 Extended settings for alarms

Parameter	Description
You can change up to 20 different alarms into a fault or suppress alarms:	
p2118	**Setting the message number for the message type** Select the alarms for which the message type should be changed
p2119	**Setting the message type** Setting the message type for the selected alarm 1: Fault 2: Alarm 3: No message

You will find details in function diagram 8075 and in the parameter description of the List Manual.

12.3 Faults

A fault displays a severe fault during operation of the inverter.

The inverter signals a fault as follows:

- at the Operator Panel with Fxxxxx
- on the converter using the red LED RDY
- in bit 3 of the status word 1 (r0052)
- via STARTER

To delete a fault message, you need to remedy the cause of the fault and acknowledge the fault.

Every fault has a clear fault code and also a fault value. You need this information to determine the cause of the fault.

Fault buffer of actual values

The converter saves a fault code and fault value for every fault it receives.

	Fault code	Fault value	
1st fault	r0945[0]	r0949[0] I32	r2133[0] Float

Figure 12-5 Saving the first fault in the fault buffer

r0949 and r2133 contain the fault value - important for diagnostics - as "fixed point" or "floating point" number.

If an additional fault occurs before the first fault has been acknowledged, then this is also saved. The first alarm remains saved. The fault cases that have occurred are counted in p0952. A fault case can contain one or several faults.

	Fault code	Fault value	
1st fault	r0945[0]	r0949[0]	r2133[0]
2nd fault	[1]	[1]	[1]

Figure 12-6 Saving the second fault in the fault buffer

The fault buffer can accept up to eight actual faults. The next to last fault is overwritten if an additional fault occurs after the eighth fault.

	Fault code	Fault value	
1st fault	r0945[0]	r0949[0]	r2133[0]
2nd fault	[1]	[1]	[1]
3rd fault	[2]	[2]	[2]
4th fault	[3]	[3]	[3]
5th fault	[4]	[4]	[4]
6th fault	[5]	[5]	[5]
7th fault	[6]	[6]	[6]
last fault	[7]	[7]	[7]

Figure 12-7 Complete fault buffer

Fault acknowledgement

In most cases, you have the following options to acknowledge a fault:

- Switch-off the inverter power supply and switch-on again.
- Press the acknowledgement button on the operator panel
- Acknowledgement signal at digital input 2
- Acknowledgement signal in bit 7 of control word 1 (r0054) for Control Units with fieldbus interface

Faults that are triggered by internal converter hardware and firmware monitoring functions can only be acknowledged by switching off and on again. You will find a note about this restricted option to acknowledge faults in the fault list of the List Manual.

Emptying the fault buffer: Fault history

The fault history can contain up to 56 faults.

The fault acknowledgement has no effect as long as none of the fault causes of the fault buffer have been removed. If at least one of the faults in the fault buffer has been removed (the cause of the fault has been removed) and you acknowledge the faults, then the following happens:

1. The inverter accepts all faults from the fault buffer in the first eight memory locations of the fault history (indices 8 ... 15).
2. The inverter deletes the faults that have been removed from the fault buffer.
3. The inverter writes the time of acknowledgement of the faults that have been removed into parameters r2136 and r2109 (fault time removed).

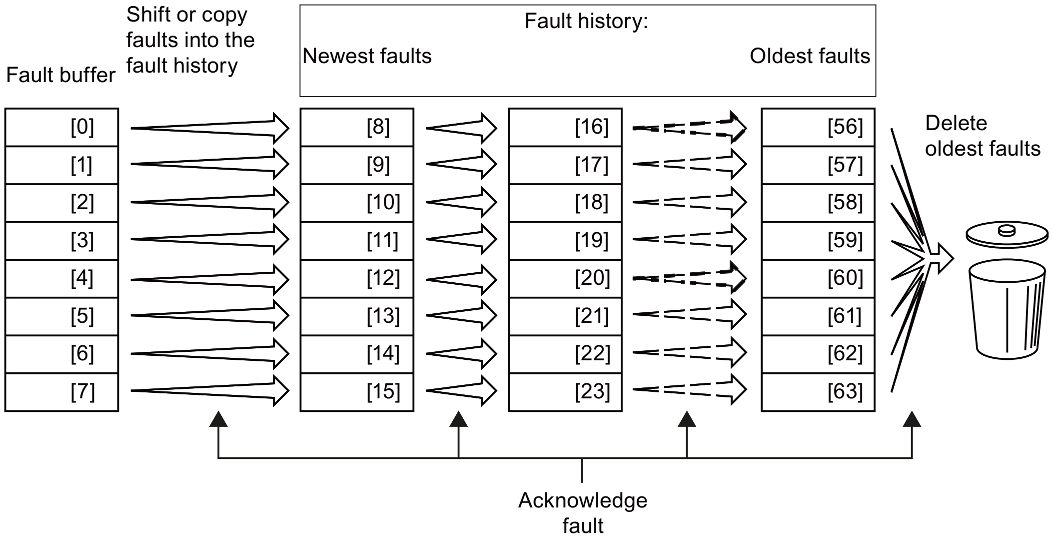


Figure 12-8 Fault history after acknowledging the faults

After acknowledgement, the faults that have not been removed are located in the fault buffer as well as in the fault history.

If less than eight faults were shifted or copied into the fault history, the memory locations with the higher indices remain empty.

The inverters shifts the values previously saved in the fault history each by eight indices. Faults, which were saved in indices 56 … 63 before the acknowledgement, are deleted.

Deleting the fault history

If you wish to delete all faults from the fault history, set parameter p0952 to zero.

Parameters of the fault buffer and the fault history

Table 12- 9 Important parameters for faults

Parameter	Description
r0945	**Fault code** Displays the numbers of faults that have occurred
r0949	**Fault value** Displays additional information about the fault
p0952	**Fault cases, counter** Number of fault cases that have occurred since the last acknowledgement The fault buffer is deleted with p0952 = 0.
r2131	**Actual fault code** Displays the code of the oldest fault that is still active
r2133	**Fault value for float values** Displays additional information about the fault that occurred for float values

The motor cannot be switched-on

If the motor cannot be switched-on, then check the following:

- Is a fault present?
  If yes, then remove the fault cause and acknowledge the fault
- Is p0010 = 0?
  If not, the converter is e.g. still in a commissioning state.
- Is the inverter reporting the "ready to start" status (r0052.0 = 1)?
- Is the inverter missing enabling (r0046)?
- Are the interfaces of the converter (p0015) correctly parameterized?
  In other words, how is the converter receiving its setpoint and its commands?

Extended settings for faults

Table 12- 10 Advanced settings

Parameter	Description
You can change the fault response of the motor for up to 20 different fault codes:	
p2100	**Setting the fault number for fault response** Selecting the faults for which the fault response should be changed
p2101	**Setting, fault response** Setting the fault response for the selected fault
You can change the acknowledgement type for up to 20 different fault codes:	
p2126	**Setting the fault number for the acknowledgement mode** Selecting the faults for which the acknowledgement type should be changed
p2127	**Setting, acknowledgement mode** Setting the acknowledgement type for the selected fault 1: Can only be acknowledged using POWER ON 2: IMMEDIATE acknowledgment after removing the fault cause
You can change up to 20 different faults into an alarm or suppress faults:	
p2118	**Setting the message number for the message type** Selecting the message for which the message type should be selected
p2119	**Setting the message type** Setting the message type for the selected fault 1: Fault 2: Alarm 3: No message

You will find details in function diagram 8075 and in the parameter description of the List Manual.

12.4 List of alarms and faults

Axxxxx Alarm

Fyyyyy: Fault

Table 12- 11 The most important alarms and faults of the safety functions

<table>
<tr><th>Number</th><th>Cause</th><th colspan="2">Remedy</th></tr>
<tr><td>F01600</td><td>STOP A Triggered</td><td colspan="2">STO Select and then deselect again.</td></tr>
<tr><td>F01650</td><td>Acceptance test required</td><td colspan="2">Carry out acceptance test and create test certificate.
Switch the Control Unit off and then on again.</td></tr>
<tr><td rowspan="5">F01659</td><td rowspan="5">Write task for parameter rejected</td><td colspan="2">Cause: The converter should be reset to the factory setting. The resetting of the safety functions is, however, not allowed, because the safety functions are currently enabled.
Remedy with operator panel:</td></tr>
<tr><td>p0010 = 30</td><td>Parameter reset</td></tr>
<tr><td>p9761 = …</td><td>Enter password for the safety functions.</td></tr>
<tr><td>p0970 = 5</td><td>Reset Start Safety Parameter.
The converter sets p0970 = 5 if it has reset the parameters.</td></tr>
<tr><td colspan="2">Then reset the converter to the factory setting again.</td></tr>
<tr><td>A01666</td><td>Static 1 signal atF-DI for safe acknowledgment</td><td colspan="2">F-DI to a logical 0 signal.</td></tr>
<tr><td>A01698</td><td>Commissioning mode active for safety functions</td><td colspan="2">This message is withdrawn after the Safety commissioning has ended.</td></tr>
<tr><td>A01699</td><td>Shutdown path test required</td><td colspan="2">After the next time that the "STO" function is deselected, the message is withdrawn and the monitoring time is reset.</td></tr>
<tr><td>F30600</td><td>STOP A Triggered</td><td colspan="2">STO Select and then deselect again.</td></tr>
</table>

Table 12- 12 Faults, which can only be acknowledged by switching the inverter off and on again (power on reset)

Number	Cause	Remedy
F01000	Software fault in CU	Replace CU.
F01001	Floating Point Exception	Switch CU off and on again.
F01015	Software fault in CU	Upgrade firmware or contact technical support.
F01018	Power-up aborted more than once	After this fault has been output, the module is booted with the factory settings. Remedy: Back up factory setting with p0971=1. Switch CU off and on again. Recommission the inverter.
F01040	Parameters must be saved	Save parameters (p0971). Switch CU off and on again.
F01044	Loading of memory data card defective	Replace memory card or CU.
F01105	CU: Insufficient memory	Reduce number of data records.
F01205	CU: Time slice overflow	Contact technical support.
F01250	CU hardware fault	Replace CU.

Number	Cause	Remedy
F01512	An attempt has been made to establish an conversion factor for scaling which is not present	Create scaling or check transfer value.
F01662	CU hardware fault	Switch CU off and on again, upgrade firmware, or contact technical support.
F30022	Power Module: Monitoring U_{CE}	Check or replace the Power Module.
F30052	Incorrect Power Module data	Replace Power Module or upgrade CU firmware.
F30053	Error in FPGA data	Replace the Power Module.
F30662	CU hardware fault	Switch CU off and on again, upgrade firmware, or contact technical support.
F30664	CU power up aborted	Switch CU off and on again, upgrade firmware, or contact technical support.
F30850	Software fault in Power Module	Replace Power Module or contact technical support.

Table 12- 13 The most important alarms and faults

Number	Cause	Remedy
F01018	Power-up aborted more than once	1. Switch the module off and on again. 2. After this fault has been output, the module is booted with the factory settings. 3. Recommission the converter.
A01028	Configuration error	Explanation: Parameterization on the memory card has been created with a different type of module (order number, MLFB) Check the module parameters and recommission if necessary.
F01033	Unit switchover: Reference parameter value invalid	Set the value of the reference parameter to a value other than 0.0 (p0304, p0305, p0310, p0596, p2000, p2001, p2002, p2003, r2004).
F01034	Unit switchover: Calculation of the parameter values after reference value change unsuccessful	Select the value of the reference parameter so that the parameters involved can be calculated in the per unit notation (p0304, p0305, p0310, p0596, p2000, p2001, p2002, p2003, r2004).
F01122	Frequency at the probe input too high	Reduce the frequency of the pulses at the probe input.
A01590	Motor maintenance interval lapsed	Carry out the maintenance.
A01900	PROFIBUS: Configuration telegram faulty	Explanation: A PROFIBUS master is attempting to establish a connection with a faulty configuration telegram. Check the bus configuration on the master and slave side.
A01910 F01910	Fieldbus SS setpoint timeout	The alarm is generated when p2040 ≠ 0 ms and one of the following causes is present: • The bus connection is interrupted • The MODBUS master is switched off • Communications error (CRC, parity bit, logical error) An excessively low value for the fieldbus monitoring time (p2040)
A01920	PROFIBUS: Cyclic connection interrupt	Explanation: The cyclic connection to PROFIBUS master is interrupted. Establish the PROFIBUS connection and activate the PROFIBUS master with cyclic operation.

Number	Cause	Remedy
F03505	Analog input, wire break	Check the connection to the signal source for interrupts. Check the level of the signal supplied. The input current measured by the analog input can be read out in r0752.
A03520	Temperature sensor fault	Check that the sensor is connected correctly.
A05000 A05001 A05002 A05004 A05006	Power Module overtemperature	Check the following: - Is the ambient temperature within the defined limit values? - Are the load conditions and duty cycle configured accordingly? - Has the cooling failed?
F06310	Supply voltage (p0210) incorrectly parameterized	Check the parameterized supply voltage and if required change (p0210). Check the line voltage.
F07011	Motor overtemperature	Reduce the motor load. Check ambient temperature. Check sensor's wiring and connection.
A07012	I2t Motor Module overtemperature	Check and if necessary reduce the motor load. Check the motor's ambient temperature. Check thermal time constant p0611. Check overtemperature fault threshold p0605.
A07015	Motor temperature sensor alarm	Check that the sensor is connected correctly. Check the parameter assignment (p0601).
F07016	Motor temperature sensor fault	Make sure that the sensor is connected correctly. Check the parameterization (p0601).
F07086 F07088	Unit switchover: Parameter limit violation	Check the adapted parameter values and if required correct.
F07320	Automatic restart aborted	Increase the number of restart attempts (p1211). The current number of start attempts is shown in r1214. Increase the wait time in p1212 and/or monitoring time in p1213. Create ON command (p0840). Increase the monitoring time of the power unit or switch off (p0857). Reduce the wait time for resetting the fault counter p1213[1] so that fewer faults are registered in the time interval.
A07321	Automatic restart active	Explanation: The automatic restart (AR) is active. During voltage recovery and/or when remedying the causes of pending faults, the drive is automatically switched back on.
F07330	Search current measured too low	Increase search current (P1202), check motor connection.
A07400	V_{DC_max} controller active	If the controller is not to intervene: • Increase the ramp-down times. • Deactivate the V_{DC_max} controller (p1240 = 0 for vector control, p1280 = 0 for V/f control).
A07409	V/f control current limiting controller active	The alarm automatically disappears after one of the following measures: • Increase the current limit (p0640). • Reduce load. • Increase the ramp-up time to the speed setpoint.

Number	Cause	Remedy
F07426	Technology controller actual value limited	• Adapt the limits to the signal level (p2267, p2268). • Check the actual value scaling (p2264).
F07801	Motor overcurrent	Check current limits (p0640). U/f control: Check the current limiting controller (p1340 … p1346). Increase acceleration ramp (p1120) or reduce load. Check motor and motor cables for short circuit and ground fault. Check motor for star-delta connection and rating plate parameterization. Check power unit / motor combination. Select flying restart function (p1200) if switched to rotating motor.
A07805	Drive: Power unit overload I2t	• Reduce the continuous load. • Adapt the load cycle. • Check the assignment of rated currents of the motor and power unit.
F07807	Short circuit detected	• Check the converter connection on the motor side for any phase-phase short-circuit. • Rule out that line and motor cables have been interchanged.
A07850	External alarm 1	The signal for "external alarm 1" has been triggered. Parameter p2112 defines the signal source of the external alarm. Remedy: Rectify the cause of this alarm.
F07860	External fault 1	Remove the external causes for this fault.
F07900	Motor blocked	• Make sure that the motor can rotate freely. • Check the torque limit: r1538 for a positive direction of rotation; r1539 for a negative direction of rotation.
F07901	Motor overspeed	Activate precontrol of the speed limiting controller (p1401 bit 7 = 1).
F07902	Motor stalled	Check whether the motor data has been parameterized correctly and perform motor identification. Check the current limits (p0640, r0067, r0289). If the current limits are too low, the drive cannot be magnetized. Check whether motor cables are disconnected during operation.
A07903	Motor speed deviation	Increase p2163 and/or p2166. Increase the torque, current and power limits.
A07910	Motor overtemperature	Check the motor load. Check the motor's ambient temperature. Check the KTY84 sensor.
A07920	Torque/speed too low	The torque deviates from the torque/speed envelope curve. • Check the connection between the motor and the load. • Adapt the parameterization corresponding to the load.
A07921	Torque/speed too high	
A07922	Torque/speed out of tolerance	
F07923	Torque/speed too low	• Check the connection between the motor and the load. • Adapt the parameterization corresponding to the load.
F07924	Torque/speed too high	
A07927	DC braking active	Not required
A07980	Rotary measurement activated	Not required

Number	Cause	Remedy
A07981	No enabling for rotary measurement	Acknowledge pending faults. Establish missing enables (see r00002, r0046).
A07991	Motor data identification activated	Switch on the motor and identify the motor data.
F08501	Setpoint timeout	• Check the PROFINET connection. • Set the controller to RUN mode. • If the error occurs repeatedly, check the monitoring time set (p2044).
F08502	Monitoring time, sign-of-life expired	• Check the PROFINET connection.
F08510	Send configuration data not valid	• Check the PROFINET configuration
A08511	Receive configuration data not valid	
A08526	No cyclic connection	• Activate the controller with cyclic operation. • Check the parameters "Name of Station" and "IP of Station" (r61000, r61001).
A08565	Consistency error affecting adjustable parameters	Check the following: • IP address, subnet mask or default gateway is not correct. • IP address or station name used twice in the network. • Station name contains invalid characters.
F08700	Communications error	A CAN communications error has occurred. Check the following: • Bus cable • Baud rate (p8622) • Bit timing (p8623) • Master Start the CAN controller manually with p8608 = 1 after the cause of the fault has been resolved!
F13100	Know-how protection: Copy protection error	The know-how protection and the copy protection for the memory card are active. An error occurred during checking of the memory card. • Insert a suitable memory card and switch the converter supply voltage temporarily off and then on again (POWER ON). • Deactivate the copy protection (p7765).
F13101	Know-how protection: Copy protection cannot be activated	Insert a valid memory card.

Number	Cause	Remedy
F30001	Overcurrent	Check the following: • Motor data, if required, carry out commissioning • Motor's connection method (Y / Δ) • U/f operation: Assignment of rated currents of motor and Power Module • Line quality • Make sure that the line commutating reactor is connected properly • Power cable connections • Power cables for short-circuit or ground fault • Power cable length • Line phases If this doesn't help: • U/f operation: Increase the acceleration ramp • Reduce the load • Replace the power unit
F30002	DC-link voltage overvoltage	Increase the ramp-down time (p1121). Set the rounding times (p1130, p1136). Activate the DC link voltage controller (p1240, p1280). Check the line voltage (p0210). Check the line phases.
F30003	DC-link voltage undervoltage	Check the line voltage (p0210).
F30004	Converter overtemperature	Check whether the converter fan is running. Check whether the ambient temperature is in the permissible range. Check whether the motor is overloaded. Reduce the pulse frequency.
F30005	I2t converter overload	Check the rated currents of the motor and Power Module. Reduce current limit p0640. When operating with U/f characteristic: Reduce p1341.
F30011	Line phase failure	Check the converter's input fuses. Check the motor cables.
F30015	Motor cable phase failure	Check the motor cables. Increase the ramp-up or ramp-down time (p1120).
F30021	Ground fault	• Check the power cable connections. • Check the motor. • Check the current transformer. • Check the cables and contacts of the brake connection (a wire might be broken).
F30027	Time monitoring for DC link pre-charging	Check the supply voltage on the input terminals. Check the line voltage setting (p0210).
F30035	Overtemperature, intake air	• Check whether the fan is running. • Check the fan filter elements. • Check whether the ambient temperature is in the permissible range.
F30036	Overtemperature, inside area	

Number	Cause	Remedy
F30037	Rectifier overtemperature	See F30035 and, in addition: • Check the motor load. • Check the line phases
A30049	Internal fan defective	Check the internal fan and if required replace.
F30059	Internal fan defective	Check the internal fan and if required replace.
F30074	Communications fault between Control Unit and Power Module	The 24V voltage supply of the converter (terminals 31 and 32) was interrupted briefly. Please check the voltage supply and the wiring.
A30502	DC link overvoltage	• Check the device supply voltage (p0210). • Check the line reactor dimensioning
A30920	Temperature sensor fault	Check that the sensor is connected correctly.
A50001	PROFINET configuration error	A PROFINET controller is attempting to establish a connection with a faulty configuration telegram. Check to see whether "Shared Device" is activated (p8929 = 2).
A50010	PROFINET name of station invalid	Correct name of station (p8920) and activate (p8925 = 2).
A50020	PROFINET: Second controller missing	"Shared Device" is activated (p8929 = 2). However, only the connection to a PROFINET controller is present.

For further information, please refer to the List Manual.

13 Technical data

13.1 Technical data of inputs and outputs

Feature	Data
Operating voltage	• Supply from the Power Module • or an external 24 V DC class 2 supply (20.4 V ... 28.8 V) via control terminals 31 and 32, a maximum of 200 VA. Use a DVC A power supply with grounded earth (DVC A = decisive voltage class A according to EN 61800-5-1:2007).
Output voltages	24 V (max. 100 mA) 10 V ± 0.5 V (max. 10 mA)
Setpoint resolution	0.01 Hz
Digital inputs	• 6 digital inputs, DI 0 … DI 5, isolated; • Low < 5 V, high > 11 V, maximum input voltage 30 V, current consumption 5.5 mA • Response time: 5.5 ms ± 1 ms
Analog input (differential input, resolution 12 bits)	AI0: configurable as additional digital inputs 0 V … 10 V, 0 mA … 20 mA and -10 V … +10 V, Low < 1.6 V, High > 4.0 V Response time: 10 ms ± 2 ms
Digital outputs / relay outputs	• DO 0: relay output, 30 V DC / max. 0.5 A with resistive load • DO 1: transistor output, 30 V DC / max. 0.5 A with resistive load, protection against incorrect voltage polarity Update time of all DO: 2 ms
Analog output	AO 0: 0 V … 10 V or 0 mA … 20 mA, reference potential: "GND", resolution 16 bit, update time: 4 ms
Temperature sensor	• PTC: Short-circuit monitoring 22 Ω, switching threshold 1650 Ω • KTY84 • ThermoClick sensor with dry contact
Fail-safe Input	• If you release the fail-safe function STO, then DI 4 and DI 5 form the fail-safe digital input • Maximum input voltage 30 V, 5.5 mA • Response time: – Typical: 5 ms + debounce time p9651 – Typical, if debounce time = 0: 6 ms – Worst-case scenario: 15 ms + debounce time – Worst case, if debounce time = 0: 16 ms
PFH	5 × 10E-8
USB-interface	Mini-B

13.2 High Overload and Low Overload

Permissible inverter overload

The inverter has two different power data: "**Low Overload**" (LO) and "**High Overload**" (HO), depending on the expected load.

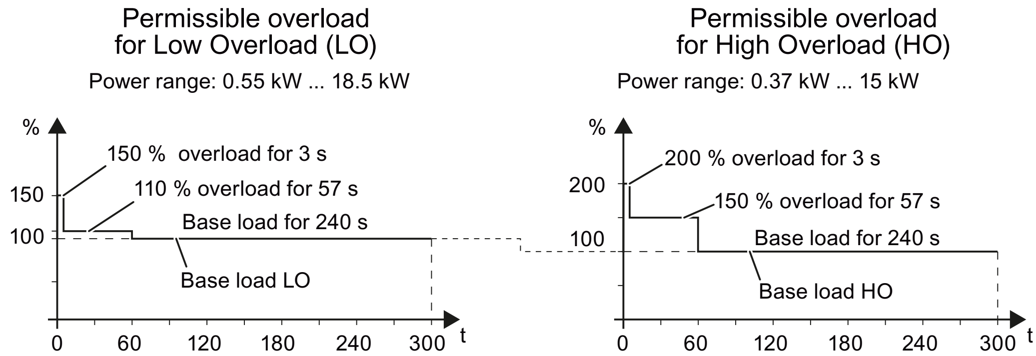


Figure 13-1 Duty cycles, "High Overload" and "Low Overload"

Note

The base load (100% power or current) of "Low Overload" is greater than the base load of "High Overload".

We recommend the "SIZER" engineering software to select the inverter based on duty cycles. See Configuring support (Page 341).

Definitions

- **LO input current** 100 % of the permissible input current for a load cycle according to Low Overload (LO base load input current).
- **LO output current** 100 % of the permissible output current for a load cycle according to Low Overload (LO base load output current).
- **LO power** Power of the inverter for LO output current.
- **HO input current** 100 % of the permissible input current for a load cycle according to High Overload (HO base load input current).
- **HO output current** 100 % of the permissible output current for a load cycle according to High Overload (HO base load output current).
- **HO power** Power of the inverter for HO output current.

If the power data comprise rated values without any further specifications they always refer to an overload capability corresponding to Low Overload.

13.3 Common technical power data

Feature	Specification		
Line voltage	3-ph. 380 V AC… 480 V + 10 % - 20 %	The actual permissible line voltage depends on the installation altitude	
Input frequency	47 Hz … 63 Hz		
Minimum line impedance U_K	1 %		
Power factor λ	0.70		
Pulse frequency	4 kHz The pulse frequency can be increased in 2 kHz steps. A higher pulse frequency reduces the permissible output current.		
Maximum motor cable length	Shielded: 50 m Unshielded: 100 m	Without choke or output options at 4 kHz switching frequency	
	25 m (shielded)	To fulfil EMC Category C2 conducted emissions at 4 kHz switching frequency	
Possible braking methods	DC braking, compound braking, dynamic braking with integrated braking chopper		
Degree of protection	IP20, cubicle mounting		
Operating temperature	-10 °C … +40 °C	Without power derating.	
	-10 °C … +55 °C	Converter with PROFINET interface.	The output power must be reduced, see also section: Temperature and voltage derating (Page 305)
	-10 °C … +60 °C	Converter with USS, MB, CANopen or PROFIBUS interface.	
Storage temperature	-40 °C … +70 °C (-40 °F … 158 °F)		
Relative humidity	< 95 % RH - condensation not permissible		
Installation altitude	Up to 1000 m above sea level	At higher installation altitudes, the output power must be reduced	
Shock and vibration	• Long-term storage in the transport packaging according to Class 1M2 to EN 60721-3-1 : 1997 • Transport in the transport packaging according to Class 2M3 to EN 60721-3-2 : 1997 • Vibration during operation according to Class 3M2 to EN 60721-3-3 : 1995		
Short Circuit Current Rating (SCCR)	65 kA		

13.4 Electromagnetic Compatibility

The SINAMICS G120 drives have been tested in accordance with the EMC Product Standard EN 61800-3:2004.

Details see declaration of conformity

Harmonic Currents

Table 13- 1 Harmonic Currents

Typical Harmonic Current (% of rated input current) at U_K 1 %							
5th	7th	11th	13th	17th	19th	23rd	25th
54	39	11	5	5	3	2	2

Note

Units installed within the category C2 (domestic) environment require supply authority acceptance for connection to the public low-voltage power supply network. Please contact your local supply network provider.

Units installed within the category C3 (industrial) environment do not require connection approval.

EMC Emissions

Note

Install all drives in accordance with the manufacturer's guidelines and in accordance with good EMC practices. See also: Installing (Page 21).

Use screened cable type CY. The maximal cable length is 25 m.

Do not exceed the default switching frequency 4 kHz.

Table 13- 2 Conducted disturbance voltage and radiated emissions

<table>
<tr><th>EMC Phenomenon</th><th>Converter type
Remark</th><th>Level acc. to
IEC 61800-3</th></tr>
<tr><td>Conducted emissions (disturbance voltage)</td><td>All converters with integrated class A filters.
Order number:
6SL3210-1KE**-*A**</td><td>Category C2
First Environment - Professional Use</td></tr>
<tr><td rowspan="2">Radiated emissions</td><td>1. All converters frame sizes A with integrated class A filter.
Order number: 6SL3210-1KE1*-*A**
2. The following converters frame sizes B with integrated class A filter.
Order number:
6SL3210-1KE21-*AB* (USS, MB)
6SL3210-1KE21-*AP* (PROFIBUS)
6SL3210-1KE21-*AC* (CANopen)
3. Converter frame size B
– with integrated class A filter,
– with PROFINET interface.
Order number: 6SL3210-1KE21-*AF*.
The converter has to be installed with a line reactor.
In a domestic environment this product may cause radio interference in which case supplementary mitigation measures may be required.</td><td>Category C2
First Environment - Professional Use</td></tr>
<tr><td>1. Converter frame size B
– with integrated class A filter,
– with PROFINET interface,
Order number: 6SL3210-1KE21-*AF*
In installations without line reactor.
2. Converter frame size C with integrated class A filter.
Order number:
6SL3210-1KE22-*A**
6SL3210-1KE23-*A**
This type of PDS is not intended to be used in low-voltage public power supply network which supplies domestic premises. Radio frequency interference is expected if used on such a network.</td><td>Category C3
Second Environment</td></tr>
</table>

EMC Immunity

The converter has been tested in accordance with the immunity requirements of category C3 (industrial) environment:

Table 13- 3 EMC Immunity

EMC Phenomenon	Standard	Level	Performance Criterion
Electrostatic Discharge (ESD)	EN 61000-4-2	4 kV Contact discharge	A
		8 kV Air discharge	
Radio-frequency Electromagnetic Field	EN 61000-4-3	80 MHz … 1000 MHz 10 V/m	A
Amplitude modulated		80 % AM at 1 kHz	
Fast Transient Bursts	EN 61000-4-4	2 kV @ 5 kHz	A
Surge Voltage	EN 61000-4-5	1 kV differential (L-L)	A
1.2/50 µs		2 kV common (L-E)	
Conducted	EN 61000-4-6	0.15 MHz … 80 MHz 10 V/rms	A
Radio-frequency Common Mode		80 % AM at 1 kHz	
Mains Interruptions & Voltage Dips 400 V	EN 61000-4-11	95 % dip for 3 ms	A
		30 % dip for 10 ms	C
		60 % dip for 100 ms	C
		95 % dip for 5000 ms	D
Interruptions & Voltage Dips 24 V		95 % dip for 3 ms	A [1]
Voltage Distortion	EN 61000-2-4	10 % THD	A
Voltage Unbalance	EN 61000-2-4	3 % Negative Phase Sequence	A
Frequency Variation	EN 61000-2-4	Nominal 50 Hz or 60 Hz (± 4 %)	A
Commutation Notches	EN 60146-1-1	Depth = 40 %	A
		Area = 250 % x degrees	

[1] only relevant if 400 V power supply is switched off. The converter reacts to short dips (1 … 3 ms) with a fault (F30074, can be acknowledged), but does not interrupt the fieldbus communication.

Note

The immunity requirements apply equally to both filtered and unfiltered units.

13.5 EMC limit values in South Korea

이 기기는 업무용(A 급) 전자파적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며, 가정외의 지역에서 사용하는 것을 목적으로 합니다. For sellers or users, please keep in mind that this device is an A-grade electromagnetic wave device. This device is intended to be used in areas other than home.

The EMC limit values to be complied with for South Korea correspond to the limit values of the EMC product standard for variable-speed electric drives EN 61800-3, Category C2 or limit value class A, Group 1 according to EN55011. By applying suitable supplementary measures, the limit values according to Category C2 or according to limit value class A, Group 1 are maintained. Further, additional measures may be required, for instance, using an additional radio interference suppression filter (EMC filter). The measures for EMC-compliant design of the system are described in detail in this manual respectively in the Installation Guideline EMC.

Please note that the final statement on compliance with the standard is given by the respective label attached to the individual unit.

13.6 Power-dependent technical data

Note

The specified input currents apply for a 400 V line where V_k = 1 % referred to the converter power. When using a line reactor, the currents are reduced by a few percent.

Table 13- 4 G120C Frame Sizes A, 3 AC 380 V … 480 V, ± 10 % - part 1
6SL3210-…

Order No.	Uniltered, IP20 Filtered, IP20	… 1KE11-8U*1 … 1KE11-8A*1	… 1KE12-3U*1 … 1KE12-3A*1	… 1KE13-2U*1 … 1KE13-2A*1
Rated / Low Overlaod values				
Rated / LO power		0.55 kW	0.75 kW	1.1 kW
Rated / LO input current		2.3 A	2.9 A	4.1 A
Rated / LO Output current		1.7 A	2.2 A	3.1 A
High Overload values				
HO power		0.37 kW	0.55 kW	0.75 kW
HO input current		1.9 A	2.5 A	3.2 A
HO output current		1.3 A	1.7 A	2.2 A
Power losses, filtered		0.041 kW	0.045 kW	0.054 kW
Power losses, unfiltered		0.040 kW	0.044 kW	0.053 kW
Fuse according to IEC		3NA3 801 (6 A)	3NA3 801 (6 A)	3NA3 801 (6 A)
Fuse according to UL		10 A class J	10 A class J	10 A class J
Required cooling air flow		5 l/s	5 l/s	5 l/s
Cross section of line and motor cable		1.0 … 2.5 mm² 18 … 14 AWG	1.0 … 2.5 mm² 18 … 14 AWG	1.0 … 2.5 mm² 18 … 14 AWG
Tightening torque for line and motor cable		0.5 Nm 4.4 lbf in	0.5 Nm 4.4 lbf in	0.5 Nm 4.4 lbf in
Weight, unfiltered		1.7 kg	1.7 kg	1.7 kg
Weight, filtered		1.9 kg	1.9 kg	1.9 kg

Table 13- 5 G120C Frame Sizes A, 3 AC 380 V … 480 V, ± 10 % - part 2
6SL3210-…

Order No.	Uniltered, IP20 Filtered, IP20	… 1KE14-3U*1 … 1KE14-3A*1	… 1KE15-8U*1 … 1KE15-8A*1	… 1KE17-5U*1 … 1KE17-5A*1
Rated / Low Overlaod values				
Rated / LO power		1.5 kW	2.2 kW	3.0 kW
Rated / LO input current		5.5 A	7.4 A	9.5 A
Rated / LO Output current		4.1 A	5.6 A	7.3 A
High Overload values				
HO power		1.1 kW	1.5 kW	2.2 kW
HO input current		4.5 A	6.0 A	8.2 A
HO output current		3.1 A	4.1 A	5.6 A
Power losses, filtered		0.073 kW	0.091 kW	0.136 kW
Power losses, unfiltered		0.072 kW	0.089 kW	0.132 kW
Fuse according to IEC		3NA3 803 (10 A)	3NA3 803 (10 A)	3NA3 805 (16 A)
Fuse according to UL		10 A class J	10 A class J	15 A class J
Required cooling air flow		5 l/s	5 l/s	5 l/s
Cross section of line and motor cable		1.0 … 2.5 mm^2 18 … 14 AWG	1.5 … 2.5 mm^2 16 … 14 AWG	1.5 … 2.5 mm^2 16 … 14 AWG
Tightening torque for line and motor cable		0.5 Nm 4.4 lbf in	0.5 Nm 4.4 lbf in	0.5 Nm 4.4 lbf in
Weight, unfiltered		1.7 kg	1.7 kg	1.7 kg
Weight, filtered		1.9 kg	1.9 kg	1.9 kg

Table 13- 6 G120C Frame Sizes A, 3 AC 380 V … 480 V, ± 10 % - part 3
6SL3210-…

Order No.	Uniltered, IP20 Filtered, IP20	… 1KE18-8U*1 … 1KE18-8A*1
Rated / Low Overlaod values		
Rated / LO power		4.0 kW
Rated / LO input current		11.4 A
Rated / LO Output current		8.8 A
High Overload values		
HO power		3.0 kW
HO input current		10.6 A
HO output current		7.3 A
Power losses, filtered		0.146 kW
Power losses, unfiltered		0.141 kW
Fuse according to IEC		3NA3 805 (16 A)
Fuse according to UL		15 A class J
Required cooling air flow		5 l/s
Cross section of line and motor cable		1.5 … 2.5 mm^2 16 … 14 AWG
Tightening torque for line and motor cable		0.5 Nm 4.4 lbf in
Weight, unfiltered		1.7 kg
Weight, filtered		1.9 kg

Table 13- 7 G120C Frame Sizes B, 3 AC 380 V … 480 V, ± 10 % - part 4
6SL3210-…

Order No.	Uniltered, IP20 Filtered, IP20	… 1KE21-3U*1 … 1KE21-3A*1	… 1KE21-7U*1 … 1KE21-7A*1
Rated / Low Overlaod values			
Rated / LO power		5.5 kW	7.5 kW
Rated / LO input current		16.5 A	21.5 A
Rated / LO Output current		12.5 A	16.5 A
High Overload values			
HO power		4.0 kW	5.5 kW
HO input current		12.8 A	18.2 A
HO output current		8.8 A	12.5 A
Power losses, filtered		0.177 kW	0.244 kW
Power losses, unfiltered		0.174 kW	0.24 kW
Fuse according to IEC		3NA3 807 (20 A)	3NA3 810 (25 A)
Fuse according to UL		20 A class J	25 A class J
Required cooling air flow		9 l/s	9 l/s
Cross section of line and motor cable		4.0 … 6.0 mm² 12 … 10 AWG	4.0 … 6.0 mm² 12 … 10 AWG
Tightening torque for line and motor cable		0.6 Nm 5.3 lbf in	0.6 Nm 5.3 lbf in
Weight, unfiltered		2.3 kg	2.3 kg
Weight, filtered		2.5 kg	2.5 kg

Table 13- 8 G120C Frame Sizes C, 3 AC 380 V … 480 V, ± 10 % - part 5
6SL3210-…

Order No.	Uniltered, IP20 Filtered, IP20	… 1KE22-6U*1 … 1KE22-6A*1	… 1KE23-2U*1 … 1KE23-2A*1	… 1KE23-8U*1 … 1KE23-8A*1
Rated / Low Overlaod values				
Rated / LO power		11 kW	15 kW	18.5 kW
Rated / LO input current		33.0 A	40.6 A	48.2 A
Rated / LO Output current		25 A	31 A	37 A
High Overload values				
HO power		7.5 kW	11 kW	15 kW
HO input current		24.1 A	36.4 A	45.2 A
HO output current		16.5 A	25 A	31 A
Power losses, filtered		0.349 kW	0.435 kW	0.503 kW
Power losses, unfiltered		0.344 kW	0.429 kW	0.493 kW
Fuse according to IEC		3NA3 817 (40 A)	3NA3 820 (50 A)	3NA3 822 (63 A)
Fuse according to UL		40 A class J	50 A class J	60 A class J
Required cooling air flow		18 l/s	18 l/s	18 l/s
Cross section of line and motor cable		6.0 … 16 mm² 10 … 5 AWG	10 … 16 mm² 7 … 5 AWG	10 … 16 mm² 7 … 5 AWG
Tightening torque for line and motor cable		1.5 Nm 13.3 lbf in	1.5 Nm 13.3 lbf in	1.5 Nm 13.3 lbf in
Weight, unfiltered		4.4 kg	4.4 kg	4.4 kg
Weight, filtered		4.7 kg	4.7 kg	4.7 kg

13.7 Temperature and voltage derating

Operating temperature derating

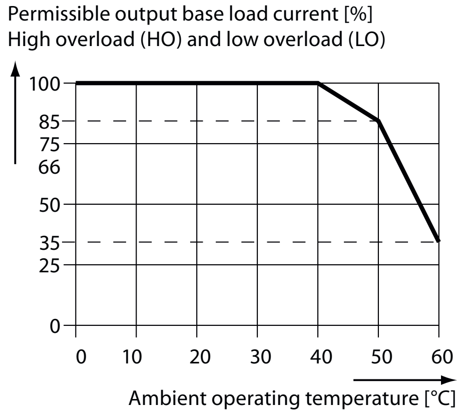


Figure 13-2 Temperature derating

Operational voltage derating

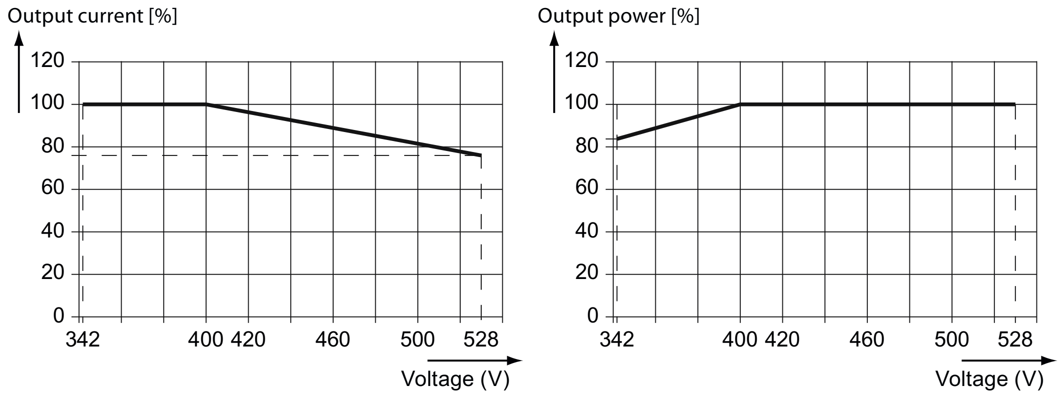


Figure 13-3 Current and Power derating required according to input voltage

13.8 Operational altitude and altitude deratings

Voltage

The clearance within the converter can isolate surge voltages in accordance with overvoltage category III in compliance with the EN 60664-1 regulation up to 2000 m above sea level.

At altitudes above 2000 m and below 4000 m above sea level, the converter has to be connected that at least one of the following conditions is fullfilled:

- It is connected to a TN-network with isolated star-point (not an external grounded connector)

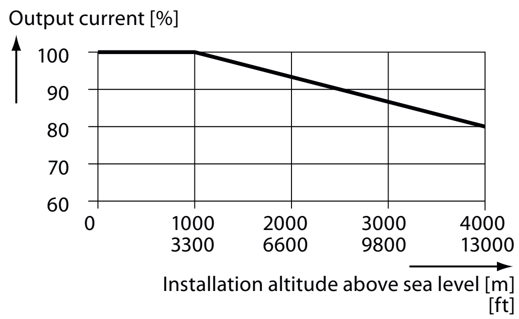
or

- it is connected through an isolating transformer that provides a TN-network with a grounded star-point.

A reduction of the line voltage is not necessary.

Note: The connected engines and power components must be considered separately.

Current



13.9 Current reduction depending on pulse frequency

Relationship between pulse frequency and output base-load current reduction

Table 13- 9 Current reduction depending on pulse frequency [1]

Rated power based on LO	Rated output current at pulse frequency of						
	4 kHz	6 kHz	8 kHz	10 kHz	12 kHz	14 kHz	16 kHz
0.55 kW	1.7 A	1.4 A	1.2 A	1.0 A	0.9 A	0.8 A	0.7 A
0.75 kW	2.2 A	1.9 A	1.5 A	1.3 A	1.1 A	1.0 A	0.9 A
1.1 kW	3.1 A	2.6 A	2.2 A	1.9 A	1.6 A	1.4 A	1.2 A
1.5 kW	4.1 A	3.5 A	2.9 A	2.5 A	2.1 A	1.8 A	1.6 A
2.2 kW	5.6 A	4.8 A	3.9 A	3.4 A	2.8 A	2.5 A	2.2 A
3.0 kW	7.3 A	6.2 A	5.1 A	4.4 A	3.7 A	3.3 A	2.9 A
4.0 kW	8.8 A	7.5 A	6.2 A	5.3 A	4.4 A	4.0 A	3.5 A
5.5 kW	12.5 A	10.6 A	8.8 A	7.5 A	6.3 A	5.6 A	5.0 A
7.5 kW	16.5 A	14.0 A	11.6 A	9.9 A	8.3 A	7.4 A	6.6 A
11.0 kW	25.0 A	21.3 A	17.5 A	15.0 A	12.5 A	11.3 A	10.0 A
15.0 kW	31.0 A	26.4 A	21.7 A	18.6 A	15.5 A	14.0 A	12.4 A
18.5 kW	37.0 A	31.5 A	25.9 A	22.2 A	18.5 A	16.7 A	14.8 A

[1] The permissible motor cable length depends on the cable type and the chosen pulse frequency.

13.10 Accessories

13.10.1 Line reactor

The major electrical specification of the line reactors is the same as for the suitable converter. This applies to:

- line voltage
- line frequency
- rated current

The admissible ambient conditions of the line reactors are the same as for the suitable converter. This applies to:

- storage and transport temperature
- operating temperature
- relative humidity
- shock and vibration load

Table 13- 10 Technical specifications of the line reactors

Feature	Suitable for converter with rated power of		
	0.55 kW ... 1.1 kW	1.5 kW ... 4.0 kW	5.5 kW … 7.5 kW
	FSA		FSB
Order no.	6SL3203-0CE13-2AA0	6SL3203-0CE21-0AA0	6SL3203-0CE21-8AA0
MLFB of the suitable converter	6SL3210-1KE11-8 □ □ 1 6SL3210-1KE12-3 □ □ 1 6SL3210-1KE13-2 □ □ 1	6SL3210-1KE14-3 □ □ 1 6SL3210-1KE15-8 □ □ 1 6SL3210-1KE17-5 □ □ 1 6SL3210-1KE18-8 □ □ 1	6SL3210-1KE21-3 □ □ 1 6SL3210-1KE21-7 □ □ 1
Inductance	2.5 mH	2.5 mH	0.5 mH
Power loss at 50/60 Hz	25 W	40 W	55 W
Cable cross section	2.5 mm² / 14 AWG	2.5 mm² / 14 AWG	6.0 mm² / 10 AWG
Tightening torque	0.6 Nm … 0.8 Nm 5 lbf in … 7 lbf in	0.6 Nm … 0.8 Nm 5 lbf in … 7 lbf in	1.5 Nm … 1.8 Nm 13 lbf in … 16 lbf in
PE connection	M4 (3 Nm / 26.5 lbf in)	M4 (3 Nm / 26.5 lbf in)	M5 (5 Nm / 44 lbf in)
Degree of protection	IP20	IP20	IP20
Overall dimensions Width Height Depth	 125 mm 120 mm 71 mm	 125 mm 140 mm 71 mm	 125 mm 145 mm 91 mm
Fixing dimensions Width Height	 100 mm 55 mm	 100 mm 55 mm	 100 mm 65 mm
Fixing screw	4 × M5 (6 Nm)	4 × M5 (6 Nm)	4 × M5 (6 Nm)
Weight	1.1 kg	2.1 kg	2.95 kg

Table 13- 11 Technical specifications of the line reactors

Feature	Suitable for converter with rated power of	
	11.0 kW … 18.5 kW	
	FSC	
Order no.	6SL3203-0CE23-8AA0	
MLFB of the suitable converter	6SL3210-1KE22-6 □ □ 1 6SL3210-1KE23-2 □ □ 1 6SL3210-1KE23-8 □ □ 1	
Inductance	0.3 mH	
Power loss at 50/60 Hz	90 W	
Cross section	16 mm² / 5 AWG	
Tightening torque	2 Nm …4 Nm 18 lbf in … 35 lbf in	
PE connection	M5 (5 Nm / 44 lbf in)	
Degree of protection	IP20	
Overall dimensions Width Height Depth	 190 mm 220 mm 91 mm	
Fixing dimensions Width Height	 170 mm 68 mm	
Fixing screw	4 × M8 (10 Nm)	
Weight	7.8 kg	

13.10.2 Braking resistor

The admissible ambient conditions of the breaking resistors are the same as for the suitable converter. This applies to:

- storage and transport temperature
- operating temperature
- relative humidity
- shock and vibration load

Table 13- 12 Technical specifications of the breaking resistors

Feature	Suitable for converter with rated power of		
	0.55 kW ... 1.5 kW	2.2 kW ... 4.0 kW	5.5 kW … 7.5 kW
	FSA		FSB
Order no.	6SL3201-0BE14-3AA0	6SL3201-0BE21-0AA0	6SL3201-0BE21-8AA0
MLFB of the suitable converter	6SL3210-1KE11-8 □ □ 1 6SL3210-1KE12-3 □ □ 1 6SL3210-1KE13-2 □ □ 1 6SL3210-1KE14-3 □ □ 1	6SL3210-1KE15-8 □ □ 1 6SL3210-1KE17-5 □ □ 1 6SL3210-1KE18-8 □ □ 1	6SL3210-1KE21-3 □ □ 1 6SL3210-1KE21-7 □ □ 1
Resistance	370 Ω	140 Ω	75 Ω
Pulse power P_{max}	1.5 kW	4 kW	7.5 kW
Rated power P_{DB}	75 W	200 W	375 W
Cable cross section	2.5 mm² / 14 AWG	2.5 mm² / 14 AWG	2.5 mm² / 14 AWG
Tightening torque	0.5 Nm / 4.5 lbf in	0.5 Nm / 4.5 lbf in	0.5 Nm / 4.5 lbf in
Temperature contact	Normally closed contact	Normally closed contact	Normally closed contact
Maximum load	AC 250 V / 2,5 A	AC 250 V / 2,5 A	AC 250 V / 2,5 A
Cable cross section	2.5 mm² / 14 AWG	2.5 mm² / 14 AWG	2.5 mm² / 14 AWG
Tightening torque	0.5 Nm / 4.5 lbf in	0.5 Nm / 4.5 lbf in	0.5 Nm / 4.5 lbf in
Degree of protection	IP20	IP20	IP20
Overall dimensions Width Height Depth	 105 mm 295 mm 100 mm	 105 mm 345 mm 100 mm	 175 mm 345 mm 100 mm
Drill pattern Width Height	 72 mm 266 mm	 72 mm 316 mm	 142 mm 316 mm
Fixing screws	4 × M4 (3 Nm)	4 × M4 (3 Nm)	4 × M4 (3 Nm)
Weight	1.5 kg	1.8 kg	2.7 kg

Table 13- 13 Technical specifications of the line reactors

Feature	Suitable for converter with rated power of	
	11.0 kW … 18.5 kW	
	FSC	
MLFB	6SL3201-0BE23-8AA0	
MLFB of the suitable converter	6SL3210-1KE22-6 □ □ 1 6SL3210-1KE23-2 □ □ 1 6SL3210-1KE23-8 □ □ 1	
Resistance	30 Ω	
Pulse power P_{max}	18.5 kW	
Rated power P_{DB}	925 W	
Cable cross section	6 mm² / 10 AWG	
Tightening torque	0.6 Nm / 5.5 lbf in	
Temperature contact	Normally closed contact	
Maximum load	AC 250 V / 2,5 A	
Cable cross section	2.5 mm² / 14 AWG	
Tightening torque	0.5 Nm / 4.5 lbf in	
Degree of protection	IP20	
Overall dimensions Width Height Depth	 250 mm 490 mm 140 mm	
Drill pattern Width Height	 217 mm 460 mm	
Fixing screws	4 × M5 (6 Nm)	
Weight	6.2 kg	

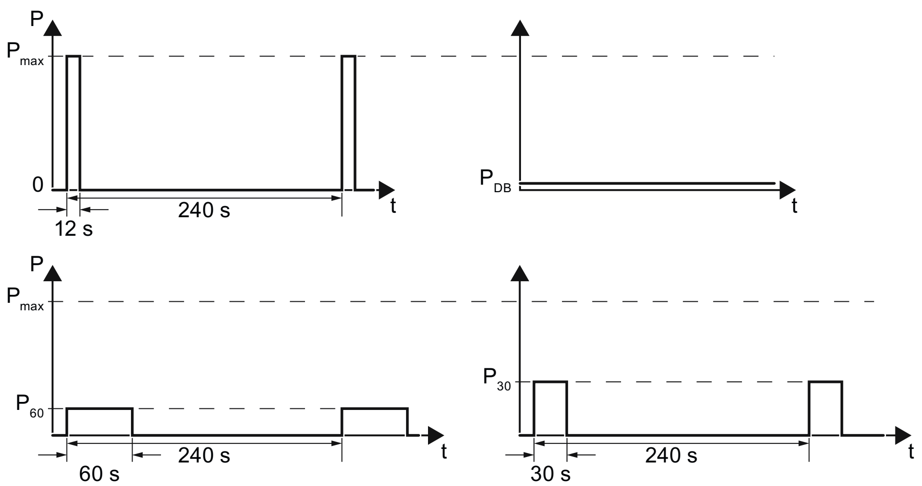


Figure 13-4 Pulse power, rated power and duty cycle examples of the braking resistor

13.11 Standards

	European Low Voltage Directive The SINAMICS G120C product range complies with the requirements of the Low Voltage Directive 2006/95/EC. The units are certified for complaince with the following standards: EN 61800-5-1 — Semiconductor converters –General requirements and line commutated converters EN 60204-1 — Safety of machinery –Electrical equipment of machines
	European Machinery Directive The SINAMICS G120C converter series does not fall under the scope of the Machinery Directive. However, the products have been fully evaluated for compliance with the essential Health & Safety requirements of the directive when used in a typical machine application. A Declaration of Incorporation is available on request.
	European EMC Directive When installed according to the recommendations described in this manual, the SINAMICS G120C fulfils all requirements of the EMC Directive as defined by the EMC Product Standard for Power Drive Systems EN 61800-3
C UL US LISTED	**Underwriters Laboratories** UL and CUL LISTED POWER CONVERSION EQUIPMENT for use in a pollution degree 2 environment.
SEMI F47	**Specification for Semiconductor Process Equipment Voltage Sag Immunity** SINAMICS G120C Converters fulfill the requirements of the SEMI F47-0706 standard.
	ISO 9001 Siemens plc operates a quality management system, which complies with the requirements of ISO 9001.

Certificates can be downloaded from the internet under the following link:

Standards (http://support.automation.siemens.com/WW/view/en/22339653/134200)

Appendix A

A.1 Parameter

Parameters are the interface between the firmware of the inverter and the commissioning tool, e.g. an operator panel.

Adjustable parameters

Adjustable parameters are the "adjusting screws" with which you adapt the inverter to its particular application. If you change the value of an adjustable parameter, then the inverter behavior also changes.

Adjustable parameters are shown with a "p" as prefix, e.g. p1082 is the parameter for the maximum motor speed.

Display parameters

Display parameters allow internal measured quantities of the inverter and the motor to be read.

Display parameters are shown with a "r" as prefix, e.g. p0027 is the parameter for the inverter output current.

Commonly used parameters

Table A- 1 **Switching to commissioning mode or restore the factory setting**

Parameter	Description
p0010	**Commissioning parameters** 0: Ready (factory setting) 1: Perform quick commissioning 3: Perform motor commissioning 5: Technological applications and units 15: Define number of data records 30: Factory setting - initiate restore factory settings

Table A- 2 **How to determine the firmware version of the Control Unit**

Parameter	Description
r0018	**The firmware version is displayed:**

Table A- 3 **How you select the command source and setpoint sources**

Parameter	Description
p0015	Parameter p0015 allows the setting of pre-defined I/O configurations. Further information is given in the section: Selecting the interface assignments (Page 44).

Table A- 4 **This is how you parameterize the up and down ramps**

Parameter	Description
p1080	**Minimum speed** 0.00 [rpm] factory setting
p1082	**Maximum speed** 1500.000 [rpm] factory setting
p1120	**Rampup time** 10.00 [s]
p1121	**Rampdown time** 10.00 [s]

Table A- 5 **This is how you set the closed-loop type**

Parameter	Description
p1300	0: V/f control with linear characteristic 1: V/f control with linear characteristic and FCC 2: V/f control with parabolic characteristic 3: V/f control with parameterizable characteristic 4: V/f control with linear characteristic and ECO 5: V/f control for drives requiring a precise frequency (textile area) 6: V/f control for drive requiring a precise frequency and FCC 7: V/f control with parabolic characteristic and ECO 19: V/f control with independent voltage setpoint 20: Speed control (without encoder)

Table A- 6 **Optimizing starting behavior for V/f control for a high break loose torque and overload**

Parameter	Description
p1310	**Voltage boost to compensate ohmic losses** The voltage boost is active from standstill up to the rated speed. It is at its highest at speed 0 and continually decreases as the speed increases. Value of voltage boost at zero speed in V: 1.732 × rated motor current (p0305) × stator resistance (r0395) × p1310 / 100%
p1311	**Voltage boost when accelerating** The voltage boost is effective from standstill up to the rated speed. It is independent of the speed and has a value in V of: 1.732 × rated motor current (p0305) × stator resistance (p0350) × p1311 / 100%
p1312	**Voltage boost when starting** Setting for an additional voltage boost when powering-up, however, only for the first acceleration phase.

A.2 Interconnecting signals in the inverter

Principle of operation of BICO technology

Open/closed-loop control functions, communication functions as well as diagnostic and operator functions are implemented in the inverter. Every function comprises one or several BICO blocks that are interconnected with one another.

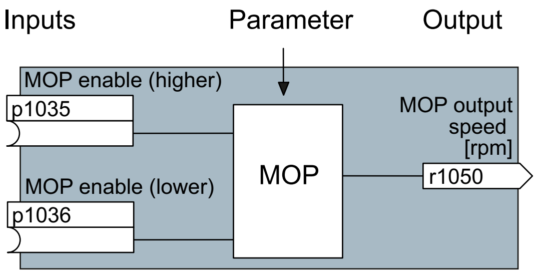


Figure A-1 Example of a BICO block: Motorized potentiometer (MOP)

Most of the BICO blocks can be parameterized. You can adapt the blocks to your application using parameters.

You cannot change the signal interconnection within the block. However, the interconnection between blocks can be changed by interconnecting the inputs of a block with the appropriate outputs of another block.

The signal interconnection of the blocks is realized, contrary to electric circuitry, not using cables, but in the software.

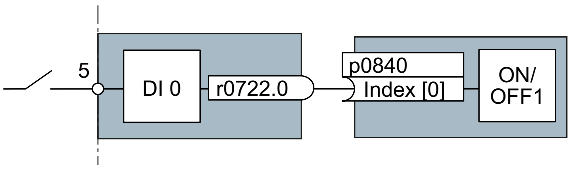


Figure A-2 Example: Signal interconnection of two BICO blocks for digital input 0

Binectors and connectors

Connectors and binectors are used to exchange signals between the individual BICO blocks:

- Connectors are used to interconnect "analog" signals. (e.g. MOP output speed)
- Binectors are used to interconnect "digital" signals. (e.g. 'Enable MOP up' command)

Definition of BICO technology

BICO technology represents a type of parameterization that can be used to disconnect all internal signal interconnections between BICO blocks or establish new connections. This is realized using **Bi**nectors and **Co**nnectors. Hence the name **BICO** technology. (Binector Connector Technology)

BICO parameters

You can use the BICO parameters to define the sources of the input signals of a block. Using BICO parameters you define from which connectors and binectors a block reads-in its input signals. This is how you "interconnect" the blocks stored in the devices according to your particular application requirements. The five different BICO parameter types are shown in the following diagram:

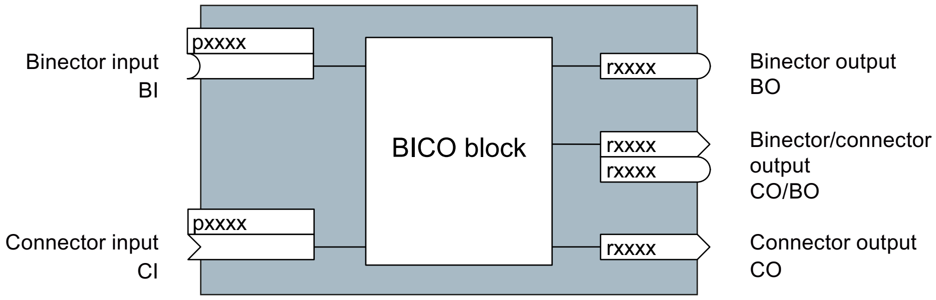


Figure A-3 BICO symbols

Binector/connector outputs (CO/BO) are parameters that combine more than one binector output in a single word (e.g. r0052 CO/BO: status word 1). Each bit in the word represents a digital (binary) signal. This summary reduces the number of parameters and simplifies parameter assignment.

BICO outputs (CO, BO, or CO/BO) can be used more than once.

When do you need to use BICO technology?

BICO technology allows you to adapt the inverter to a wide range of different requirements. This does not necessarily have to involve highly complex functions.

Example 1: Assign a different function to a digital input.

Example 2: Switch the speed setpoint from the fixed speed to the analog input.

What precautions should you take when using BICO technology?

Always apply caution when handling internal interconnections. Note which changes you make as you go along since the process of analyzing them later can be quite difficult.

The STARTER commissioning tool offers various screens that make it much easier for you to use BICO technology. The signals that you can interconnect are displayed in plain text, which means that you do not need any prior knowledge of BICO technology.

What sources of information do you need to help you set parameters using BICO technology?

- This manual is sufficient for simple signal interconnections, e.g. assigning a different significance to the to digital inputs.
- The parameter list in the List Manual is sufficient for signal interconnections that go beyond just simple ones.
- You can also refer to the function diagrams in the List Manual for complex signal interconnections.

Principle when connecting BICO blocks using BICO technology

An interconnection between two BICO blocks comprises a connector or binector and a BICO parameter. The interconnection is always established from the perspective of the input of a particular BICO block. This means that the output of an upstream block must always be assigned to the input of a downstream block. The assignment is always made by entering the number of the connector/binector from which the required input signals are read in a BICO parameter.

This interconnection logic involves the question: **where does the signal come from?**

Example

You have to use the BICO technology when adapting the function of inputs and outputs. You find examples in the section Adapting the terminal strip (Page 73).

NOTICE
For the basic commissioning, you determine the function of the interfaces for your inverter via predefined settings (p0015). If you subsequently select a different predefined setting for the function of the interfaces, then all BICO interconnections that you changed will be lost.

A.3 Application examples

A.3.1 Configuring the PROFIBUS communication with STEP 7

Using a suitable example, the following section provides information on how you connect an inverter to a higher-level SIMATIC control via PROFIBUS.

What prior knowledge is required?

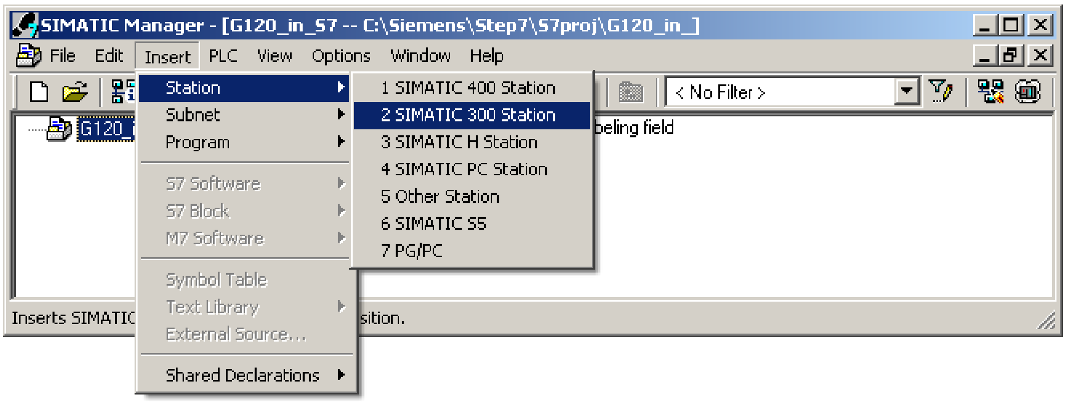
In this example, it is assumed that readers know now to basically use an S7 control and the STEP 7 engineering tool and is not part of this description.

A.3.1.1 Creating a STEP 7 project

PROFIBUS communication between the inverter and a SIMATIC control is configured using the SIMATIC STEP 7 and HW Config software tools.

Procedure

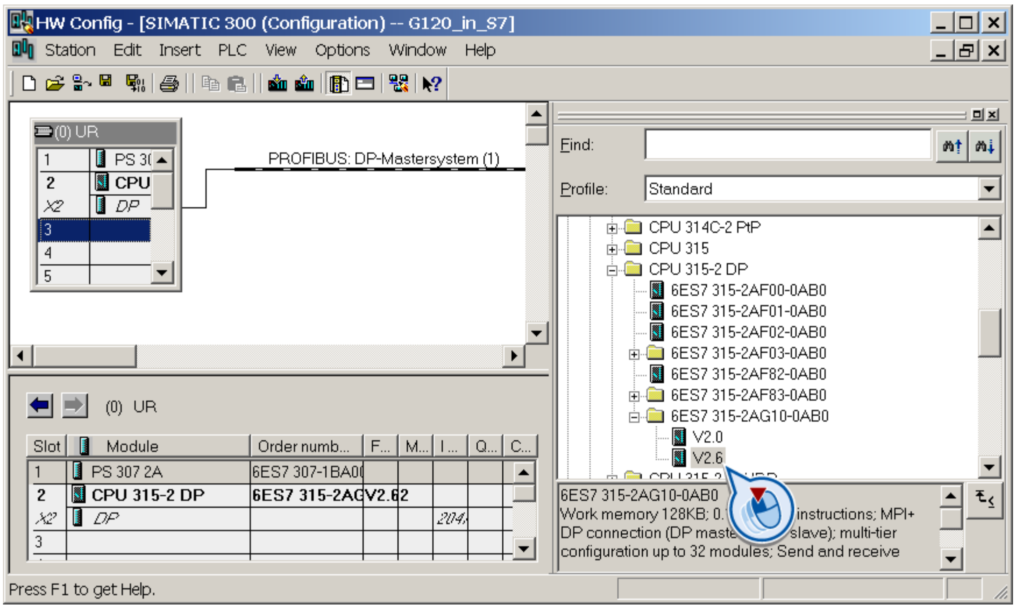
- Create a new STEP 7 project, e.g. "G120_in_S7 ". Add an S7 300 CPU.



- Select the SIMATIC 300 station in your project and open the hardware configuration (HW Config) by double clicking on "Hardware".
- Add an S7 300 mounting rail to your project by dragging and dropping it from the "SIMATIC 300" hardware catalog. Locate a power supply at slot 1 of the mounting rail and a CPU 315-2 DP at slot 2.

When you add the SIMATIC 300, a window is displayed in which you can define the network.

- Create a PROFIBUS DP network.



A.3.1.2 Configuring communications to a SIMATIC control

The inverter can be connected to a SIMATIC control in two ways:

1. Using the inverter GSD
2. Using the STEP 7 object manager

   This somewhat more user-friendly method is only available for S7 controls and installed Drive ES Basic (see Section Commissioning tools (Page 18)).

The following section describes how to configure the inverter using the GSD.

A.3.1.3 Inserting the converter into the STEP 7 project

- Install the GSD of the converter in STEP 7 via HW Config (Menu "Options - Install GSD files").
  Once the GSD has been installed, the converter appears under "PROFIBUS DP - Additional field devices" in the hardware catalog of HW Config.

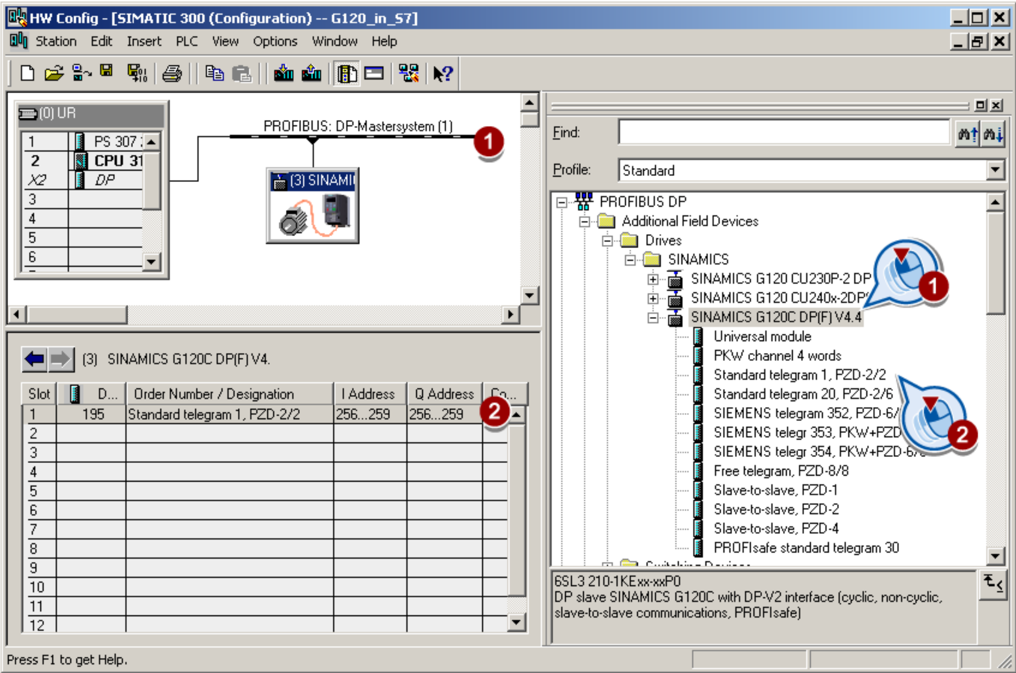


Figure A-4 Inserting a drive object

- Drag and drop the converter into the PROFIBUS network. Enter the PROFIBUS address set at the converter in HW Config.
- Insert the required telegram type from the HW Catalog to slot 1 of the converter by 'dragging and dropping'.
  More information on the telegram types can be found in Chapter Cyclic communication (Page 93).

Sequence when assigning the slots

1. PROFIsafe module (if one is used)
   Information on connecting the converter via PROFIsafe can be found in the Safety Integrated Function Manual.
2. PKW channel (if one is used)
3. Standard, SIEMENS or free telegram (if one is used)
4. Slave-to-slave module

If you do not use one or several of the modules 1, 2 or 3, configure the remaining modules starting with the 1st slot.

Note regarding the universal module

It is not permissible to configure the universal module with the following properties:

- PZD length 4/4 words
- Consistent over the complete length

With these properties, the universal module has the same DP identifier (4AX) as the "PKW channel 4 words" and is therefore identified as such by the higher-level control. As a consequence, the control does not establish cyclic communication with the inverter.

Remedy: Change the length to 8/8 bytes in the properties of the DP slave. As an alternative, you can also change the consistency to "unit".

Final steps

- Save and compile the project in STEP 7.
- Establish an online connection between your PC and the S7 CPU and download the project data to the S7 CPU.
- In the inverter, select the telegram type, which you configured in STEP 7, using parameter P0922.

The inverter is now connected to the S7 CPU. This therefore defines the communication interface between the CPU and the inverter. An example of how you can supply this interface with data can be found in the next section.

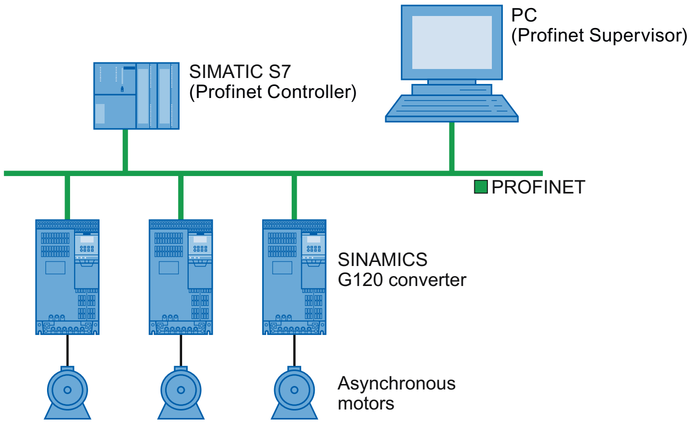
A.3.2 Configuring the PROFINET communication with STEP 7

A.3.2.1 Communication via PROFINET - example

Profinet network in a line topology

The adjacent example shows the structure of a Profinet network in a line topology, with one controller (S7-300), three devices (G120 converters) and one supervisor (programming device).

Communication is established via "twisted-pair lines" with RJ45 connectors. 100 Mbit/s in the full duplex mode is required as transmission rate.



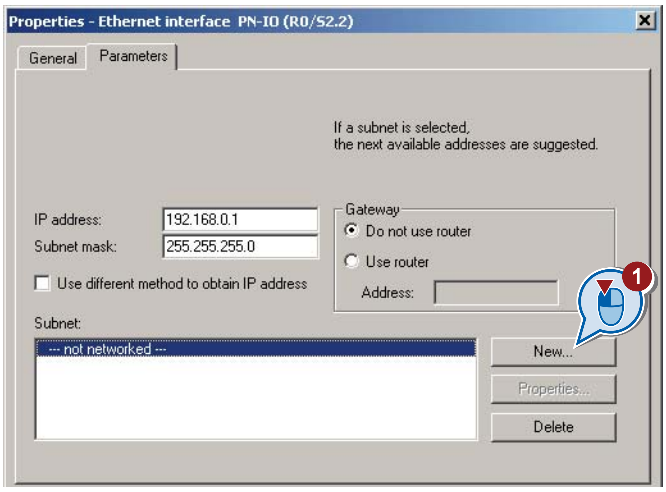
A.3.2.2 Configuring the system in HW Config

Open HW Config in STEP 7 via "Insert/[Station]", and create the components in accordance with your hardware structure. The following example is limited to the components that are absolutely required.

Insert the CPU if you have configured your station with a rack and power supply.

NOTICE
Device name for PROFINET Based on the device name, when booting, the PROFINET controller assigns the IP address; as a consequence, the device names within a subnet must be unique. In the SIMATIC Manager, only lower-case letters may be used for the device name. Spaces and special characters are replaced by "x".

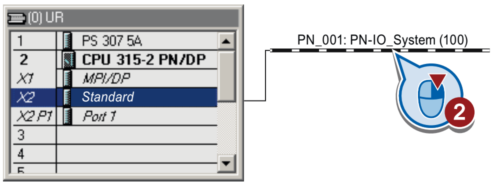
In the screen form that opens, HW Config proposes the next free IP address and a subnet mask. If you have configured a local area network, and are not working within a larger Ethernet network, you can use the proposed entries. Otherwise, ask your administrator about the IP addresses for the PROFINET participants and subnet mask. The subnet mask must have the same address that you assigned when addressing the supervisor.



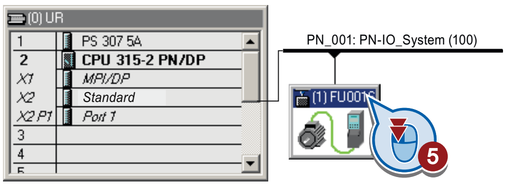
Use the "New" button (①) to either create a new PROFINET subnet or select an existing one.

Assign a name for your PROFINET network there. Additional modifications are not necessary. Exit this screen form and the next one with OK.

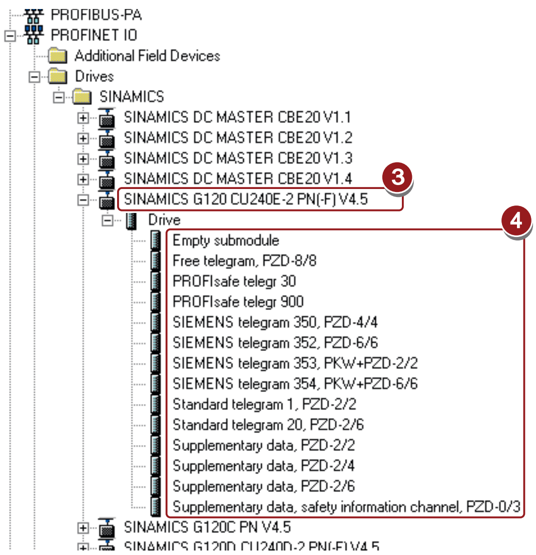
In the next step, select the bus (②), and via the hardware catalog using drag-and-drop, first insert the converter (③) and then the communication telegram (④).



Open the properties window of the converter (⑤) and enter a unique and descriptive device name for the converter. You will also find the proposed IP address in this screen form. If required, you can change the IP address via "Properties".



Hardware catalog



Then save your hardware configuration with "Save and compile" ( ). You have now completed configuring the device in STEP 7.

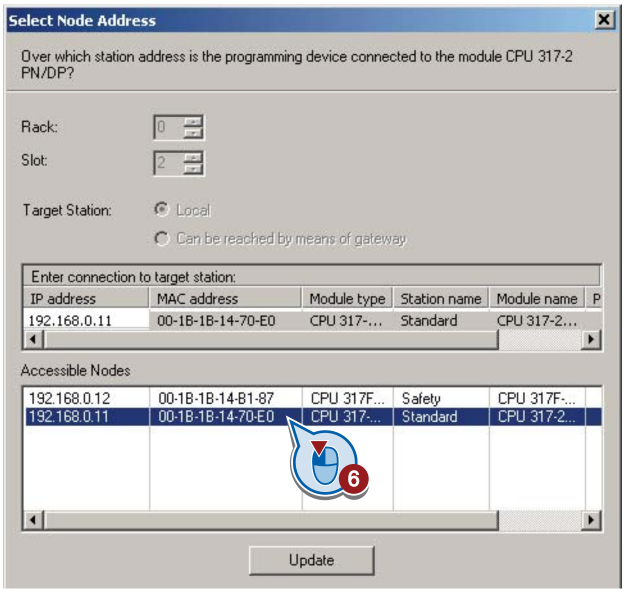
Note

STEP 7 with Drive ES Basic

If you have installed Drive ES Basic, you can now integrate the converter via the object manager and open STARTER in HW Config by double-clicking the converter. In this case, STARTER automatically accepts the device name and IP address. As a consequence, the procedure described in Section Connect the converter to PROFINET (Page 87) is superfluous.

In the next step, load the configuration into the control by clicking the button. In the next screen form, set the IP address of the control.

If you do not have the IP address readily available, you can display the participants that can be reached by clicking the "Display" button. Select the control from the list of accessible participants (⑥), and exit the screen form with OK.



The CPU must be stopped to complete the loading process.

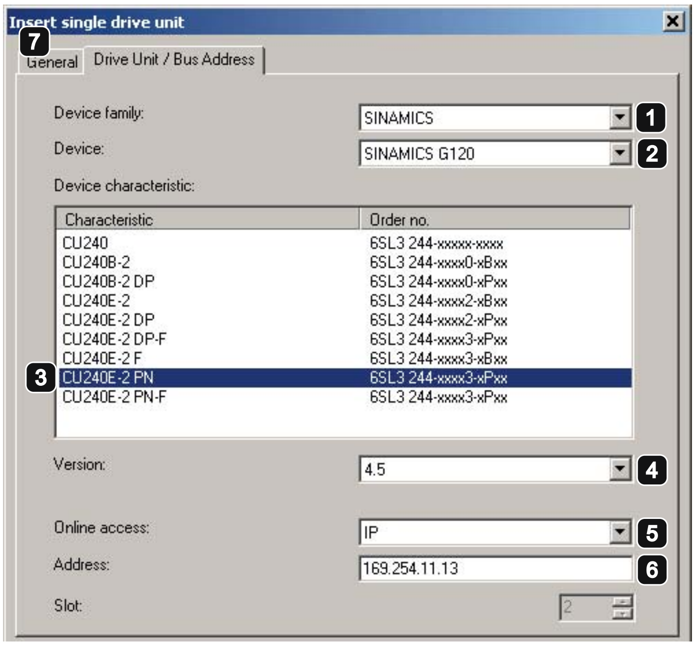
If you have installed Drive ES Basic, open STARTER by double-clicking the converter symbol in the Hardware Manager and configure the converter in STARTER.

If you are working with the GSDML, now close HW Config and insert the converter in the SIMATIC Manager as described in the following section.

A.3.2.3 Inserting the converter into the SIMATIC Manager

Select your project in the SIMATIC Manager and open the "Insert single drive unit" screen form by right clicking on "Insert New Object/SINAMICS".

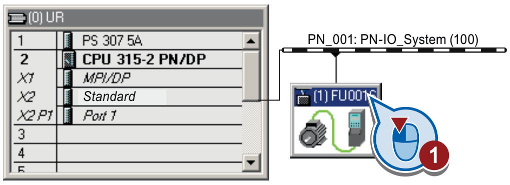
There, under the tab "Drive unit/bus address", as shown in the diagram, select your converter and under the tab "General" (⑦) enter the PROFINET device name. Exit the screen form with OK.



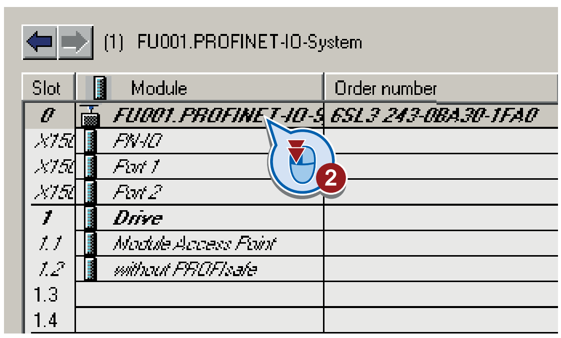
The converter is now displayed in your project in the SIMATIC Manager.

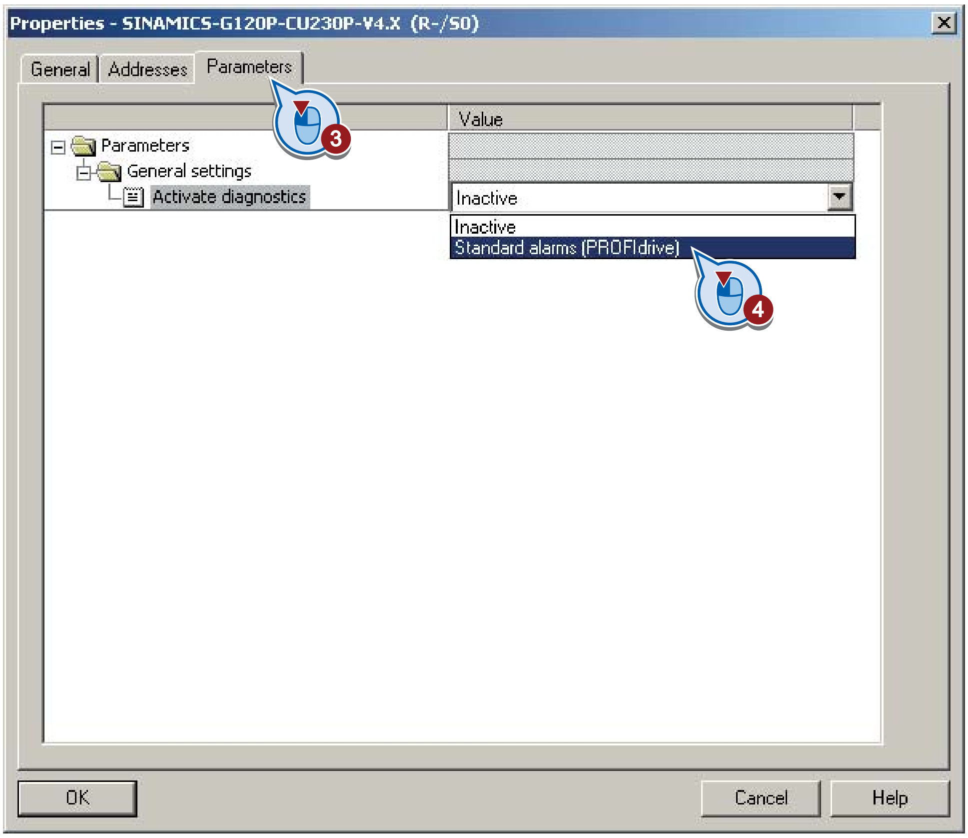
A.3.2.4 Activate diagnostic messages via STEP 7

In HW Config, select the converter ①



Open by double-clicking on slot 0 in the station window ② the properties window for the network settings of the converter and activate there in the parameter ③ tab as shown the standard alarms ④.



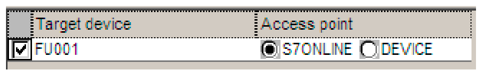


With the next ramp-up of the controller, the diagnostic messages of the converter are then transferred to the controller.

A.3.2.5 Go online with STARTER via PROFINET

Select the converter in SIMATIC Manager with the righthand mouse button and open STARTER via "Open object".

Configure the converter in STARTER and click on the Online button ( ). In the following window, select the converter and then the S7ONLINE as access point.



Exit the screen form with OK and the online connection will be established.

A.3.3 STEP 7 programming examples

A.3.3.1 Data exchange via the fieldbus

Data exchange via the fieldbus

Analog signals

The inverter always scales signals, which are transferred via the fieldbus, to a value of 4000 hex.

Table A- 7 Signal category and associated scaling parameters

Signal category	4000 Hex ≙ …	Signal category	4000 Hex ≙ …
Speeds, frequencies	p2000	Torque	p2003
Voltage	p2001	Power	p2004
Current	p2002	Temperature	p2006

Control and status words

Control and status words consist of a higher-value and a lower-value byte. A SIMATIC control interpretes words differently than the converter: the higher-value and the lower-value byte are exchanged in each case during transmission. See also the following program example.

A.3.3.2 STEP 7 program example for cyclic communication

Network 1: Control word 1 and setpoint

Control word 1: 047E hex Setpoint: 2500 hex

```
L   W#16#47E
T   MW    1
L   W#16#2500
T   MW    3
```

Network 2: Acknowledge fault

```
U   E     0.6
=   M     2.7
```

Network 3: Switch the motor on and off

```
U   E     0.0
=   M     2.0
```

Network 4: Write process data

```
L   MW    1
T   PAW   256
L   MW    3
T   PAW   258
```

Network 4: Read process data

Status word 1: MW 5 Actual value: MW 7

```
L   PEW   256
T   MW    5
L   PEW   258
T   MW    7
```

The control and inverter communicate via standard telegram 1. The control specifies control word 1 (STW1) and the speed setpoint, while the inverter responds with status word 1 (ZSW1) and its actual speed.

In this example, inputs E0.0 and E0.6 are linked to the -bit ON/OFF1 or to the "acknowledge fault" bit of STW 1.

Control word 1 contains the numerical value 047E hex. The bits of control word 1 are listed in the following table.

The hexadecimal numeric value 2500 specifies the setpoint frequency of the inverter. The maximum frequency is the hexadecimal value 4000 (also see Configuring the fieldbus (Page 85)).

The control cyclically writes the process data to logical address 256 of the inverter. The inverter also writes its process data to logical address 256. You define the address area in HW Config, seeInserting the converter into the STEP 7 project (Page 320).

Table A- 8 Assignment of the control bits in the inverter to the SIMATIC flags and inputs

HEX	BIN	Bit in STW1	Significance	Bit in MW1	Bit in MB1	Bit in MB2	Inputs
E	0	0	ON/OFF1	8		0	E0.0
	1	1	ON/OFF2	9		1	
	1	2	ON/OFF3	10		2	
	1	3	Operation enable	11		3	
7	1	4	Ramp-function generator enable	12		4	
	1	5	Start ramp-function generator	13		5	
	1	6	Setpoint enable	14		6	
	0	7	Acknowledge fault	15		7	E0.6
4	0	8	Jog 1	0	0		
	0	9	Jog 2	1	1		
	1	10	PLC control	2	2		
	0	11	Setpoint inversion	3	3		
0	0	12	Irrelevant	4	4		
	0	13	Motorized potentiometer ↑	5	5		
	0	14	Motorized potentiometer ↓	6	6		
	0	15	Data set changeover	7	7		

A.3.3.3 STEP 7 program example for acyclic communication

```
OB1:    Cyclic control program

Network 1:    Reading and writing parameters

 // read parameters
        O(
        U      M      9.2
        UN     M      9.1
        )
        O(
        U      M      9.0
        UN     M      9.1
        )
        R      M      9.3

        SPB    RD

 // write parameters
        O(
        U      M      9.3
        UN     M      9.0
        )
        O(
        U      M      9.1
        UN     M      9.0
        )
        R      M      9.2

        SPB    WR
        BEA

RD:     NOP    0
        CALL   FC     1
        BEA
WR:     NOP    0      9.1
        CALL   FC     3
```

M9.0 Starts reading parameters

M9.1 Starts writing parameters

M9.2 displays the read process

M9.3 displays the write process

The number of simultaneous requests for acyclic communication is limited. More detailed information can be found on http://support.automation.siemens.com/WW/view/de/15364459 (http://support.automation.siemens.com/WW/view/en/15364459).

FC1: PAR_RD

Network 1: Parameters for reading

```
      L      MB       40
      T      DB1.DBB  0
      L      B#16#01
      T      DB1.DBB  1
      T      DB1.DBB  2
      L      MB       62
      T      DB1.DBB  3
// ----------------------------------------
      L      MW       50
      T      DB1.DBW  6
      L      MB       58
      T      DB1.DBB  5
      L      MW       63
      T      DB1.DBW  8
// ----------------------------------------
      L      MW       52
      T      DB1.DBW  12
      L      MB       59
      T      DB1.DBB  11
      L      MW       65
      T      DB1.DBW  14
// ----------------------------------------
      L      MW       54
      T      DB1.DBW  18
      L      MB       60
      T      DB1.DBB  17
      L      MW       67
      T      DB1.DBW  10
// ----------------------------------------
      L      MW       56
      T      DB1.DBW  24
      L      MB       61
      T      DB1.DBB  23
      L      MW       69
      T      DB1.DBW  26
```

Network 2: Read request, part 1

```
CALL    SFC    58
  REQ        :=M9.0
  IOID       :=B#16#54
  LADDR      :=W#16#170
  RECNUM     :=B#16#2F
  RECORD     :=P#DB1.DBX0.0 BYTE 28
  RET_VAL    :=MW10
  BUSY       :=M8.1

U      M       8.1
R      M       9.0
S      M       9.2
```

Network 3: Read delay after a read request

```
U      M       8.1
UN     M       9.1
L      S5T#1s
SS     T       1
U      M       8.3
R      T       1
U      T       1
=      M       8.2
```

Network 4: Read request, part 2

```
CALL    SFC    59
  REQ        :=M8.2
  IOID       :=B#16#54
  LADDR      :=W#16#170
  RECNUM     :=B#16#2F
  RET_VAL    :=MW12
  BUSY       :=M8.3
  RECORD     :=P#DB2.DBX0.0 BYTE 36

U      M       8.3
R      M       8.2
```

Figure A-5 Reading parameters

Note

With PROFINET standard function blocks (SFB) instead of system functions (SFC)

With acyclic communication via PROFINET, you must replace the system functions with standard function blocks as follows:

- SFC 58 -> SFB 53
- SFC 59 -> SFB 52

Explanation of FC 1

Table A- 9 Request to read parameters

Data block DB 1	Byte n	Bytes n + 1	n
Header	Reference *MB 40*	01 hex: Read request	0
	01 hex	Number of parameters (m) *MB 62*	2
Address, parameter 1	Attribute *10 hex: Parameter value*	Number of indices *MB 58*	4
	Parameter number *MW 50*		6
	Number of the 1st index *MW 63*		8
Address, parameter 2	Attribute *10 hex: Parameter value*	Number of indices *MB 59*	10
	Parameter number *MW 52*		12
	Number of the 1st index *MW 65*		14
Address, parameter 3	Attribute *10 hex: Parameter value*	Number of indices *MB 60*	16
	Parameter number *MW 54*		18
	Number of the 1st index *MW 67*		20
Address, parameter 4	Attribute *10 hex: Parameter value*	Number of indices *MB 61*	22
	Parameter number *MW 56*		24
	Number of the 1st index *MW 69*		26

SFC 58 copies the specifications for the parameters to be read from DB 1 and sends them to the converter as a read request. No other read requests are permitted while this one is being processed.

After the read request and a waiting time of one second, the control takes the parameter values from the converter via SFC 59 and saves them in DB 2.

FC3: PAR_WR

Network 1: Parameters for writing

```
      L    MB      42
      T    DB3.DBB   0
      L    B#16#02
      T    DB3.DBB   1
      L    B#16#01
      T    DB3.DBB   2
      L    MB      44
      T    DB1.DBB   3
 // -----------------------------------------
      L    MW      21
      T    DB3.DBW   6
      L    MW      23
      T    DB3.DBW   8
      L    MW      35
      T    DB3.DBW   12
      L    MB      25
      T    DB3.DBB   10
      L    MB      27
      T    DB3.DBB   11
```

Network 2: Write request:

```
CALL   SFC   58
  REQ       :=M9.1
  IOID      :=B#16#54
  LADDR     :=W#16#170
  RECNUM    :=B#16#2F
  RECORD    :=P#DB3.DBX0.0 BYTE 14
  RET_VAL   :=MW10
  BUSY      :=M8.1

U    M    8.1
R    M    9.1
S    M    9.3
```

Figure A-6 Writing parameters

Explanation of FC 3

Table A- 10 Request to change parameters

Data block DB 3	Byte n	Bytes n + 1	n
Header	Reference *MB 42*	**02 hex**: Change request	0
	01 hex	Number of parameters *MB 44*	2
Address, parameter 1	**10 hex**: Parameter value	Number of indices *00 hex*	4
	Parameter number *MW 21*		6
	Number of the 1st index *MW 23*		8
Values, parameter 1	Format *MB 25*	Number of index values *MB 27*	10
	Value of 1st index *MW35*		12

SFC 58 copies the specifications for the parameters to be written from DB 3 and sends them to the converter. No other write requests are permitted while this one is being processed.

A.3.4 Configuring slave-to-slave communication in STEP 7

Two drives communicate via standard telegram 1 with the higher-level control. In addition, drive 2 receives its speed setpoint directly from drive 1 (actual speed).

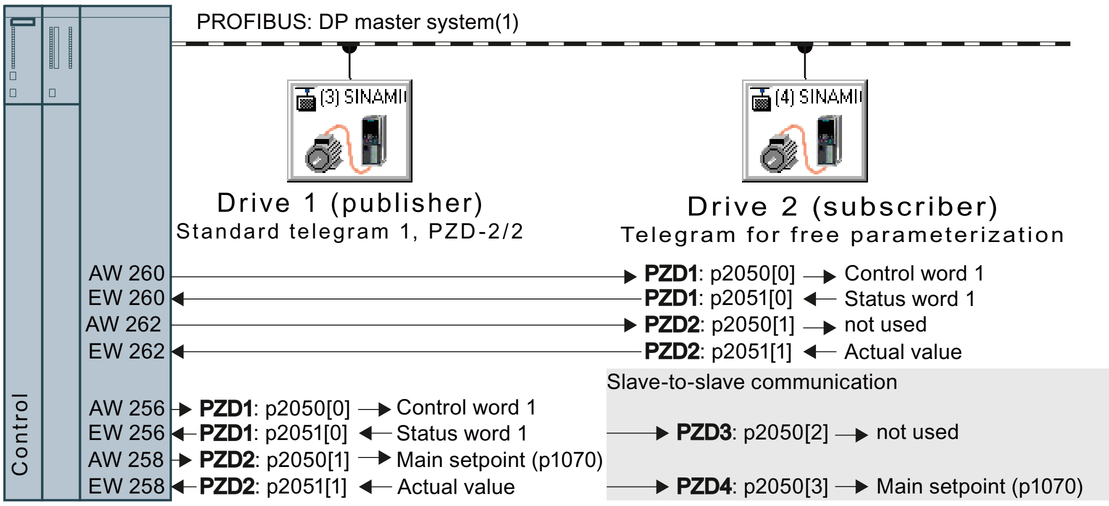
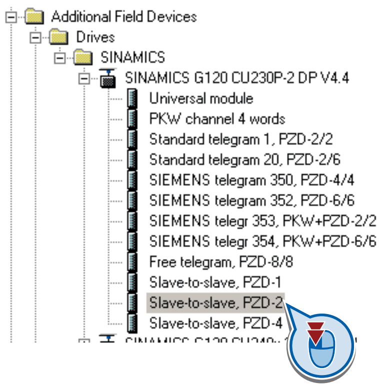


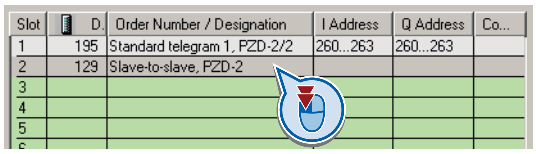
Figure A-7 Communication with the higher-level control and between the drives with slave-to-slave communication

Settings in the control

In HW Config in drive 2 (subscriber), insert a slave-to-slave communication object, e.g. "Slave-to-slave, PZD2".



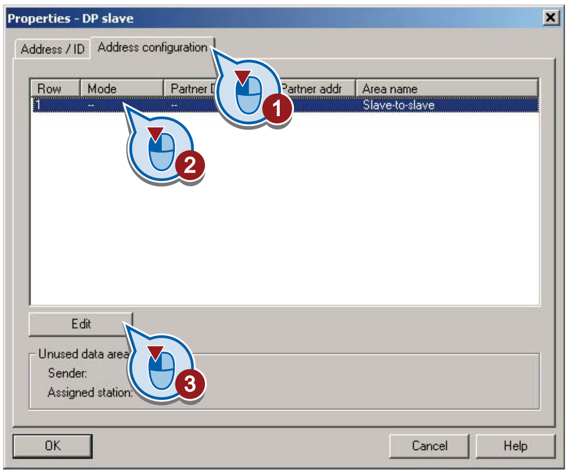
With a double-click, open the dialog box to make additional settings for the slave-to-slave communication.



① Activate the tab "Address configuration".

② Select line 1.

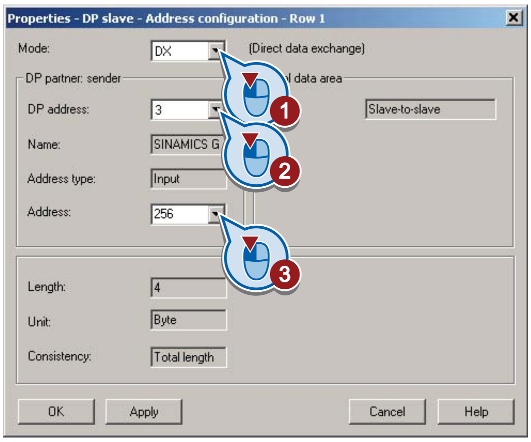
③ Open the dialog box in which you define the Publisher and the address area to be transferred.



① Select DX for direct data exchange

② Select the PROFIBUS address of drive 1 (publisher).

③ In the address field, select the start address specifying the data area to be received from drive 1. In the example, these are the status word 1 (PZD1) and the speed actual value with the start address 256.



Close both screen forms with OK. You have now defined the value range for slave-to-slave communication.

In the slave-to-slave communication, drive 2 receives the sent data and writes this into the next available words, in this case, PZD3 and PZD4.

Settings in drive 2 (subscriber)

Drive 2 is preset in such a way that it receives its setpoint from the higher-level control. In order that drive 2 accepts the actual value sent from drive 1 as setpoint, you must set the following:

- In drive 2 ,set the PROFIdrive telegram selection to "Free telegram configuration with BICO" (p0922 = 999).
- In drive 2, set the source of the main setpoint to p1070 = 2050.3.

A.3.5 Connecting fail-safe digital inputs

The examples comply with PL d according to EN 13849-1 and SIL2 according to IEC 61508 for the case that all components are installed within one control cabinet.

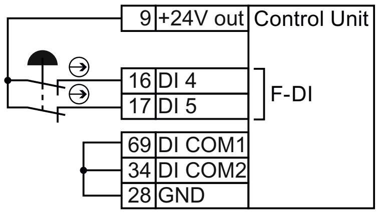


Figure A-8 Connecting a sensor, e.g. Emergency Stop mushroom pushbutton or limit switch

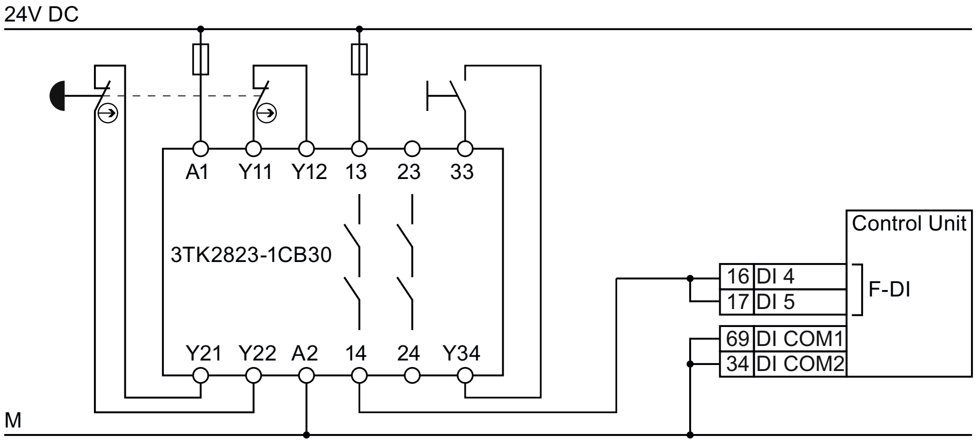


Figure A-9 Connecting a safety relay, e.g. SIRIUS 3TK28

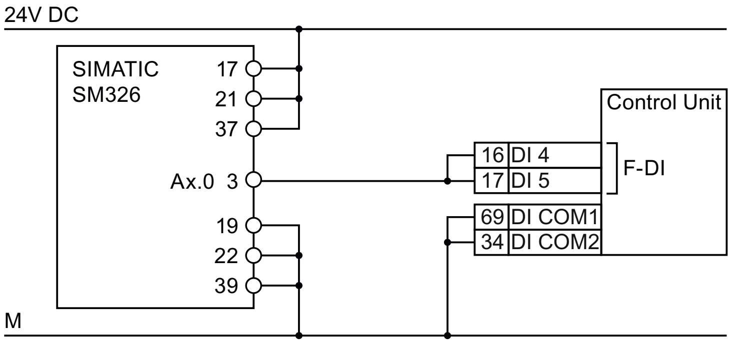


Figure A-10 Connecting an F digital output module, e.g. SIMATIC F digital output module

You can find additional connection options and connections in separate control cabinets in the Safety Integrated Function Manual, see Section: Further information on your inverter (Page 340).

A.4 Documentation for acceptance of safety functions

A.4.1 Machine documentation

Machine or plant description

Designation	…
Type	…
Serial number	…
Manufacturer	…
End customer	…
Block diagram of the machine and/or plant: … … … … … … …	

Inverter data

Table A- 11 Hardware version of the safety-related inverter

Labeling the drive	Order number and hardware version of the inverter
…	…
…	…

Function table

Table A- 12 Active safety functions depending on the operating mode and safety equipment

Operating mode	Safety equipment	Drive	Selected safety function	Checked
…	…	…	…	
…	…	…	…	
Example:				
Automatic	*Protective door closed*	*Conveyor belt*	---	---
	Protective door open	*Conveyor belt*	*STO*	
	Emergency Stop button pressed	*Conveyor belt*	*STO*	

Acceptance test reports

File name of the acceptance reports
…
…

Data backup

Data	Storage medium			Holding area
	Archiving type	Designation	Date	
Acceptance test reports	…	…	…	…
PLC program	…	…	…	…
Circuit diagrams	…	…	…	…

Countersignatures

Commissioning engineer

This confirms that the tests and checks have been carried out properly.

Date	Name	Company/dept.	Signature
…	…	…	…

Machine manufacturer

This confirms that the settings recorded above are correct.

Date	Name	Company/dept.	Signature
…	…	…	…

A.4.2 Log of the settings for the basic functions, firmware V4.4 and V4.5

Drive = <pDO-NAME_v>

Table A- 13 Firmware version

Name	Number	Value
Control Unit firmware version	r18	<r18_v>
SI version, safety functions integrated in the drive (processor 1)	r9770	<r9770_v>

Table A- 14 Monitoring cycle

Name	Number	Value
SI monitoring clock cycle (processor 1)	r9780	<r9780_v>

Table A- 15 Checksums

Name	Number	Value
SI target checksum SI parameters	p9799	<p9799_v>

Table A- 16 Settings of the safety function

Name	Number	Value
SI enable, functions integrated in the drive	p9601	<p9601_v>
SI PROFIsafe address	p9610	<p9610_v>
SI F-DI changeover, tolerance time	p9650	<p9650_v>
SI STO debounce time	p9651	<p9651_v>
SI forced dormant error detection timer	p9659	<p9659_v>

Table A- 17 Safety logbook

Name	Number	Value
SI checksum to check changes	r9781[0]	<r9781[0]_v>
SI checksum to check changes	r9781[1]	<r9781[1]_v>
SI change control time stamp	r9782[0]	<r9782[0]_v>
SI change control time stamp	r9782[1]	<r9782[1]_v>

A.5 Further information on your inverter

A.5.1 Manuals for your inverter

Table A- 18 Manuals for your converter

Depth of the information	Manual	Contents	Available languages	Download or order number
++	Getting Started SINAMICS G120C	Installing and commissioning the converter.	Chinese, English, French, German, Italian, Spanish, Turkish	Download (http://support.automation.siemens.com/WW/view/en/22339653/133300) SINAMICS Manual Collection Documentation on DVD, order number 6SL3097-4CA00-0YG0
+++	Operating instructions	(this manual)		
+++	Function Manual for Safety Integrated	Configuring PROFIsafe. Installing, commissioning and operating fail-safe functions of the converter.	English, German	
+++	List Manual SINAMICS G120C	Complete list of all parameters, alarms and faults. Graphic function diagrams.	Chinese, English, German	
+	Installation Instructions for reactors and braking resistors	Installing components	English	
+++	Operating Instructionsfor Operator Panels BOP-2 and IOP	Operating operator panels, installing door assembly for IOP	English, German	

A.5.2 Configuring support

Table A- 19 Support when configuring and selecting the converter

Manual or tool	Contents	Languages	Download or order number
Catalog D 31	Ordering data and technical information for the standard SINAMICS G converters	English, German, Italian, French, Spanish	All about SINAMICS G120C (www.siemens.com/sinamics-g120c)
Online catalog (Industry Mall)	Ordering data and technical information for all SIEMENS products	English, German	
SIZER	The overall configuration tool for SINAMICS, MICROMASTER and DYNAVERT T drives, motor starters, as well as SINUMERIK, SIMOTION controls and SIMATIC Technology	English, German, Italian, French	You obtain SIZER on a DVD (Order number: 6SL3070-0AA00-0AG0) and in the Internet: Download SIZER (http://support.automation.siemens.com/WW/view/en/10804987/130000)
Configuration Manual	Selecting geared motors, motors, converters and braking resistor based on calculation examples	English, German	Download engineering manual (http://support.automation.siemens.com/WW/view/en/37728795)

A.5.3 Product Support

If you have further questions

You can find additional information on the product and more in the Internet under: Product support (http://support.automation.siemens.com/WW/view/en/4000024).

In addition to our documentation, under this address we offer our complete knowledge base online: You can find the following information:

- Actual product information (Update), FAQ (frequently asked questions), downloads.
- The Newsletter contains the latest information on the products you use.
- The Knowledge Manager (Intelligent Search) helps you find the documents you need.
- Users and specialists from around the world share their experience and knowledge in the Forum.
- You can find your local representative for Automation & Drives via our contact database under "Contact & Partner".
- Information about local service, repair, spare parts and much more can be found under "Services".

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